Innovation and Green Development 3 (2024) 100114

Contents lists available at ScienceDirect

Innovation and Green Development

journal homepage: www.journals.elsevier.com/innovation-and-green-development

Full Length Article

Can FinTech transform corporate liquidity? Evidence from China

Chenguang Fan, Seongho Bae *, Yu Liu

School of Business Administration, Kyungpook National University, 80, Daehak-ro, Buk-gu, Daegu, Republic of Korea

ARTICLE INFO

Keywords:
FinTech
Financing constraints
Corporate liquidity

ABSTRACT

The rapid growth of China's financial technology has had a significant impact on businesses. The study of the relationship between macrofinancial technology and microbusinesses has important theoretical and practical implications. We empirically examined the relationship between FinTech, financing constraints, and corporate liquidity using the China Provincial Fintech Development Index and the data of A-share manufacturing companies listed on the Shanghai and Shenzhen Main Boards between 2011 and 2020. We found that financing constraints have a negative effect on a company's liquidity. The greater the constraints on corporate financing, the worse the liquidity. However, financial technology will have positive external effects and will mitigate the negative effect of financing constraints on corporate liquidity. In addition, we find that non-state-owned enterprises, small and medium-sized enterprises, and young enterprises face greater financing constraints and are thus more impacted by FinTech.

1. Introduction

Under the perfect capital market hypothesis, capital markets are frictionless. In this scenario, when companies experience a lack of funds, they do not need to make financial decisions because they can simply adjust their capital structure at no cost to meet their funding requirements. However, this is not the case in the real world. Financing constraints make liquidity management important for companies (Campello, Giambona, Graham, & Harvey, 2012). Upon surveying 392 chief financial officers in the U.S. and Canada, Graham and Harvey (2001) determined that corporate liquidity is the most important factor in financing decisions. Further, financial distress is believed to drive corporate financial decisions, and corporate illiquidity and bankruptcy are two causes of financial distress (Gryglewicz, 2011). At both the theoretical and practical levels, the study of corporate financing constraints and liquidity is an important and interesting topic.

FinTech combines financial services and information technology (Arner, Barberis, & Buckley, 2015), including online and mobile terminal payments, banking, insurance, and funds. Similar concepts include Internet finance and digital finance; however, the present study does not distinguish between the two. Since Alipay opened its Internet-based money market fund Yu'ebao in 2013, the year 2013 has been regarded as the beginning of China's FinTech development. In just over a decade, China's FinTech sector has experienced explosive growth. The scale of China's digital economy has grown from 11 trillion yuan in 2012 to 45.5 trillion yuan in 2021, and its share of China's GDP increased from 21.6% to 39.8% (CCTV.com, 2022). China is now the world's largest FinTech market and serves as the torch-bearer of global FinTech development.

FinTech's influence has permeated all areas of social and economic development. In the macroeconomic field, FinTech promotes economic growth (Narayan, 2019), sustainable economic development (Awais, Afzal, Firdousi, & Hasnaoui, 2023; Tao, Su, Naqvi, & Rizvi, 2022; Yang, Su, & Yao, 2021), and financial inclusion (Lyons, Kass-Hanna, & Fava, 2022), among others. In the microeconomic field, FinTech improves bank efficiency (Lee, Li, Yu, & Zhao, 2021; Liu et al., 2021; Wang, Xiuping, & Zhang, 2021), reduces bank credit risk (Cheng & Qu, 2020), enhances corporate investment efficiency (Huang, 2022; Lv & Xiong, 2022), broadens corporate financing channels, and alleviates financing constraints (Beck, Pamuk, Ramrattan, & Uras, 2018). However, the impact of FinTech on corporate liquidity has not been discussed although this field has been extensively researched in recent years.

Our research focuses on two aspects: the impact of financing constraints on corporate liquidity and that of FinTech on the connection between financing constraints and corporate liquidity. We obtained data from A-share manufacturing companies listed on the main board of China's Shenzhen Stock Exchange and Shanghai Stock Exchange from 2011 to 2020, matched these data with the digital financial inclusion index data released by the Digital Finance Research Center of Peking University, and performed regression analysis using a fixed effects model. The empirical results show that the greater the degree of corporate

* Corresponding author.
E-mail addresses: fcg@knu.ac.kr (C. Fan), shobae@knu.ac.kr (S. Bae), liuyu722@knu.ac.kr (Y. Liu).

https://doi.org/10.1016/j.igd.2023.100114
Received 29 August 2023; Received in revised form 3 October 2023; Accepted 14 October 2023
Available online 20 November 2023

financing constraints, the worse the liquidity of the corporation. The results also demonstrate that FinTech mitigates the lack of corporate liquidity caused by financing constraints. The group test results show that this impact is more pronounced for non-state-owned and small and medium-sized enterprises.

The potential contributions of our study are as follows: first, our results contribute to the existing literature on the relationship between financing constraints and corporate liquidity. Most existing studies discusses financing constraints in groups, for instance, firms are evenly divided into two groups according to the median book value of total assets or whether dividend payout (Chan, Lu, & Zhang, 2013; Chang, Tan, Wong, & Zhang, 2007). Unlike previous research, our study examines the relationship between financing constraints and corporate liquidity in the full sample size. Second, it fills the gap in our understanding of the impact of FinTech on corporate liquidity. To our knowledge, this topic has not been investigated previously. Third, our findings are useful for theoretical research and have practical significance for guiding corporate conduct. Non-state-owned enterprises and small and medium-sized enterprises are disadvantaged in terms of financing. They should fully utilize the benefits of FinTech to lessen financing constraints and improve corporate liquidity.

The remainder of this article is structured as follows. Section 2 provides a review of the relevant literature and formulates the hypotheses. Section 3 presents the data, variables, models, and descriptive statistics. Section 4 outlines the empirical results. Section 5 presents the conclusion.

2. Literature review and hypothesis

2.1. Theoretical basis

The financing constraint theory was developed alongside the capital structure theory and has undergone various stages of development. Initially, the Modigliani–Miller (MM) theorem Modigliani and Miller (1958) held that the various financing methods of an enterprise have the same cost and can be completely mutually substitutable. There are no financing constraints and no optimal capital structure. However, these conclusions are based on an important premise: the perfect capital market hypothesis.

The assumptions of the MM theorem were excessively harsh and inconsistent with reality. Later, Kraus and Litzenberger (1973) proposed the trade-off theory. According to this theory, when the debt ratio is low, the tax shield effect of debt increases a company's value. In contrast, when the debt ratio is high, financing constraints increase and the cost of financial distress decreases the company's value. At the optimal debt-to-equity ratio, when a company has the greatest value, it reaches a tipping point.

Due to information asymmetry, the agency theory (Fama & Jensen, 1983; Jensen & Meckling, 1976) holds that the interests of principals and agents are usually inconsistent. As the proportion of corporate debt increases, agents experience greater financing constraints. The agency's cost of equity decreases, whereas its cost of debt increases. Companies must compare the two agency fees and select the optimal debt ratio.

The pecking order theory proposed by Myers and Majluf (1984)holds that due to information asymmetry, management is better informed about the value of a company than potential investors. Internal financing costs are lower than external financing costs, and equity financing causes the stock price to decline. Therefore, companies prioritize internal financing, followed by debt financing and equity financing. As a result of the disparity between internal and external financing costs, companies experience financing constraints.

According to Baker and Wurgler (2002)market timing theory, capital structure is the cumulative result of past attempts to seize stock market timing. Companies should dynamically evaluate the debt-to-equity ratio rather than establishing a fixed capital structure target that imposes unnecessary financing restrictions.

2.2. Financing constraints and corporate liquidity

The history of corporate liquidity management can be traced to *The General Theory of Employment, Interest, and Money* by (Keynes, 1936). He believed that under the assumption of perfect capital markets, there are no financing constraints and companies are not required to manage liquidity. It is evident that liquidity management is linked to financing constraints and that it only becomes significant in the presence of market frictions.

The close relationship between financing constraints and liquidity has been established by previous research. According to Huberman (1984), operating income is an important source of liquidity. To maintain their liquidity, enterprises seek external financing owing to low anticipated income. Consequently, financing constraints are the driving force behind corporate liquidity management. Fazzari, Hubbard, and Petersen (1988) believed that companies with limited financing constraints can use external financing to smooth investment when internal financing is difficult, whereas companies with large financing constraints experience difficulty obtaining external financing when internal funds are depleted. Consequently, investments in cash flow are more sensitive. Later, Hubbard (1998) revealed that due to the imperfection of the capital market, companies should maintain a higher level of liquidity to mitigate potential financing constraints and ensure the smooth progression of investment.

On this basis, subsequent studies have conducted more in-depth demonstrations. For instance, Almeida, Campello, and Weisbach (2004) simulated the relationship between financing constraints and corporate liquidity needs and proposed that financing constraints affect the cash holding policy of companies. Firms with financing constraints tend to hold more cash than firms without financing constraints. The findings of Faulkender and Wang (2006) showed that market friction significantly increases the cost of external financing. The marginal cash value of companies with significant financing constraints is greater, and the market valuates companies that retain liquidity.

Other scholars have demonstrated the relationship between financing constraints and liquidity from various perspectives. From the hedging perspective of corporate financial policies, Acharya, Almeida, and Campello (2007) showed that companies with significant financing constraints are more willing to allocate excess cash to cash holdings. Firms with modest financing constraints utilize surplus cash to repay debt. Meanwhile, García-Teruel, Martínez-Solano, and Sánchez-Ballesta (2009) showed that higher accounting quality can decrease information asymmetry and adverse selection costs, reduce corporate cash holdings, and improve investment efficiency from the perspective of accounting information quality. Lee et al. (2023) provided the perspective of uncertainty; their study showed that under the uncertainty of oil price fluctuations and geopolitical risks, companies increase their cash reserves, and companies with high financing constraints save more cash.

In conclusion, financing constraints negatively impact the liquidity of enterprises. Therefore, we propose the following hypothesis:

H1. The greater the financing restrictions, the worse the enterprise's liquidity.

2.3. Impact of FinTech

FinTech can compensate for the shortcomings of traditional financial services and has the advantages of low cost, high speed, and extensive coverage. Existing research indicates that FinTech can reduce information asymmetry between banks and enterprises and positively influence the growth of businesses. Lin, Prabhala, and Viswanathan (2013) found that digital technology platforms can mine more accurate and exhaustive

corporate data and reduce information asymmetry between lenders and borrowers. Meanwhile, Cole, Cumming, and Taylor (2019) examined U.S. crowdfunding data and showed that FinTech and the traditional financial industry complement each other. FinTech has lower financing costs and can improve the availability of financing. Fuster, Plosser, Schnabl, and Vickery (2019) found that between 2010 and 2016, FinTech lenders increased their share of the U.S. mortgage market from 2% to 8% and processed mortgage applications 20% faster than other lenders, and this faster processing did not result in higher default rates. Huang, Lin, Sheng, and Wei (2018) revealed that institutions such as Ant Financial used big data and artificial intelligence technology to intelligently approve loans, thereby reducing the lender's financing costs, drastically decreasing the loan approval time, and easing the financing constraints of small and medium-sized enterprises.

The emergence of FinTech has undeniably had a negative impact as well. For example, Buchak, Matvos, Piskorski, and Seru (2018) used U.S. residential mortgage loan data to show that the rise of FinTech has resulted in a decline in the traditional banking industry's market share due to regulatory burdens, convenience, and loan costs. Using Indonesian data, Phan, Narayan, Rahman, and Hutabarat (2020) confirmed that the expansion of FinTech inhibits the growth of bank performance, with the negative impact being most pronounced for high-value, mature, and state-owned banks. Zhao, Li, Yu, Chen, and Lee (2022) examined the impact of FinTech on China's banking industry and found mixed results: FinTech decreased banks' profitability and asset quality but increased their capital sufficiency and management efficiency. Lee, Ni, and Zhang (2023) found that the advancement of financial technology has diminished the overall efficiency of commercial banks, particularly impacting their debt management. The rise in debt costs has consequently led to a reduction in the efficiency of commercial banks.

FinTech is a new phenomenon; emerging phenomena invariably have negative effects in the early stages of their development. However, these negative effects are temporary in the long run. The benefits of FinTech in facilitating high-quality and sustainable social and economic development will become increasingly apparent (Awais et al., 2023; Tao et al., 2022; Yang et al., 2021). Therefore, we propose the following hypothesis:

H2. FinTech will mitigate the adverse impact of financing constraints on corporate liquidity.

3. Research design

3.1. Data

The FinTech data in this article come from the Peking University Digital Financial Inclusion Index of China, which has been compiled and published by a research team from the Institute of Digital Finance of Peking University and Ant Group Research Institute since 2016 using the Ant Group's massive data on inclusive digital finance. This report is the third update (Guo et al., 2020). Financial and other data were obtained from the China Stock Market & Accounting Research Database using data on A-share manufacturing listed companies on the main boards of China's Shenzhen Stock Exchange (SZSE) and the Shanghai Stock Exchange (SSE) from 2011 to 2020. To make the sample more representative, we processed the data as follows: (1) we excluded listed companies with ST for three consecutive years, and (2) we excluded samples that were missing data for the main variables. To eliminate the influence of extreme values, the data for the main continuous variables of the sample that were less than 1% and greater than 99% were winsorized. We finally constructed panel data for 1714 samples and 12,603 observations.

3.2. Variables

3.2.1. Key variables

We measure the quality of WCM using the cash conversion cycle (CCC), and as a proxy for corporate liquidity, a variable that has been widely used in related studies (Baños-Caballero, García-Teruel, & Martínez-Solano, 2010; Deloof, 2003; Padachi, 2006). It is calculated as follows:

(accounts receivables/sales) * 365 + (inventories/purchases) * 365 − (accounts payable/purchases) * 365

The higher the value, the longer the cash flow cycle and the worse the company's liquidity. In this article, CCC is logarithmically transformed.

To measure financing constraints, this article draws on the research of Kaplan and Zingales (1997) to calculate the KZ index, which is used as a proxy variable for financing constraints (KZ). A higher value of this index represents greater financing constraints.

To measure FinTech, this study draws on Guo et al. (2020) and uses their provincial index as a proxy variable (DIF) for FinTech. The index contains 33 specific indicators in three dimensions as follows: breadth of coverage (account coverage), depth of use (payment business, money fund business, credit business, insurance business, investment business and credit business) and degree of digitalization (mobile, affordable, credit and convenience). This indicator system has been widely used in the related literature (Tang, Wu, & Zhu, 2020; Teng & Ma, 2020; Yuan & Zeng, 2020) to measure a region's level of FinTech development: the greater the value, the higher the region's level of FinTech development. In this article, DIF is log-transformed.

3.2.2. Control variables

Using the findings of prior research (Almeida et al., 2004; Baños-Caballero et al., 2010; Deloof, 2003; Opler, Pinkowitz, Stulz, & Williamson, 1999), we select the following control variables:

Fixed asset investment ratio (FA): the quotient of dividing fixed assets by total assets;

Operating cash flow ratio (CFLOW): the quotient of dividing operating cash flow by total assets;

Leverage (LEV): the quotient of dividing total liabilities by total assets;

Return on assets (ROA): earnings before interest and taxes/total assets;

Gross profit margin (GPM): the difference between sales revenue and cost of goods sold divided by sales revenue;

Tobin's Q value (TobinsQ): the ratio of a company's market value to the cost to replace its assets; and.

Firm size (SIZE): the natural logarithm of its market capitalization.

3.3. Model

To test the hypothesis, this study employs (Brambor, Clark, & Golder, 2006) analysis method and develops the following testing model:

$$CCC_{i,t} = \beta_0 + \beta_1 KZ_{i,t} + \beta_2 FA_{i,t} + \beta_3 LEV_{i,t} + \beta_4 CFLOW_{i,t} + \beta_5 ROA_{i,t} + \beta_6 GPM_{i,t} + \beta_7 \mathrm{TobinsQ}_{i,t} + \beta_8 SIZE_{i,t} + u_i + \lambda_t + \theta_j + \varepsilon_{i,t} \quad (1)$$

$$CCC_{i,t} = \beta_0 + \beta_1 KZ_{i,t} + \beta_2 DIF_{i,t} + \beta_3 FA_{i,t} + \beta_4 LEV_{i,t} + \beta_5 CFLOW_{i,t} + \beta_6 ROA_{i,t} + \beta_7 GPM_{i,t} + \beta_8 \mathrm{TobinsQ}_{i,t} + \beta_9 SIZE_{i,t} + u_i + \lambda_t + \theta_j + \varepsilon_{i,t} \quad (2)$$

$$CCC_{i,t} = \beta_0 + \beta_1 KZ_{i,t} + \beta_2 DIF_{i,t} + \beta_3 KZ_{i,t} \times DIF_{i,t} + \beta_4 FA_{i,t} + \beta_5 LEV_{i,t} + \beta_6 CFLOW_{i,t} + \beta_7 ROA_{i,t} + \beta_8 GPM_{i,t} + \beta_9 \mathrm{TobinsQ}_{i,t} + \beta_{10} SIZE_{i,t} + u_i + \lambda_t + \theta_j + \varepsilon_{i,t} \quad (3)$$

Here, the explanatory variable CCC represents the cash conversion cycle of firm i in year t; the explanatory variable KZ represents the financing constraints of firm i in year t, and the variable DIF represents the FinTech index of firm i's province in year t. $KZ_{i,t} \times DIF_{i,t}$ represents the cross-product interaction term of FinTech and financing constraints, which is used to observe the moderating effects. The control variables include FA, the asset–liability ratio (LEV), the operating cash flow ratio (CFLOW), ROA, GPM, Tobin's Q value (TobinsQ) and firm size (SIZE). u_i denotes individual fixed effects, λ_t denotes time fixed effects, and θ_j denotes regional fixed effects. $\varepsilon_{i,t}$ denotes a random error term, which we

estimate using a fixed-effects model and by clustering robust standard errors.

3.4. Descriptive statistics

Since the mean value of CCC in the original data is much greater than the median, indicating the existence of obvious right-skewed features, this article transforms it logarithmically. Nonetheless, since there are negative values of CCC, the change is performed using the following: $CCC_1 = \text{sign}\ (CCC_0) \times \log_{10}\ (|CCC_0| + 1)$ (Wicklin, 2014). A similar problem exists for the values of DIF, but since all are positive, the natural logarithm is taken directly. The specific descriptive statistics for each variable are shown in Table 1.

4. Empirical results

4.1. Correlations

Table 2 presents the Pearson correlation matrix, which allows a preliminary determination of the relationship between the three key variables. There is a significantly positive correlation between liquidity (CCC) and FinTech (DIF) and financing constraints (KZ) and a significant negative correlation between FinTech (DIF) and financing constraints (KZ). In addition, a high correlation between the independent and dependent variables does not lead to multicollinearity, but a high correlation between independent variables does indicate the presence of multicollinearity (Brooks, 2008). In addition, multicollinearity exists when the correlation coefficient is greater than 0.80 or 0.90 (Field, 2013), while, as seen in Table 2, all of the coefficients are less than this critical value. Therefore, the model does not suffer from multicollinearity.

4.2. Baseline regression

The baseline regression results are shown in Table 3. Column (3) reports the regression results of the fixed effects model including year and region. For comparison, we also report additional company-individual clustered robust standard errors in column (1). The results of the OLS estimation, in column (2), report the results of the OLS estimation including time, regional control variables and additional firm-individual clustering robust standard errors. The coefficients of the impact of financing constraints (KZ) on liquidity (CCC) are all significantly positive in the three methods, indicating that the greater the financing constraints of the enterprise, the longer the cash conversion period, and the worse the liquidity of the enterprise. It can be seen that hypothesis 1 is verified.

4.3. The impact of FinTech

By including the interaction term (KZ × DIF) between FinTech and financing constraints in the model and performing stepwise regression on Models 1–3, we can determine whether FinTech will exacerbate or mitigate the negative impact of financing constraints on corporate liquidity. We use a fixed effects model.

The outcomes of stepwise regression are displayed in Table 4. Since column (1) is identical to that of Tables 3 and it will not be described again. The coefficient of the impact of FinTech (DIF) on WCM (CCC) is not statistically significant, indicating that FinTech has no direct effect on corporate liquidity. Column (3) displays the results after the interaction term between financing constraints and FinTech has been added. The financing constraints coefficient (KZ) is significantly positive, and the interaction term regression coefficient (KZ × DIF) is significant and negative, indicating that FinTech will mitigate the negative impact of

Table 1
Summary statistics.

variable	N	mean	SD	min	p50	max
CCC	12603	1.766	0.954	−1.826	2.006	3.016
DIF	12603	5.408	0.570	3.392	5.579	6.035
KZ	12603	1.315	2.094	−4.748	1.446	6.315
FA	12603	0.241	0.139	0.021	0.216	0.638
LEV	12603	0.424	0.196	0.063	0.414	0.924
CFLOW	12603	0.051	0.066	−0.142	0.048	0.235
ROA	12603	0.054	0.065	−0.217	0.050	0.240
GPM	12603	0.264	0.163	−0.004	0.232	0.786
TobinsQ	12603	2.012	1.233	0.868	1.604	8.020
SIZE	12603	22.80	1.054	20.92	22.67	25.94

Table 3
Baseline regression.

	(1)	(2)	(3)
	OLS	OLS	FE
KZ	0.096***	0.159***	0.048***
	(0.011)	(0.016)	(0.010)
FA	−1.800***	−1.889***	−0.835***
	(0.170)	(0.161)	(0.166)
CFLOW	−0.132	0.684***	0.433***
	(0.212)	(0.248)	(0.152)
LEV	−0.898***	−1.162***	−0.506***
	(0.143)	(0.156)	(0.157)
ROA	−1.179***	−0.734***	−0.803***
	(0.230)	(0.229)	(0.183)
SIZE	−0.105***	−0.101***	−0.021
	(0.025)	(0.025)	(0.033)
GPM	1.126***	1.275***	0.110
	(0.126)	(0.124)	(0.166)
TobinsQ	−0.014	−0.056***	−0.024*
	(0.015)	(0.016)	(0.014)
Constants	4.654***	4.466***	3.338***
	(0.520)	(0.526)	(0.859)
Firm FE	YES	YES	YES
Year FE	NO	YES	YES
Province FE	NO	YES	YES
Observations	12603	12603	12603
Within-R^2	0.182	0.231	0.038

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2
Correlation matrix.

	CCC	DIF	KZ	FA	LEV	CFLOW	ROA	GPM	TobinsQ	SIZE
CCC	1									
DIF	0.022**	1								
KZ	0.022**	−0.292***	1							
FA	−0.304***	−0.088***	0.122***	1						
LEV	−0.179***	−0.089***	0.648***	0.152***	1					
CFLOW	−0.147***	0.135***	−0.611***	0.158***	−0.187***	1				
ROA	−0.043***	−0.017*	−0.516***	−0.098***	−0.327***	0.458***	1			
GPM	0.200***	0.090***	−0.415***	−0.224***	−0.418***	0.273***	0.434***	1		
TobinsQ	0.096***	0.048***	−0.004	−0.126***	−0.241***	0.093***	0.153***	0.277***	1	
SIZE	−0.204***	0.138***	0.032***	0.043***	0.365***	0.146***	0.152***	−0.011	0.020**	1

Coefficients marked with *, **, and *** indicate significance at the 10, 5 and 1% levels, respectively.

Table 4
The impact of FinTech.

	(1)	(2)	(3)
	CCC	CCC	CCC
KZ	0.048***	0.047***	0.048***
	(0.010)	(0.010)	(0.010)
DIF		−0.020	0.057
		(0.089)	(0.091)
KZ × DIF			−0.020***
			(0.007)
FA	−0.835***	−0.835***	−0.849***
	(0.166)	(0.166)	(0.166)
CFLOW	0.433***	0.432***	0.453***
	(0.152)	(0.152)	(0.154)
LEV	−0.506***	−0.507***	−0.536***
	(0.157)	(0.157)	(0.160)
ROA	−0.803***	−0.803***	−0.824***
	(0.183)	(0.183)	(0.183)
SIZE	−0.021	−0.021	−0.025
	(0.033)	(0.033)	(0.033)
GPM	0.110	0.110	0.110
	(0.166)	(0.166)	(0.166)
TobinsQ	−0.024*	−0.024*	−0.024*
	(0.014)	(0.014)	(0.014)
Constants	3.338***	3.425***	3.166***
	(0.859)	(0.945)	(0.944)
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
Province FE	YES	YES	YES
Observations	12603	12603	12603
Within-R^2	0.0381	0.0382	0.0398

Standard errors in parentheses * $p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

financing constraints on corporate liquidity, thereby confirming hypothesis 2. In addition, because the coefficient of FinTech (DIF) in column (3) is not statistically significant, there is no mutual substitution relationship between FinTech and financing constraints.

4.4. Alternative tests and robustness

4.4.1. Time lag consideration

To eliminate the endogeneity problem caused by reverse causality, we lagged the core explanatory variables by one period. Table 5 displays the regression results, which are not significantly different from those of the primary regression analysis. In column (1), the coefficient of the lagged one-period (L.KZ) financing constraint on liquidity (CCC) is significantly positive, and in column (3), the coefficient of the lagged one-period (L.KZ) financing constraint is significantly positive, the interaction term's regression coefficient (L.KZ × L.DIF) is significant and negative, indicating that FinTech will mitigate the negative impact of financing constraints on corporate liquidity. Moreover, the coefficient of FinTech (L.KZ) is not significant, indicating that no relationship of mutual substitution between FinTech and financing constraints. In summary, the findings of the primary regression analysis are robust.

4.4.2. Key variable alternatives

To ensure the validity of the conclusions, we replace the proxies for the key variables successively, beginning with the explanatory variables. (Gertler & Gilchrist, 1994) demonstrated that enterprises of varying sizes face distinct financing constraints, and this finding has been widely acknowledged by the academic community. Therefore, the natural logarithm of the book value of total assets is utilized as a new proxy for financing constraints (ASSET) and regression analysis is repeated. Table 6 provides the results. Consistent with the results of the main regression, the regression coefficient of the interaction term (ASSET × DIF) between financing constraints and FinTech in column (3) is significantly negative, indicating that FinTech will mitigate the negative impact of financing constraints on corporate liquidity. It demonstrates the robustness of results of the primary regression.

Table 5
Include lagged term as a robustness check.

	(1)	(2)	(3)
	CCC	CCC	CCC
L.KZ	0.033***	0.033***	0.031***
	(0.006)	(0.006)	(0.006)
L.DIF		0.013	0.083
		(0.086)	(0.091)
L.KZ × L.DIF			−0.019**
			(0.008)
FA	−0.683***	−0.683***	−0.686***
	(0.181)	(0.181)	(0.181)
CFLOW	−0.204*	−0.205*	−0.189*
	(0.106)	(0.107)	(0.107)
LEV	−0.401***	−0.401***	−0.427***
	(0.138)	(0.138)	(0.140)
ROA	−0.745***	−0.745***	−0.756***
	(0.187)	(0.187)	(0.187)
SIZE	−0.047	−0.047	−0.053
	(0.035)	(0.035)	(0.035)
GPM	−0.028	−0.028	−0.031
	(0.184)	(0.184)	(0.184)
TobinsQ	0.004	0.004	0.004
	(0.014)	(0.014)	(0.014)
Constants	4.123***	4.065***	3.883***
	(0.887)	(0.981)	(0.984)
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
Province FE	YES	YES	YES
Observations	10637	10637	10637
Within-R^2	0.0376	0.0376	0.0392

Standard errors in parentheses * $p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Next, the explained variable is replaced. Cash is the most liquid asset, and prior research frequently used cash holdings as a proxy for corporate liquidity (Ozkan & Ozkan, 2004). Therefore, we divide cash and cash equivalents by total assets as a new proxy (CASH) for liquidity (Ozkan & Ozkan, 2004), and conduct another regression analysis. Table 7 reveals that the coefficient of financing constraints (KZ) in column (1) is significantly negative, indicating that financing constraints reduce changes in

Table 6
Alternative proxy for KZ.

	(1)	(2)	(3)
	CCC	CCC	CCC
ASSET	0.028	0.029	0.031
	(0.065)	(0.065)	(0.065)
DIF		−0.039	−0.040
		(0.090)	(0.089)
ASSET × DIF			−0.029**
			(0.014)
FA	−0.701***	−0.700***	−0.681***
	(0.163)	(0.163)	(0.163)
CFLOW	−0.153	−0.152	−0.149
	(0.103)	(0.103)	(0.103)
LEV	−0.230*	−0.231*	−0.238*
	(0.132)	(0.132)	(0.132)
ROA	−0.920***	−0.920***	−0.907***
	(0.186)	(0.186)	(0.186)
SIZE	−0.056	−0.058	−0.060
	(0.061)	(0.061)	(0.061)
GPM	0.074	0.073	0.059
	(0.166)	(0.166)	(0.166)
TobinsQ	0.008	0.008	0.007
	(0.021)	(0.021)	(0.021)
Constants	3.490***	3.657***	3.703***
	(0.887)	(0.961)	(0.963)
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
Province FE	YES	YES	YES
Observations	12603	12603	12603
Within-R^2	0.033	0.033	0.035

Standard errors in parentheses * $p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Table 7
Alternative proxy for CASH.

	(1)	(2)	(3)
	CASH	CASH	CASH
KZ	−0.031***	−0.031***	−0.031***
	(0.001)	(0.001)	(0.001)
DIF		−0.016*	−0.002
		(0.009)	(0.009)
KZ × DIF			−0.003***
			(0.001)
FA	0.003	0.003	0.001
	(0.012)	(0.012)	(0.012)
CFLOW	−0.064***	−0.065***	−0.061***
	(0.023)	(0.023)	(0.023)
LEV	0.229***	0.229***	0.224***
	(0.013)	(0.013)	(0.013)
ROA	0.003	0.003	−0.001
	(0.021)	(0.021)	(0.021)
SIZE	0.010***	0.010***	0.010***
	(0.003)	(0.003)	(0.002)
GPM	−0.016	−0.017	−0.017
	(0.016)	(0.016)	(0.015)
TobinsQ	0.012***	0.012***	0.012***
	(0.001)	(0.001)	(0.001)
Constants	−0.292***	−0.224***	−0.269***
	(0.056)	(0.068)	(0.067)
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
Province FE	YES	YES	YES
Observations	12603	12603	12603
Within-R^2	0.183	0.183	0.185

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

cash holdings and maintain stable corporate liquidity. Moreover, the interaction term in column (3) (KZ × DIF) is also significantly negative, indicating that FinTech will amplify the positive impact of financing constraints on corporate liquidity; that is, the impact of FinTech is beneficial. This conclusion is also supported by the findings of the main regression.

4.4.3. Industry fixed effect consideration

To exclude the possible influence of industry, we include industry fixed effects to solve the problem of omitting important variables that do not change over time at the industry level, which would lead to inconsistent estimation results if they were not included. Individual, time, and industry fixed effects are reported in the inconsistent first three columns of Table 8, whereas individual, time, region, and industry fixed effects are reported in the last three columns. The regression coefficients of the interaction term (KZ × DIF) are all significantly negative at the 5% level, which is the same as the result of the main regression, indicating the robustness of the main regression result.

4.4.4. Instrumental variable test

To solve the endogeneity problem that may exist in the model, we use the instrumental variable method to estimate the model again. Following Fisman and Svensson (2007), we use the industry-annual average of financing constraints as the instrumental variable of financing constraints, because the same The average degree of financing constraints of the industry in the same year is related to the financing constraints of a single company, but does not directly affect the liquidity of a single company, which better meets the requirements of correlation and exogeneity of instrumental variables. The results are shown in Table 9. The regression coefficient of the interaction term (KZ × DIF) between financing constraints and FinTech in column (3) is significantly negative, which again shows that FinTech will mitigate the negative impact of financing constraints on corporate liquidity, which is consistent with the results of the main regression. Also, it can be seen that there is no problem of under identification and weak identification, indicating that the results are robust.

4.5. Heterogeneity

Firms face varying degrees of financing constraints (Almeida et al., 2004; Fazzari et al., 1988) and may be heterogeneous, so we will discuss them individually in this section. For the classification of corporate financing constraints, we adopt the two most commonly used

Table 8
Consider the industry fixed effect.

	(1)	(2)	(3)	(4)	(5)	(6)
	CCC	CCC	CCC	CCC	CCC	CCC
KZ	0.042***	0.042***	0.042***	0.042***	0.042***	0.042***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
DIF		−0.019	0.036		−0.012	0.047
		(0.086)	(0.088)		(0.086)	(0.087)
KZ × DIF			−0.014**			−0.015**
			(0.007)			(0.007)
FA	−0.739***	−0.739***	−0.749***	−0.721***	−0.720***	−0.732***
	(0.159)	(0.159)	(0.159)	(0.157)	(0.158)	(0.158)
CFLOW	0.394***	0.394***	0.408***	0.385***	0.385***	0.402***
	(0.146)	(0.146)	(0.147)	(0.139)	(0.139)	(0.140)
LEV	−0.509***	−0.509***	−0.528***	−0.479***	−0.479***	−0.500***
	(0.147)	(0.147)	(0.149)	(0.146)	(0.146)	(0.149)
ROA	−0.840***	−0.840***	−0.854***	−0.789***	−0.790***	−0.804***
	(0.177)	(0.177)	(0.178)	(0.176)	(0.176)	(0.177)
SIZE	−0.019	−0.019	−0.023	−0.020	−0.020	−0.024
	(0.032)	(0.032)	(0.032)	(0.031)	(0.031)	(0.030)
GPM	0.133	0.133	0.131	0.153	0.153	0.151
	(0.160)	(0.160)	(0.160)	(0.161)	(0.161)	(0.162)
TobinsQ	−0.021	−0.021	−0.021	−0.022	−0.022	−0.022
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Constants	3.218***	3.299***	3.103***	3.025***	3.080***	2.863**
	(1.097)	(1.197)	(1.188)	(1.091)	(1.189)	(1.181)
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Province FE	NO	NO	NO	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Observations	12603	12603	12603	12603	12603	12603
Within-R^2	0.059	0.059	0.060	0.075	0.075	0.076

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 9
Instrumental variable test.

	(1)	(2)	(3)
	CCC	CCC	CCC
KZ	0.292***	0.296***	0.300***
	(0.106)	(0.108)	(0.109)
DIF		0.072	0.284**
		(0.070)	(0.135)
KZ × DIF			−0.055**
			(0.026)
FA	−1.480***	−1.492***	−1.540***
	(0.306)	(0.312)	(0.322)
CFLOW	3.501***	3.552***	3.649***
	(1.316)	(1.344)	(1.366)
LEV	−1.927***	−1.948***	−2.047***
	(0.618)	(0.630)	(0.651)
ROA	−0.180	−0.169	−0.219
	(0.293)	(0.299)	(0.293)
SIZE	0.020	0.022	0.012
	(0.026)	(0.026)	(0.026)
GPM	0.293**	0.298**	0.302**
	(0.122)	(0.124)	(0.124)
TobinsQ	−0.143***	−0.145***	−0.147***
	(0.053)	(0.054)	(0.055)
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
Province FE	YES	YES	YES
Observations	12511	12511	12511
Anderson canon. corr. LM statistic	43.778	42.152	41.049
Cragg-Donald Wald F statistic	43.809	42.172	20.530

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

classification methods: company size (Gertler & Gilchrist, 1994) and age (Devereux & Schiantarelli, 1990). Moreover, we employ a method of classification with the most Chinese features: the nature of company equity (Liu, Wang, & Zhu, 2021).

The results are grouped by type of firm ownership in Table 10. Columns (1)–(3) report the regression results of the fixed effects model for state-owned enterprises, whereas columns (4)–(6) contain the regression results for the fixed effects model for non-state-owned enterprises. Empirical results show that for state-owned enterprises, column (3) shows the results after adding the interaction term (KZ × DIF) between financing constraints and FinTech. The coefficient of financing constraints (KZ) is significantly positive at the 10% level, while the interaction The regression coefficient of the term (KZ × DIF) is not significant and cannot prove the impact of FinTech. For non-state-owned enterprises, column (6) shows the results after adding the interaction term (KZ × DIF) between financing constraints and FinTech. The coefficient of financing constraints (KZ) is significantly positive, and the regression coefficient of the interaction term is significantly negative, indicating that FinTech will weaken the impact of financing constraints on corporate liquidity, showing the same results as the full sample.

It can be seen that the role of FinTech is different for enterprises with different forms of ownership. Due to their government background, state-owned enterprises have a strong voice on the financial market, and the role of FinTech is unclear. FinTech's role is more apparent for non-state-owned enterprises, which are subject to greater financing restrictions and whose liquidity is significantly affected.

Table 11 reports the results grouped by firm size. Columns (1) to (3) report the regression results of the fixed effects model for large enterprises, and columns (4) to (6) report the regression results of the fixed effects model for small and medium enterprises. Empirical results show that for large enterprises, column (3) shows the results after adding the interaction term (KZ × DIF) between financing constraints and FinTech. The coefficient of financing constraints (KZ) is significantly positive at the 5% level, while the interaction The regression coefficient of the term (KZ × DIF) is not significant and cannot prove the impact of FinTech. For non-state-owned enterprises, column (6) shows the results after adding the interaction term (KZ × DIF) between financing constraints and FinTech. The coefficient of financing constraints (KZ) is significantly positive at the 5% level, and the interaction term (KZ × DIF) is significantly negative at the 10% level, indicating that FinTech will weaken the impact of financing constraints on corporate liquidity, showing the same results as the full sample.

Table 10
State-owned enterprises (SOEs) vs. non-state-owned (non-SOEs).

	SOEs			Non-SOEs		
	(1)	(2)	(3)	(4)	(5)	(6)
	CCC	CCC	CCC	CCC	CCC	CCC
KZ	0.046**	0.046**	0.046**	0.043***	0.044***	0.044***
	(0.018)	(0.018)	(0.018)	(0.012)	(0.012)	(0.012)
DIF		−0.070	−0.020		0.089	0.155
		(0.135)	(0.143)		(0.132)	(0.129)
KZ × DIF			−0.013			−0.024***
			(0.012)			(0.009)
FA	−0.756***	−0.758***	−0.760***	−0.810***	−0.814***	−0.836***
	(0.263)	(0.262)	(0.262)	(0.215)	(0.216)	(0.217)
CFLOW	0.437	0.438	0.466*	0.357**	0.360**	0.381**
	(0.277)	(0.277)	(0.279)	(0.172)	(0.173)	(0.176)
LEV	−0.669***	−0.666***	−0.681***	−0.403*	−0.401*	−0.433**
	(0.228)	(0.228)	(0.231)	(0.212)	(0.212)	(0.215)
ROA	−0.473	−0.466	−0.456	−0.889***	−0.884***	−0.932***
	(0.393)	(0.394)	(0.395)	(0.197)	(0.198)	(0.198)
SIZE	0.006	0.005	0.002	−0.035	−0.035	−0.038
	(0.056)	(0.056)	(0.057)	(0.041)	(0.041)	(0.040)
GPM	0.030	0.025	0.024	0.028	0.029	0.027
	(0.265)	(0.266)	(0.266)	(0.220)	(0.220)	(0.220)
TobinsQ	−0.033	−0.033	−0.033	−0.017	−0.017	−0.017
	(0.026)	(0.026)	(0.026)	(0.017)	(0.017)	(0.017)
Constants	2.315*	2.607*	2.430*	3.342**	2.966**	2.732**
	(1.265)	(1.382)	(1.381)	(1.303)	(1.383)	(1.378)
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES
Observations	4500	4500	4500	8103	8103	8103
Within-R^2	0.0324	0.0325	0.0331	0.0451	0.0453	0.0480

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 11
Large firms vs. small & medium enterprises (SMEs).

	Large firms			SMEs		
	(1)	(2)	(3)	(4)	(5)	(6)
	CCC	CCC	CCC	CCC	CCC	CCC
KZ	0.063***	0.063***	0.065***	0.026**	0.026**	0.026**
	(0.016)	(0.016)	(0.017)	(0.011)	(0.011)	(0.011)
DIF		−0.027	0.031		0.071	0.108
		(0.130)	(0.137)		(0.103)	(0.099)
KZ × DIF			−0.016			−0.017*
			(0.011)			(0.009)
FA	−1.127***	−1.127***	−1.125***	−0.360*	−0.362*	−0.388*
	(0.231)	(0.231)	(0.231)	(0.218)	(0.218)	(0.220)
CFLOW	0.696***	0.696***	0.731***	0.040	0.040	0.067
	(0.232)	(0.232)	(0.239)	(0.166)	(0.166)	(0.169)
LEV	−0.500**	−0.500**	−0.523**	−0.569***	−0.568***	−0.586***
	(0.242)	(0.243)	(0.247)	(0.129)	(0.129)	(0.132)
ROA	−0.745***	−0.746***	−0.746***	−0.859***	−0.860***	−0.894***
	(0.284)	(0.285)	(0.285)	(0.192)	(0.192)	(0.192)
SIZE	−0.006	−0.006	−0.007	−0.041	−0.041	−0.041
	(0.044)	(0.044)	(0.043)	(0.046)	(0.046)	(0.046)
GPM	0.051	0.050	0.052	0.224	0.226	0.216
	(0.234)	(0.234)	(0.234)	(0.203)	(0.204)	(0.204)
TobinsQ	−0.049**	−0.049**	−0.049**	0.008	0.008	0.006
	(0.020)	(0.020)	(0.020)	(0.016)	(0.016)	(0.016)
Constants	2.885***	2.997***	2.740**	0.926	0.626	0.481
	(0.986)	(1.084)	(1.103)	(1.030)	(1.193)	(1.184)
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES
Observations	7428	7428	7428	5175	5175	5175
Within-R^2	0.0518	0.0518	0.0525	0.0789	0.0791	0.0810

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

It can be seen that the role of FinTech is different for companies of different sizes. For large companies, where the company has a strong voice in the market and abundant capital flow, the role of FinTech is not obvious. For small and medium enterprises, which are subject to greater financing constraints and corporate liquidity is greatly affected, the role of FinTech is more obvious.

The results are grouped by firm age in Table 12. The. regression results of the fixed effects model for mature companies are reported in

Table 12
Mature firms vs. young firms.

	Mature firms			Young firms		
	(1)	(2)	(3)	(4)	(5)	(6)
	CCC	CCC	CCC	CCC	CCC	CCC
KZ	0.067**	0.068**	0.067**	0.031***	0.031***	0.032***
	(0.026)	(0.026)	(0.027)	(0.009)	(0.009)	(0.009)
DIF		0.505**	0.486**		−0.089	0.010
		(0.239)	(0.243)		(0.084)	(0.081)
KZ × DIF			0.005			−0.028***
			(0.022)			(0.007)
FA	−1.216***	−1.218***	−1.222***	−0.488***	−0.486***	−0.513***
	(0.403)	(0.401)	(0.403)	(0.163)	(0.163)	(0.164)
CFLOW	0.720*	0.717*	0.714*	0.297*	0.293*	0.347**
	(0.384)	(0.383)	(0.384)	(0.153)	(0.153)	(0.157)
LEV	−0.564*	−0.564*	−0.560*	−0.549***	−0.551***	−0.592***
	(0.299)	(0.298)	(0.302)	(0.120)	(0.120)	(0.123)
ROA	−0.667*	−0.658*	−0.658*	−0.809***	−0.806***	−0.848***
	(0.382)	(0.382)	(0.382)	(0.165)	(0.165)	(0.165)
SIZE	−0.015	−0.015	−0.014	−0.033	−0.034	−0.036
	(0.073)	(0.073)	(0.073)	(0.039)	(0.039)	(0.039)
GPM	0.193	0.202	0.201	0.119	0.115	0.120
	(0.329)	(0.327)	(0.327)	(0.180)	(0.180)	(0.181)
TobinsQ	−0.043	−0.042	−0.043	−0.001	−0.001	−0.004
	(0.030)	(0.029)	(0.029)	(0.015)	(0.015)	(0.015)
Constants	3.102*	1.098	1.171	1.997**	2.391**	1.997*
	(1.692)	(1.905)	(1.929)	(0.957)	(1.033)	(1.036)
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES
Observations	3643	3643	3643	8960	8960	8960
Within-R^2	0.0645	0.0666	0.0667	0.0570	0.0573	0.0619

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

columns (1)–(3), whereas the regression results of the fixed effects model for young companies are reported in columns (4)–(6). Empirical results indicate that for mature companies; the results after the interaction term (KZ × DIF) between financing constraints and FinTech has been added are presented in column (3). The coefficient of financing constraints (KZ) is significantly positive at the 5% level, whereas the interaction term's regression coefficient (KZ × DIF) is not significant and cannot be used to demonstrate the impact of FinTech. For young companies, the results of adding the interaction term (KZ × DIF) between financing constraints and FinTech are displayed in column (6). The coefficient of financing constraints (KZ) is significantly positive at the 1% level, and the interaction term (KZ × DIF) is significantly negative at the 1% level, indicating that FinTech will reduce the impact of financing constraints on corporate liquidity, with the same outcomes as the full sample.

It is evident that FinTech plays a different role for companies of different ages. For mature companies with wide financing channels and abundant capital flows, the role of FinTech is not obvious. For young companies, which are subject to greater financing constraints and corporate liquidity is greatly affected, the role of FinTech is more obvious.

5. Conclusions

Concerning the effect of financial technology on corporate liquidity, the existing literature is still ambiguous. Therefore, we verify in two steps: first, the impact of financing constraints on corporate liquidity, and then the impact of financial technology. We found that, whether in the full or classified sample, the impact of financing constraints on corporate liquidity is negative, meaning that the greater the financing constraints, the worse the corporate liquidity. We also discovered that financial technology has a positive effect and can mitigate the negative effect of financing constraints on corporate liquidity. In addition, we discovered that financial technology has a greater impact on non-state-owned businesses, small and medium enterprises, and young enterprises than on state-owned enterprises, large enterprises, and mature enterprises.

Our research also has some practical application. Initially, the development of the traditional banking industry has been affected by the advancement of financial technology. However, the traditional banking industry has used the pressure as an impetus to comprehensively improve financial service levels and offer businesses better and more convenient services. Services, such as lowering loan thresholds, simplifying loan procedures, expanding loan coverage, aim to alleviate corporate financing restrictions and promote corporate growth. Second, local governments should place a high priority on the development of financial technology, cultivate and support small and medium financial technology companies, and provide appropriate guidance and oversight so that small and medium financial technology companies can develop quickly and healthily and better serve the local social and economic development. Third, enterprises should seize the opportunities presented by the advancement of financial technology, particularly non-state-owned enterprises, small and medium enterprises, and young enterprises, which face greater financing challenges than their state-owned counterparts. They should also actively respond to the national call, accelerate the pace of digital transformation, and fully leverage the advantages of financial technology to facilitate rapid enterprise growth.

This article features certain limitations. The firms most affected by the development of FinTech should be smaller firms and micro-enterprises. The sample selection process did not include small and micro-enterprises due to data availability issues. The analytical process examined a sample of the small and medium-sized versions of the SZSE separately. However, with continued development, the companies listed in the small and medium-sized versions of the SZSE have become or are close to becoming the same size as the listed companies on the main board. Eventually, the small and medium-sized versions of the SZSE will merge with the main board, indicating that it is no longer an SMEs in the strictest sense of the term. Therefore, future research should focus on expanding the sample size to further validate the relationship between FinTech and corporate liquidity. In addition, we focus on the relationship between financial technology, financing constraints and corporate liquidity, and future research should further study the economic consequences of financial technology affecting corporate liquidity.

Author contributions

Chenguang Fan: Conceptualization, Methodology, Data curation, Writing-Original draft preparation. Seongho Bae: Conceptualization, Supervision. Yu Liu: Methodology, Validation, Writing-Reviewing and Editing.

Funding

This research was supported by the Ministry of Education and the National Research Foundation of Korea (BK21 FOUR, No.419999 0413953).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Chenguang Fan is a Ph.D. Candidate at School of Business Administration, Kyungpook National University. His research interests focus on corporate finance, liquidity management and financial decision making. (E-mail: fcg@knu.ac.kr)

Seongho Bae is an associate professor at School of Business Administration, Kyungpook National University. His research interests focus on e auditor's behaviors, current tax issues and analysts' forecasts properties. Professor Bae is a licensed CPA in South Korea. (E-mail: shobae@knu.ac.kr)

Yu Liu is a Ph.D. Student at School of Business Administration, Kyungpook National University. His research interests focus on corporate finance, supply chain management decision-making. (E-mail: liuyu722@knu.ac.kr)