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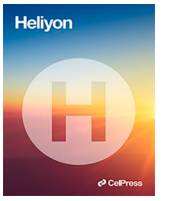

Research article

Does corporate digitization affect shadow banking business? Evidence from Chinese listed companies

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ABSTRACT

How to govern non-financial enterprises engaged in shadow banking activities is of great practical significance. This study investigates whether and how corporate digitization affects shadow banking. Using a sample of Chinese listed companies for the period 2012–2022, we find that corporate digitization has a significant negative effect on shadow banking business. Mechanism tests show that corporate digitization is conducive to enhancing product core competencies, broadening market channels, and improving operational efficiency, thus inhibiting firms from engaging in shadow banking activities. Moreover, the negative impact of corporate digitization on corporate shadow banking is especially noticeable for non-state-owned companies and in areas where local governments have more stringent financial risk regulations. The findings contribute to enriching the literature on the determinants of corporate shadow banking business, and deepen our understanding of the economic consequences of corporate digitization.

1. Introduction

Over the past decades, the Chinese economy has experienced continuous and remarkable growth. During this period, shadow banking activities have made a notable and indispensable contribution, which serves as an instrumental role in business prosperity[1] [1,2]. With active participation of non-financial enterprises, particularly small and medium-sized enterprises (SMEs), shadow banking activities have emerged as significant constituents within the informal credit system of China [3,4]. According to Quarterly China Shadow Banking Monitor (2023), the magnitude of shadow banking activities has expanded significantly from 1.11 trillion dollar in 2013 to 8.07 trillion dollar by the conclusion of 2021, exhibiting an annual growth rate exceeding 20 %, which underscores the substantial enlargement of the scope of shadow banking business within China [5].

Besides financial participants' direct or indirect involvement in shadow banking activities through private lending, trust business, entrusted loans, financial management products, a considerable number of non-financial enterprises, as a representative entity, actively participate in shadow banking operations [3,6]. However, contrary to investing in physical business ventures, an excessive engagement of non-financial enterprises in shadow banking endeavors exacerbates the challenge of "shifting from real to virtual". Such trend inevitably contributes to a sustained decline in corporate physical investments, progressively eroding their competitive

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[1] Shadow banking business is one of typical components of corporate financial investments. Non-financial companies invest their own funds from two perspectives: the first is through Credit intermediary activities, including private lending, entrusted financial management and entrusted loans; the second is through the purchase of financial products (e.g., trust products, structure deposits), which is an important component of capital gains.

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advantage in traditional manufacturing sectors [7–9]. In order to tackle this issue, the Central Financial Work Conference in October 2023, emphasized the imperative for government to strictly adhere to the fundamental purpose of providing financial services for real economy and to discourage non-financial enterprises from increasing their involvement in financial investments. Moreover, during his visit to Shenzhen on April 9, 2023, President Xi underscored the paramount importance of prioritizing the real economy for economic growth. Building upon this context, our objective is to investigate the underlying factors that effectively incentive non-financial businesses to cut back on their involvement in shadow banking.

Existing literature examining determinants of corporate shadow banking business primarily focuses on legal regulations, financial development, government intervention and executive traits [1,3,6,10–12]. A series of studies demonstrate that deep integration of digital technology within enterprises plays a crucial role in reshaping their core competitive advantage [13,14]. Consequently, non-financial firms, particularly SMEs, will spontaneously undergo corporate digitization to generate greater profits [15]. Especially with the pressure of sluggish business growth, the progress of digital technology is expected to exert a substantial influence on corporate financial investments [16]. As an important component of corporate investment, financial activities including shadow banking, are inevitably impacted by digital technology. However, there are still lack of empirical evidence supporting the implications of digital change, especially corporate digitization, on non-financial firms' shadow banking activities. Therefore, this paper intends to address this gap by investigating the relationship between corporate digitization and shadow banking business.

Using a sample of Chinese listed companies for the period 2012–2022, this paper comprehensively explores and examines the effects and mechanisms of corporate digitization on shadow banking business. We empirically investigate that more digitally transformed firms are significantly likely to reduce shadow banking business. That is, corporate digitization will effectively boost corporate physical investment, thereby restraining the corporate shadow banking activities. Moreover, mechanism tests indicate that corporate digitization can drive enterprises to reduce shadow banking activities by bolstering the core competitiveness of products, broadening market channels and boosting operational efficiency. Cross-sectional tests show that the negative impact of corporate digitization on shadow banking is especially noticeable for non-state-owned companies and in areas where local governments have more stringent financial risk regulations. Our results are robust to alternative measures of corporate digitization, and still valid after using Difference-in-Differences (DID) approach and alternative measurement to mitigate endogenous problems.

This study makes several contributions to the existing literature. Firstly, this study expands the growing literature on economic consequences of corporate digitization. The proliferation of digital technology has thoroughly reshaped traditional business models, injecting fresh dynamism into economic development [17]. Previous studies examining the corporate digitization of micro-level enterprises have primarily focused on the effects of innovative outputs, corporate governance, customer connectivity, and firm performance [6,8,18,19]. This work greatly advances the merger of the digital and real economies by elucidating how digital technology empowers real firms [20]. The results of this paper indicate that corporate digitization, by enhancing core product competitiveness, market channels, and operational efficiency, leads to improved and sustained development trends within enterprises. Drawing on survey data from China, this study identifies a substantial negative association between corporate digitization and the growth of corporate shadow banking, providing new empirical evidence on the economic impacts of corporate digitization.

Second, our paper expands and complements the literature on the determinants of non-financial enterprises' shadow banking business. Chinese non-financial companies have demonstrated a propensity to aggressively engage in shadow banking operations in recent years. Typically, enterprises allocate their limited resources between shadow banking activities and physical business investments, ultimately favoring shadow banking in their corporate investment decisions due to profitability pressures. Previous literature mainly focuses on the impact of legal and regulatory, political intervention, financial development, and corporate governance on shadow banking [1,3,6,12]. While corporate digitization has progressively transformed their investment activities, the influence of corporate digitization on the shadow banking practices of non-financial enterprises remains largely unexplored. Given the deepening integration of digital technology with the real economy, this study explores the impact of corporate digitization on the development of shadow banking, along with underlying mechanisms involved.

This paper also provides several practical insights for policymakers. Our findings offer significant insights into the nexus between corporate digitization and sustainable development at the micro level of enterprises. The digital-driven development strategy in China is extremely compatible with corporate digitization. Notably, non-financial enterprises are encouraged to proactively engage in digital transformation initiatives to secure government resources and capitalize on preferential policies, thereby mitigating the risks associated with corporate shadow banking. Furthermore, government digitization serves as a major instrument for preventing and resolving financial risks while promoting the high-quality development of the real economy. Specifically, recommendations for the government include embracing the digitization wave through promoting digital strategies, establishing digital governments, and reinforcing digital infrastructure.

The remaining portion of this paper is as follows. Section 2 describes the institutional background and hypothesis development, Section 3 introduces the data and methodology, and Section 4 provides the empirical results, including robustness tests and cross-sectional tests. Finally, Section 5 summarizes the main conclusions.

2. Institutional background and hypothesis development

2.1. Shadow banking activities in China

Shadow banking activities is one of typical components of corporate financial investments. In China, shadow banking is a major activity for financial and quasi-financial entities (financial assurance businesses, asset management firms, banks, securities, trusts, etc). Notably, a considerable number of non-financial enterprises, as a representative group, have direct or indirect involvement in shadow

banking activities through private lending, entrusted financial management and entrusted loans [3]. Specifically, the proliferation of shadow banking is to some extent positive for corporate development of business performance. On supply side, shadow banking as a fresh profitability tool increases the flexibility of corporate capitalization, and thus adds additional earnings for firms. On the demand side, institutions like conventional banks participate in shadow banking by giving businesses credit money through off-balance-sheet accounts, thereby meeting their operating and development capital needs in the process [1,21]. The lure of substantial benefits has enticed a significant number of non-financial enterprises to actively partake in shadow banking activities, consequently contributing to substantial increase in overall magnitude of the shadow banking sector [22].

Given the limitations of the Basel Accords, shadow banking, operating with less stringent regulatory oversight than traditional banks, has significant room for growth, particularly within China's imperfect and distorted financial markets [23,24]. For the past few years, China's shadow banking sector has experienced a noteworthy surge in business activities, attributable to various factors. For one thing, companies who lack confidence in their primary operation are more inclined to engage in shadow banking activities when confronted with the dual challenges of economic downturn and overcapacity. For another thing, following the Chinese government's unprecedented multitrillion-dollar stimulus package in response to the 2008 financial crisis, the supply of money dramatically increased in the market, thus creating favorable conditions for capital operations [25]. Against this backdrop, shadow banking experienced a vigorous expansion [2,26,27]. From 2008 to 2022, Fig. 1 illustrates an average yearly growth rate that surpasses 20 %. By 2022, the scale of shadow banking in China had reached $6.91 trillion, with shadow banking assets constituting 41.6 % of nominal GDP during the same period.

Although shadow banking is considered part of corporate financial profitability, unchecked expansion of shadow banking can significantly diminish corporate investment in physical assets, thereby impeding the overall development of corporate entities [24]. Moreover, the high leverage, elevated risk levels, and ambiguous legal structures inherent in shadow banking contribute to increased financial system instability, potentially triggering systemic risks [28]. Hence, the Chinese government has implemented a number of laws designed to guide and regulate non-financial enterprises in response to this challenges. The objective is to encourage these enterprises to robustly pursue physical investments, thereby reducing their reliance on financial activities, including shadow banking. For instance, in an effort to reduce and eliminate financial risks, the government limited the ability of non-financial businesses to engage in financial operations by introducing *Guiding Opinions on Regulating the Asset Management Business of Financial Institutions* in 2018. Furthermore, the Chinese Annual Government Work Report underscored the imperative to prevent firms from engaging in excessive financial investment, emphasizing the need to bolster the financial support capacity for the physical economy. While these regulatory interventions have succeeded in partially curbing swift growth of shadow banking, the total magnitude remains considerable, which poses serious detrimental effects on the economy that cannot be neglected.

2.2. Hypothesis development

Corporate digitization refers to the deep integration of complex digital technology systems, such as information technology, computing technology and communications technology, with all corporate elements. Such transformation can dramatically stimulate and enhance corporate mining and integrated utilization of data, which shapes the dynamic capability of corporate information processing [29,30]. Dynamic capability theory also suggests that construction and reconfiguration of information technology will promote dynamic capability development of enterprises, which will assist companies adapting to external environments and seizing market development opportunities and thus shaping competitive advantages [31]. That is, widely application of digital technology will help enterprises build stronger dynamic capabilities, which in turn helps break through the boundary of decision-making information

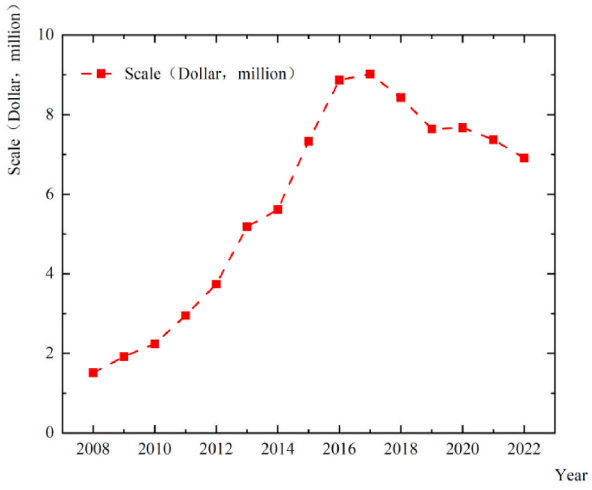

Fig. 1. Scale of shadow banking business.
Source: Quarterly China Shadow Banking Monitor (2023).

utilization [32], and facilitates enterprises to realize effective information integration, thus gaining sustainable competitive advantages. Related studies reveal that corporate dynamic capabilities enhance green innovation capacity through resource building and reorganization, resulting in increased green product innovation and improved market competitiveness [33]. Verhoef et al. [34] also point out that companies will more accurately grasp own actual situation and external market changes through digitization, which continuously facilitates the improvement of production process, management process and operation mechanism, thus achieving higher operating efficiency. For financial investment decisions, dynamic capabilities brought by corporate digitization developments have significant impacts on curbing shadow banking activities, mainly in the following ways.

Corporate digitization strengthens product core competencies to enhance corporate profitability, which in turn reduces the motivation for enterprises to engage in shadow banking. With the proliferation of digital analytics, consumers actively and conveniently communicate with companies and each other across numerous digital media channels, which help enterprises incorporate user ideas into innovation process of digital products [34]. Specifically, digital technologies enable better understanding of customer requirements resulting in tailored products and new products to meet specific customer needs in pre-sales [35]. Furthermore, due to innovations of digital technology, after-sales service as additional attribute of the product becomes major factor in enhancing its competitiveness [36]. Under the framework of Internet development and cloud ecosystems, enterprises will promptly gather feedback from customers to fulfill their demands. Taken together, the product competitive advantage stemming from corporate digitization can effectively alleviate the profit pressure faced by physical enterprises. As a result, the inclination of firms to seek highly profitable financial assets is mitigated, which leads to a decrease in shadow banking activities.

Moreover, corporate digitization broadens market channels, which improve market share, reducing reliance on shadow banking arbitrage. Faced with the dilemma of constantly squeezing business space in marketplace, companies conduct shadow banking to compensate for lost profits [37]. On one hand, as digitization has characteristics of shortening spatial distances, companies expand online sales channels to facilitate dramatic expansion of business scale [38]. When combined with the transparency and visibility of online sales, enterprises can create economies of scale, which in turn propels the growth of offline physical entities [20]. On the other hand, enterprises, as relatively closed organizations, the scope of business is limited by the boundary of firms and to some extent hinders cross-regional development [39]. Based on digital connectivity, enterprises can obtain efficient information and dynamic changes in remote markets by sharing data promptly [40]. As a result, the remarkable information integration capability, advanced by digital technology, empowers enterprises to enhance their coordination and integration capacities, thus fostering cross-regional cooperation. Apparently, corporate digitization reduces reliance on shadow banking for short-term profits by widening market share.

In addition, corporate digitization improves operational efficiency, which increases the potential for businesses to generate revenue, thereby reducing the possibility for profitability through shadow banking. In order to facilitate holistic benefits, corporate digitization improves operational efficiency in terms of optimizing resource utilization and minimizing management costs [40]. First, the precise detection and flexible deployment of resources by digital analytics improves operational efficiency [41]. With high-granularity data from big data, companies can promptly observe resource usage and trends. Coupled with the assistance of intelligent tools, enterprises enhance utilization efficiency by optimizing resource allocation [18]. Second, the evolution of digital technology reduces management costs by unblocking information transfer obstacles and enhancing timeliness. Unlike traditional approach, intelligent management systems for enterprises play a crucial role in facilitating specialized division of labor and cross-sectoral synergies. A digital platform characterized by hierarchical modularization, self-growth and network effects can reduce information asymmetry and management costs [42]. Clearly, the implementation of digital technology drastically boosts efficiency of corporate operations to unleash greater potential in real business development.

This paper posits that the trajectory of corporate digitization is conducive to amplifying physical investments, concurrently mitigating arbitrage activities linked to shadow banking, and thereby attenuating the shadow banking trend among non-financial enterprises. Drawing on existing literature that underscores the adverse impact of shadow banking's "crowding-out effect" on real sector investment, which serves as a crucial factor causing the shadow banking of non-financial business [7]. This research demonstrates that corporate digitization serves as a catalyst for bolstering the physical potential of enterprises, which is achieved through the enhancement of core competencies, the expansion of market share, and the optimization of operational efficiency. As a result, corporate digitization emerges as a mechanism that counters the excessive non-financial enterprises' shadow banking. In light of this study, we put up the following hypothesis:

H1. Corporate digitization is negatively associated with shadow banking business.

3. Data and methodology

3.1. Sample selection and data source

A-share companies listed from 2012 to 2022 on the Shenzhen and Shanghai Stock Exchanges in China comprise the majority of the original sample for this study. We excluded companies in the financial sector and data lacking certain variables, resulting in a final dataset comprising 26085 observations representing 3052 companies. Data on corporate digitization are sourced from the "Management Discussion and Analysis" (MD&A) section of company annual report, while data on corporate shadow banking business came from the China Stock Market & Accounting Research (CSMAR) database and company announcements. In order to reduce the possibility of extreme values interfering, the 1st and 99th percentiles of all continuous variables are winsorized.

3.2. Measurement of corporate digitization

Prior research suggests that the textual content of the company annual reports' management discussion and analysis (MD&A) section contains substantial firm-specific business information. Hence, exploiting and leveraging the textual information to define research variables is a sound choice [43,44]. Drawing on existing literature, we utilize Python software to capture digitization-related terms' frequency within the MD&A section, aiming to measure the corporate digitization levels [45]. Specifically, we initially constructed a Chinese lexicon of digitization terms. Through Python software, we segment the official government policy documents and authoritative reports related to digitization, to screen out the digitization-related terms[2] with a high frequency. Then these terms are supplemented with existing literature on corporate digitization, resulting in a lexicon of 157 digital terms. Subsequently, we conduct textual analysis of the MD&A sections in company's annual report to tally digitization-related terms' frequency. A higher frequency of digitization-related terms indicates deeper involvement in corporate digitization. Based on this, we defined two variables to gauge the intensity of corporate digitization: (1) $Digital_1$ is the natural logarithm of digital terms frequency within the MD&A section; (2) $Digital_2$ is the frequency of digital terms divided by the total number of sentences in the MD&A section.

3.3. Measurement of corporate shadow banking business

Drawing on existing literature, this study measures the extent of corporate shadow banking business from two perspectives: (1) Credit intermediary activities, in which businesses directly function as lenders and credit creators, providing funds through entrusted loans, entrusted wealth management, and private lending; (2) Credit chain activities, where companies indirectly engage in shadow banking activities by investing in structured deposits, trust products, wealth management goods etc [6,46,47]. Consequently, to determine the extent of the shadow banking sector in corporations, the amounts of credit chain and credit intermediary operations are aggregated. In the research, our dependent variable, *Shadow*, is defined as the ratio of corporate shadow banking activities to total assets.

3.4. Empirical model

We construct the regression model below to investigate how corporate digitization affects shadow banking business:

$$Shadow_{i,t} = \alpha + \beta_1 Digital_{i,t} + \beta_2 Roe_{i,t} + \beta_3 Lev_{i,t} + \beta_4 Growth_{i,t} + \beta_5 Margin_{i,t} + \beta_6 Soe_{i,t} + \beta_7 Own_{i,t} + \beta_8 Dual_{i,t} + \beta_9 Board_{i,t} + \beta_{10} Indratio_{i,t} + Indratry_i + Year_t + \varepsilon_{i,t}$$

where t represents a year and i stands for a company. The dependent variable of Shadow is corporate shadow banking business. Digital indicates corporate digital development, measured as $Digital_1$ and $Digital_2$. Drawing on the existing literature [6,48], we select control variables to mitigate the interference that might arise in testing the baseline effect, which more explicitly yields the findings of this paper. *Size* is calculated using the corporate total assets' natural logarithm; *Roe* is the net income to net asset ratio; *Lev* denotes the ratio of all obligations to total assets; *Growth* represents the growth rate of business revenue; *Margin* is calculated as the difference between return on financial assets and return on entity activities; *Soe* assumes a value of 0 in the absence of state ownership and, and one otherwise; *Own* is calculated using the greatest shareholder's share ratio; *Dual* indicates CEO and Chairman duality; *Board* is calculated as the whole number of directors' natural logarithm; *Indratio* represents the proportion of independent directors to total directors. Furthermore, the regression model is additionally modified by adding year and industry dummies to account for time- and industry-specific impacts.

4. Empirical results

4.1. Descriptive statistics

Table 1 presents the descriptive statistics for the study's main variables. The mean values of the independent variables $Digital_1$ and $Digital_2$ are 1.2386 and 0.0567, respectively. The average of *Shadow* is 0.0817, meaning that companies allocate around 8.17 % of their total assets to shadow banking operations, suggesting a notable presence of shadow banking activities in commercial practices. The magnitude of other control variables is comparable to existing literature.

4.2. Pearson correlation analysis

Table 2 presents the results of the Pearson correlation analysis for the variables. The correlations between *Shadow* and $Digital_1$ ($Digital_2$) at the 1 % level, both are substantially negative, providing initial support for our prediction that corporate digitization plays a negative role in shadow banking business. In addition, there are few pairwise correlations between the other control variables, revealing that running regressions with them together will not pose serious multicollinearity issues.

[2] Digitalization-related terms include digitization, information, Internet, integrate, automation, e-commerce business, incorporation, data management, artificial intelligence (AI) etc.

Table 1
Descriptive statistics.

Variable	Mean	Median	SD	Min	Max	N
Shadow	0.0817	0.0149	0.1612	0.0003	0.8029	26085
$Digital_1$	1.2386	1.0986	1.1994	0.0000	5.6836	26085
$Digital_2$	0.0567	0.0194	0.0763	0.0000	2.3125	26085
Size	22.0041	21.8213	1.2777	19.7682	25.6766	26085
Roe	0.0689	0.0715	0.1023	−0.4038	0.3048	26085
Lev	0.4420	0.4410	0.2059	0.0626	0.8617	26085
Growth	0.4062	0.1322	1.0544	−0.5873	6.4961	26085
Margin	−0.0260	−0.0334	0.1310	−0.3602	0.4970	26085
Soe	0.4438	0.0000	0.4968	0	1	26085
Own	35.7065	33.8600	14.8217	10.4000	72.6300	26085
Dual	0.2353	0.0000	0.4242	0	1	26085
Board	2.1542	2.1972	0.2004	1.6094	2.7081	26085
Indratio	0.3713	0.3333	0.0515	0.3333	0.5556	26085

4.3. The impact of corporate digitization on shadow banking activities

Table 3 shows the regression findings of the corporate digitization influence on shadow banking activities. Columns (1)–(4) show that, the regression coefficients of $Digital_1$ and $Digital_2$ all exhibit statistical negativity at the 1 % level, demonstrating that corporate digitization exerts a restraint on corporate shadow banking activities, providing empirical support for Hypothesis 1 in the study. In economic significance, one standard deviation increase in $Digital_1$ ($Digital_2$) is accompanied by a 7.63 % (6.83 %) reduction in shadow banking business. In relation to control variables, the coefficients of *Lev* are significantly negative, while coefficients of *Roe* and *Margin* are significantly positive, aligning with existing literature [6].

4.4. Mechanism tests

This section explores how corporate digitization affects shadow banking activities. The first channel through which corporate digitization can curb shadow banking activities of companies is by boosting core competencies of products. Typically, in the context of higher industry competition levels, companies can enhance product core competencies through digital transformation to achieve advantages in the highly competitive product environment, thereby reducing the relatively risky shadow banking business. Hence, in order to explore how product core competitiveness affects the connection between corporate digitization and shadow banking, after comparing the average values of product competitive intensity, drawing on the thinking of relevant literature, two categories are formed from the sample firms, namely “strong product competition group” and “weak product competition group” [49,50]. We then apply regression analysis to the subsample data. Estimates for the subsample are shown in Panel A of Table 4. The coefficients of corporate digitization are all negative and significant at the level of 1 % in the subsample with intense product rivalry, while for the subsample with weak product competition, the corporate digitization coefficients are also negative, but they are not significant. The findings demonstrate the significance of digitization in curbing shadow banking becoming more noticeable when product competition fiercer. That is, corporate digitization is effectively shown to enhance the core competitiveness of products, thereby curbing shadow banking activities within enterprises.

The second channel for curbing shadow banking is the expansion of market channels. The application of digital technologies will efficiently expand market share for companies, thus increasing the revenue of entities. We conjecture that in the context of lower market share, companies can broaden market channels through corporate digitization, which increases corporate market share to enhance profits and reduces reliance on shadow banking arbitrage. Hence, in order to analyze how market share affects the connection between corporate digitization and shadow banking, after comparing the average values of market share size, the sample firms are split into two categories, namely “great market share group” and “small market share group”. Regression analysis is then used to examine the subsample data. In the subsample with small market share, the coefficients of corporate digitization are all negative and significant at the level of 1 %, while the corporate digitization coefficients for the subsample with small market share are also negative, but they are not significant. The results show the role of digitization in curbing shadow banking is more pronounced when sales channels are narrower. This also serve as evidence that corporate digitization, by broadening sales channels, augments the profit potential within the marketplace, thereby reducing reliance on short-term profits through shadow banking.

Lastly, we investigate if corporate digitization can impact shadow banking through the channel of operational efficiency. We consider that deep integration of digital technology with physical enterprises will improve operational efficiency, which empowers physical development of enterprises. In the context of lower operational efficiency, companies can improve operational efficiency through corporate digitization, which increases potential to increase revenue and ultimately reduces the possibility of profiting from shadow banking. Hence, in order to investigate how operational effectiveness affects the connection between corporate digitization and shadow banking, after comparing the average values of degree of operational efficiency, two categories are formed from the sample firms, namely “high operational efficiency group” and “low operational efficiency group”. Then we perform group regression tests on the model. In the subsample with low operational efficiency, all of the corporate digitization coefficients are negative, while the corporate digitization coefficients for the subsample with high operational efficiency have a negative value but lack statistical significance. The findings show the significance of digitization in curbing shadow banking gets more noticeable when operational

Table 2
Pearson correlation matrix.

	Shadow	$Data_1$	$Data_2$	Size	Roe	Lev	Growth	Margin	Soe	Own	Dual	Board	Indratio
Shadow	1												
Digital$_1$	−0.176***	1											
Digital$_2$	−0.109***	0.746***	1										
Size	−0.066***	0.121***	0.002*	1									
Roe	0.030***	0.012*	0.001	0.125***	1								
Lev	−0.205***	−0.123***	−0.112***	0.357***	−0.117***	1							
Growth	0.001	−0.005	0.027***	0.015**	0.052***	0.089***	1						
Margin	−0.013**	−0.059***	−0.042***	0.029***	−0.462***	0.293***	0.008	1					
Soe	−0.150***	−0.185***	−0.146***	0.307***	−0.037***	0.301***	−0.001	0.116***	1				
Own	−0.020***	−0.074***	−0.097***	0.222***	0.126***	0.065***	0.009	−0.111***	0.214***	1			
Dual	0.075***	0.118***	0.095***	−0.163***	0.008	−0.153***	−0.001	−0.069***	−0.294***	−0.060***	1		
Board	−0.084***	−0.110***	−0.093***	0.229***	0.047***	0.140***	−0.061***	−0.001	0.282***	0.026***	−0.183***	1	
Indratio	0.026***	0.089***	0.070***	0.038***	−0.021***	−0.015**	0.033***	0.005	−0.075***	0.043***	0.116***	−0.388***	1

Note: *, ** and *** indicate significance at the 10 %, 5 % and 1 % level, respectively.

Table 3
The impact of corporate digitization and shadow banking business.

	Shadow	Shadow	Shadow	Shadow
	(1)	(2)	(3)	(4)
Digital$_1$	−0.0268***	−0.0052***		
	(-18.65)	(-3.08)		
Digital$_2$			−0.2729***	−0.0731***
			(-14.02)	(-3.37)
Size		0.0001		0.0001
		(0.02)		(0.03)
Roe		0.0258**		0.0255**
		(2.22)		(2.19)
Lev		−0.1119***		−0.1128***
		(-8.36)		(-8.42)
Growth		−0.0002		−0.0002
		(-0.17)		(-0.20)
Margin		0.1046***		0.1034***
		(8.98)		(8.90)
Own		−0.0001		−0.0001
		(-0.64)		(-0.51)
Dual		0.0006		0.0007
		(0.15)		(0.16)
Board		0.0112		0.0109
		(0.92)		(0.89)
Indratio		0.0091		0.0079
		(0.25)		(0.21)
Constant	0.0754***	0.1376*	0.0979***	0.1432*
	(25.12)	(1.74)	(35.27)	(1.82)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	26085	26085	26085	26085
Adj_R^2	0.0405	0.1066	0.0180	0.1068

Note: *, ** and *** indicate significance at the 10 %, 5 % and 1 % level, respectively.

efficiency is lower. That is, corporate digitization drastically boosts operational efficiency in enterprises which unleashes greater potential in real business development, thus reducing the possibility of improving revenue generation through shadow banking.

4.5. Robustness checks

4.5.1. Alternative measures

Aimed at enhancing the robustness of the results obtained, we incorporate alternative measures of corporate digitization and shadow banking activities in our robustness checks. Although the digitization degree indicator constructed based on text analytics are valuable in reflecting the level of companies' digital operations, enterprise reveals of corporate digitization are suspected of being strategically hype or buzzworthy, which makes disclosed information inconsistent with the actual operation of enterprises. Hence, to enhance the robustness of our results, we specifically highlight the levels of corporate practice in order to re-carve the corporate digitization metrics and conduct robustness tests in this research. Our findings evaluates the level on digital development from the perspective of both digital investment amounts and digital patent applications to accurately reflect the true state of digitization within enterprises.

Referring to existing literature, we manually collect data on the amount of digital money and the number of digital patents [16]. Specifically, we hand extract detailed data on digital investments in both software (intangible assets) and hardware (fixed assets) from the annual financial statement notes. Then, we aggregate these amounts to obtain the total annual digital investment for each enterprise. *Money_Digital* is measured as the amount invested in digital assets as percentage of intangible and fixed assets. Moreover, based on the corporation's patent acquisition, we screen and filter the textual information of corporation's patent applications and count the digitization-related patents, in order to re-measure the level of corporate digitization practice. *Patent_Digital* is measured as the share of digitization-related patents in total number of patents filed by companies. Table 5' s regression outcomes demonstrate this in columns (1) and (2). In keeping with our earlier inferences, the coefficients of *Money_Digital* and *Patent_Digital* are also considerably negative around the 1 % and 5 % levels, respectively. Therefore, the negative effect of corporate digitization on shadow banking remains valid after robustness tests using alternative measures of explanatory variables.

In addition, we define a proxy variable for shadow banking business as well. The natural logarithm of the volume of corporate shadow banking activity is used to calculate *Shadow*$_2$. Regression results in Table 5 show this in columns (3) and (4). Both of *Digital*$_1$ and *Digital*$_2$'s regression coefficients in Columns (3)–(4) are significantly negative at the 1 % level, showing that after replacing shadow banking, corporate digitization exerts a suppressive effect on corporate shadow banking activities, providing empirical support for Hypothesis 1.

Table 4
Result for mechanism test.

Panel A: Product competition mechanism.				
	Strong	Weak	Strong	Weak
	(1)	(2)	(3)	(4)
Digital$_1$	−0.0056***	−0.0009		
	(-3.05)	(-0.20)		
Digital$_2$			−0.0811***	−0.0090
			(-3.37)	(-0.15)
Controls	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	13276	12809	13276	12809
Adj_R^2	0.1036	0.1348	0.1040	0.1348
Panel B: Market share mechanism.				
	Great	Small	Great	Small
	(1)	(2)	(3)	(4)
Digital$_1$	−0.0025 (−0.92)	−0.0093*** (−4.36)		
Digital$_2$			−0.0516 (−1.50)	−0.1036*** (−3.34)
Controls	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	11458	14627	11458	14627
Adj_R^2	0.1147	0.1073	0.1149	0.1068
Panel C: Management efficiency mechanism.				
	High	Low	High	Low
	(1)	(2)	(3)	(4)
Digital$_1$	−0.0008	−0.0080***		
	(-0.32)	(-3.71)		
Digital$_2$			−0.0352	−0.0784***
			(-1.01)	(-2.75)
Controls	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	14087	11998	14087	11998
Adj_R^2	0.1071	0.1032	0.1072	0.1025

Note: *, ** and *** indicate significance at the 10 %, 5 % and 1 % level, respectively.

Table 5
Robustness tests with alternative measurement variables.

	Shadow	*Shadow*	*Shadow*$_2$	*Shadow*$_2$
	(1)	(2)	(3)	(4)
Money_Digital	−0.9459***			
	(-2.83)			
Patent_Digital		−0.5522**		
		(-2.54)		
Digital$_1$			−0.0701***	
			(-3.73)	
Digital$_2$				−0.7514***
				(-3.40)
Controls	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	26085	26085	26085	26085
Adj_R^2	0.1607	0.1297	0.3370	0.3368

Note: *, ** and *** indicate significance at the 10 %, 5 % and 1 % level, respectively.

4.5.2. Instrumental variable analysis

The company's digitization is probably affected by omitted variables and reverse causality problems. To further reduce endogeneity concerns, our research conduct a quasi-natural experiment by using regional digitization policy shocks. During August 2013, the Chinese government first put forward the "Broadband China" strategic layout. Subsequently, the National Development and Reform Commission (NDRC) as well as the Ministry of Industry and Information Technology (MIIT) initiated three batches of 120 cities (clusters) as "Broadband China" demonstration cities, successively in 2014, 2015 and then 2016. On one hand, local governments in

the pilot zones will vigorously improve construction of digital infrastructure, which provides a solid foundation for enterprises towards digitization. On the other hand, the expansionary nature of the pilot policy offers a favorable quasi-natural experimental research strategy. Drawing on existing studies [16,51], we conduct the following multi-period DID model to alleviate endogeneity concerns.

$$Shadow_{i,t} = \alpha + \beta_1 Citydt_{i,t} + \beta_2 \sum Control_{i,t} + Year_i + Firm_t + \varepsilon_{i,t}$$

Citydt indicates the exogenous impact of "Broadband China". An enterprise is included in the regional sample as a 1 for the year of selection and subsequent years if the city where it is located is designated as a "Broadband China" pilot city during the sample period; otherwise it is regarded as 0. Table 6 displays outcomes of the DID regression. Column (1) without considering the control variables of Table 6, shows that the *Citydt*'s coefficient is −0.0197, which is exceptionally negative at a level of 5 %. The regression coefficient of *Citydt* in Column (2) with the control variables included is −0.0178, a statistically low level. This result demonstrates that, as a result of "Broadband China" external policy intervention, there exists a substantial causative connection among shadow banking and the rise of digital commerce, which validates corporate digitization effectively reduces corporate shadow banking.

4.5.3. Lagged one-period processing

This section intends to conduct robustness tests to rule out mutual causality. Endogeneity problems stem primarily from potentially reverse causality between corporate digitization and shadow banking: For one thing, the intensification of corporate digitization significantly affects shadow banking activities; For another, shadow banking development's degree will inevitably influence the process of corporate digitization. As corporate digitization and shadow banking may interact with each other in same year, and aimed at avoiding potential reverse causation, we lag the variable *Digital* in the regression analysis by a year. Relying upon the preceding study, our research further estimates these equations and reports theses findings in Table 7. As shown in columns (1) and (2), the estimated coefficients of corporate digitization are −0.0077 and −0.0543, both of which are significantly negative at the 1 % level. The outcomes demonstrate that the negative effects of corporate digitization upon shadow banking remains robust after lagging the independent variables by one period.

4.6. Cross-sectional tests

4.6.1. Influence of nature of property rights

The natural political relationship between governments and state-owned enterprises (SOEs) leads to greater vulnerability to government influence in business development. The study shows that based on undertaking market-based business objectives, SOEs inherently bear greater governmental societal responsibilities as compared to their emphasis on profit-oriented investments [52]. Private enterprises, characterized by profit pursuit, exhibit greater emphasis on profit-oriented investments, including financial activities such as shadow banking. The benefits of corporate digitization, including enhanced product competitiveness, broadened sales channels and improved operational efficiency, can enhance core competitive advantages to empower entities. This facilitates higher physical profitability for firms, which in turn reduces investment in shadow banking activities. Therefore, we can conjecture that the role of digitally empowered entities will be more prominent in private firms, which are more sensitive to profitability. On the contrary, corporate digitization is relatively ineffective in SOEs.

We introduce the interaction term between nature of property rights (*Soe*, 1 for private firms) and corporate digitization, so as to test whether the impact of corporate digitization on shadow banking activities will differ according to the nature of corporate property rights. Table 8 reports results of grouped regressions in which the nature of firm's ownership as dependent variable. In column (1), the coefficients of $Digital_1 \times Soe$ is positive and significant at the level of 5 %, while the $Digital_2 \times Soe$ coefficients for column (2) is also positive, but they are significant at the level of 10 %. The results show that the inhibiting effect of corporate digitization on shadow banking business is more pronounced in private firms compared to state-owned enterprises. The results suggest that private firms are more negatively affected by corporate digitization on shadow banking than state-owned firms. That is, the role of corporate digitization empowering entities plays a more significant impact in market-oriented private firms.

4.6.2. Influence of local government regulation

Corporation business strategy along with behavioral decisions are significantly influenced by the institutional environment

Table 6
Robustness tests with differences-in-differences (DID) approach.

	Shadow	*Shadow*
	(1)	(2)
Citydt	−0.0157**	−0.0158**
	(-2.49)	(-2.56)
Controls	Yes	Yes
Industry	Yes	Yes
Year	Yes	Yes
N	26085	26085
Adj_R²	0.0956	0.1075

Note: *, ** and *** indicate significance at the 10 %, 5 % and 1 % level, respectively.

Table 7
Robustness tests with lagged one-period processing.

	Shadow	*Shadow*
	(1)	(2)
$LDigital_1$	−0.0077***	
	(-4.23)	
$LDigital_2$		−0.0543***
		(-2.79)
Controls	Yes	Yes
Industry	Yes	Yes
Year	Yes	Yes
N	22715	22715
Adj_R^2	0.1042	0.1034

Note: *, ** and *** indicate significance at the 10 %, 5 % and 1 % level, respectively.

Table 8
The moderating role of state ownership.

	Shadow	*Shadow*
	(1)	(2)
$Digital_1$	−0.0085***	
	(-3.71)	
$Digital_2$		−0.0863***
		(-3.26)
$Digital_1 \times Soe$	0.0069**	
	(2.18)	
$Digital_2 \times Soe$		0.0257*
		(1.76)
Soe	0.0002	0.0053
	(0.02)	(0.55)
Controls	Yes	Yes
Industry	Yes	Yes
Year	Yes	Yes
N	26085	26085
Adj_R^2	0.1080	0.1078

Note: *, ** and *** indicate significance at the 10 %, 5 % and 1 % level, respectively.

elements [53]. As an important micro-component of economic development, the investment decisions of enterprises will obviously be influenced by political interventions of local governments. Especially under the background of vigorously developing physical entities, the constraints and regulations on financial investment by local governments to some extent apparently reduced the financial investment activities of enterprises, including shadow banking activities. Thus, we can conjecture that the effect of corporate digitization, which empowers entities, in curtailing shadow banking activities within enterprises becomes more prominent when local governments exercise lenient supervision. In other words, the leniency of local government regulation introduces a substitution effect,

Table 9
The moderating role of local government regulations.

	Shadow	*Shadow*
	(1)	(2)
$Digital_1$	−0.0019**	
	(-1.97)	
$Digital_2$		−0.0729**
		(-2.01)
$Digital_1 \times Regu$	0.0021*	
	(1.83)	
$Digital_2 \times Regu$		0.0017*
		(1.69)
Regu	−0.0121***	−0.0095***
	(-4.22)	(-3.69)
Controls	Yes	Yes
Industry	Yes	Yes
Year	Yes	Yes
N	26085	26085
Adj_R^2	0.1085	0.1087

Note: *, ** and *** indicate significance at the 10 %, 5 % and 1 % level, respectively.

enhancing the constraining impact of corporate digitization on shadow banking activities.

Our research introduce a interaction term between corporate digitization and local government regulation (*Regu*), so as to test whether the influence of corporate digitization on shadow banking activities will differ according to the strength of local government regulation. Table 9 displays the results of subgroup regressions with strength of local government regulation where firms are located as dependent variable. The interaction term (*Digital* × *Regu*) has significantly negative coefficients at the 10 % level (0.0021 with t = 1.83, 0.0017 with t = 1.69). This suggests that corporate digitization has a greater inhibitory effect on shadow banking when local government regulations are laxer. That is, corporate digitization and local government regulation play a substitutive role in curbing shadow banking activities.

4.7. Further analysis

Considering relatively unsoundness of current regulatory system and comparatively strong information asymmetry between credit sides, shadow banking business frequently accompanied by high risk characteristics. If companies excessively participate in shadow banking business, the corporate exposure to operational risks will be exacerbated, which is not conducive to their healthy growth. The previous study found that corporate digitization can curb shadow banking activities, then, this section will further explore whether corporate digitization can mitigate the negative economic consequences caused by shadow banking business. Referring to existing studies [54,55], this paper utilizes the level of firm risk (*Risk*) using corporate earnings volatility, as measured by the standard deviation of the firm's return on net assets over a three-year period (t, t+1, t+2). The larger the value of R, the higher the risk level of the firm.

On this basis, we further conduct empirical tests to examine whether corporate digitization can mitigate corporate risk. Table 10 presents the regression results. The coefficients of corporate digitization ($Digital_1$ and $Digital_2$) are −0.0023 and −0.0257 respectively and are significantly positive at the 1 % level. The results show that corporate digitization significantly dampens corporate risk, providing empirical support for corporate digitization to mitigate the negative consequences of shadow banking business.

5. Conclusions

For the past few years, the over-sprouting of shadow banking operations has become a major trigger for economic "shifting from real to virtual" phenomenon. Using the data of non-financial listed companies in the Shenzhen and Shanghai stock markets from 2012 to 2022, our study investigates whether and how corporate digitization affects shadow banking business. The empirical findings show that corporate digitization can effectively curb shadow banking activities of non-financial enterprises, thus motivating companies to pay more attention to physical business. Moreover, mechanism tests show that corporate digitization will assist enterprises to exploit their business potential by improving core competitiveness of products, expanding market channels, and enhancing operational efficiency. Furthermore, cross-sectional tests show that the negative impact of corporate digitization on shadow banking is especially noticeable for non-state-owned companies and in areas where local governments have more stringent financial risk regulations. Our results are robust to alternative measures of corporate digitization, and still valid after using the alternative measurement and DID to address potential endogeneity.

Our study also provides several important implications. Firstly, the mismatch of credit resources has resulted in many enterprises for a long time, especially SMEs, impeding their ability to secure adequate loans. When undergoing downturns in real economy and pressures on business performance, enterprises tend to gravitate towards financial investments characterized by high returns and short cycles, particularly including shadow banking business, which is often a prominent corporate choice. However, shadow banking business exhibits characteristics such as high leverage, elevated risk profiles, and ambiguous legal structures, which will further raise systemic financial risks. Therefore, this study underscores the capacity of corporate digitization to effectively mitigate corporate shadow banking, offering viable solutions for governments grappling with the non-financial corporate shadow banking activities. Second, positioned as a strategic priority, digitization emerges as a pivotal catalyst propelling high-quality economic development. Presently, global corporate digitization rates remain relatively modest, with approximately 75 % of enterprises still in nascent or growth stages [56]. To realize the visions in fiercely competitive landscape, enterprises are urged to comprehend the positive impact of digital technology in empowering the development of real enterprises. In particular, governments should actively accelerate the process of digitization to create favorable external environment for corporate digitization of enterprises to establish a supportive external environment for digital transformation of firms by promoting digital strategies, constructing digital governments and strengthening digital infrastructure.

This paper has certain limitations in terms of exploring corporate digitization. We portrays the overall level of corporate digitization development and on this basis empirically tests the association between corporate digitization and shadow banking activities. However, with regard to the level of digital development in specific business segments within the enterprise (production, R&D, sales, etc.), this paper doesn't achieve detailed portrayal and accurate measurement of them. Therefore, it is necessary to further classify and measure the digitization practices of enterprises in more specific details. On this basis, we can analyze and compare the effects of corporate digitization on shadow banking activities in different aspects of enterprises, which will deepen and improve the study. Moreover, in corporate management practice, corporate digitization may affect other management decisions in addition to financial investment decisions. For example, digital development may also have implications for corporate decisions on financial management, employee motivation and market competition. Further research perspectives can be expanded to financial management, employee incentives and other business behaviors in the future to enrich the research related to the topic of corporate digitization.

Table 10
The economic consequences of corporate digitization.

	Risk	*Risk*
	(1)	(2)
$Digital_1$	−0.0023***	
	(-2.73)	
$Digital_2$		−0.0257***
		(-2.86)
Controls	Yes	Yes
Industry	Yes	Yes
Year	Yes	Yes
N	22716	22716
Adj_R^2	0.1451	0.1379

Note: *, ** and *** indicate significance at the 10 %, 5 % and 1 % level, respectively.

Data availability statement

Data of this paper are available on request.

CRediT authorship contribution statement

Youliang Yan: Writing – review & editing, Writing – original draft, Resources, Investigation, Conceptualization. **Xinhao Qiu:** Investigation, Data curation. **Xuefang Wang:** Methodology, Funding acquisition, Conceptualization.

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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