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Article

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Regional digital finance and inefficient corporate investments: Empirical evidence from China

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ABSTRACT

Using data of 1,457 Chinese A-share listed enterprises from 2012 to 2021, this study investigates the impact of regional digital finance development on inefficient corporate investments. Data for core explanatory variables, including Digital Finance and Breadth, were obtained from the Peking University Digital Finance Research Center, while firm-level variables' data were sourced from CSMAR. The baseline results show that regional digital finance development significantly reduces inefficient corporate investments in China. These findings are further supported by a series of robustness tests. Additionally, we identify two mechanisms through which regional digital finance development mitigates inefficient corporate investments: alleviating financing constraints and increasing cash flow circulation. The mitigation effects of digital finance are more pronounced in state-owned firms, firms with strong governance, firms located in western regions, firms in areas with a high degree of marketization, and firms in innovative and competitive industries. Overall, this study offers significant insights for developing countries, suggesting that regional digital finance development can enhance firms' resource allocation efficiency.

IMPACT STATEMENT

By analyzing data of Chinese A-share listed firms over 2012-2021, the study discovers that digital finance alleviates financing constraints and enhances cash flow circulation, thereby optimizing resource allocation. This research highlights the strategic role of digital finance in fostering more efficient investment decisions, with broader implications for economic development and policy-making in developing countries.

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Digital finance; inefficient corporate investments; under-investments; over-investments; financing constraints; cash flow circulations

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Finance; Economics; Business, Management and Accounting

1. Introduction

Digital finance with cutting-edge technologies has the potential to promote financial inclusion, inclusive growth, and efficiency of financial services (Ozili, 2018; Siddik & Kabiraj, 2020). The advanced form of information technology has permeated the financial industry, improving the accuracy and efficiency of financial support, expanding the availability and scope of financial services, and accelerating the expansion of financial business (Makina, 2019; Morgan, 2022). Consequently, enterprises of every size are developing digitization strategies to revamp their current operational processes and structures, and to optimize their competitiveness (Chen et al., 2019). Employing digital finance, which includes services like digital mobile payments, online lending, and online financial services, has gained prominence to address corporate and individual needs.

Digital finance with its micro-perspective allows firms to increase corporate risk-taking (Tian et al., 2022), boost corporate innovation (Zhang et al., 2023), reduce bankruptcy risk (Ji et al., 2022), enhance corporate green investments (Ding et al., 2023), and allow firms to make efficient capital allocation decisions (Fan & Chen, 2022). It alleviates financing constraints (Li et al., 2023), reduces information asymmetry (Kong et al., 2022), and opens new financing channels to fund business operations (Han & Gu, 2021). Investment is the

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fundamental pillar for growth, development, and value expansion of any enterprise, and there are several frictional factors, including agency costs, financing constraints, information asymmetry, and cognitive biases of decision makers, tend to influence investment behaviors of managers, and lead to inefficient corporate investments (Almeida & Campello, 2007; Childs et al., 2005; Fazzari et al., 1988; McDonald & Siegel, 1986; Myers & Majluf, 1984; Wang, 2010). Inefficient corporate investments are classified as over-investments and under-investments. Over-investments occur when managers allocate cash flows to these projects which have negative net present value, while under-investments occur when managers neglect those projects with positive net present value. These both forms of investments reflect inefficiency in resource allocation and therefore might not contribute to increasing corporate value. However, existing literature lacks conclusive evidence that resolving financing constraints or agency problems can definitively solve investment inefficiency. Traditional finance allocates resources inefficiently because of information asymmetry, financing constraints, and market imperfections (Fan & Chen, 2022). In this context, digital finance, as an emerging financial development tool, can help firms reduce inefficient investments by reducing information asymmetry and easing financing constraints.

By employing digital technologies, digital finance gains a more efficient integration of user information compared to traditional finance, thereby helping to decrease the information asymmetry that exists between parties involved in a credit transaction (Yao & Yang, 2022). These technological innovations can help firms determine their investment needs; digital finance boosts corporate innovations, which include both technological and non-technological innovations (Khan et al., 2023). In this way, digital finance enriches firms with potential investment opportunities and allows them to select the most viable investment choices, thus reducing inefficiency in corporate investments with the help of digital tools (Puschmann, 2017). Most of the previous studies on digital finance development focused on its macro-level outcomes, such as its influence on financial stability (Risman et al., 2021), household consumption (Li et al., 2020), and financing constraints (Chen & Zhang, 2021). There are only a few studies focused on the micro-level benefits of digital finance (Ding et al., 2022; Ji et al., 2022; Kong et al., 2022; Tian & Shao, 2023); however, none of these focused on investigating the role of digital finance in reducing inefficient corporate investments. So, recognizing the benefits delivered by digital finance development and the existing research gap, this study aims to achieve these research objectives: (1) to what extent digital finance development reduces inefficient corporate investments; (2) how digital finance development alleviates financing constraints and increases cash flow circulations to discourage inefficient corporate investments; and (3) how firm-level, industry-level, and regional-level characteristics influence the impact of digital finance development on inefficient corporate investments.

Analyzing the impact of digital finance on inefficient corporate investments is significantly magnified when considering China's distinct position as an economic powerhouse with a superficial financial ecosystem. The potential impact of digital finance in impeding inefficient investments becomes a crucial question with far-reaching implications when the Chinese government is steering the country toward a market-oriented economy. China, as the world's largest exporter with a share of 18% of global exports, has a major role in the global supply chain (Lunness, 2023). The production lines and factories of China, often termed as the 'world's factory,' are woven deeply into the global supply chain fabric. So, any business distress challenge in the form of inefficient investments to Chinese firms can disrupt the global supply chain. The ripple effects of inefficient investments would send shockwaves through global supply chain disruptions in the form of impacting everything from the availability of raw materials to consumer goods. By considering the importance of this domain, this paper examines how digital finance can serve as a safeguard against the disruptions that could threaten the smooth operations of the global supply ecosystem.

Theoretically, digital finance with its comprehensive impact (L. Liu et al., 2022), may help firms to reduce inefficient investments through different possible mechanisms. There are two mechanisms considered by this paper through which digital finance can reduce inefficient investments: easing financing constraints and helping cash flow circulations. First, digital finance may reduce financing constraints and help enterprises to extend a firm's access to capital. Via platforms of crowdfunding, peer-to-peer lending, and digital payment systems, firms may gain faster and more affordable access to funding. Thus, by alleviating the financing constraints for firms (Li et al., 2023), digital finance facilitates an efficient resource allocation paradigm and allows them to invest in profitable investment opportunities. The second mechanism by which digital finance reduces inefficient investments is to enhance cash flow circulations within the business process and accelerate corporate financialization (Jiang et al., 2022). Firms adopting digital

finance technologies become more efficient at circulating cash in a manner that generates better returns. It facilitates the rapid movement of funds to enhance liquidity and enables them to respond efficiently to operational needs and investment opportunities.

This paper uses inefficient investment data of Chinese listed firms and the "Peking University Digital Inclusive Finance Index" (Guo et al., 2020), to conduct an empirical investigation on the above issue. The benchmark results suggest that digital finance development significantly reduces the inefficient corporate investments of Chinese listed companies. Specifically, an increase of 1% in digital finance leads to a reduction in inefficient investment by 3.2465%. The results remain robust after using the 2SLS endogenous test, replacing the explanatory variable, and using a one-lagged period for the explanatory variables. Mechanism analysis shows that digital finance reduces inefficient corporate investments by easing financing constraints and increasing cash flow circulations. Firm-level heterogeneity analysis shows that digital finance has greater inhibitory effects on firms with SOE ownership rights and strong governance. Regional-level heterogeneity analysis shows that firms located in the western region and in areas with a high marketization degree are more exposed to the benefits of digital finance to reduce their inefficient investments. Industry-level heterogeneity analysis shows there are greater inhibitory effects of digital finance for firms in innovative industries and less-heavily polluted industries compared to firms in non-innovative and heavily polluted industries.

This study makes significant contributions to the existing literature on the micro-level effects of digital finance. First, it bridges the research gap by presenting micro-level empirical evidence on how regional digital finance development influences inefficient corporate investments, an area that is relatively unexplored compared to the macro-level outcomes of regional digital finance development (Chen et al., 2019; Chen et al., 2021; Ding et al., 2022). Second, this study provides a nuanced understanding by examining the effects of regional digital finance development on the classification of inefficient corporate investments into under-investments and over-investments, a sub-classification of inefficient investments unexplored in the literature (Lv & Xiong, 2022). Third, this study investigates the channels through which digital finance affects corporate investment inefficiencies, such as alleviating financing constraints and improving cash flow circulation (Li et al., 2023; Wu & Huang, 2022). Fourth, by incorporating firm-level, regional-level, and industry-level heterogeneity analyses, this study offers deeper insights into how the benefits of regional digital finance vary across firms of different sizes, ownership structures, governance strengths, and those in high marketization regions, innovative industries, and competitive sectors (Guo et al., 2020; Huang et al., 2023). Last, this study underscores the potential of digital finance as a strategic tool to aid China's transition to a market-oriented economy, with significant implications for the global supply chain and economic development (Tang et al., 2020).

The remaining structure of this paper is as follows: Section 2 presents the theoretical discussion and develops some hypotheses. Section 3 discusses the research design, including the empirical model, main variables, variable measurement, data sources, and descriptive statistics. Section 4 presents the baseline regression results, a series of robustness tests, mechanism analysis tests, and heterogeneity tests at the firm-level, industry-level, and regional-level. Section 5 concludes the paper with potential policy implications.

2. Theoretical analysis and hypotheses development

There are significant social and economic developments led by digital finance, as the crucial element to boost the digital economy (Goldfarb & Tucker, 2019). Inefficient corporate investments as a business distress challenge have gained much attention from industry and academia, and are considered a barrier to economic growth. The People's Bank of China has indicated that it is necessary to use digital finance for optimizing the credit process, alleviating financing problems, enhancing the financial systems' ability, and reducing firms' financing costs (Fullerton & Morgan, 2022). On the basis of these grounds, we may argue that digital finance can ease financing constraints and discourage inefficient corporate investments.

In a perfect market economy, the weight of marginal benefits and costs determines investment decisions. Stein (2003) states that the availability of investment options influences corporate investment performance. However, agency costs (Childs et al., 2005; Wang, 2010), information asymmetry (Fazzari et al., 1988; Myers & Majluf, 1984), and financing constraints (Almeida & Campello, 2007; Hirth & Viswanatha, 2011; McDonald & Siegel, 1986) may lead firms to make inefficient investments. Digital finance, with its ability to eliminate spatial and temporal barriers, reduces information asymmetry (Tian & Shao, 2023),

and alleviates financing constraints (Alber & Dabour, 2020; Gomber et al., 2017; Khan et al., 2018). Additionally, Fin-tech boosts corporate innovation in the form of technological and non-technological innovations (Chen et al., 2019; Ding et al., 2022). These technological innovations assist firms in identifying their investment needs, enriching them with a variety of available investment opportunities, and encouraging them to select more advantageous opportunities with high investment value (Puschmann, 2017; Xu et al., 2023), thereby increasing corporate investment efficiency. So, drawing on information asymmetry theory, it may be argued that digital finance reduces information asymmetry to help firms make well-informed decisions, and thus reduces inefficient corporate investments (Tian & Shao, 2023).

Digital finance development has a profound impact on corporate investment decisions, and thus potentially leads to a reduction in the volume of inefficient corporate investments. Al-Smadi (2023) suggests that digital finance development enhances financial inclusion and increases access to capital, which can further reduce information asymmetry and improve information efficiency. However, this increased access to funds may also encourage firms to undertake excessive investments due to managerial overconfidence or misallocation of resources (Fan & Chen, 2022). Empirical studies support this dual effect, indicating that while digital finance may streamline financial operations and increase capital allocation efficiency, it may simultaneously result in overinvestment or underinvestment depending on a firm's governance and corporate structure (Lin et al., 2023). Drawing on the theoretical framework explained by information asymmetry theory and the dual effect of digital finance presented by prior empirical studies, there is a need to investigate the impacts of digital finance development on inefficient corporate investments, so we propose the following hypothesis;

H_1: Digital finance reduces inefficient corporate investments for Chinese listed firms.

This paper postulates that digital finance eases firms' financing constraints, optimizes their financing access, and thus reduces their inefficient investments. Financing constraints for firms can be in form of limited access to external capital, which lead to high costs and stringent borrowing conditions, imposed by traditional financial institutions (Kaplan & Zingales, 1997). Inefficient corporate investments are directly linked with the functioning of capital markets and credit markets (Beck & Demirguc-Kunt, 2006). In other words, it can be stated that if a firm faces a fund deficiency that hampers its operations, it moves toward external financing, which incurs high costs and barriers. Therefore, financing constraints are significant barriers preventing firms from obtaining low-cost external financing, which consequently leads them to inefficient investments (Brown & Petersen, 2009). The digital finance system introduces new financing channels which promote fair market competition and reduce information asymmetry between all market participants (Qu & Zhu, 2023). Digital finance overcomes the issues associated with traditional finance services that are not inclusive enough, and helps firms make timely decisions on the basis of abundant information availability.

Digital platforms introduced by digital finance utilize big data analytics to assess the creditworthiness of firms more accurately, thereby reducing information asymmetry between borrowers and lenders (Chen & Yoon, 2022). This improvement in credit assessment processes allows even small and medium-sized enterprises (SMEs) to acquire necessary funds at lower costs, which might not be offered by traditional banking systems (Li et al., 2020). J. Liu et al. (2022) demonstrate that digital finance development fosters a more competitive lending environment, encouraging traditional banks to innovate and mitigate their borrowing costs. The rapid development of digital finance in China has been instrumental in enhancing financial inclusion and reducing regional disparities in financing access (Guo et al., 2020). By alleviating financing constraints, digital finance helps firms undertake profitable investments that they might have otherwise missed, thereby reducing the prevalence of inefficient corporate investments (Li et al., 2021). Drawing on these views, this paper proposes that digital finance improves firms' access to funds and reduces transaction costs, thereby helping them to make more efficient investment decisions and curb inefficient corporate investments. Therefore, we postulate this hypothesis;

H_2: Digital finance reduces inefficient corporate investments by alleviating financing constraints.

Digital finance enables firms to quickly access funds, allowing them to secure funds according to their investment needs by absorbing social capital into financing markets (Tang et al., 2020). Thus, with digital finance, firms are not restricted to internal capital reserves, as there is a possibility to obtain market

capital prompting them to increase their investments to enhance investment performance (Han & Gu, 2021). Digital finance can aid firms in optimizing capital allocation efficiency and enhancing control over investment opportunities by increasing cash flow circulations. It improves internal capital adequacy and encourages an abundance of cash flows which provide a stable source of funding (L. Liu et al., 2022), for firms to reinvest and curb inefficient investments. Free cash flow theory argues that easy access to cash leads to wasteful spending; digital finance streamlines financing processes and improves transparency of cash flows (Dhumale, 2003). Digital finance, with data analytics tools, can help firms allocate cash funds adequately, monitor investment performance, and optimize cash reinvestments in a timely manner. Thus, drawing on these theoretical grounds, we propose this hypothesis;

H_3: Digital finance reduces inefficient corporate investments by increasing cash flow circulations.

3. Research design

3.1. Empirical model

This paper tests the effect of digital finance on inefficient corporate investments by using the degree of inefficient investment presented by previous literature (Biddle et al., 2009; Chen et al., 2016; Richardson, 2006). The basic empirical model is constructed as:

$$\mathrm{Inv}_{it} = \beta_0 + \beta_1\ \mathrm{DgF}_{\ it} + \beta_n\ \mathrm{Controls}_{\ it} + v_i + \lambda_t + \gamma_j + \varepsilon_{ijn} \tag{1}$$

where *i*, *t*, and *j* represent firm, year, and industry respectively. $In_{Inv}it$ as the dependent variable denotes the degree of firm's inefficient investments. *DgF*, as the core explanatory variable represents digital finance index of the city in which firm is registered. *Controls* denotes the set of control variables, while ε represents the error term. This study fixed the firm, industry, and year effects in benchmark regression model, and it mainly considers the firm-specific characteristics as the control variables. Moreover, regional-level variables have been employed to perform heterogeneity analysis.

Additionally, this study examines the two potential mechanism channels of regional digital finance development: enterprise financing constraints (*KZ*) and enterprise cash flow circulations (*Cash*). These both are incorporated as the mediating variables into our baseline empirical model. The empirical models to test the mediating effects of financing constraints (KZ) will be constructed as:

$$\mathrm{KZ}_{it} = \beta_0 + \beta_1\ \mathrm{DgF}_{\ it} + \beta_n\ \mathrm{Controls}_{\ it} + v_i + \lambda_t + \gamma_j + \varepsilon_{ijn} \tag{2}$$

$$\mathrm{Inv}_{it} = \beta_0 + \beta_1\ \mathrm{DgF}_{\ it} + \beta_2\ \mathrm{KZ}_{\ it} + \beta_n\ \mathrm{Controls}_{\ it} + v_i + \lambda_t + \gamma_j + \varepsilon_{ijn} \tag{3}$$

where SA_{it} represents the financing constraints experienced by an enterprise *i* in year *t*. These models will test how regional digital finance development influence inefficient corporate investments through incorporating the effects of cash flow circulations (*Cash*):

$$\mathrm{Cash}_{it} = \beta_0 + \beta_1\ \mathrm{DgF}_{\ it} + \beta_n\ \mathrm{Controls}_{\ it} + v_i + \lambda_t + \gamma_j + \varepsilon_{ijn} \tag{4}$$

$$\mathrm{Inv}_{it} = \beta_0 + \beta_1\ \mathrm{DgF}_{\ it} + \beta_2\ \mathrm{Cash}_{\ it} + \beta_n\ \mathrm{Controls}_{\ it} + v_i + \lambda_t + \gamma_j + \varepsilon_{ijn} \tag{5}$$

where $Cash_{it}$ represents cash reinvestment ratio of firm *i* in year *t*.

3.2. Definition of variables

3.2.1. Inefficient investment

Instead of measuring inefficient investment degree by ourselves, we have used inefficient investment degree estimated by CSMAR. Following previous literature on firm-level investment decisions (Biddle et al., 2009; Chen et al., 2016; Richardson, 2006), CSMAR measures firm inefficient investment by estimating the expected investment with the following model;

$$\mathrm{Newinv}_{\ i,t} = \alpha + \beta \boldsymbol{X}_{i,t-1} + \sum \mathrm{Industry}\ + \sum \mathrm{Year}\ + \varepsilon_{i,t} \tag{6}$$

where explained variable is $Newinv_{\ i,t}$ which denotes firm *i*'s actual new investment in year *t*. The matrix ***X*** includes economic determinants (TobinQ, Cash, Lev, Listage, Ret, Size) of firm-level investment decisions in year *t-1*. We also control industry fixed effects ($\sum$ *Industry*) and year fixed effects ($\sum$ *Year*).

$\varepsilon_{i,t}$ denotes the error term. The fitted value from the regression estimates the expected investment, while the residual represents the unexplained investment, indicating *inefficient corporate investments*[1]. A positive (negative) residual suggests that the actual investment exceeds (falls short of) the expected investment, corresponding to overinvestment (underinvestment) (Gomariz & Ballesta, 2014). The absolute value of the residual measures the deviation of real investment from the expected investment, reflecting the degree of *inefficient corporate investments* in a given firm-year. Consequently, our primary measure of inefficient investment In_{Inv}, is defined as the absolute value of the residual. We then differentiate between types of *inefficient corporate investments* with two additional measures. Underinvest quantifies underinvestment as the absolute value of the residual for samples with negative residuals, equating to zero otherwise. Overinvest, on the other hand, measures overinvestment as the absolute value of the residual for samples with positive residuals, also equating to zero otherwise. In the robust tests, we apply the same measures for underinvestment and overinvestment, but based on underinvestment and overinvestment subsamples, respectively.

3.2.2. Regional digital finance

The Digital Inclusive Financial Development Index as a prevalent metric to assess digital finance development in China. The digital finance research department at Peking University has compiled this index in collaboration with Ant Financial Services Group, which is a well-recognized and credible digital finance company in China (Guo et al., 2020). The transaction data of this enterprise have the advantage of comprehensive index composition, solid pertinence, nationwide user coverage, and low error. There are three sub-dimensions of this index including breadth, depth, and digitization degree. This paper uses city level main digital inclusive financial development index (*Def.*) and sub-dimension of breadth (*Brdth)* to perform regression analysis and confirm the robustness of findings.

3.2.3. Control variables

Following literature (Ding et al., 2023; Han & Gu, 2021; Huang et al., 2023; Ji et al., 2022; Puschmann, 2017), this study includes firm-specific control variables of firm profitability, tangibility, firm size, stock yield, cash flow status, growth and age. These control variables have direct linkage with the dependent variable to get the influence of the digital finance.

3.3. Data sources

Data for core explanatory variables *DgF* and *Brdth* are obtained from Peking University Digital Finance Inclusion Index (Guo et al., 2020). Firm-level variables' data is sourced from CSMAR. Data for city and provincial level variables are sources from China Statistical Yearbook. Data on industry classification is obtained from CSRC industry classifications. The data used in this paper cover 1,457 Chinese A-share listed companies on Shenzhen Stock Exchange and Shanghai Stock Exchange, and distributed across 366 cities and 31 provinces in China. The latest version of digital finance index covering the period is 2011-2021 is used in this paper. The time interval of this paper is from 2012-2021, which is selected on the basis of rich data availability for the maximum number of firms.

3.4. Summary statistics

The definitions and descriptive statistics of all variables of this study including the explained variable; inefficient investments (In_inv), explanatory variables; digital finance index (*DgF*), Digital finance_breadth (*Brdth*), and control variables; profitability (*ROA*), tangibility, (*Tang*), firm size (*F_size*), stock yield (*Yield*), cash flow (*Cash*), assets growth (*Growth*), and firm age (*Age*), are shown in Table 1. Inefficient corporate investment has mean value of -4.177, with standard deviation of 10.405, which suggests notable variability in the degree of inefficient corporate investments across the Chinese listed firms. Conversely, the explanatory variable, DgF has mean value of 2.266 with standard deviation of 0.654, suggesting the modest variability in digital finance development across the prefectures and cities in which firms are registered. The same pattern is observed for the supporting explanatory variable *Brdth*. Additionally, descriptive statistics for all other control variables fall within acceptable ranges.

Table 1. Descriptive statistics.

Variable	Symbol	Definition	Mean	Std. dev	Min	Max
Inefficient investment degree	In_Inv	The degree of inefficient corporate investments.	−4.177	10.405	−860.99	−0.001
Digital inclusive finance index	DgF	The digital inclusive finance index of the city in which the firm is registered.	2.266	0.654	0.620	3.597
Digital finance_breadth	Brdth	The breadth index of firm's registered city.	2.258	0.659	0.401	3.718
Profitability	ROA	Net profit/Total assets	0.028	0.137	−4.782	7.446
Tangibility	Tang	Tangible assets / Total assets	0.231	0.178	0.000	0.954
Firm size	F_size	Natural logarithm of total assets	22.619	1.404	14.940	28.640
Stock yield	Yield	Firm's annual stock yield.	0.153	0.512	−0.806	7.355
Cash flow	Cash	Net cash flow from operating activities / Total assets at beginning of the period	0.052	0.099	−4.050	1.209
Asset growth	Growth	The annual change in total assets.	0.308	6.961	−0.899	529.944
Firm age	Age	The difference between firm's listing year and fiscal year.	14.442	6.496	2	31

Table 2. The benchmark regression results.

Variables	(1) In_Inv	(2) In_Inv
DgF	−3.2465***	
	(−3.64)	
Brdth		−2.3677**
		(−2.48)
ROA	−7.9885***	−8.0250***
	(−12.59)	(−12.64)
Tang	6.8666***	6.8150***
	(5.9)	(5.85)
F_size	−1.3569***	−1.4178***
	(−6.54)	(−6.87)
Yield	−0.9742***	−0.8183***
	(−5.94)	(−4.85)
Cash	29.4373***	29.5195***
	(30.14)	(30.23)
Growth	−0.0846***	−0.0851***
	(−6.94)	(−6.98)
Age	0.9818***	0.7897***
	(5.17)	(3.95)
Constant	16.9851***	19.1130***
	(3.7)	(4.22)
Firm, Industry and Year FE	Yes	Yes
R-Squared	0.154	0.181
Obs.	14,570	14,570

Notes: Robust t-statistic are presented in parentheses; ***, **, and *, denote significant levels of 1%, 5% and 10%, respectively.

4. Results and discussion

4.1. Benchmark regression

Benchmark regression results for digital finance and inefficient corporate investments are reported in Table 2. The *DgF* coefficient is −3.2465, which is statistically significant at 1%, suggesting that digital finance reduces inefficient investments for Chinese listed firms. This influence is further verified by *Brdth* with regression coefficient of −2.3677. This shows that digital finance allows Chinese listed firms to reduce their inefficient investments. Hence, $\boldsymbol{H_1}$ is accepted. These results further show that profitability (*ROA*), Firm Size (*F_size*), Stock Yield (*Yield*), and Growth (*Growth*) as control variables also negatively influence inefficient corporate investments. This paper further classifies inefficient corporate investments into over-investments and under-investments, and re-estimates the empirical model. Columns (1) and (2) of Table 3 report the results for the over-investments, and columns (3) and (4) in same table report the results for the under-investments. In both cases, digital finance significantly reduces inefficient corporate investments as *DgF* and *Brdth* coefficients are negative and statistically significant. However, digital finance's influence is more pronounced in reducing the degree of inefficient corporate investments for those making under-investments. Overall, it can be claimed that digital finance helps the firms to reduce the

Table 3. Inefficient investment classification.

	(1)	(2)	(3)	(4)
	Over-investment		Under-investment	
Variables	In_Inv	In_Inv	In_Inv	In_Inv
DgF	−3.353**		−4.478***	
	(−2.05)		(−6.58)	
Brdth		−4.368**		−4.409***
		(−2.12)		(−5.98)
ROA	−9.347***	−9.298***	−7.346***	−7.407***
	(−4.12)	(−4.1)	(−17.8)	(−17.93)
Tang	8.822***	8.738***	4.696***	4.680***
	(3.26)	(3.23)	(4.95)	(4.93)
F_size	−3.996***	−4.002***	0.575***	0.503***
	(−8.94)	(−9.03)	(3.33)	(2.92)
Yield	−2.069***	−2.173***	0.201	0.488***
	(−5.78)	(−5.9)	(1.54)	(3.61)
Cash	64.851***	64.972***	0.160	0.269
	(31.49)	(31.54)	(0.20)	(0.34)
Growth	−0.063***	−0.063***	−0.118***	−0.117***
	(−3.35)	(−3.32)	(−7.77)	(−7.71)
Age	0.416	0.035	1.092***	1.057***
	(0.96)	(0.08)	(7.49)	(6.87)
Constant	74.331***	76.148***	−22.686***	−20.805***
	(7.98)	(7.82)	(−5.93)	(−5.5)
Firm, Industry, and Year FE	Yes	Yes	Yes	Yes
R-Squared	0.2024	0.2025	0.137	0.13
Obs.	6,020	6,020	8,550	8,550

Notes: Robust t-statistic are presented in parentheses; ***, **, and *, denote significant levels of 1%, 5% and 10%, respectively.

inefficient corporate investments by mitigating both, over-investments and under-investments, so all firms can benefit from digital finance development to achieve the better returns.

4.2. Checking the robustness of baseline results

4.2.1. Endogeneity tests

To handle the endogeneity problem, we use a two-stage least squares (2SLS) regression approach. Following existing literature (Chen & Zhang, 2021; Ji et al., 2022; Tang et al., 2020), the provincial internet penetration rate is used as an instrumental variable. The history of internet technology development reveals that internet penetration broadly represents the application of internet technology in the prefectures, cities, and provinces of China. Additionally, the internet penetration rate is selected as an instrumental variable because it does not direct influence inefficient corporate investments. The results of the 2SLS approach are reported in Table 4. Column (1) of Table 4 presents the results for the first stage regression and verifies that provincial internet penetration positively influences digital finance. Furthermore, the Wald F-statistic indicates that selected instrumental variable is effective in our analysis. Column (2) of Table 4 presents the second stage regression results and reports the *DgF* coefficient of -0.3363 which is statistically significant at 1%. The second stage regression coefficient of *Brdth* is -0.3226, which is reported in column (4) of Table 4. Therefore, after addressing the endogeneity concerns of variables, the coefficients of *DgF* and *Brdth* remain statistically significant and negative; thus, the benchmark regression results remain robust and confirm the negative influence of digital finance on inefficient corporate investments.

4.2.2. Other robustness tests

Following previous literature (Huang et al., 2023; Wang, 2022; Wei et al., 2023), this paper uses the proxy of provincial level digital finance index *(P_DgF)* and sub-dimension (*P_Brdth*) for explanatory variables of city level finance index (*DgF*) and sub-dimension (*Brdth*) to further confirm the robustness of benchmark results. The results for the proxies of explanatory variables are reported in columns (1) and (2) of Table 5. After including the proxies of explanatory variables in the empirical model, regression coefficients for *P_DgF* and *P_Brdth* still remain negative and significant at 1% and 5% respectively. This confirms the robustness of baseline results and verifies that digital finance significantly reduces inefficient corporate investments.

In addition to this, we re-estimate the empirical model to examine the temporal dynamic influence of digital finance on inefficient corporate investments (Yao & Yang, 2022). After introducing one-period lags

Table 4. Endogenous test.

Variables	(1) First Stage DgF	(2) Second Stage ln_Inv	(3) First Stage Brdth	(4) Second Stage ln_Inv
P_Int	0.0273***		0.0285***	
	(91.32)		(95.09)	
DgF		−0.3363***		
		(−3.68)		
Brdth				−0.3226**
				(−2.54)
ROA	−0.1403***	−8.5642***	−0.1535***	−8.5665***
	(−4.85)	(−13.75)	(−5.3)	(−13.75)
Tang	−0.1703***	−2.7063***	−0.1849***	−2.7087***
	(−7.52)	(−5.46)	(−8.16)	(−5.46)
F_size	0.0299***	0.5606***	0.0305***	0.5604***
	(10.44)	(8.93)	(10.64)	(8.93)
Yield	−0.0657***	−1.0307***	−0.0069	−1.0108***
	(−8.6)	(−6.26)	(−0.91)	(−6.16)
Cash	0.1484***	25.5613***	0.1185***	25.5497***
	(3.65)	(29.19)	(2.91)	(29.2)
Growth	−0.0017***	−0.0941***	−0.0018***	−0.0942***
	(−3.00)	(−7.88)	(−3.32)	(−7.88)
Age	0.0272***	0.0701***	0.0255***	0.0691***
	(43.89)	(4.47)	(41.06)	(4.51)
Constant	−0.4483***	−17.373***	−0.5204***	−17.3906***
	(−7.06)	(−12.85)	(−8.18)	(−12.87)
Firm, Industry, and Year FE	Yes	Yes	Yes	Yes
Wald F Statistic	1761.62		1809.86	
R-Squared	0.4918	0.1746	0.4986	0.1745
Obs.	14,570	14,570	14,570	14,570

Notes: Robust t-statistic are presented in parentheses in columns (1) and (3), and z-statistics are presented in parentheses in columns (2) and (4) ; ***, **, * and denote significant levels of 1%, 5% and 10%, respectively.

Table 5. Other robustness tests.

	(1)	(2)	(3)	(4)
	Proxy for explanatory Var		One-period lags	
Variables	ln_Inv	ln_Inv	ln_Inv	ln_Inv
P_DgF	−1.5694**			
	(−2.19)			
P_Brdth		−2.1439**		
		(−2.37)		
L.DgF			−3.8950***	
			(−3.96)	
L.Brdth				−11.2018***
				(−9.36)
Constant	−24.6129***	−25.9778***	−60.3108***	−66.0831***
	(−5.26)	(−5.36)	(−11.27)	(−12.5)
Control Variables	Yes	Yes	Yes	Yes
Firm, Industry, and Year FE	Yes	Yes	Yes	Yes
R-Squared	0.223	0.163	0.132	0.144
Obs.	14,570	14,570	14,570	14,570

Notes: Robust t-statistic are presented in parentheses; ***, **, and *, denote significant levels of 1%, 5% and 10%, respectively.

for core explanatory and control variables, Model (1) is re-estimated and results are reported in columns (3) and (4) of Table 5. The regression coefficients for *L.DgF* and *L.Brdth* still remain negative and significant at 1%, confirming the robustness of baseline results. Thus, based on robustness tests' results, it is found that digital finance significantly reduces inefficient corporate investments for Chinese listed firms.

4.3. Potential mechanism test

4.3.1. Financing constraints

Digital finance brings a new landscape diversified service modes and supply chains, which further facilitates a favorable market capital environment to support well-informed corporate investment decisions. It serves as the tool to ease financing constraints, reduce the firms' over-reliance on financial institutions/bank credit, and enhance their ability to gain market capital (Feng et al., 2022). Digital finance

Table 6. Potential mechanism test: financing constraints.

Variables	(1) KZ	(2) KZ	(3) ln_Inv	(4) ln_Inv
DgF	−3.2092***		−2.2782**	
	(−29.6)		(−2.53)	
Brdth		−2.5989***		−2.0648**
		(−22.08)		(−2.17)
KZ			1.7215***	1.705541***
			(24.53)	(24.64)
Constant	2.4955***	4.3536***	12.6889***	11.6876***
	(4.6)	(7.79)	(2.82)	(2.63)
Control Variables	Yes	Yes	Yes	Yes
Firm, Industry, and Year FE	Yes	Yes	Yes	Yes
R-Squared	0.3039	0.284	0.131	0.128
Obs.	14,570	14,570	14,570	14,570

Notes: Robust t-statistic are presented in parentheses; ***, **, and *, denote significant levels of 1%, 5% and 10%, respectively.

Table 7. Potential mechanism test: cash flow circulations.

Variables	(1) Cash	(2) Cash	(3) ln_Inv	(4) ln_Inv
DgF	0.2825**		−3.2591***	
	(2.30)		(−3.65)	
Brdth		0.2084**		−2.3831**
		(2.39)		(−2.48)
Cash			0.0934**	.0897*
			(2.12)	(1.74)
Constant	−2.5847	−3.4480	17.0092***	19.1439***
	(0.434)	(−1.06)	(3.70)	(4.23)
Control Variables	Yes	Yes	Yes	Yes
Firm, Industry and Year FE	Yes	Yes	Yes	Yes
R-Squared	0.11	0.09	0.081	0.079
Obs.	14,570	14,570	14,570	14,570

Notes: Robust t-statistic are presented in parentheses; ***, **, and *, denote significant levels of 1%, 5% and 10%, respectively.

downgrades the information asymmetry and lowers the cost of external financing (Tian & Shao, 2023), thereby, it decreases inefficient corporate investments. This paper uses the KZ index[2] as the measure of financing constraints (Kaplan & Zingales, 1997; Wu & Huang, 2022; Zhang, 2023), and performs mechanism analysis by testing (2) and (3) empirical models. The columns (1) and (2) of Table 6 report that regional digital finance development reduces the financing constraints (*KZ*) significantly. When financing constraints are included as mediating variable into baseline model, the effects of regional digital finance on corporate inefficient investment reduced (compared to the baseline results), suggesting that regional digital finance development eases financing constraints to affect corporate inefficient investments. The regression coefficients of *DgF* and *Brdth* demonstrate the negative and significant influence of digital finance on financing constraints. Thus, our findings claim that digital finance discourages inefficient corporate investments by alleviating the financing constraints, supporting $\mathbf{H_2}$.

4.3.2. Cash flows circulations

Intra-firm capital has the characteristics of a high degree of autonomy and low financing costs, and it is closely linked to business performance. Digital finance helps firms in alleviating their liquidity constraints and enhance corporate internal capital allocation efficiency with more abundant cash flows (Chen & Zhang, 2021; Colombo et al., 2013), thus, it boosts the motivation to achieve better corporate investments. Therefore, we consider cash flows as the mechanism to verify the impact of digital finance on inefficient corporate investment. Digital finance can support firms in making timely and informed decisions with digital data analytics to smoothly perform cash-reinvestment, becoming more efficient in achieving higher returns. The results of empirical models (4) and (5) are reported in columns (1) to (4) of Table 7. Columns (1) to (2) of Table 7 present the results of the impact of digital finance on cash-reinvestment ratio (*Cash*). The regression coefficients of 0.2825 and 0.2084 for *DgF* and *Brdth* respectively reveal the positive impact of digital finance on cash-reinvestment for Chinese listed firms. When incorporating the mediating effect of cash re-investment ratio (*Cash*) into baseline model, the results shown in columns (3) and (4) of Table 7, present the improved impact of regional digital finance development on

Table 8. Firm-level heterogeneity: Ownership rights and governance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Firm ownership rights				Firm governance			
Variables	SOEs		Non SOEs		Strong		Weak	
DgF	−4.060***		−2.108		−3.694***		−2.434*	
	(−5.47)		(−1.3)		(−3.59)		(−1.8)	
Brdth		−3.411***		−1.922		−2.826***		−1.553***
		(−4.28)		(−1.11)		(−2.57)		(−1.07)
Constant	−12.865***	−11.21***	35.408***	36.606***	7.010	9.656*	17.859***	19.446*
	(−2.82)	(−2.46)	(4.92)	(5.17)	(1.30)	(1.83)	(2.59)	(2.85)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm, Industry and Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.149	0.181	0.1297	0.1296	0.0697	0.0688	0.0953	0.1079
Obs.	7,330	7,330	7,240	7,240	7,110	7,110	7,640	7,640

Notes: Robust t-statistic are presented in parentheses; ***, **, and *, denote significant levels of 1%, 5% and 10%, respectively.

inefficient corporate investment, suggesting that digital finance tools firms can circulate capital smoothly, allocate and promote corporate cash reserves, and adjust them to the optimal level. This finding supports $\mathbf{H_3}$, which states that digital finance reduces the inefficient investments by improving the cash flow circulations.

4.4. Heterogeneity analysis

4.4.1. Firm-level heterogeneity

We examine the impact of digital finance on inefficient corporate investments by considering firm ownership rights and corporate governance, as they both can influence the firms' capability to leverage the impact of digital finance. Table 8 presents the firm-level heterogeneity analysis results. Columns (1) to (4) report the results for the firms' ownership rights and show that only state-owned firms (SOEs) benefit from the positive impact of digital finance, reducing their inefficient investments. The impact of digital finance on non-stated owned firms (non-SOEs)' inefficient investments is not statistically significant. Corporate governance strength is measured by the proportion of independent directors on the board (Chapple et al., 2009; Kumar & Singh, 2012; Merendino & Melville, 2019); firms with a greater number of independent directors than the median value are considered as firms with strong governance, while firms with low number of independent directors than median value are considered as firms with weak governance. Columns (5) to (8) of Table 8 present the results for the firms' governance strength and show that firms with strong governance are more efficient at leveraging the impact of digital finance to reduce their inefficient investments compared to the firms with weak governance. Overall, the findings claim that firms with SOE ownership rights and strong governance are more efficient at reducing their inefficient investments by leveraging the benefits of digital finance development in China.

4.4.2. Regional level heterogeneity

The effects of digital finance on inefficient corporate investments may vary due to the regional development and marketization degree of different provinces of China. We perform regional heterogeneity analysis by considering regional development and marketization degree of areas in which firms are registered. Regional development is used to classify the sample; central and eastern regions are classified developed, while western regions are classified under-developed regions. The results for regional location are reported in columns (1) to (4) of Table 9, which indicate the firms located in western regions are more efficient in leveraging the impact of digital finance to reduce their inefficient investments. This can be because they are more exposed to the opportunities of expansion and reaching the new markets.

The marketization degree measures market access in different areas of China (Zhao & Chen, 2022), and it may be a critical factor influencing firms' ability to be exposed to benefit from digital finance development. The results for marketization heterogeneity are presented in columns (5) to (8) of Table 9. The findings reveal that *DgF* coefficient is almost similar for the firms in areas with high marketization degree and low marketization degree, while *Brdth* coefficient is greater and statistically significant for the firms located in areas with a high marketization degree. Overall, it can be claimed that a high

Table 9. Regional-level heterogeneity: Regional location and marketization.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Regional location				Marketization degree			
Variables	Central and Eastern region		Western region		High		Low	
DgF	−2.941***		−4.554***		−3.405***		−3.413***	
	(−2.81)		(−3.9)		(−3.07)		(−2.65)	
Brdth		−2.206**		−2.417*		−3.650***		−1.545
		(−2.04)		(−1.74)		(−3.27)		(−1.1)
Constant	25.578***	27.514***	−16.487***	−12.868**	11.876**	13.134***	16.854**	20.081***
	(4.75)	(5.2)	(−2.86)	(−2.22)	(2.37)	(2.68)	(2.36)	(2.84)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm, Industry and Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.1132	0.1129	0.048	0.0423	0.116	0.11	0.1851	0.1844
Obs.	12,310	12,310	2,260	2,260	6,680	6,680	7,890	7,890

Notes: Robust t-statistic are presented in parentheses; ***, **, and *, denote significant levels of 1%, 5% and 10%, respectively.

Table 10. Industry-level heterogeneity: Innovativeness and regulations.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Industry innovativeness				Industry regulations			
Variables	Innovative		Non-innovative		Regulated		Competitive	
DgF	−7.333***		−2.567***		−2.199		−4.618***	
	(−3.64)		(−2.61)		(−1.12)		(−5.52)	
Brdth		−5.570***		−1.587		−1.898		−3.313**
		(−2.71)		(−1.5)		(−0.90)		(−3.71)
Constant	24.239**	29.737***	22.839***	24.838***	34.420***	35.698***	4.821	7.900
	(2.41)	(3.02)	(4.3)	(4.74)	(2.85)	(3.00)	(1.09)	(1.81)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm, Industry and Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Squared	0.0586	0.0557	0.1032	0.1028	0.1328	0.1358	0.12	0.152
Obs.	2,160	2,160	12,410	12,410	4,590	4,590	9,980	9,980

Notes: Robust t-statistic are presented in parentheses; ***, **, and *, denote significant levels of 1%, 5% and 10%, respectively.

marketization degree allows the firms to experience more serious impacts of digital finance, reducing their inefficient investments.

4.4.3. Industry level heterogeneity

We further explore the heterogeneity of industry innovations and regulations, which can also influence firms' ability to benefit from digital finance development, and thus reduce their inefficient investments. The firms in innovative industries are likely to be more attracted to the benefits of digital finance as shown by previous literature (Tang et al., 2020; Yao & Yang, 2022). The results of industry level heterogeneity, considering innovation classification[3], are presented in columns (1) to (4) of Table 10. It can be seen that impact of digital finance is significant and more pronounced for firms in innovative industries, reducing their inefficient investments. It can be argued that firms with high innovation levels are more exposed to the benefits of digital finance, tackling their business challenges such as inefficient investments.

Industry regulations can restrict firms making different business decisions, allowing them to manage their operations and processes freely and smoothly (Huang et al., 2023). By considering this, we perform industry level heterogeneity analysis and classify firms as competitive and regulated[4]. The results are shown in columns (5) to (8) of Table 10, which indicate the greater influence of digital finance on inefficient corporate investments for the firms in competitive industries. These results suggest that industry regulations significantly influence the firms' capability to make decisions regarding the benefits of digital finance. On the other hand, firms in competitive industries reduce their inefficient investments by integrating digital finance tools in their operations and decision-making processes.

4.5. Discussion

The findings of this study uncover the positive impact of digital finance development for Chinese A-share listed enterprises in reducing their inefficient corporate investments. The impeding effect of digital finance development is particularly pronounced in firms suffering from under-investment inefficiency,

suggesting that digital finance mitigates financing constraints and improves investment efficiency. Provincial internet penetration is used as an instrumental variable in a two-stage least squares (2SLS) regression approach to address endogeneity concerns and reinforces the robustness of baseline results. These findings emphasize the role of digital finance development in easing financing constraints and fostering cash flow circulations, which in turn results in reducing inefficient corporate investments.

From an economic perspective, digital finance's ability to reduce inefficient corporate investments is attributed to its facilitation of improved market access and better cash management. Digital finance platforms enable firms to access alternative financing channels, allowing them to bypass traditional banking constraints and secure funding more effectively. This is particularly beneficial for firms located in regions with underdeveloped financial markets or those with limited access to traditional financial services. By increasing cash flow circulations, digital finance ensures that firms maintain only the needed liquidity levels so they can pursue investment opportunities in a timely manner, thus reducing the tendency toward both under- and over-investments. The empirical evidence from this study signifies the economic rationale that digital finance enables firms to make more strategic and efficient investment decisions by easing financial constraints and improving cash flow circulations.

Additionally, the heterogeneity analysis shows that the impact of digital finance development on inefficient corporate investments varies across different firm characteristics, regions, and industries. SOEs and firms with strong corporate governance are more exposed to the benefits of digital finance development in reducing the volume of their inefficient investments. Similarly, firms in western regions, areas with a high degree of marketization, and innovative and competitive industries see greater positive impacts of digital finance development. These findings reveal that the effectiveness of digital finance is amplified in environments where the traditional finance system is less effective or where firms are more innovative and agile. Consequently, prioritizing digital financial systems offers opportunities for inclusive and efficient investment practices, thus supporting the broader economic development goals of China.

5. Conclusion and implications

In the era of the digital economy, digital finance facilitates firms in allocating financial resources efficiently. Subject to economic development, corporate investments are influenced by digital inclusive finance, which offers new financing channels and expands market access. Recognizing the benefits of digital finance, this paper examines the effect of digital finance on inefficient corporate investments using data from Chinese listed firms over 2012-2021. The results show that digital finance significantly reduces inefficient corporate investments, with a more pronounced impact on firms engaged in under-investments. These findings remain robust across a series of robustness tests. Specifically, this paper finds that easing financing constraints and increasing cash flow circulations are the two mechanism channels through which digital finance reduces inefficient corporate investments. Moreover, findings from firm-level, regional-level, and industry-level heterogeneity analysis show that digital finance has greater effects in reducing inefficient corporate investments for SOEs, firms with strong governance, western region firms, firms located in areas with a high degree of marketization, and firms in innovative and competitive industries. Conclusively, digital financial systems can be prioritized over traditional financial systems because of their inclusiveness in helping firms make efficient investment decisions. This paper contributes significantly to the corporate finance field by demonstrating that digital finance tools can be used to reduce inefficient corporate investments and support China's economic development.

This paper highlights several policy recommendations. First, it suggests that governments should foster the development of digital finance infrastructure, focusing on broadening the depth and scope of digital finance systems, and enhancing the efficiency of financial services by introducing new financing channels and aligning demand with supply. Second, it advocates for companies to leverage the advantages of digital finance, aiming to augment cash flow circulations and alleviate financing constraints, which will ultimately decrease their inefficient investments. Investment managers at firms should use the data analytics offered by digital finance to efficiently monitor investment performance and make timely decisions to gain optimal returns. Finally, to boost digital finance inclusive services, policymakers should extend digital finance support to firms in eastern and central regions, firms in areas with a low marketization degree, non-SOEs, and firms in regulated and non-innovative industries. Providing subsidies to

these firms could motivate them to utilize the benefits of digital finance, thereby helping to build an inclusive market.

Despite the significant findings, this study has certain limitations that warrant attention and highlight areas for future research. First, the sample of this study is limited to Chinese listed firms, which may not reflect the global applicability of the results. Future researchers could extend this analysis by focusing on other countries and regions to explore the broader implications of digital finance development on inefficient corporate investments. Second, this study has used a regional level digital finance index as a proxy measure of digital finance development and examined its connection with corporate level scenarios. In the future, if data on digital finance at the firm level become available, research could connect firm-level digital finance with firm-level corporate inefficiency issues. Third, this study is primarily focused on the mechanisms of easing financing constraints and increasing cash flow circulations, although there could be other mechanisms that influence the nexus of digital finance and inefficient corporate investments, which could be considered by future researchers. Lastly, given the rapid evolution of digital finance, continuous updates and longitudinal studies are essential to understand its long-term impacts and dynamic interactions with corporate investments.

Notes

1. Inefficient corporate investments include both under-investments and over-investments, meaning that when firms experience information asymmetries in capital markets, and thus they are not well informed to make timely investment decisions. Due to these constraints, firms either are reluctant to make investments or they make higher investments than the actual profit potential of investment projects. In both cases, they remain inefficient in garnering the actual benefits of investments, thereby resulting in corporate investment inefficiencies.
2. KZ-index is measured by following the Kaplan and Zingales (1997).
3. Following Industry Classification (2012 Edition), C29, C39, I and M are defined as innovative industries, while other industries are considered as non-innovative industries.
4. Specifically, SEC's Industry Classification (2012 Edition) considers industries with industry codes B, C25, C31, C32, C36, C37, D, E48, G53, G54, G55, G56, I63, I64, K, and R as regulated industries, while other industries as competitive industries.

CRediT authorship contribution statement

Asad Nisar: Conceptualization, Methodology, Data Analysis, Writing; **Haolin Li:** Validation, Review, Proof-Reading; **Syed Sadaqat Ali Shah:** Data Curation, Investigation, Review and Editing; **Rabia Rafique**: Resources, Data Curation, Supervision.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

Firm-level data is sourced from CSMAR and authors don't have authority to share due to copyright issue. Digital Inclusive Financial Development Index data is sourced Peking University, and authors don't have the right to share it.

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