Digital Inclusive Finance and the Shadow Banking of Non-Financial Enterprises

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Abstract. In consideration of the macro background of guarding against diverting out of the real economy and the rapid development of digital inclusive finance, this study selects the A-share listed companies on the Shanghai and Shenzhen stock exchanges from 2011 to 2019 as samples to empirically investigate the impact of digital finance on the shadow banking of non-financial enterprises. The research finds that digital finance suppresses the expansion of shadow banking business scale in non-financial enterprises. Further examination reveals that the impact of digital finance development on the shadow banking of non-financial enterprises is mainly achieved through alleviating financing constraints and reducing financing costs. Heterogeneity tests indicate that the inhibitory effect of digital finance on non-financial enterprise shadow banking is more pronounced in companies with smaller scales, poorer information disclosure quality, and higher management expense ratios. Additionally, this inhibitory effect is primarily generated by the depth of digital finance development. This study provides empirical evidence and decision-making references to clarify the inhibition of shadow banking by digital finance and guide the development of digital finance.

Keywords: Digital finance; shadow banking; financing constraints; financing costs.

1. Introduction

In recent years, China's economic development has been constrained by both slow economic structural transformation and lagging financial system reforms. In terms of economic structure, long-standing structural imbalances have prompted the government to implement "supply-side structural reforms" policies. In terms of external demand, influenced by the 2008 financial crisis, although China achieved short-term economic recovery through the "four trillion yuan economic stimulus program," major global economies have continued to stagnate, with sustained declines in external demand, especially in export-oriented economies dominated by low-end manufacturing industries gradually shrinking. Regarding internal demand, China's macroeconomic situation has entered a new normal, with optimized industrial structure, upgraded consumption structure, and difficulty in meeting demand with effective supply in the market. Overcapacity issues have become prominent, particularly in traditional industries such as coal and steel, facing both shrinking demand and upgrading difficulties [1]. However, in stark contrast to the insufficient demand in the real sector and sluggish growth in productive investment, the financial industry has flourished, and due to weak regulation and high financial asset returns, it has gradually attracted a large number of non-financial enterprises to enter the financial field [2, 3].

Conventional financial institutions such as commercial banks tend to provide financing to state-owned enterprises and large listed companies due to the existence of credit discrimination, leading to difficulties for small and medium-sized enterprises (SMEs) in accessing capital markets. Although the People's Bank of China announced interest rate liberalization reforms in October 2015, non-market-oriented interest rate differentials still persist. The interest rates on loans and deposits of conventional financial institutions such as commercial banks are much lower than those of informal lending, resulting in SMEs facing credit discrimination due to their inadequate conditions and difficulty obtaining support from the formal financial system. Against this background, state-owned enterprises and listed companies with financing advantages, acting as credit intermediaries, lend to cash-strapped entities with insufficient liquidity in pursuit of profit maximization. They engage in shadow banking activities through bridge financing and other means to meet the financing needs of some SMEs [4].

It is worth noting that although this approach can to some extent alleviate the funding shortage of small and medium-sized enterprises (SMEs) and increase the stability of enterprise profits, these dominant entities are not professional financial operators and thus face challenges in effectively managing a range of issues involved in credit operations, including credit risk, liquidity risk, operational risk, and market risk. Furthermore, these entities often allocate more funds to financial assets rather than operational assets. The "shadow banking" of non-financial listed companies, to a large extent, occupies valuable financial resources, leading to an extension of the funding supply chain in the real economy, which may not be conducive to reducing the credit costs of real enterprises.

In recent years, rapid technological advancements have seen the emergence of numerous digital technologies such as big data, cloud computing, the Internet of Things (IoT), blockchain, and artificial intelligence (AI), injecting new vitality into China's socio-economic sustainable development and bringing forth new possibilities. These digital technologies continue to penetrate the traditional financial sector and closely integrate with finance, giving rise to digital finance. Digital finance aims to meet the financial needs of fund seekers while providing sustainable financial services [5]. As a novel financial format, digital finance integrates digital information technology with traditional finance, driving transformative changes in the financial industry over the past few years and profoundly influencing the development of traditional finance.

In March 2015, Premier Li Keqiang proposed vigorously developing inclusive finance during the Third Session of the Twelfth National People's Congress, aiming to ensure that all segments of society have equal access to various financial services, thereby enabling valuable financial resources to serve the real economy more extensively. Furthermore, the government explicitly stated in the "Fourteenth Five-Year Plan" outline the need to accelerate digital development and build a digital China, as digital technology continues to rise and find widespread application across various sectors. The "G20 High-Level Principles for Digital Financial Inclusion," released in 2016, officially proposed the integration of "digital information technology" with the concept of "inclusive finance," utilizing digital technology to address the "last mile" issue of inclusive finance policies. In the financial market, digital technology has gradually encroached upon the market share of traditional commercial banks. Diversified financing channels have greatly supplemented the financing needs of non-financial enterprises, while also compelling commercial banks to actively participate in market competition and improve financial services. As a result, non-financial enterprises have seen increased credit support from commercial banks [6]. The development of digital technology has brought about technological and data spillovers in the financial market, effectively addressing the information asymmetry problem in the traditional financial system and reducing enterprise financing costs, which is conducive to long-term business operations. Consequently, this weakens the role of dominant entities, especially non-listed financial companies, in acting as "shadow banks" and providing financing services to SMEs along their supply chains. This may prompt non-listed financial companies to be more inclined to allocate funds to operational assets. Therefore, within this context, can we infer that the development of digital finance can suppress the shadow banking of listed companies? Answering this question would contribute to preventing and resolving financial risks, effectively controlling the shadow banking of listed companies, and is of significant importance for enhancing the development level of China's real economy and promoting the high-quality development of specialized, refined, unique, and novel enterprises.

Given these considerations, this paper employs digital transformation indicators obtained through annual report text analysis and utilizes data from Chinese A-share listed companies from 2011 to 2019 to empirically examine the impact of digital finance on enterprise shadow banking, providing valuable recommendations based on the research findings.

2. Theoretical Analysis and Research Hypotheses

The shadow banking of non-financial enterprises manifests as the pursuit of informal financial support and profit motives outside of formal finance under financial repression, credit rationing, and

credit discrimination [7]. Traditional financing methods in the financial system impose high requirements on enterprise financial management standards and credit levels. Enterprises with poor transparency and lack of credit collateral find it difficult to obtain credit support [8]. Therefore, non-financial enterprises with financing advantages often engage in activities such as lending from their own capital or credit funds, entrusted wealth management, etc. [9], thereby forming shadow banking. Digital finance serves as an external governance mechanism, enhancing the information gathering capabilities of financial institutions and improving enterprise transparency. It ensures the authenticity and accuracy of information transmission, alleviating information asymmetry between financial institutions and enterprises, and reducing information frictions [10]. Compared to traditional finance, digital finance features high digitization, high accessibility, and low costs. Therefore, the development of digital finance may have an inhibitory effect on the shadow banking of non-financial enterprises. Based on the above analysis, the following hypothesis is proposed:

H: Digital finance helps to inhibit the trend of shadow banking in non-financial enterprises, restraining their engagement in shadow banking activities.

Currently, digital innovation is leading to a significant enhancement in developmental capabilities, with a noticeable increase in the level of intelligence. The integration of digital technology with the real economy has achieved remarkable results. As a widely encompassing new financial service model, digital finance can connect funding demand and supply from geographically distant parties [11], expanding the coverage and reach of financial services [12], especially for those customers whom traditional financial institutions find it challenging to reach [13], including many small and medium-sized enterprises. With the support of information technology, digital finance can provide them with a completely new service model, breaking the constraints of time and space, alleviating financing constraints, reducing financing costs, and thereby enhancing the accessibility of financial services.

Firstly, digital finance can expand traditional collateral lists, increase the value of enterprise collateral, alleviate existing financing constraints, thereby enhancing financing availability, and reducing dependence on shadow banking funds. By providing more collateral assets required for credit operations by commercial banks and other financial institutions, such as transforming new types of equity assets, pure credit value, etc., into intangible assets such as data credit, digital finance can effectively assist numerous enterprises, especially small and medium-sized enterprises, in expanding traditional collateral lists, promoting credit model innovation, and suppressing enterprise shadow banking. Moreover, with the development of financial technology, the application of technologies such as the Internet of Things and blockchain in the financial field also provides excellent solutions for addressing the risk control challenges of chattel mortgage. Through comprehensive monitoring throughout the entire process, chattels are endowed with the attributes of immovables, significantly reducing the risk of chattel mortgages, and enabling comprehensive supervision of chattels without omissions. With the help of Internet of Things and blockchain data, commercial banks and others can fully understand the operation of enterprises in various links such as procurement, inventory, and sales, integrate information such as trade, goods, and funds, form a real operating view of enterprises, establish the link between credit and chattel, achieve real-time transfer of chattel ownership and risk monitoring, and significantly increase the value of some collateral assets. For example, for some small and medium-sized enterprise merchants with a large number of accounts receivable, such as commercial customers, in many cases, the payers of these accounts receivable are large state-owned enterprises and other institutions with good credit ratings, and the quality is high. These accounts receivable are also the main assets of their production and operation. However, due to the lack of necessary information registration, these accounts receivable are difficult to be effectively verified and become qualified collateral. The rise of digital technology, such as the official launch of the debt registration system, has made these accounts receivable have strong credibility, thereby becoming qualified collateral. Commercial banks and other financial institutions can use this to provide reasonable amounts of inclusive credit to holders of accounts

receivable assets in need, greatly improving the accessibility of financial services, and thus alleviating financing constraints.

Secondly, digital finance can utilize emerging digital technologies such as big data, cloud computing, and artificial intelligence to enhance the level of enterprise information disclosure, reduce information asymmetry, alleviate financial mismatch issues, lower financing costs, thereby improving financing availability, and playing a role in inhibiting the shadow banking of non-financial enterprises. Digital finance, as a fusion of digital means and financial services, is an important supplement and extension to traditional finance [14], enabling enterprises to benefit from the advantages of information technology, enhance their information disclosure level, and mitigate information asymmetry. Adverse selection and moral hazard caused by information asymmetry are important factors hindering enterprises from obtaining loans. Small and medium-sized enterprises have relatively poor information disclosure, but the construction of digital financial infrastructure facilitates enterprises in disclosing their financial conditions to the outside world, encouraging them to actively disclose their financial status [15]. Financial institutions can obtain information on the actual operating conditions and real-time fund utilization of enterprises, enabling them to comprehensively evaluate the repayment ability of debtors with sufficient "soft information" [16]. This can reduce the information collection and evaluation costs of financial institutions when providing credit to enterprises, alleviating their reluctance to lend.

Moreover, shadow banking activities are to some extent caused by the inefficiency of financial markets, namely financial mismatch. Research by Han X. and Li J. [17] indicates that the higher the level of financial mismatch, the more serious the problem of enterprise financing costs, which will reduce the main investment activities of enterprises and exacerbate the scale of enterprise shadow banking. However, the advancement of various digital technologies such as big data and cloud computing has made data storage, accumulation, and mining more convenient and cost-effective, largely addressing the inefficiency of the credit market and significantly improving the efficiency and effectiveness of commercial banks and other financial institutions in conducting investigation, examination, approval, and post-loan management of inclusive credit business. This has partly alleviated the problem of financial mismatch. Under the premise of fully complying with national laws and regulations on personal information protection, commercial banks and other financial institutions can, on one hand, fully utilize the accumulated customer data in daily operations or cooperate with third parties to conduct statistical analysis or data mining of basic information, transaction information, fund flows, etc., of users applying for inclusive credit business. This allows for quick and efficient identification of default characteristics, thereby making business decisions on whether to provide inclusive financial credit and the specific amount of credit. On the other hand, they can analyze the daily transaction flow of customers, monitor key risk indicators such as repayment status in real-time, provide sufficient decision-making support for post-loan management, and take timely asset preservation measures such as compressing investment credit limits and early settlement and exit in response to risk warning signals.

Therefore, based on the analysis of financing availability above, the following hypothesis is proposed:

H1: The development of digital finance can alleviate financing constraints, reduce financing costs, thereby enhancing financing availability, and help suppress the shadow banking of non-financial enterprises.

3. Research Design

3.1 Data Source and Sample Selection

This study selects data from Chinese A-share listed companies from 2011 to 2019 as the initial sample, and filters the data as follows: (1) Exclude samples of ST and *ST companies; (2) Exclude samples of financial and real estate companies; (3) Delete samples with missing variable observations; (4) Exclude samples with asset-liability ratios greater than 1 and samples of companies listed in the

first year. After the above screening, a total of 20,913 samples were obtained for this study. The data for this study are from three sources: shadow banking business data obtained manually, digital inclusive finance index data from the Digital Finance Research Center of Peking University, and corporate financial and governance data from the CSMAR and Wind databases.

3.2 Variable Definitions

3.2.1 Non-financial Enterprise Shadow Banking (Shb)

Drawing on the studies of Li Jianjun and Han Xun [18] and Si Dengkui et al. [6], this paper measures the degree of shadow banking of non-financial enterprises by the sum of entrusted loans, entrusted wealth management, and private lending, and takes the natural logarithm of the sum. Entrusted loan data are identified and compiled manually from announcements and footnotes of sample companies' financial statements; entrusted wealth management data are obtained by querying the Chinese outward investment sub-database in the CSMAR database; private lending uses the "other receivables" item in the balance sheet of listed companies in the CSMAR database as a proxy variable.

3.2.2 Digital Financial Index (Index)

Drawing on the studies of Nie Xiuhua et al. [19] and Guo Feng et al. [20], this paper selects the Digital Inclusive Finance Index compiled jointly by Peking University Digital Finance Research Center and Ant Group Research Institute from 2011 to 2020 as the explanatory variable to measure the level of digital finance development in various provinces nationwide. The index covers three primary indicators: coverage breadth (Cov), usage depth (Dep), and digitization level (Dig), which effectively reflect the characteristics and trends of financial innovation in China in recent years. The size of the digital finance index represents the level of local digital inclusive finance development, with a larger index indicating a higher level of digital finance development.

3.2.3 Control Variables

Drawing on previous research, this paper introduces the following series of control variables: enterprise size (*Size*, the natural logarithm of total assets), enterprise growth (*Sg*, current year's main business income divided by previous year's main business income minus 1), enterprise nature (*Soe*, state-owned enterprises coded as 1, non-state-owned enterprises coded as 0), leverage ratio (*Lev*, total liabilities divided by total assets), return on assets (*Roa*, net profit divided by total assets), age of listed company (*Agelist*, current year minus the year of company listing), cash flow level (*Cfo*, net cash flow from operating activities divided by total assets), and equity concentration (*Top10*, the sum of the shareholding ratios of the top ten shareholders divided by 100). Additionally, this paper also controls for year fixed effects (*Year*), industry fixed effects (*Industry*), and firm fixed effects (*Firm*) to account for the effects of annual trends, differences between industries, and individual characteristics of enterprises.

Table 1 Variable Definitions

Variable Symbol	Variable Name	Variable Definition
Shb	non-financial enterprise shadow banking	ln(entrusted loans + entrusted wealth management + private lending)
Index	digital financial index	the "Digital Inclusive Finance Index" compiled by Peking University Digital Finance Research Center
Size	enterprise size	the natural logarithm of total assets
Sg	enterprise growth	current year's main business income / previous year's main business income - 1
Soe	enterprise nature	state-owned enterprises=1, non-state-owned enterprises=0
Lev	leverage ratio	total liabilities / total assets

Roa	return on assets	net profit / total assets
Agelist	age of listed company	current year - the year of company listing
Cfo	cash flow level	net cash flow from operating activities / total assets
Top10	equity concentration	the sum of the shareholding ratios of the top ten shareholders / 100

3.3 Model Construction

To investigate the impact of digital transformation on corporate shadow banking, this paper constructs the following econometric model:

$$Shb_{i,t} = \alpha_0 + \alpha_1 Index_{i,t} + Controls_{i,t} + Year + Industry + Firm + \varepsilon_{i,t} \quad (1)$$

In Model, i represents individual enterprises and t represents years. Shbank is the dependent variable, indicating the extent of shadow banking of listed company i in year t. Index is the explanatory variable, representing the degree of digital finance development of listed company i in year t. Controls denote the main control variables selected in this study. Year and Industry represent year fixed effects and industry fixed effects, respectively. ε is the error term. This model aims to examine the relationship between digitalization and corporate shadow banking, controlling for various factors.

4. Empirical Analysis

4.1 Descriptive Statistical Analysis

Table 2 presents the descriptive statistics of the main variables in this study. It can be observed that the mean value of the scale of shadow banking activities in non-financial enterprises is 19.12, with a maximum value of 23.93 and a minimum value of 13.91, indicating widespread participation of non-financial enterprises in shadow banking activities and significant differences in the degree of shadow banking among different enterprises. The mean value of Index is 5.234, with a standard deviation of 0.412 and a range of 3.913 to 5.729, suggesting a moderately high level of dispersion. This indicates significant differences in the development of digital finance among different enterprises, with some enterprises already advancing towards or even leading in digital finance services, while others are still in the initial stages of development.

Table 2 Descriptive Statistics of Variables

variable	N	mean	sd	p50	min	max
Shb	20913	19.12	2.088	19.19	13.91	23.93
Index	20913	5.234	0.412	5.356	3.913	5.729
Lev	20913	0.425	0.209	0.415	0.0520	0.904
Size	20913	22.17	1.301	22.00	19.73	26.17
Agelist	20913	17.87	5.264	18	7	33
Sg	20913	0.195	0.464	0.114	-0.544	3.142
Roa	20913	0.0400	0.0540	0.0370	-0.199	0.195
Soe	20913	0.380	0.485	0	0	1
Top10	20913	0.587	0.151	0.597	0.233	0.904
Cfo	20913	0.0450	0.0690	0.0440	-0.161	0.240

4.2 Multivariate Regression

Table 3 presents the main regression results of this study. In column (1), the results of the regression with only the core explanatory variable Index, along with year, industry and firm fixed effects, show a coefficient of -1.076, which is significant at the 1% level and negative. In column (2), after adding the control variables of this study, the coefficient of the explanatory variable Index is -0.605, which is significant at the 5% level and negative, confirming hypothesis H. Using column (2)

as the baseline, it can be observed that for each increase of one standard deviation (0.412) in Index, the shadow banking phenomenon in the corresponding enterprises will decrease by 11.94% of a standard deviation (0.412 × 0.605 / 2.088 × 100%). Thus, both statistically and economically, digital finance helps to restrain the expansion of shadow banking activities in non-financial enterprises, exerting a certain inhibitory effect on the shadow banking phenomenon.

Teble 3 Multivariate Regression Result

	(1)	(2)
	Shb	*Shb*
Index	**-1.076*** **	**-0.605** **
	(-3.154)	**(-2.014)**
Lev		-0.723***
		(-4.727)
Size		1.154***
		(29.447)
Agelist		0.130***
		(3.007)
Sg		-0.020
		(-0.927)
Roa		-0.474*
		(-1.686)
Soe		-0.075
		(-0.599)
Top10		-0.700***
		(-3.825)
Cfo		-0.464***
		(-2.614)
-cons	22.208***	-5.811***
	(15.040)	(-3.532)
Firm	Yes	Yes
Year	Yes	Yes
Industry	Yes	Yes
N	20913	20913
r2_a	0.397	0.476

Note: Robust standard errors are given in parentheses, ***,**, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

4.3 Mechanism Examination

The above regression results indicate that digital finance can reduce shadow banking in non-financial enterprises. So, what are its underlying mechanisms and channels of action? Based on the theoretical deduction of hypothesis H1, this study believes that digital finance can influence the development of shadow banking activities through the following two potential channels: (1) Digital finance can effectively integrate financial resources in the market, break the spatial constraints of traditional financial services, expand the traditional collateral inventory, enhance the value of enterprise collateral, alleviate the financing constraints faced by enterprises, thereby reducing their dependence on informal financing channels due to severe financing constraints, and restraining the lending activities of informal financial institutions; (2) Digital finance can leverage emerging digital technologies such as big data, cloud computing, and artificial intelligence to enhance the quality and extent of enterprise information disclosure, reduce information asymmetry, alleviate financial mismatches, lower financing costs, and thereby enhance the accessibility of financing, exerting a restraining effect on shadow banking in non-financial enterprises. Following the logic above, two potential impact channels are examined.

First, we examine the impact of digital finance on financing constraints. Drawing on Kaplan and Zingales [21], we use a comprehensive set of financial indicators including operational net cash flow,

dividends, cash holdings, leverage ratio, and Tobin's Q to measure financing constraints (KZ index). Following Zheng Jun et al. [22], this study uses the ratio of financial expenses to total liabilities at the end of the period to measure financing costs (Cost). The remaining variables are consistent with the previous analysis, and the results of the examination are listed in Table 4. The regression results show that the coefficients of Index are significantly negatively correlated at the 1% level. This indicates that digital finance indeed helps alleviate financing constraints and reduce financing costs. Therefore, digital finance can play a restraining role on shadow banking through these two channels.

Table 4 Mechanism Examination Result

	(1)	(2)
	KZ index	*Cost*
Index	**-1.032*** **	**-0.023*** **
	(-3.710)	**(-3.134)**
Controls	Yes	Yes
Firm	Yes	Yes
Year	Yes	Yes
Industry	Yes	Yes
N	19,745	20,488
r2_a	0.597	0.192

4.4 Robustness Test

To ensure the robustness of the empirical research results and to ensure that the conclusions obtained are not affected by changes in variable measurement methods and sample selection, this paper conducts a series of robustness tests on the baseline regression results.

4.4.1 Replacement of Dependent Variable Measurement Methods

In the previous analysis, the natural logarithm of the sum of entrusted loans, entrusted wealth management, and private lending was used to measure shadow banking. To demonstrate its robustness, this paper follows the approach of previous studies and replaces the measurement method of enterprise shadow banking with the ratio of the sum of entrusted loans, entrusted wealth management, and private lending to total assets, as well as the ratio to operating income. The regression results are re-examined, and the results are shown in Table 5. The coefficients of the digital finance index are all negative, and the significance levels are consistent with the main regression, significant at the 1% and 5% levels, respectively, indicating the robustness of the fundamental conclusions obtained in this study.

Table 5 Regression Results of Dependent Variable Measurement Method Replacement

	(1)	(2)
	szyh	*szyh3*
Index	**-0.173*** **	**-0.373** **
	(-3.734)	**(-2.313)**
Controls	Yes	Yes
Firm	Yes	Yes
Year	Yes	Yes
Industry	Yes	Yes
N	20,913	20,913
r2_a	0.092	0.083

4.4.2 Modification of Research Sample Scope

4.4.2.1 Exclusion of the Impact of the 2015 Stock Market Crash

In 2015, China's stock market experienced a major crash, which directly affected enterprises' behavior of raising funds directly from the stock market. Shadow banking, based on stringent financial regulations and credit discrimination, serves as a supplement to formal financial services. Therefore, the stock market crash event in 2015 is likely to affect the shadow banking of non-financial enterprises and disrupt regression results. Referring to Tang et al. [23], the sample affected by the

2015 financial crisis factors was excluded for testing. The regression results after changing the sample are shown in Table 6 (1), and the coefficient of the Index remains significant at the 5% level. This indicates that digital finance can still inhibit the trend of shadow banking in non-financial enterprises, and the conclusion of the multiple regression study remains robust.

4.4.2.2 Retention of Only Manufacturing Industry Samples

Many studies have shown that investment in technological research and development (R&D) has a positive effect on enterprise efficiency and development. However, sustained R&D investment and technological innovation require substantial financial support. As the largest industry in China, the manufacturing industry has long faced difficulties in financing, hindering opportunities for enterprises to obtain funds through the financial market for sustained development. Therefore, retaining only data from manufacturing enterprises can more clearly test the positive effects of introducing digital finance on financing and its inhibitory effect on shadow banking. The regression results after changing the sample are shown in Table 6 (2), with the coefficient of the Index being negative and significant at the 1% level. This indicates that digital finance can significantly inhibit the shadow banking of non-financial enterprises, and thus the conclusion of the multiple regression study remains robust.

Table 6 Regression Results of Research Sample Modification

	(1)	(2)
	Shb	*Shb*
Index	**-0.593****	**-1.008*****
	(-1.979)	**(-2.797)**
Controls	Yes	Yes
Firm	Yes	Yes
Year	Yes	Yes
Industry	Yes	Yes
N	18,586	13,393
r2_a	0.497	0.459

4.4.3 Endogeneity Test

Although the level of development in digital finance is a macro variable less affected by external environmental uncertainty, there is still a possibility of endogeneity issues arising from omitted variables or measurement errors. Therefore, instrumental variable two-stage least squares (IV-2SLS) method is employed to examine the presence of endogeneity issues in the model. Specifically, following the research framework of Wu et al. [24], the natural logarithm of postal service volume at the location of the enterprise (YD) is used as the instrumental variable, and the test results are presented in Table 7. In column (1), the regression results of the first stage indicate that the coefficient of postal service volume (YD) is significantly positive at the 1% level, with a weak instrument test statistic of 4447.411, indicating the validity of instrumental variable selection. In column (2), the regression results of the second stage show that the coefficient of digital finance is significantly negative at the 1% level. It can be observed that even after alleviating endogeneity issues using the instrumental variable approach, the inhibitory effect of digital finance on shadow banking remains significant, indicating the robustness of the main results.

Table 7 Regression Results of Endogeneity Test

	(1)	(2)
	Index	*Shb*
Yd	**0.050*****	
	(14.28)	
Index		**-4.726*****
		(-3.51)
Controls	Yes	Yes
Firm	Yes	Yes
Year	Yes	Yes

Industry	Yes	Yes
N	20913	20913

4.5 Heterogeneity Analysis

4.5.1 Heterogeneity Analysis Based on Different Dimensions of Digital Finance

According to the Digital Inclusive Finance Index compiled by the Digital Finance Research Center of Peking University, the index comprises three secondary indicators: digital finance coverage breadth, usage depth, and digitalization level. Specifically, digital finance coverage breadth reflects the situation of electronic account openings in regions; digital finance usage depth mainly includes payment services, money market fund services, credit services, insurance services, investment services, and credit services; and digital finance digitalization level primarily encompasses mobility, affordability, creditworthiness, and convenience. Considering that different dimensions may have heterogeneous impacts on shadow banking, to elucidate the main channels through which digital finance development affects the shadow banking of non-financial enterprises, this study, following the research of Tang et al. [23] and others, examines the impact of two dimensions—digital finance coverage breadth (Cov) and usage depth (Dep)—on the shadow banking of non-financial enterprises.

The regression results are presented in Table 8. Column (1) shows that the regression coefficient of digital finance usage depth (Dep) is negative and significant at the 1% level, indicating that the higher the level of digital finance development and usage depth, the smoother the enterprise financing channels, and the lower the demand for shadow banking. In column (2), the regression coefficient of digital finance coverage breadth (Cov) is also negative but not significant, suggesting that a broad coverage of digital finance can only exert a certain degree of inhibitory effect on shadow banking, albeit weakly. This may be because the inhibition of digital finance on the shadow banking of non-financial enterprises cannot be achieved solely through popularization and increased coverage breadth; rather, it should involve deep usage under a certain coverage breadth. Merely opening electronic accounts without fully utilizing them in various business operations cannot leverage the advantages of digital finance. It should penetrate into business processes, making the various business processes and management procedures of enterprises increasingly transparent, enhancing information symmetry, enabling banks and other financial institutions to fully assess the creditworthiness of enterprises using digital technology, thereby enhancing the accessibility of enterprise financing. The hypothesis H1 proposed earlier is validated.

Table 8 Heterogeneity Analysis Results Based on Different Dimensions of Digital Finance

	(1)	(2)
	Shb	*Shb*
Cov		**-0.1620**
		(-1.122)
Dep	**-0.559*** **	
	(-3.260)	
Controls	Yes	Yes
Firm	Yes	Yes
Year	Yes	Yes
Industry	Yes	Yes
N	20,913	20,912
r2_a	0.476	0.475

4.5.2 Heterogeneity Analysis Based on Enterprise Size

For enterprises, internal characteristics are important factors affecting their access to credit resources, especially the scale of enterprises, which significantly influences the availability of financial resources for enterprises. On the one hand, banks tend to favor larger enterprises with greater credit and other financial service demands due to their commercial and security requirements. On the other hand, as mentioned earlier, large-scale enterprises often have better credit and collateral resources. Therefore, in traditional financial markets, small-scale enterprises constrained by financing

often become the main participants in the secondary market for fund allocation, engaging in shadow banking activities. However, with the development of digital finance, financial institutions such as banks can conduct risk modeling and assessment based on real-time enterprise behavioral data and actual operating conditions, enabling them to formulate more reasonable risk pricing. The decision-making philosophy of financial institutions has shifted from relying solely on "hard information" to optimizing information decision-making frameworks across multiple dimensions, including both "hard information" and "soft information". As a result, the weight of enterprise scale as a basis for loan decisions has decreased.

Therefore, this study divides the sample into large-scale enterprises and small and medium-sized enterprises (SMEs) based on the median enterprise scale for each year. Enterprises with a scale greater than the median are classified as large-scale enterprises, assigned a value of 1; otherwise, they are classified as SMEs, assigned a value of 0. The regression results in Table 4, columns (1) and (2), show that in the regression of SME samples, the coefficient of the digital finance index is -1.264, significant at the 1% level. This indicates that for every 100-point increase in the digital finance index, the shadow banking index of SMEs decreases by an average of 126.4%. In contrast, in the regression of large-scale enterprise samples, the development of digital finance does not have a significant impact on the shadow banking index, although the coefficient is still -0.087. This suggests that the development of digital finance does inhibit the shadow banking of non-financial enterprises, with a more pronounced effect on SMEs, thus validating hypothesis H proposed earlier.

Table 9 Heterogeneity Analysis Results Based on Enterprise Size

	(1)	(2)
	Shb	*Shb*
Index	**-0.0870**	**-1.264*****
	(-0.196)	**(-2.745)**
Controls	Yes	Yes
Firm	Yes	Yes
Year	Yes	Yes
Industry	Yes	Yes
N	10,457	10,456
r2_a	0.402	0.389

4.5.3 Heterogeneity Analysis Based on Information Disclosure Quality

The enhancement of corporate information transparency serves as another important channel through which digital finance suppresses the shadow banking of non-financial enterprises. Leveraging multidimensional information technology, the improvement in information disclosure quality reduces the opacity of corporate and market information. This not only enhances the credit allocation efficiency of financial sectors such as banks but also strengthens the supervisory governance role of external stakeholders over enterprises, thereby comprehensively restraining shadow banking. In this study, the KV index is used as a measure of information disclosure quality. This index is a negative indicator, where a higher index value indicates poorer information disclosure quality and higher information asymmetry.

Similarly, using the median of this index as a benchmark, enterprises with values below the median are considered to have high information disclosure quality, while those above the median are considered to have low information disclosure quality. The regression results in Table 6 show that the regression coefficients of digital finance in columns (1) and (2) are both negative, indicating that the development of digital finance has a suppressive effect on shadow banking for firms with information asymmetry. Further examining the impact of digital finance on enterprises with different levels of information transparency reveals that the coefficient of the Index in column (1) is -1.324 and significant at the 5% level. This indicates that digital finance has a greater impact on firms with lower information disclosure quality, potentially increasing corporate information transparency to a

greater extent and thus restraining corporate shadow banking. This validates the hypothesis H1 proposed earlier.

Table 10 Heterogeneity Analysis Results Based on Information Disclosure Quality

	(1)	(2)
	Shb	*Shb*
Index	**-1.324****	**-0.5370**
	(-2.530)	**(-1.510)**
Controls	Yes	Yes
Firm	Yes	Yes
Year	Yes	Yes
Industry	Yes	Yes
N	10,664	10,249
r2_a	0.423	0.488

4.5.4 Heterogeneity Analysis Based on Management Expense Ratio

The management expense ratio is also a crucial indicator for enterprises, as it relates to the level of financing costs. Digital finance empowers enterprises with stronger technological capabilities, thereby enhancing capacity utilization [25], optimizing production and operation processes, reducing internal and external transaction costs, and improving business process management. Through various digital technologies such as big data and cloud computing, digital finance can assist enterprises in integrating existing resources [26], storing operational management processes in structured data format, optimizing the coupling between data information collection, processing, analysis, and application, breaking down "data silos" between departments, making various business processes and management processes increasingly transparent, and facilitating smoother communication and collaboration between departments. All these factors contribute to enhancing internal transaction efficiency, reducing intermediary transaction costs, information costs, and management costs for enterprises, improving internal management efficiency, reducing management expenses incurred by enterprises, and thereby lowering the management expense ratio.

Therefore, in this study, enterprises with costs and serious agency problems are identified as those with values above the median for this indicator. The regression results in Table 7 show that in column (1), the regression coefficient is negative and significant at the 1% level. This indicates that the development of digital finance has a suppressive effect on shadow banking for enterprises with initially high management expense ratios, potentially enhancing enterprise efficiency, reducing agency costs, and thereby improving the accessibility of financing. This validates the hypothesis H1 proposed earlier.

Table 11 Heterogeneity Analysis Results Based on Management Expense Ratio

	(1)	(2)
	Shb	*Shb*
Index	**-1.121*****	**-0.0530**
	(-2.628)	**(-0.126)**
Controls	Yes	Yes
Firm	Yes	Yes
Year	Yes	Yes
Industry	Yes	Yes
N	10,457	10,456
r2_a	0.449	0.473

5. Research Conclusions and Policy Recommendations

5.1 Research Conclusions

Against the backdrop of China vigorously developing digital finance and non-financial enterprises widely engaging in shadow banking activities, which significantly impact the financial stability of China, this paper, based on financial theory and existing research on shadow banking, analyzes the internal and external factors influencing non-financial enterprises' involvement in shadow banking activities. Using panel data of non-financial enterprises listed on the China A-share market from 2011 to 2019, this study empirically examines the impact of digital finance on the shadow banking of non-financial enterprises.

The research findings are as follows: First, the development of digital finance significantly inhibits the shadow banking of listed companies. Second, digital finance enhances the accessibility of corporate financing by alleviating financing constraints and reducing financing costs, thereby reducing enterprises' reliance on shadow banking financing channels and consequently suppressing corporate shadow banking activities. Third, heterogeneous analysis suggests that for smaller-scale enterprises with lower information disclosure quality and higher management expense ratios, the inhibitory effect of digital finance development on shadow banking activities is more pronounced, and this effect becomes more significant with the deepening usage of digital finance by enterprises.

5.2 Policy Recommendations

Based on the above research conclusions, the following recommendations are proposed: Firstly, deepen the construction of digital financial infrastructure. While expanding coverage breadth, emphasis should be placed on promoting usage depth to comprehensively enhance the accessibility and convenience of digital inclusive finance. Currently, there exists a certain degree of regional imbalance in the development of digital inclusive finance in China. Compared to the developed eastern regions, there is greater room for improvement in the construction of digital inclusive finance infrastructure in central and western regions. In addition to the significant differences between the eastern, central, and western regions, there are also substantial disparities among different provinces within the same region, different prefecture-level cities within the same province, and even between urban and rural areas. These relatively underdeveloped regions have a stronger demand for digital finance. Therefore, the next step should focus more on the popularization and deep usage of digital financial infrastructure, address infrastructure shortcomings, reduce objective barriers to accessing digital financial services in different regions, enhance the accessibility of digital finance, and better curb the trend of shadow banking.

Secondly, enhance the regulatory intensity and functions of digital finance. Improve the financial statement disclosure mechanism and implement penetrating supervision over the sources, destinations, and changes of funds raised through digital finance to achieve bidirectional information transparency. For example, blockchain technology in digital finance can enable traceable and trackable transaction information, thereby strengthening supervision over shadow banking activities.

Thirdly, build multi-departmental information sharing platforms to bridge the digital divide, promote information resource integration, and alleviate financial mismatch problems. In the era of the digital economy, the production and operation information collected by enterprise departments and consumer information of residents will become the basis for financial institutions to optimize decisions. Data, as an information carrier, has become a production factor for financial institutions. The collection and verification costs of credit and information disclosure for small and medium-sized enterprises, as well as the regulatory costs of fund usage, are important reasons for financial mismatch. However, information resources, as the basic carrier of digital finance, have non-exclusivity and non-rivalry characteristics. Therefore, it is necessary to fully leverage the economies of scale and scope of information resources, promote the circulation, sharing, and integration of information resources, maximize the functions of digital finance in alleviating financial mismatch and enhancing enterprise efficiency, and effectively curb shadow banking activities.

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