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journal homepage: www.elsevier.com/locate/asiecoRegional financial technology and shadow banking activities of non-financial firms: Evidence from China[☆]Qiuyue Zhang^a, Jiangjing Que^{b,*}, Xiuting Qin^c^a School of Economics and Management, Beijing University of Technology, China^b School of International Economics and Management, Beijing Technology and Business University, China^c Institute of Finance Research, Postal Scientific Research and Planning Institute Limited, China

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ABSTRACT

Financial technology has greatly revolutionized the finance industry. However, the impact of financial technology on the shadow banking activities of non-financial firms has not been examined. Using a sample of Chinese listed firms from 2011 to 2018, we find that regional financial technology is positively associated with the shadow banking activities of non-financial firms, which is more pronounced for firms with low profitability and firms listed only in China's A-share market. We show that financial technology can enhance the shadow banking activities by alleviating financing constraints. In addition, an increase in the equalization of profit rate and an increase in investment in the real economy reduce the positive effect of financial technology on the shadow banking activities. Further analysis suggests that financial regulations can attenuate excessive shadow banking activities of non-financial firms driven by financial technology.

1. Introduction

The shadow banking activities in China experience rapid expansion in recent years. The value generated in shadow banking activities is almost 35% of gross domestic product (GDP) in 2014 and achieves a peak in 2016 at over 80% of GDP (Le et al., 2021). The shadow banking activities can provide convenience for non-financial firms to obtain credit, especially for small and medium-sized firms who face serious obstacles to access formal finance (Du et al., 2017). Meanwhile, the shadow banking activities of non-financial firms may cause a decrease of investment in the real economy and the financialization of enterprises (Seo et al., 2012), resulting in stock price crashes and financial risks (Si et al., 2021). Therefore, research on shadow banking activities is vitally important for both non-financial firms and the whole financial system.

Financial technology has greatly revolutionized the finance industry (Cho and Chen, 2021) and affected credit performance through big data, cloud computing, artificial intelligence and other new technologies (Gu et al., 2020; Sheng, 2021; Lee et al., 2021). It is well documented that financial technology can mitigate information asymmetry (Phan et al., 2021), reduce transaction costs (Cho and Chen, 2021; Grennan and Michaely, 2021) and improve the efficiency of the whole process of the financial industry (Villero de Galhau (2016); Lee et al., 2021). As an important component of finance industry, the shadow banking activities of non-financial firms will be inevitably affected by financial technology. However, few literature studies the relationship between financial technology and shadow banking activities of non-financial firms. In this study, we focus on non-financial firms and answer three questions: (i) How

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dose financial technology affect the shadow banking activities of non-financial firms? (ii) What are the underlying mechanisms? (iii) Whether financial regulations can reduce excessive shadow banking activities driven by financial technology?

To answer our questions, we first construct a comprehensive measure of regional financial technology of 31 Chinese provincial administrative regions. Relying on this measure, we explore the impact of financial technology on the shadow banking activities of non-financial firms. The results show that regional financial technology is positively associated with the shadow banking activities of non-financial firms. Further, we examine two components of shadow banking activities (including credit intermediary¹ and credit chain²) separately and find that financial technology is more closely related to credit intermediary than credit chain of non-financial firms. In addition, we also examine two heterogeneous effects of financial technology on the shadow banking activities of non-financial firms based on firm profitability and stock markets. Our results suggest that the effect of financial technology on the shadow banking activities is more pronounced for firms with lower profitability and for firms only listed in China's A-share market³.

Furthermore, additional robustness tests are conducted to validate our findings. First, in order to reduce the effect of industry policies, we introduce the interaction between industry and year dummy variables into the baseline model. Second, in order to eliminate the influence of data skewness, we use the natural logarithm of the scale of shadow banking as an alternative dependent variable. Third, considering the effect of time trend, we add time trend and its square term into the baseline model. Fourth, we exclude firms located in Beijing, Tianjin, Shanghai and Chongqing to eliminate the impact of administrative factors. Fifth, we use a lagged independent variable (lagged *Fintech*) as an instrumental variable to address endogeneity problem. Sixth, considering the unbalanced development of provinces in China, we eliminate one province from the whole sample each time and repeat the baseline regression (a total of 31 times). The results show that our conclusions carry through with all robustness tests.

Next, we perform two tests to understand the underlying mechanisms through which financial technology affects the shadow banking activities of non-financial firms. First, small and medium-sized firms are difficult to access formal finance and face serious financing constraints. Financial technology can reduce information asymmetry between credit-constrained small firms and large firms and further alleviate financing constraints. Therefore, we expect to find that financial technology can promote the shadow banking activities by reducing financing constraints. Second, the pursuit of high returns drives non-financial firms to engage in more financial activities and even crowd out investment in the real economy. Financial technology can decrease transaction costs and improve the return on capital. Therefore, we examine both the equalization of profit rate between firms in the financing industry and non-financial firms and the investment in the real economy. We explore whether an increase in the equalization of profit rate and an increase in investment in the real economy reduce the positive effect of financial technology on the shadow banking activities of non-financial firms. The answers in both analyses are positive, indicating that our results shed light on the mechanisms.

Finally, we explore whether financial regulations can reduce the effect of financial technology on excessive shadow banking activities of non-financial firms. As shown in the mechanisms, financial technology promotes non-financial firms to engage in more financial investment and reduce investment in the real economy. Therefore, the development of financial technology may cause liquidity constraints, resulting in operating risk of firms and stock price crashes (Seo et al., 2012; Si et al., 2021). The final section explores whether financial regulations can reduce the excessive shadow banking activities driven by financial technology. Using loan-to-GDP ratio to measure financial regulations, we find that the excessive effect of financial technology on shadow banking activities can be attenuated by financial regulations.

Our study contributes to two strands of literature. First, our paper contributes to emerging literature on shadow banking. A series of studies have analyzed the shadow banking activities in terms of stimulus loan (Chen et al., 2020), entrusted loans (Allen et al., 2019) and undiscounted bank acceptance bills (An and Yu, 2018). There are also some factors that influence the shadow banking including monetary policy shock (Nelson et al., 2018), monetary transmission (Chen, Ren and Zha, 2018) and regulation scheme (Feve et al., 2019). Unlike previous studies, our paper focuses on non-financial firms and is the first to examine the effect of financial technology on the shadow banking activities of non-financial firms.

Our paper also extends the literature on financial technology. Financial technology can affect banking performance (Goh and Kauffman, 2013; Gomber et al., 2018; Dong et al., 2020; Cho and Chen, 2021), bank efficiency (Lee et al., 2021), green development (Cao et al., 2021), poverty alleviation (Ye et al., 2022) and credit risk (Cheng and Qu, 2020). However, there is little insight into the relationship between financial technology and shadow banking activities of non-financial firms. We fill in this gap.

The remainder of this paper is organized as follows. Section 2 discusses institutional background, literature review and hypothesis development. Section 3 describes sample selection and reports summary statistics. Section 4 examines the effect of financial technology on shadow banking activities of non-financial firms. Section 5 provides robustness tests. Section 6 explores possible mechanisms. Section 7 discusses financial regulations. Section 8 concludes the paper.

¹ Credit intermediary is defined as sum of the scale of entrusted loans, entrusted financial management and private lending divided by total assets.

² Credit chain is defined as the sum of wealth management products, trust products, structured deposits and asset management plan divided by total assets.

³ In our sample, all listed firms are classified in two types: firms listed only in China's A-share market and firms listed in both the A-share market (Mainland China) and the H-share market (Hong Kong).

2. Institutional background, literature review and hypothesis development

2.1. Institutional background

China provides a unique market for the research on the shadow banking activities of non-financial firms. China's shadow banking activities experience rapid expansion in recent years. Specifically, shadow banking activities begin to expand since China has launched a 4 trillion yuan stimulus package in 2008 (Yang et al., 2019a, 2019b). The size of shadow banking has taken the fifth place in the world in 2012 and the third in 2014 (Du et al., 2017). The value generated in shadow banking activities is almost 35% of gross domestic product (GDP) in 2014 and achieves a peak in 2016 at over 80% of GDP (Le et al., 2021). However, the shadow banking activities have fallen due to a series of regulatory measures initiated since 2016. The total value of shadow banking activities in China reaches 84.8 trillion yuan in 2019 and decreases to 57 trillion yuan in 2021 according to Moody's (2021).

In addition, the shadow banking system in China is crucially different from those in advanced economies (Chen et al., 2018). The shadow banking system in China is much more bank-centric and interacts with traditional banks more seriously than in the West (Elliott et al., 2015; Chen et al., 2018). The major components of shadow banking activities in China include wealth management products, entrusted loans, agencies of assets management, trust business and private lending (Du et al., 2017). In addition, shadow banking in China is much less complex, mainly engaging in providing credit that otherwise would have been provided by the regulated commercial banks (Le et al., 2021).

As important components of shadow banking, the shadow banking activities of non-financial firms are also influenced by the unique features of the Chinese financial system and may exhibit totally different performance. Therefore, these distinct characteristics are worthy to further research to figure out the implications of shadow banking of non-financial firms and their underlying mechanisms.

2.2. Literature review and hypothesis development

The shadow banking activities of non-financial firms involve two forms: credit intermediary and credit chain. When non-financial firms act as credit intermediaries and lend out to credit-constrained small firms, there exists an information asymmetry problem. Financial technology can mitigate information asymmetry (Phan et al., 2021) and alleviate financing constraints, which strengthens the role of credit intermediary of non-financial firms. In addition, when non-financial firms participate in credit chain of shadow banking system, they mainly purchase financial products, trust products, structured deposits and asset management. Financial technology can provide less expensive and more efficient services in those financial services (Villero de Galhau (2016);) and reduce transaction costs (Cho and Chen, 2021; Grennan and Michaely, 2021), which enhances the scale of credit chain of non-financial firms. Therefore, we propose:

Hypothesis 1. Financial technology facilitates the shadow banking activities of non-financial firms.

We also examine the potential mechanisms through which financial technology affects the shadow banking activities of non-financial firms. Due to the imperfect financial system in China (Haselmann et al., 2016), many small and medium-sized firms are difficult to obtain credit from formal banking system, while large companies have privileged access to formal finance (Du et al., 2017) and even have more spare funds (Stein, 2002; Song et al., 2011). When small and medium-sized firms raise money from large companies, there is serious information asymmetry between lenders (i.e., large companies) and borrowers (i.e., small and medium-sized firms). The use of financial technology, such as big data and cloud computing, could effectively mitigate information asymmetry and reduce financing constraints (Grennan and Michaely, 2021; Zhao et al., 2022), which helps lenders to better screen potential borrowers (Buchak et al., 2018). Therefore, we propose:

Hypothesis 2. Financial technology can enhance the shadow banking activities of non-financial firms by reducing financing constraints.

There is an obvious difference of profit rate between firms in the financing industry and non-financial firms. If the difference of profit rate is bigger, it means that the profit rate of non-financial firms becomes lower or the profit rate of firms in the financing industry becomes higher. To obtain higher profitability, non-financial firms have strong incentives to engage in more financial activities. On the other hand, financial technology can provide less expensive and efficient financial services and improve the efficiency of the whole process of the financial industry (Phan et al., 2021; Lee et al., 2021). As a result, financial technology can decrease transaction costs (Cho and Chen, 2021) and improve the return on capital in the financial industry (Grennan and Michaely, 2021). Therefore, financial technology will promote the shadow banking activities of non-financial firms due to the motivation of reducing the difference of profit rate between firms in the financing industry and non-financial firms (measured by the equalization of profit rate⁴). Based on the above analysis, we propose:

⁴ The difference of profit rate (*Diff_Profit*) is defined as the difference between the mean profit rate of net assets of all listed firms in the financial industry and the profit rate of net assets of the specific non-financial firm. The smaller the difference is, the greater the equalization of profit rate becomes. In other words, an increase in the equalization of profit rate means a decrease in the difference of profit rate between firms in the financing industry and non-financial firms.

Table 1

Indicators of China's financial technology development. This table presents the three-level indicators of China's financial technology development. The data of Peking University Digital Inclusive Finance Index comes from the Institute of Digital Finance at the Peking University. The data of the other indicators in Level 3 Dimension comes from the National Bureau of Statistics of China.

Level 1 Dimension	Level 2 Dimension	Level 3 Dimension
Digital finance application	Indicator of inclusive finance	Peking University Digital Inclusive Finance Index
Internet penetration	Internet development	Internet broadband users
	Proportion of Internet users	Internet penetration rate
Service capability of communication infrastructure	Development of communication infrastructure	Length of optical cable line (km)
	Computer development	Number of computers at the end of the period
Service capability of software and information technology	Development of e-commerce	Number of enterprises with e-commerce transactions
	Development of software and information technology	Revenue of software and information technology services
	Number of IT related firms	Number of legal entities in information transmission, computer service and software industry
Communication service capacity	Informatization capability	Number of websites
	Mobile internet capabilities	Mobile Internet access traffic (10 thousand GB)

Hypothesis 3a. . An increase in the equalization of profit rate reduces the positive effect of financial technology on the shadow banking activities of non-financial firms.

Asset allocation in enterprises mainly refers to the balance between financial assets and physical assets. According to previous studies (Li and Han, 2019), firm investment in the financial market will reduce the funds used by enterprises for the investment in the real economy. In other word, an increase in investment in financial business will crowd out the investment in the real economy, such as main business or R&D (Seo et al., 2012; Shin, 2012). The development of financial technology can improve efficiency in financial services (Phan et al., 2021; Lee et al., 2021), decrease transaction costs of financial business (Cho and Chen, 2021) and thus improve the return on capital in the financial industry (Grennan and Michaely, 2021). Therefore, financial technology can help non-financial firms to enhance firm profitability and stimulate them to increase financial activities and in turn reduce the investment in the real economy, which promotes the shadow banking activities of non-financial firms.

Hypothesis 3b. . An increase in investment in the real economy reduces the positive effect of financial technology on the shadow banking activities of non-financial firms.

3. Data and descriptive statistics

3.1. Data and sample construction

We obtain the list of all firms listed in China's A-share market from 2011 to 2018. Firms that are financial institutions or receive delisting notices are excluded from our sample. The information of shadow banking activities of non-financial firms comes from the China Stock Market and Accounting Research (CSMAR) database⁵ and company announcements. The data used to measure financial technology is obtained from the National Bureau of Statistics of China and the Institute of Digital Finance at the Peking University. The information of control variables including firm financial information and firm characteristics comes from the CSMAR database and RESSET database. We measure shadow banking activities and control variables of non-financial firms at the firm-year level and financial technology at the province-year level⁶. Every firm is located in a specific province and thus we match each firm to the corresponding province to construct our sample. In the end, there are 21601 firm-year observations from 3,419 companies.

3.2. Construction of financial technology

Following Zhao et al. (2020), financial technology development index includes five dimensions: digital finance application, internet penetration, service capability of communication infrastructure, service capability of software and information technology, and communication service capacity. First, following previous literature (Guo et al., 2020; Cao et al., 2021), digital finance application is measured using the Peking University Digital Financial Inclusive Index of China⁷. Second, internet penetration is measured based on

⁵ The CSMAR is a leading data vendor, which is developed according to the standard of CRSP and COMPUSTAT and can be obtained from Wharton Research Data Services (WRDS). The CSMAR database provides stock information and firm-year financial data for all listed companies in China.

⁶ There are 31 provincial administrative regions in mainland China.

⁷ The Peking University Digital Financial Inclusion Index of China (PKU-DFIIC) is a product of a collaboration between the Institute of Digital Finance at the Peking University and the Ant Financial Services Group. Ant Financial Services Group is the largest fintech company in China. PKU-DFIIC utilizes the big data of Ant Financial Services Group's trading account, which is quite reliable (following Cao et al., (2021)). The index covers three geographical levels: province, prefecture-level municipality and county.

Table 2

Variable definitions. This table presents the definitions of all variables in our paper.

Variable	Definition
<i>FinTech</i>	Financial technology development index includes five dimensions: digital finance application, internet penetration, service capability of communication infrastructure, service capability of software and information technology, and communication service capacity. Financial technology is measured by weighting ^a the indicators in Level 3 Dimension in Table 1.
<i>Shadow_Banking</i>	Defined as the sum of <i>Credit_Intermediary</i> and <i>Credit_Chain</i> .
<i>Credit_Chain</i>	Defined as the sum of wealth management products, trust products, structured deposits and asset management plan divided by total assets.
<i>Credit_Intermediary</i>	Defined as sum of the scale of entrusted loans, entrusted financial management and private lending divided by total assets.
<i>Leverage</i>	Defined as the total liabilities divided by total assets.
<i>Margin</i>	Defined as the difference between the financial earnings scaled by financial assets and operating earnings scaled by operating assets.
<i>External_F</i>	Defined as the sum of equity financing and bond financing scaled by total assets.
<i>ROE</i>	Defined as the ratio of net income to total equities.
<i>Grevenue</i>	Defined as the main business income at the end of the year divided by main business income at the end of the previous year minus one.
<i>Salary</i>	Defined as the natural logarithm of total annual salary of managers.
<i>Size</i>	Defined as the natural logarithm of total assets.
<i>Ownership</i>	Defined as the share of listed firms owned by actual controllers.
<i>Law_Region</i>	Defined as the index of "service conditions of lawyers, accountants and other market intermediary organizations" in the marketization index of the province.
<i>P2P</i>	Defined as the average interest rate of online lending.

^a The weight is calculated using an entropy approach.

the internet development and the proportion of internet users. Third, the service capability of communication infrastructure includes the development of communication infrastructure and computer development. Fourth, the service capability of software and information technology is measured based on the development of e-commerce, the development of software and information technology and the number of IT related firms. Fifth, communication service capacity includes informatization capability and mobile internet capabilities. The data of other dimensions comes from the National Bureau of Statistics of China. Financial technology is measured by weighting⁸ the indicators in Level 3 Dimension in Table 1, labelled as *FinTech*. All variables are measured at the province level. See Table 1 for details.

3.3. Construction of shadow banking of non-financial firms

Following prior studies (Li and Han, 2019; Han and Li, 2021), we construct the measure of shadow banking of non-financial firms. The shadow banking activities of non-financial firms involve two forms: credit intermediary and credit chain. First, credit intermediary is measured by the sum of the scale of entrusted loans, entrusted financial management and private lending⁹ divided by total assets, labelled as *Credit_Intermediary*. The data of entrusted loan is obtained from the entrusted loan announcements issued by listed companies¹⁰ (Allen et al., 2019). The data of entrusted financial management and private lending comes from the CSMAR database.

Credit chain of shadow banking system refers mainly to the behaviors of firms' participation in investment and financing activities in the credit market by purchasing financial products, such as bank financing, brokerage financing, trust products and structured deposits. We define credit chain as the sum of financial products, trust products, structured deposits and asset management plan divided by total assets, labelled as *Credit_Chain*. The data of financial products comes from the "Other current assets" of "Notes to financial statements" in the CSMAR database¹¹. In the end, the scale of shadow banking activities of non-financial firms is measured by the sum of *Credit_Intermediary* and *Credit_Chain*, labelled as *Shadow_Banking*.

3.4. Descriptive statistics

Following Li and Han (2019), we first control for three direct proxies to affect the shadow banking activities of non-financial firms: external financing (*External_F*), the difference of returns between financial investment and investment in the real economy (*Margin*) and online lending (*P2P*). *External_F* is defined as the sum of equity financing and bond financing scaled by total assets. *Margin* is defined as the difference between financial earnings scaled by financial assets and operating earnings scaled by operating assets. *P2P* is defined as the average interest rate of online lending. The interest rate may affect the scale of lending between firms with spare funds or privileged access to formal finance and firms with high credit constraints.

Second, we control for two indirect proxies to affect the shadow banking activities of non-financial firms: the salary of managers

⁸ The weight is calculated using an entropy approach.

⁹ When measuring the private lending, we take "other accounts receivable" as a proxy variable to measure the capital lending between enterprises (Jiang et al., 2010).

¹⁰ The official website of Shanghai/Shenzhen Stock Exchange discloses the information of entrusted loan announcements for all listed companies.

¹¹ Unlike balance sheet, there is no standard items for each firm and thus we need to extract the items related to financial products. Specifically, we choose the items that contain "bank financing", "trust products", "structured deposits", "National debt reverse repurchase" and other related items and define credit chain as the sum of all items related to financial products divided by total assets.

Table 3

Descriptive statistics. This table reports the descriptive statistics for non-financial firms listed in China's A-share market from 2011 to 2018. *Shadow_Banking* is defined as the sum of *Credit_Intermediary* and *Credit_Chain*. *Credit_Chain* is defined as the sum of financial products, trust products, structured deposits and asset management plan divided by total assets. *Credit_Intermediary* is defined as the sum of entrusted loan, entrusted financing and private lending divided by total assets. The other independent variables include *Leverage*, *Margin*, *External_F*, *ROE*, *Grevenue*, *Salary*, *Size*, *Ownership*, *Law_Region* and *P2P*, which are defined in Table 2. Data sources are the CSMAR database and RESSET database.

Variable	Obs.	Min	Mean	Median	Max	Std. Dev.
Shadow_Banking	21,601	0.020	11.213	1.476	138.262	24.330
Credit_Chain	21,601	0.000	0.658	0.000	10.132	1.689
Credit_Intermediary	21,601	0.020	10.482	1.453	132.024	23.031
FinTech	21,601	9.206	14.942	15.948	17.340	2.235
Leverage	21,601	0.011	0.036	0.024	0.204	0.032
Margin	21,601	-0.931	-0.145	-0.132	0.789	0.227
External_F	21,601	0.047	0.411	0.375	1.871	0.268
ROE	21,601	-0.563	0.061	0.069	0.361	0.120
Grevenue	21,601	-0.558	0.187	0.107	3.099	0.459
Salary	21,601	13.271	15.191	15.169	17.151	0.729
Size	21,601	19.475	22.043	21.880	25.731	1.289
Ownership	21,601	0.000	34.586	33.710	74.980	17.849
Law_Region	21,601	1.460	10.306	10.580	21.570	5.191
P2P	21,601	0.000	44.674	39.384	109.062	32.171

Table 4

Regression analysis of financial technology on the shadow banking activities of non-financial firms. This table presents the effect of financial technology on the shadow banking activities of non-financial firms. Columns (1)-(3) report the baseline results and the dependent variables in Columns (1)-(3) are *Shadow_Banking*, *Credit_Chain* and *Credit_Intermediary*, respectively. Columns (4)-(6) report the results of the second stage of the instrumental variable approach. The dependent variables in Columns (4)-(6) are *Shadow_Banking*, *Credit_Chain* and *Credit_Intermediary*, respectively. *Shadow_Banking* is defined as the sum of *Credit_Intermediary* and *Credit_Chain*. *Credit_Chain* is defined as the sum of financial products, trust products, structured deposits and asset management plan divided by total assets. *Credit_Intermediary* is defined as the sum of entrusted loan, entrusted financing and private lending divided by total assets. The other independent variables include *Leverage*, *Margin*, *External_F*, *ROE*, *Grevenue*, *Salary*, *Size*, *Ownership*, *Law_Region* and *P2P*, which are defined in Table 2. T-statistics are reported in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

	OLS			2SLS		
	<i>Shadow_Banking</i> (1)	<i>Credit_Chain</i> (2)	<i>Credit_Intermediary</i> (3)	<i>Shadow_Banking</i> (4)	<i>Credit_Chain</i> (5)	<i>Credit_Intermediary</i> (6)
FinTech	0.8175*** (3.68)	0.0285* (1.76)	0.7916*** (3.80)	2.8249*** (3.30)	0.2102*** (3.33)	2.5967*** (3.21)
Leverage	44.5729*** (3.44)	4.5471*** (4.99)	41.2101*** (3.37)	45.9253*** (4.43)	4.6696*** (6.35)	42.4262*** (4.30)
Margin	12.6847*** (8.87)	0.2625*** (2.79)	12.4353*** (9.07)	12.5734*** (11.09)	0.2524*** (3.21)	12.3353*** (11.34)
External_F	5.3329*** (2.80)	0.4992*** (3.97)	4.6381** (2.57)	5.5039*** (3.91)	0.5147*** (5.00)	4.7919*** (3.58)
ROE	5.1452*** (3.81)	0.3070*** (3.18)	4.7861*** (3.76)	5.1163*** (4.21)	0.3043*** (3.35)	4.7601*** (4.12)
Grevenue	0.2554 (0.79)	0.0133 (0.59)	0.2269 (0.73)	0.2191 (0.67)	0.0100 (0.41)	0.1943 (0.64)
Salary	1.1758** (2.13)	0.0312 (0.76)	1.1095** (2.14)	1.1794*** (2.73)	0.0315 (1.00)	1.1127*** (2.72)
Size	-1.9237*** (-3.19)	-0.0749* (-1.73)	-1.8074*** (-3.17)	-1.8707*** (-4.21)	-0.0701** (-2.21)	-1.7598*** (-4.17)
Ownership	0.0071 (0.36)	0.0001 (0.07)	0.0082 (0.44)	0.0080 (0.52)	0.0002 (0.15)	0.0090 (0.62)
Law_Region	-0.0047 (-0.03)	0.0020 (0.20)	-0.0115 (-0.08)	-0.2683 (-1.64)	-0.0219* (-1.86)	-0.2486 (-1.60)
P2P	0.1242*** (3.26)	0.0085*** (3.18)	0.1145*** (3.19)	-0.1273 (-1.17)	-0.0143* (-1.77)	-0.1117 (-1.09)
Constant	17.0367 (1.30)	0.6141 (0.66)	16.0617 (1.29)			
Kleibergen-Paap rk LM statistic				128.039***	128.039***	128.039***
Kleibergen-Paap rk Wald F statistic				234.018 [16.38]	234.018 [16.38]	234.018 [16.38]
Observations	21,601	21,601	21,601	21,504	21,504	21,504
Adjusted R-squared	0.068	0.052	0.066	-0.106	-0.127	-0.108
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes

(*Salary*), and the regional law index (*Law_Region*). Following Wu et al. (2019), *Salary* is defined as the natural logarithm of the total salary of managers. We add *Salary* into our model considering that the salary of managers may affect the decision-making, such as engaging in more financial activities or investment in the real economy, and further affect the shadow banking activities of non-financial firms. *Law_Region* is defined as the index of "service conditions of lawyers, accountants and other market intermediary organizations" in the marketization index of the province. We control for *Law_Region* considering that law enforcement is associated with the protection of private property rights and the implementation of regulation policies, affecting the shadow banking activities of non-financial firms.

Third, we control for some baseline characteristics of firms, including leverage (*Leverage*), return on equity (*ROE*), firm size (*Size*), main business income (*Grevenue*), structure of share (*Ownershare*). *Leverage* is defined as the total liabilities divided by total assets. *ROE* is defined as the ratio of net income to total equities. *Size* is defined as the natural logarithm of total assets. *Grevenue* is defined as the main business income at the end of the year divided by main business income at the end of the previous year minus one. *Ownershare* is defined as the share of listed firms owned by actual controller. Those proxies measure the operation level of non-financial firms and their operating risk, which may affect the scale of shadow banking of non-financial firms. All information of those variables comes from the CSMAR database and RESSET database. The detailed definitions for all variables are provided in Table 2.

Table 3 presents descriptive statistics of our sample. To eliminate the influence of outliers, the main control variables are winsorized at the 1th and 99th percentile. The mean of shadow banking is 11.21, in which the mean of credit chain is 0.66 and the mean of credit intermediary is 10.48, suggesting that credit intermediary accounts for the main shadow banking activities of non-financial firms. The mean of financial technology index is about 14.94 and its standard deviation is 2.235, indicating that there is little difference among provincial administrative regions. In addition, we also summaries descriptive statistics for other control variables including *Leverage*, *ROE*, *Size*, *Grevenue*, *Salary*, *Ownershare*, *Law_Region* and *P2P*.

4. Empirical results

4.1. Baseline result

Following the previous study in shadow banking (Du, Li and Wang, 2017), we examine the effect of financial technology on the shadow banking activities of non-financial firms. Specifically, the test is performed using the following model:

$$Y_{i,t} = \beta_0 + \beta_1 FinTech_{i,t} + \beta_2 Z_{i,t} + \delta_t + \varphi_i + \varepsilon_{i,t}. \quad (1)$$

where i represents the firm and t represents the year. $Y_{i,t}$ is one of the measures for shadow banking activities of non-financial firms: *Shadow_Banking*, *Credit_Chain*, *Credit_Intermediary*. $Z_{i,t}$ is a vector of control variables that may affect the shadow banking activities of non-financial firms. All variables are defined in detail in Table 2. δ_t are year fixed effects and φ_i are firm fixed effects.

We first examine the effect of financial technology on the shadow banking activities of non-financial firms and report the baseline regression results in Column (1) - (3) in Table 4. We find that the coefficient of *FinTech* in Column (1) is significant and positive, indicating that the shadow banking activities of non-financial firms become more active with the development of financial technology. In addition, we also examine the impact of financial technology on different types of shadow banking activities. Column (2) and (3) report the results of credit chain and credit intermediary, respectively. We find that financial technology is positively associated with both credit chain and credit intermediary of shadow banking activities of non-financial firms.

In order to address endogeneity problem, we adopt an instrumental variable approach in our analysis. We use the weighted average of financial technology in other provinces (i.e., excluding the province where the non-financial firm is located) as the instrumental variable. The weight is the economic distance of spatial weights matrix¹² documented in Shao et al. (2016). The weighting method not only considers the spatial impact of geographical distance, but also reflects the fact that economic factors have regional spillover effects and radiation effects. Columns (4) - (6) in Table 4 report the regression results of the second stage of the instrumental variable approach (2SLS¹³). We find that Kleibergen-paap RK LM is significant, and Cragg-donald Wald F is greater than Stock-Yogo's F test, indicating that the instrumental variable is reasonable and reliable. The results show that financial technology facilitates the shadow banking activities of non-financial firms, which is consistent with the baseline conclusion.

4.2. Heterogeneity analysis

Non-financing firms with low profitability may prefer to shift from main business to financial business, which makes the positive effect of financial technology on the shadow banking activities more pronounced. In addition, Hong Kong, as a link between mainland

¹² $W_1 = 1/d^2$, where d is the distance between the centers of the two provinces. $W_2 = 1/|y_1 - y_2| + 1$, where y_i represents the per capita GDP of i province. The weight matrix of economic distance space is $W = \theta W_1 + (1-\theta)W_2$. The value of θ ranges from 0 to 1. In this paper, the value is 0.5, indicating that the economic and geographical weight matrix account for 50%, respectively.

¹³ Jiang (2017) find that the IV estimates almost always exponentially exceed the un-instrumented estimates by surveying 255 papers published in the "Big Tree" finance journal. She attributes the phenomenon to the local average treatment effect. Local average treatment effect is produced by heterogeneity, that is, the treatment effect of each individual is different. In this case, the adoption of instrumental variables may lead to a bias measurement of the average treatment effect of only a subset of individuals in the treatment group, rather than the average treatment effect of the treatment group.

Table 5

Regression analysis of heterogeneity analyses. This table reports the results of heterogeneity analyses. Columns (1) and (3) report the results for firms with high profitability. Columns (2) and (4) report the results for firms with low profitability. Firms are split into two groups (High and Low) based on the median of *ROE*. Columns (5) and (7) report the results for firms listed in both the A-share market (Mainland China) and the H-share market (Hong Kong) (AH-share). Columns (6) and (8) report the results for firms listed only in China's A-share market (A-share). *Shadow Banking* is defined as the sum of *Credit Intermediary* and *Credit Chain*. *Credit Chain* is defined as the sum of financial products, trust products, structured deposits and asset management plan divided by total assets. *Credit Intermediary* is defined as the sum of entrusted loan, entrusted financing and private lending divided by total assets. The other independent variables include *Leverage*, *Margin*, *External_F*, *ROE*, *Grevenue*, *Salary*, *Size*, *Ownership*, *Law_Region* and *P2P*, which are defined in Table 2. T-statistics are reported in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

	OLS		2SLS		OLS		2SLS	
	High (1)	Low (2)	High (3)	Low (4)	AH-share (5)	A-share (6)	AH-share (7)	A-share (8)
FinTech	0.5393* (1.66)	0.8217** (2.42)	1.5889 (1.23)	2.9797** (2.37)	0.5922 (1.13)	0.8852*** (3.86)	0.5877 (0.44)	2.9216*** (3.28)
Leverage	61.1426*** (3.35)	32.9782* (1.78)	61.6253*** (4.05)	34.6565** (2.22)	-8.7532 (-0.18)	45.7606*** (3.50)	-8.7452 (-0.26)	47.2379*** (4.51)
Margin	20.7342*** (9.23)	7.7942*** (3.86)	20.6747*** (10.97)	7.6840*** (4.50)	3.0100 (1.06)	12.8095*** (8.81)	3.0090 (1.23)	12.6871*** (11.00)
External_F	5.4217 (1.51)	7.9939*** (3.30)	5.5198** (1.99)	8.0897*** (4.21)	7.3262 (1.08)	5.2020*** (2.71)	7.3251 (1.43)	5.3630*** (3.77)
ROE	1.6436 (0.32)	6.1057*** (3.13)	1.3254 (0.29)	6.1446*** (3.55)	-0.7183 (-0.25)	5.2784*** (3.82)	-0.7192 (-0.28)	5.2343*** (4.21)
Grevenue	0.8949* (1.85)	-0.2439 (-0.52)	0.8869* (1.87)	-0.2729 (-0.55)	0.6034 (0.66)	0.2590 (0.79)	0.6035 (0.64)	0.2238 (0.68)
Salary	0.8863 (0.92)	1.5715** (2.12)	0.8813 (1.10)	1.5617*** (2.66)	-0.2576 (-0.39)	1.1773** (2.07)	-0.2573 (-0.34)	1.1813*** (2.65)
Size	-3.2456*** (-3.89)	-1.8383** (-2.05)	-3.2465*** (-4.53)	-1.7608*** (-2.58)	2.8661* (1.79)	-2.0611*** (-3.36)	2.8649** (2.11)	-2.0183*** (-4.47)
Ownership	-0.0345 (-1.31)	0.0449 (1.39)	-0.0339 (-1.54)	0.0450* (1.66)	0.0183 (0.58)	0.0075 (0.37)	0.0183 (0.55)	0.0088 (0.56)
Law_Region	-0.2375 (-1.01)	0.1018 (0.44)	-0.3743 (-1.46)	-0.1708 (-0.71)	-0.9139 (-1.37)	0.0271 (0.17)	-0.9131** (-2.16)	-0.2381 (-1.41)
P2P	0.2422*** (3.97)	0.1001* (1.75)	0.1096 (0.66)	-0.1683 (-1.06)	0.0687 (0.80)	0.1191*** (3.05)	0.0693 (0.35)	-0.1350 (-1.20)
Constant	59.4438*** (2.91)	4.2625 (0.22)			-64.8884 (-1.58)	18.9451 (1.42)		
Kleibergen-Paap rk LM statistic			58.737***	67.922***			5.218**	123.588***
Kleibergen-Paap rk Wald F statistic			108.409 [16.38]	131.059 [16.38]			10.383 [16.38]	224.789 [16.38]
Observations	10,903	10,698	10,344	10,304	592	21,009	587	20,917
Adjusted R-squared	0.075	0.068	-0.214	-0.181	0.084	0.069	-0.059	-0.106
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

China and the international capital market, has attracted many domestic enterprises to list on the Hong Kong stock exchange due to high liberalized market and low financing constraints. Firm profitability and stock market may result in heterogeneous effects of financial technology on the shadow banking activities of non-financial firms. Therefore, we perform some heterogeneity analyses in this section.

We first examine the heterogeneity of firm profitability and report the result in Column (1)-(4) in Table 5. Firms are split into two groups (Low and High) based on the median of *ROE*. The coefficient of *FinTech* is positive and significant for firms with low profitability in Column (1), but not significant for firms with high profitability in Column (2), indicating that the effect of financial technology on the shadow banking activities is more pronounced for firms with poor profitability. We rerun the baseline regression using an instrumental variable approach and report the results in Columns (3)-(4). The results show that our conclusion is consistent.

Columns (5)-(8) in Table 5 report the results of heterogeneity analysis of stock market. We split all listed firms into two groups: firms listed only in China's A-share market and firms listed in both the A-share market (Mainland China) and the H-share market (Hong Kong). We find that the coefficients of *FinTech* are significant in Column (6) and (8), but not significant in Column (5) and (7). The evidence suggests that the effect of financial technology on the shadow banking activities is more pronounced for firms listed only in China's A-share market. The findings in Table 5 show that low profitability and listing only in China's A-share market can promote financial technology to play a positive role in the shadow banking activities of non-financial firms.

5. Robustness tests

5.1. Controlling for industry impact

Considering that the shadow banking activities may be affected by industry policies, we introduce the interaction term between

Table 6

Regression analysis of robustness tests. This table presents the robustness tests. Column (1) and (2) report the results after controlling for the interaction term between industry and year dummy variables. In Column (3) and (4), the dependent variable is the natural logarithm of the scale of shadow banking. Column (5) and (6) report the results after controlling for time trend and its square term. Column (7) and (8) report the results after excluding the firms located in Beijing, Tianjin, Shanghai and Chongqing. Columns (9) - (11) report the results of the second stage of the instrumental variable (lagged *Fintech* with one week) approach. *Shadow_Banking* is defined as the sum of *Credit_Intermediary* and *Credit_Chain*. *Credit_Chain* is defined as the sum of financial products, trust products, structured deposits and asset management plan divided by total assets. *Credit_Intermediary* is defined as the sum of entrusted loan, entrusted financing and private lending divided by total assets. The other independent variables include *Leverage*, *Margin*, *External_F*, *ROE*, *Grevenue*, *Salary*, *Size*, *Ownershare*, *Law_Region* and *P2P*, which are defined in Table 2. T-statistics are reported in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

	<i>Shadow_Banking</i>		<i>Ln(Shadow_Banking)</i>		<i>Shadow_Banking</i>		<i>Shadow_Banking</i>		<i>Shadow_Banking</i>	<i>Credit_Chain</i>	<i>Credit_Intermediary</i>
	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)	OLS (5)	2SLS (6)	OLS (7)	2SLS (8)	2SLS (9)	2SLS (10)	2SLS (11)
FinTech	0.7940*** (3.54)	2.7187*** (3.11)	0.1042*** (4.71)	0.4169*** (4.37)	0.8175*** (3.68)	0.4169*** (4.37)	0.1705*** (5.97)	2.3610*** (3.53)	11.3570*** (18.89)	0.6128*** (14.06)	10.6895*** (18.70)
Leverage	49.4340*** (3.77)	50.8123*** (4.90)	-0.6609 (-0.59)	-0.4503 (-0.49)	44.5729*** (3.44)	-0.4503 (-0.49)	-0.7678 (-0.57)	50.3003*** (4.22)	66.5414*** (4.97)	5.9143*** (6.23)	62.6631*** (4.91)
Margin	12.1685*** (8.59)	12.0595*** (10.65)	0.9947*** (8.69)	0.9774*** (10.62)	12.6847*** (8.87)	0.9774*** (10.62)	1.0517*** (8.26)	13.8352*** (11.37)	9.9281*** (8.01)	0.1232 (1.37)	9.8298*** (8.26)
External_F	5.1331*** (2.69)	5.3119*** (3.77)	-0.0025 (-0.01)	0.0241 (0.18)	5.3329*** (2.80)	0.0241 (0.18)	0.0511 (0.27)	3.7851** (2.53)	6.9986*** (4.21)	0.5906*** (4.90)	6.1616*** (3.90)
ROE	4.9964*** (3.71)	4.9942*** (4.14)	0.0269 (0.20)	0.0224 (0.18)	5.1452*** (3.81)	0.0224 (0.18)	0.1775 (1.27)	6.7055*** (5.20)	4.8918*** (3.74)	0.3178*** (3.23)	4.5330*** (3.64)
Grevenue	0.2249 (0.70)	0.1938 (0.61)	0.0287 (0.99)	0.0231 (0.81)	0.2554 (0.79)	0.0231 (0.81)	0.0073 (0.23)	0.0286 (0.08)	0.1012 (0.28)	0.0198 (0.73)	0.0682 (0.20)
Salary	0.9863* (1.79)	1.0011** (2.31)	0.1422*** (2.81)	0.1427*** (3.49)	1.1758** (2.13)	0.1427*** (3.49)	0.1071* (1.93)	0.9887** (1.99)	-0.0397 (-0.08)	-0.0635* (-1.76)	-0.0080 (-0.02)
Size	-2.0005*** (-3.27)	-1.9343*** (-4.28)	1.0441*** (20.84)	1.0524*** (28.01)	-1.9237*** (-3.19)	1.0524*** (28.01)	1.0613*** (18.98)	-2.0984*** (-4.20)	-2.0048*** (-3.88)	-0.0766** (-2.08)	-1.8630*** (-3.80)
Ownershare	0.0168 (0.85)	0.0178 (1.15)	-0.0026 (-1.32)	-0.0025 (-1.57)	0.0071 (0.36)	-0.0025 (-1.57)	-0.0031 (-1.36)	-0.0047 (-0.26)	0.0046 (0.25)	-0.0001 (-0.05)	0.0067 (0.40)
Law_Region	-0.0176 (-0.11)	-0.2604 (-1.60)	-0.0168 (-1.22)	-0.0579*** (-3.47)	-0.0047 (-0.03)	-0.0579*** (-3.47)	-0.0239 (-1.58)	-0.1828 (-1.18)	-1.4411*** (-10.02)	-0.0807*** (-8.34)	-1.3535*** (-9.87)
P2P	0.1694 (0.18)	0.1588 (0.12)	0.0078** (2.19)	-0.0314*** (-2.58)	0.6743*** (6.02)	0.0537*** (4.93)	0.0008 (0.18)	-0.0531 (-0.66)	-0.0042 (-1.03)	0.0007** (2.22)	-0.0050 (-1.29)
t					-4.3797*** (-2.79)	-0.9241*** (-4.63)					
t2					0.1427 (1.32)	0.0495*** (3.43)					
Constant	20.1032 (0.53)		-8.5265*** (-7.04)		21.2737 (1.63)		-9.0952*** (-6.74)				
Kleibergen-Paap rk LM statistic		125.242***		128.039***		128.039***		193.744***	3257.236***	3257.236***	3257.236***
Kleibergen-Paap rk Wald F statistic		222.778 [16.38]		234.018 [16.38]		234.018 [16.38]		418.257 [16.38]	13000 [16.38]	13000 [16.38]	13000 [16.38]
Observations	21,601	21,504	21,601	21,504	21,601	21,504	17,416	17,337	17,749	17,749	17,749
Adjusted R-squared	0.072	-0.102	0.258	0.114	0.068	0.114	0.255	-0.103	-0.155	-0.168	-0.156
Industry×Year	Yes	Yes	No	No	No	No	No	No	No	No	No
Year fixed effect	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

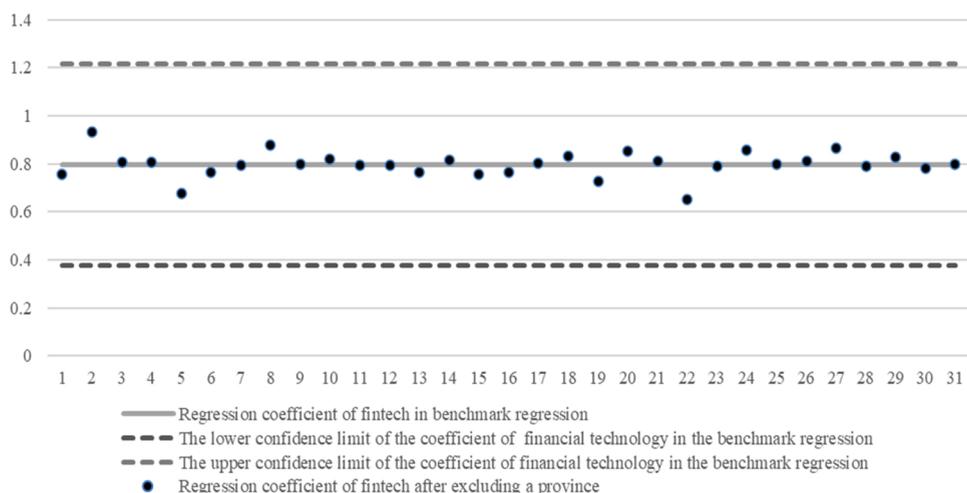


Fig. 1. Scatter plot of regression coefficients of financial technology after removing provinces.

industry and year dummy variables into the model. Table 6 Column (1) and (2) present the results of baseline regression and the instrumental variable approach after controlling for $Industry \times Year$, respectively. The significant coefficients suggest that the development of financial technology stimulates the shadow banking activities of non-financial enterprises, consistent with our baseline findings.

5.2. Examining an alternative dependent variable

In order to eliminate the influence of data skewness, we use the natural logarithm of shadow banking scale as an alternative dependent variable in our model. We report the results of baseline regression and the instrumental variable approach in Table 6 Column (3) and (4), respectively. The coefficients of *Fintech* are positive and significant, indicating that the development of financial technology promotes an increase in the shadow banking activities of non-financial firms. Our conclusion continues to hold with this alternative measure.

5.3. Controlling for time trend

Considering that shadow banking activities may be affected by time trend, we add time trend and its square term into the baseline model. Table 6 Column (5) and (6) present the results of baseline regression and the instrumental variable approach, respectively. Our results show that the coefficients of *Fintech* are still positive and significant at the 1% level, indicating that the benchmark regression result is not affected by time trend.

5.4. Excluding the effect of municipalities

There are four municipalities, including Beijing, Tianjin, Shanghai and Chongqing, that are directly under the jurisdiction of the central government in China. These four municipalities usually receive more economic resources and policy supports from the local and central governments, making their economic development better than the other cities or regions. Therefore, in order to eliminate the impact of administrative factors, we exclude firms located in Beijing, Tianjin, Shanghai and Chongqing and re-run the baseline model and report the results in Column (7) - (8) in Table 6. The results show that financial technology still plays a significant role in promoting the shadow banking activities of non-financial firms.

5.5. Eliminating the effect of endogeneity

There might be a reverse causality concern that a rise in financial technology could cause an increase in shadow banking activities or vice versa. Therefore, we further examine the results of lagged independent variables (lagged *Fintech*) to alleviate this concern besides the analysis in Section 4.1. We use *Fintech* with one lag as an instrumental variable to address endogeneity problem. We report the regression results of the second stage of the instrumental variable approach in Column (9)-(11) of Table 6 and find that our conclusions carry through with the lagged independent variable.

5.6. Eliminating the effect of unbalanced development of regions

Considering the unbalanced development of provinces in China, the outlier of a province may cause serious consequences to the

Table 7

Regression analysis of financing constrains. This table reports the effect of financing constrains on the relationship between financial technology and shadow banking activities of non-financial firms. Financing constrains are measured using KZ index, which is well constructed in Section 6.1. *Shadow_Banking* is defined as the sum of *Credit_Intermediary* and *Credit_Chain*. *Credit_Chain* is defined as the sum of financial products, trust products, structured deposits and asset management plan divided by total assets. *Credit_Intermediary* is defined as the sum of entrusted loan, entrusted financing and private lending divided by total assets. The other independent variables include *Leverage*, *Margin*, *External_F*, *ROE*, *Grevenue*, *Salary*, *Size*, *Ownershare*, *Law_Region* and *P2P*, which are defined in Table 2. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

	OLS			2SLS		
	<i>Shadow_Banking</i>	<i>Credit_Chain</i>	<i>Credit_Intermediary</i>	<i>Shadow_Banking</i>	<i>Credit_Chain</i>	<i>Credit_Intermediary</i>
	(1)	(2)	(3)	(4)	(5)	(6)
KZ	3.1672*** (5.46)	0.1181*** (3.24)	3.0695*** (5.53)	3.3271*** (5.86)	0.1700*** (4.65)	3.1469*** (5.79)
FinTech	0.8724*** (3.91)	0.0304* (1.87)	0.8449*** (4.03)	2.8424*** (3.32)	0.2105*** (3.34)	2.6140*** (3.24)
KZ × FinTech	-0.2473*** (-5.99)	-0.0108*** (-4.26)	-0.2377*** (-6.01)	-0.2580*** (-6.43)	-0.0144*** (-5.45)	-0.2427*** (-6.32)
Leverage	41.2325*** (3.16)	4.1702*** (4.61)	38.2855*** (3.11)	42.6829*** (4.07)	4.3143*** (5.82)	39.5676*** (3.97)
Margin	13.0262*** (9.15)	0.2998*** (3.20)	12.7358*** (9.33)	12.9058*** (11.36)	0.2879*** (3.63)	12.6293*** (11.58)
External_F	5.0661*** (2.69)	0.4805*** (3.84)	4.3904** (2.46)	5.2304*** (3.75)	0.4941*** (4.80)	4.5405*** (3.42)
ROE	4.3203*** (3.18)	0.2382** (2.46)	4.0338*** (3.16)	4.2946*** (3.50)	0.2338** (2.53)	4.0142*** (3.44)
Grevenue	0.1523 (0.46)	-0.0020 (-0.09)	0.1412 (0.45)	0.1249 (0.38)	-0.0034 (-0.14)	0.1146 (0.37)
Salary	1.2216** (2.23)	0.0340 (0.83)	1.1526** (2.24)	1.2262*** (2.87)	0.0347 (1.10)	1.1561*** (2.86)
Size	-2.2091*** (-3.72)	-0.0964** (-2.27)	-2.0706*** (-3.69)	-2.1589*** (-4.96)	-0.0930*** (-2.97)	-2.0234*** (-4.90)
Ownershare	0.0076 (0.39)	-0.0000 (-0.02)	0.0088 (0.49)	0.0087 (0.57)	0.0001 (0.09)	0.0098 (0.67)
<i>Law_Region</i>	0.0053 (0.03)	0.0029 (0.29)	-0.0026 (-0.02)	-0.2533 (-1.54)	-0.0206* (-1.75)	-0.2350 (-1.51)
P2P	0.1382*** (3.62)	0.0092*** (3.48)	0.1278*** (3.54)	-0.1078 (-0.99)	-0.0130 (-1.61)	-0.0935 (-0.91)
Constant	21.8966* (1.69)	1.0465 (1.15)	20.4604* (1.66)			
Kleibergen-Paap rk LM statistic				126.425***	126.425***	126.425***
Kleibergen-Paap rk Wald F statistic				114.880 [7.03]	114.880 [7.03]	114.880 [7.03]
Observations	21,601	21,601	21,601	21,504	21,504	21,504
Adjusted R-squared	0.071	0.054	0.069	-0.102	-0.124	-0.104
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes

overall results. Therefore, we eliminate one province from the whole sample each time and repeat the baseline regression (a total of 31 times). Fig. 1 presents the estimated coefficients in the regression results. The figure shows that all coefficients of *FinTech* in each regression are located in the confidence interval estimated in the baseline regression, indicating that the impact of financial technology on the shadow banking of non-financial firms is robust.

6. Mechanism analyses

The above analyses provide direct evidence that the development of financial technology can promote the shadow banking activities of non-financial firms, we next will explore the underlying mechanisms in this section.

6.1. Financing constraints

Many small and medium-sized firms are difficult to obtain credit from the formal banking system and suffer serious financing constraints (Du, Li and Wang, 2017). The use of financial technology, such as big data and cloud computing, could effectively mitigate information asymmetry and reduce financing constraints (Grennan and Michaely, 2021; Zhao et al., 2022), which helps large companies to better screen potential borrowers (i.e., small and medium-sized firms) (Buchak et al., 2018). Therefore, we predict that financial technology can promote the shadow banking activities of non-financial firms by reducing financing constraints.

To test our prediction, we first measure the degree of financing constrains using KZ index. Following previous studies (Kaplan and Zingales, 1997; Lamont et al., 2001), KZ index is constructed following five steps. First, we calculate the following five indicators:

Table 8

Regression analysis of the equalization of profit rate. This table reports the effect of the equalization of profit rate on the relationship between financial technology and shadow banking activities of non-financial firms. *Diff_Profit* is defined as the mean profit rate of net assets of listed firms in the financial industry minus the profit rate of net assets of non-financial firms. *Shadow_Banking* is defined as the sum of *Credit_Intermediary* and *Credit_Chain*. *Credit_Chain* is defined as the sum of financial products, trust products, structured deposits and asset management plan divided by total assets. *Credit_Intermediary* is defined as the sum of entrusted loan, entrusted financing and private lending divided by total assets. The other independent variables include *Leverage*, *Margin*, *External_F*, *ROE*, *Grevenue*, *Salary*, *Size*, *Ownership*, *Law_Region* and *P2P*, which are defined in Table 2. T-statistics are reported in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

	OLS			2SLS		
	<i>Shadow_Banking</i> (1)	<i>Credit_Chain</i> (2)	<i>Credit_Intermediary</i> (3)	<i>Shadow_Banking</i> (4)	<i>Credit_Chain</i> (5)	<i>Credit_Intermediary</i> (6)
Diff_Profit	-4.7397*** (-2.76)	0.0136 (0.33)	-4.7447*** (-2.72)	-6.7984** (-2.07)	0.1406 (1.00)	-7.0250** (-2.19)
FinTech	0.8863*** (3.97)	0.0299* (1.85)	0.8590*** (4.09)	3.0880*** (3.60)	0.2153*** (3.42)	2.8551*** (3.53)
Diff_Profit × FinTech	0.2915*** (2.71)	-0.0005 (-0.18)	0.2912*** (2.66)	0.4247** (2.00)	-0.0087 (-0.95)	0.4388** (2.10)
Leverage	28.8017** (2.26)	4.2153*** (4.72)	25.7553** (2.15)	30.4297*** (2.97)	4.3534*** (6.05)	27.2298*** (2.80)
External_F	6.4119*** (3.48)	0.5273*** (4.20)	5.6897*** (3.27)	6.5608*** (4.72)	0.5439*** (5.31)	5.8191*** (4.40)
ROE	2.6748** (2.14)	0.2613*** (2.75)	2.3579** (2.02)	2.6790** (2.32)	0.2599*** (2.92)	2.3641** (2.15)
Grevenue	-0.2913 (-0.93)	0.0019 (0.09)	-0.3089 (-1.03)	-0.3302 (-1.03)	-0.0007 (-0.03)	-0.3450 (-1.15)
Salary	0.8043 (1.44)	0.0232 (0.56)	0.7457 (1.42)	0.8132* (1.88)	0.0237 (0.75)	0.7540* (1.84)
Size	-1.4203** (-2.39)	-0.0645 (-1.51)	-1.3140** (-2.34)	-1.3626*** (-3.10)	-0.0603* (-1.92)	-1.2607*** (-3.02)
Ownership	-0.0061 (-0.31)	-0.0002 (-0.12)	-0.0048 (-0.26)	-0.0054 (-0.35)	-0.0001 (-0.05)	-0.0042 (-0.29)
Law_Region	0.0379 (0.24)	0.0028 (0.27)	0.0303 (0.20)	-0.2483 (-1.51)	-0.0218* (-1.85)	-0.2286 (-1.47)
P2P	0.1187*** (3.11)	0.0086*** (3.20)	0.1090*** (3.02)	-0.1595 (-1.46)	-0.0145* (-1.81)	-0.1437 (-1.40)
Constant	9.3474 (0.72)	0.4542 (0.49)	8.5251 (0.70)			
Kleibergen-Paap rk LM statistic				128.311***	128.311***	128.311***
Kleibergen-Paap rk Wald F statistic				117.327 [7.03]	117.327 [7.03]	117.327 [7.03]
Observations	21,601	21,601	21,601	21,504	21,504	21,504
Adjusted R-squared	0.058	0.051	0.055	-0.118	-0.128	-0.121
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes

operating net cash flow divided by total assets in the previous year ($CF_{it}/Asset_{it-1}$), cash dividends divided by total asset in the previous year ($Div_{it}/Asset_{it-1}$), cash holdings divided by total assets in the previous year ($Cash_{it}/Asset_{it-1}$), leverage and Tobin'Q. Second, we define KZ_1 as one if $CF_{it}/Asset_{it-1}$ is lower than its median and zero otherwise. Similarly, we define KZ_2 and KZ_3 as one if $Div_{it}/Asset_{it-1}$ and $Cash_{it}/Asset_{it-1}$ are lower than their medians and zero otherwise, respectively. If leverage and Tobin'Q are higher than their medians, we define KZ_4 and KZ_5 as one and zero otherwise, respectively. Third, we define KZ index as the sum of KZ_1 , KZ_2 , KZ_3 , KZ_4 and KZ_5 . Fourth, we adopt an ordered logistic regression in which the dependent variable is the KZ index and the independent variables are the above financial variables. Fifth, based on estimated parameters, we calculate the measure of financing constraints for each company. The larger the KZ value is, the more serious financing constraints the firm suffers.

In Table 7, we examine the effect of financing constraints on the relationship between financial technology and shadow banking activities of non-financial firms. In Column (1), we find that the coefficient of $KZ \times FinTech$ is negative and significant at the 1% level, showing that financing constraints reduce the positive effect of financial technology on the shadow banking activities. This evidence implies that financial technology can enhance the shadow banking activities of non-financial firms by reducing financing constraints. In Columns (2) and (3), we examine credit chain and credit intermediary of shadow banking activities, respectively. The results in Columns (2) and (3) are consistent with our baseline findings. In Columns (4)-(6), we investigate the results of instrumental variables and find that our results carry through with this approach.

6.2. Motivation of profitability

Next, we examine the effect of the motivation of profitability on the relationship between financial technology and shadow banking activities of non-financing firms. Financial technology provides less expensive and efficient financial services (Phan et al., 2021),

Table 9

Regression analysis of investment in the real economy. This table reports the effect of investment in the real economy on the relationship between financial technology and shadow banking activities of non-financial firms. *Entity* is measured by the natural logarithm of one plus the cash paid for the purchase of fixed assets, intangible assets and other long-term assets. *Shadow_Banking* is defined as the sum of *Credit_Intermediary* and *Credit_Chain*. *Credit_Chain* is defined as the sum of financial products, trust products, structured deposits and asset management plan divided by total assets. *Credit_Intermediary* is defined as the sum of entrusted loan, entrusted financing and private lending divided by total assets. The other independent variables include *Leverage*, *Margin*, *External_F*, *ROE*, *Grevenue*, *Salary*, *Size*, *Ownership*, *Law_Region* and *P2P*, which are defined in Table 2. T-statistics are reported in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

	OLS			2SLS		
	<i>Shadow_Banking</i> (1)	<i>Credit_Chain</i> (2)	<i>Credit_Intermediary</i> (3)	<i>Shadow_Banking</i> (4)	<i>Credit_Chain</i> (5)	<i>Credit_Intermediary</i> (6)
Entity	1.7967** (2.44)	0.2576*** (6.49)	1.4201** (2.04)	2.0497*** (2.71)	0.2752*** (6.76)	1.6470** (2.32)
FinTech	2.8216*** (3.23)	0.3342*** (6.35)	2.3621*** (2.88)	5.0583*** (4.27)	0.5265*** (6.62)	4.3811*** (3.95)
Entity × FinTech	-0.1081** (-2.34)	-0.0165*** (-6.27)	-0.0847* (-1.95)	-0.1255** (-2.55)	-0.0177*** (-6.50)	-0.1003** (-2.17)
Leverage	43.6550*** (3.38)	4.4425*** (4.88)	40.4649*** (3.32)	44.8733*** (4.34)	4.5518*** (6.19)	41.5662*** (4.22)
Margin	12.6490*** (8.85)	0.2575*** (2.74)	12.4070*** (9.06)	12.5380*** (11.06)	0.2477*** (3.15)	12.3068*** (11.31)
External_F	5.8896*** (3.09)	0.5639*** (4.34)	5.0891*** (2.84)	6.0992*** (4.28)	0.5817*** (5.50)	5.2783*** (3.92)
ROE	5.1864*** (3.84)	0.3136*** (3.28)	4.8181*** (3.79)	5.1661*** (4.24)	0.3116*** (3.43)	4.7998*** (4.14)
Grevenue	0.2085 (0.64)	0.0059 (0.26)	0.1904 (0.62)	0.1660 (0.51)	0.0023 (0.09)	0.1519 (0.50)
Salary	1.0262* (1.85)	0.0141 (0.34)	0.9881* (1.89)	1.0178** (2.34)	0.0136 (0.43)	0.9805** (2.39)
Size	-2.1016*** (-3.54)	-0.0839* (-1.94)	-1.9600*** (-3.49)	-2.0414*** (-4.46)	-0.0789** (-2.34)	-1.9057*** (-4.39)
Ownership	0.0043 (0.22)	-0.0002 (-0.12)	0.0059 (0.32)	0.0051 (0.33)	-0.0001 (-0.10)	0.0065 (0.45)
Law_Region	0.0045 (0.03)	0.0037 (0.37)	-0.0046 (-0.03)	-0.2449 (-1.50)	-0.0185 (-1.58)	-0.2300 (-1.48)
P2P	0.1273*** (3.31)	0.0086*** (3.21)	0.1172*** (3.23)	-0.1131 (-1.04)	-0.0127 (-1.60)	-0.1000 (-0.97)
Constant	-10.2817 (-0.59)	-3.7223*** (-3.43)	-5.2227 (-0.32)			
Kleibergen-Paap rk LM statistic				128.184***	128.184***	128.184***
Kleibergen-Paap rk Wald F statistic				116.942 [7.03]	116.942 [7.03]	116.942 [7.03]
Observations	21,601	21,601	21,601	21,504	21,504	21,504
Adjusted R-squared	0.069	0.055	0.066	-0.105	-0.122	-0.107
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes	Yes	Yes	Yes

which decreases transaction costs and improve the return on capital in the financial industry (Grennan and Michaely, 2021). When the profitability of non-financial firms is lower, the firm would have an incentive to engage in more financing activities, and even crowd out investment in the real economy (Seo et al., 2012; Shin, 2012). Therefore, we expect that an increase in the equalization of profit rate and an increase in investments in the real economy reduce the positive effect of financial technology on the shadow banking activities.

To test this expectation, we first follow Yang et al., 2019a,2019b and examine the difference of profit rate between firms in the financing industry and non-financial firms. The smaller the difference is, the greater the equalization of profit rate becomes. In other words, an increase in the equalization of profit rate means a decrease in the difference of profit rate between firms in the financing industry and non-financial firms. Specifically, we define the difference of profit rate as the mean profit rate of net assets of all listed firms in the financial industry minus the profit rate of net assets of the specific non-financial firm in the current year, labelled as *Diff_Profit*. As shown in Table 8 in Column (1), we find that the coefficient of *Diff_Profit* × *FinTech* is positive and significant, suggesting that an increase in the equalization of profit rate reduces the positive effect of financial technology on shadow banking activities. Further, Columns (2) and (3) examine the results of credit chain and credit intermediary of shadow banking activities, respectively. The result shows that the credit chain of shadow banking activities is not enhanced significantly. In addition, we also investigate the results of the instrumental variable approach and report them in Columns (4) - (6). Our results carry through with an instrumental variable approach.

Table 9 examines the effect of investment in the real economy on the relationship between financial technology and shadow banking activities of non-financial firms. We follow Taylor et al. (2021) and define *Entity* as the natural logarithm of one plus the cash

Table 10

Regression analysis of financial regulations. This table reports the effect of financial regulations on the relationship between financial technology and the shadow banking activities of non-financial firms. *Regulation* is the ratio of regional bank loans to regional GDP. *Shadow Banking* is defined as the sum of *Credit Intermediary* and *Credit Chain*. *Credit Chain* is defined as the sum of financial products, trust products, structured deposits and asset management plan divided by total assets. *Credit Intermediary* is defined as the sum of entrusted loan, entrusted financing and private lending divided by total assets. The other independent variables include *Leverage*, *Margin*, *External_F*, *ROE*, *Grevenue*, *Salary*, *Size*, *Ownership*, *Law_Region* and *P2P*, which are defined in Table 2. T-statistics are reported in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

	<i>Shadow_Banking</i> (1)	<i>Credit_Chain</i> (2)	<i>Credit_Intermediary</i> (3)
Regulation	78.4047** (2.36)	1.3564 (0.61)	77.2092** (2.48)
FinTech	1.2357*** (4.77)	0.0477*** (2.64)	1.1890*** (4.86)
Regulation × FinTech	-14.2143*** (-3.70)	-0.4855* (-1.89)	-13.7099*** (-3.80)
Leverage	45.3422*** (3.51)	4.5695*** (5.04)	41.9567*** (3.44)
Margin	12.7408*** (8.91)	0.2645*** (2.81)	12.4893*** (9.11)
External_F	5.3180*** (2.80)	0.4989*** (3.97)	4.6234** (2.57)
ROE	5.1171*** (3.80)	0.3073*** (3.19)	4.7574*** (3.75)
Grevenue	0.2749 (0.85)	0.0141 (0.62)	0.2455 (0.79)
Salary	1.1745** (2.13)	0.0302 (0.73)	1.1094** (2.14)
Size	-1.9260*** (-3.20)	-0.0740* (-1.72)	-1.8107*** (-3.18)
Ownership	0.0070 (0.35)	0.0000 (0.03)	0.0081 (0.44)
Law_Region	-0.0209 (-0.13)	0.0031 (0.31)	-0.0293 (-0.20)
P2P	0.0930** (2.19)	0.0057* (1.87)	0.0865** (2.16)
Constant	16.4849 (1.26)	0.6065 (0.65)	15.5159 (1.25)
Observations	21,601	21,601	21,601
Adjusted R-squared	0.069	0.052	0.067
Year fixed effect	Yes	Yes	Yes
Firm fixed effect	Yes	Yes	Yes

paid for the purchase of fixed assets, intangible assets and other long-term assets. The result in Columns (1) shows that the coefficient of *Entity* × *FinTech* is negative and significant, indicating that an increase in investment in the real economy reduces the positive effect of financial technology on the shadow banking activities of non-financial firms. We also examine the results of credit chain and credit intermediary of shadow banking activities in Columns (2) and (3) respectively and find that our results are robust. In addition, our conclusions also persist in the instrumental variable regressions in Column (4)-(6) in Table 9.

7. Financial regulations

Shadow banking activities could provide some convenience for non-financial firms to obtain privileged access to formal finance or lend out to credit-constrained small firms (Du, Li and Wang, 2017; Yang et al., 2019a, 2019b). However, shadow banking activities also cause excessive borrowing of firms (Liu et al., 2014) and increase the risk of bankruptcy due to liquidity constraints once the capital chain breaks. On the other hand, financial technology can improve the efficiency in financial services and further increase shadow banking activities, which may also result in operating risk of firms and stock price crashes (Seo et al., 2012; Si et al., 2021). Therefore, we wonder whether financial regulations can reduce the excessive shadow banking activities of non-financial firms driven by financial technology in this section.

Following Han and Li (2020), we measure the proxy of financial regulations using the ratio of regional bank loans to regional GDP, labelled as *Regulation*. In Column (1) in Table 10, the coefficient of *Regulation* × *FinTech* is significantly negative, indicating that financial regulations can attenuate the effect of financial technology on the shadow banking activities of non-financial firms. Further, Columns (2) and (3) examine the results of credit chain and credit intermediary of shadow banking activities, respectively. We find that our main findings continue to hold. The evidence suggests that financial regulations can impede the excessive expansion of the shadow banking activities of non-financial firms caused by financial technology.

8. Conclusion

This paper explores the relationship between financial technology and shadow banking activities of non-financial firms. Unlike previous analyses, our paper, as far as we know, provides the first empirical study on how financial technology influences the shadow banking performance of non-financial firms.

Using a comprehensive measure of financial technology constructed in our paper, we first find that regional financial technology significantly increases the scale of shadow banking of non-financial firms. This promoting effect is more pronounced for firms with poor profitability and firms listed only in China's A-share market. Our result is robust to a variety of diagnostics analyses, including controlling for industry policy, alternative measures of shadow banking and time trend, as well as excluding the influence of municipalities and unbalanced development of provinces. Second, we find that the effect of financial technology on the shadow banking activities of non-financial firms can be enhanced in the following three situations: (1) when financing constrains of firms are lower; (2) when the equalization of profit rate is lower; (3) when the investment in the real economy is lower. Third, we find that financial regulations can impede the excessive shadow banking activities of non-financial firms driven by financial technology.

Further research for regulation policies in shadow banking can be expanded from the following two directions. First, in the emerging economies such as China, the unique financial systems and inadequate financial regulations provide convenience for the development of the shadow banking activities. In order to reduce the scale of shadow banking, the government may take a series of regulatory measures to prevent financial risks. Therefore, future research can carry out some systematic comparisons on the performance of these regulatory measures in shadow banking. Second, the research on the effect of regulation policies on shadow banking in this paper focuses on the non-financial firms and ignores the exploration of different types of firms. If future research can compare the different effects of regulation policies on shadow banking in different types of firms, such as state-owned enterprises and non-state-owned enterprises or politically-connected private firms and non-politically-connected private firms, it may further enrich the theoretical results of regulation policies in shadow banking. Importantly, the emerging economies can find the most appropriate policies in shadow banking by comparing the performance of different regulation policies.

Conflict of interest

There are no Conflict of Interest.

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