

## Retraction

# Retracted: Digital Finance and Firm Exit: Mathematical Model and Empirical Evidence from Industrial Firms

### Discrete Dynamics in Nature and Society

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

### References

- [1] F. Ma, L. Lei, Z. Chen, and M. Wang, "Digital Finance and Firm Exit: Mathematical Model and Empirical Evidence from Industrial Firms," *Discrete Dynamics in Nature and Society*, vol. 2021, Article ID 4879029, 7 pages, 2021.

## Research Article

# Digital Finance and Firm Exit: Mathematical Model and Empirical Evidence from Industrial Firms

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From the perspective of financial constraint, this paper constructs a mathematical model to analyze the impact of digital financial development on firm exit probability. The relationship between digital finance and firm exit was tested empirically based on the industrial firm data in 2011–2013. The results show that digital financial development significantly suppresses firm exit probability. Mechanism analysis suggests that digital financial development can ease the information asymmetry of the credit market, facilitate the credit acquisition of firms, and alleviate the constraint on corporate financing, thereby reducing the probability of firm exit. This paper provides the theoretical basis and empirical evidence for controlling firm exit from the angle of digital finance development.

## 1. Introduction

The operation and survival of firms are the foundation of the sustainable development of the entire economy and a major source of innovation and growth. However, Chinese firms face a grim reality: compared with their western counterparts, Chinese firms survive for a relatively short time and have a high probability of exiting the market [1].

The academia generally agrees on the important influence of finance on firm exit. The improving financial environment makes it easier for firms to get funds [2]. In well-developed financial markets, firms facing market shocks can effectively cope with economic fluctuations and extend their lifespan in the market [3]. In China, the financial system is dominated by state-owned banks, which prefer to issue loans to state-owned firms. Meanwhile, private firms and small and medium firms (SMFs) are under severe financial constraints, due to the lack of guarantees and the low transparency of financial information. The difficulty in financing makes it easy for these two types of firms to exit the market [4].

Ma and Li [5] found that the exit probability of high-productivity firms can be reduced by improving the regional efficiency of financial contracts. Wu and Jia [6] suggested that small and medium banks can lower the market exit risks of SMFs by alleviating their financing constraints. Lu et al. [7] discovered that the alleviation of financing constraints can significantly extend the survival time of firms in the market. Li [8] showed that financing constraints magnify the firm exit risk, as they intensify liquidity constraints and push up the cost of external funds. Ye and Bao [9] found that private firms can effectively utilize credit resources and commercial credit to survive longer. Jin and Zhang [10] discovered that during the development of the banking market, the firms survive much longer in the market by reducing the financing cost. The existing studies clearly indicated that financial development mainly reduces firm exit probability by alleviating financing constraints.

In recent years, digital finance has been in vogue. Digital finance refers to the new financial business model under which the traditional financial institutions and Internet firms realize financing, payment, and investment with the

aid of digital technology [11]. Mobile payment, online credit, and crowdfunding are popular forms of digital finance.

Due to the extensive use of the Internet, a lot of information related to the firm operations have been accumulated online. During credit approval and decision-making, financial institutions need to apply big data and other techniques to mine the non-financial information related to firm operation and evaluate the operation state and default risk of firms. This practice could greatly reduce the information asymmetry in the credit market.

The information asymmetry in the credit market is an important reason why some firms have difficulty in receiving loans [12]. Firms mainly display their operation and profit conditions through the financial statement. But financial statement alone presents very limited information to the outside. For example, the financial statement cannot reflect the independent innovation ability, the market prospects of products, or the local supply chain of firms. This creates an information asymmetry between firms and financial institutions. When a firm lacks enough guarantees and transparent financial information, financial institutions, unable to evaluate its operation state and default risk, will impose a high interest rate on the firm and even refuse to issue loans to the firm. This brings financing constraints to the firm.

The development of digital finance can reduce information asymmetry. Thanks to the popularity of the Internet, a huge volume of data on firm operation accumulates online. Through big data analysis, financial institutions can mine information more effectively. Digital technology empowers financial institutions to collect, analyze, decide on, and share the basic information of firms in real-time and in an intelligent manner. The mining of massive data could produce more information about firm credit and operation state, which enables financial institutions to make more accurate evaluation of firm risks. In addition, financial institutions could establish a joint firm credit database, share the data on firm credit, and thereby minimize information asymmetry. By weakening information asymmetry, digital finance development can alleviate the financing constraint of firms [13], which, in turn, reduces the firm exit induced by financing constraints. However, there is little research on how digital finance development suppresses firm exit.

Through the above analysis, this paper establishes a mathematical model to analyze the theoretical mechanism of how digital finance development affects firm exit and empirically tests this mechanism by analyzing the data in 2011–2013 from the Chinese Industrial Enterprises Database. The research results provide microscale evidence and a realization mechanism for reducing firm exit by developing digital finance.

There are two major contributions of this research. First, the research scope of factors affecting firm exit was expanded from the angle of digital finance, and the relationship between digital finance and firm exit was clarified with a mathematical model. Second, this paper measures the application level of financial technology among banks in different cities, paving the way for subsequent research on the influence of financial technology application among banks.

The remainder of this article is arranged as follows: Section 2 introduces the theoretical model and research hypothesis; Section 3 provides the data sources and variable settings; Section 4 implements the empirical analysis; and Section 5 draws the conclusions and summarizes the implications.

## 2. Theoretical Model and Research Hypothesis

Drawing on Buera and Shin's model [14], the influence of digital finance development on firm exit was analyzed under the assumption that productivity varies from firm to firm.

*2.1. Production Function.* This paper aims to clarify how digital financial development affects firm exit via the credit acquisition of the firm. For simplicity, the capital was considered as the only input. The conclusion will not be affected if both labor and capital inputs are counted.

Let  $a$  be the individual wealth of each entrepreneur in the economy,  $z$  be firm productivity, and  $F(a, z)$  be the joint distribution function of  $a$  and  $z$ . The production function of a firm can be defined as an AK production function as follows:

$$y_i = z_i k_i, \quad (1)$$

where  $k_i$  is the production equipment rented by the firm. The rental incurs a rent rate of  $R$ , under the premise of constant returns to scale of firm production and heterogenous productivity across firms.

*2.2. Credit Market.* It is assumed that the credit market is completely competitive, and banks can only achieve zero profit. Let  $r$  be the interest rate. In the credit market, each entrepreneur deposits his/her individual wealth  $a$  into a bank and then rents production equipment  $k$  from the bank. The rent rate  $R = r + \delta$ , where  $\delta$  is the depreciation rate.

Upon obtaining the loan, the entrepreneur can get the production profit and his/her deposit in the bank  $zk - (r + \delta)k + (1 + r)a$ , if he/she repays the principal and interest.

If the entrepreneur defaults, his/her deposit in the bank will be confiscated, and he/she can get a portion of the production profit and the residual value of the equipment:  $1 - \phi [zk + (1 - \delta)k]$ , where,  $\phi \in (0, 1)$  is the contractual implementation efficiency. The higher the efficiency, the greater the  $\phi$  value, and the smaller the portion available for the defaulting entrepreneur [5].

The entrepreneur decides whether to default by weighing the revenue of loan repayment against that of default. If loan repayment is more profitable than default, he/she will choose to repay the loan; if default is more profitable than loan repayment, he/she will not honor the contract. Only if the entrepreneur chooses to repay the loan, could the bank be willing to issue the loan to him/her. In this case, the borrowing contract between the bank and the entrepreneur satisfies incentive compatibility. The expression is as follows:

$$zk - (r + \delta)k + (1 + r)a \geq (1 - \phi)[zk + (1 - \delta)k]. \quad (2)$$

There is an upper limit  $\bar{k}$  on the loan issued by the bank to the entrepreneur. If the loan amount is greater than  $\bar{k}$ , the entrepreneur will breach the contract, and the bank will not be willing to issue the loan. If the loan amount is smaller than  $\bar{k}$ , the entrepreneur will repay the loan, and the bank will be willing to issue the loan. The expression is as follows:

$$\bar{k}(a, z) = \frac{(1+r)a}{(1-\phi)(1-\delta) + r + \delta - \phi z}. \quad (3)$$

$\bar{k}(a, z)$  is the increasing function of  $z$ : the greater the firm productivity, the higher the upper limit on loan amount. The productivity of the company can ultimately reflect the net return on assets. The higher the productivity, the higher the net return on assets. Most empirical studies [15] treat the net return on assets as a control variable and examine its influence over financing constraints, revealing that the net return on assets suppresses the financing constraints faced by firms. Therefore, the empirical results confirm that a firm with high productivity faces fewer financing constraints and could obtain a large sum of loans.  $\bar{k}(a, z)$  is also the increasing function of  $a$ : the greater the entrepreneur's deposit in the bank, the higher the upper limit on the loan amount.

**2.3. Entrepreneur's Decisions.** Under the given rent rate  $R$ , interest rate, and upper limit on loan amount  $\bar{k}$ , the entrepreneur chooses the investment amount  $k$  to maximize the firm profit:

$$\begin{cases} \pi(a, z) = \max_k zk - (r + \delta)k \\ \text{s.t. } k \leq \bar{k} \end{cases} \quad (4)$$

Formula (4) has a corner solution. When  $z \geq r + \delta$ , the firm can get positive profit and choose to enter the market; in this case, the firm investment equals the upper limit on loan amount  $\bar{k}$ . When  $z < r + \delta$ , the firm will lose profit if it enters the market and will choose to exit the market. Therefore, there is a critical value of firm productivity  $\underline{z} = r + \delta$ . The firms with productivity higher than  $\underline{z}$  will enter the market, while those with productivity lower than  $\underline{z}$  will exit the market.

Suppose there exists an upper limit  $z^m$  on productivity that satisfies  $(1-\phi)(1-\delta) + r + \delta - \phi z > 0$  for any  $\phi$ , such that  $k(a, z)$  is always positive. Then, the firm productivity falls in the value range of  $[0, z^m]$ . The loan amount of each firm can be expressed as follows:

$$k(a, z) = \begin{cases} \frac{(1+r)a}{(1-\phi)(1-\delta) + r + \delta - \phi z}, & z \geq \underline{z} \\ 0, & z < \underline{z} \end{cases} \quad (5)$$

## 2.4. Digital Finance and Loan Acquisition

**2.4.1. Digital Finance and Information Asymmetry.** Traditionally, banks issue loans based on credit and guarantees. The development of digital finance empowers financial institutions to apply digital technologies such as big data,

artificial intelligence, and blockchain to mine the non-financial information related to corporate operations and evaluate the prospects and default risks of firms, before deciding whether to issue loans [16]. Based on the borrowers' social network relations, Prosper lending platform assessed the default risks of borrowers before deciding whether to issue loans [17]. Compared with traditional innovations in financial technology, digital finance development can effectively mine massive data and thus weaken information asymmetry.

Let  $\gamma \in [0, 1]$  denote the development level of digital finance. The more advanced the digital finance, the greater the value of  $\gamma$ . Let  $\phi \in [0, 1]$  denote the degree of information asymmetry in the credit market. The more asymmetric the information, the greater the value of  $\phi$ . Since digital finance development can suppress information asymmetry,  $\phi$  can be considered as a decreasing function of  $\gamma$ :  $\partial\phi/\partial\gamma < 0$ .

**2.4.2. Information Asymmetry and Loan Acquisition.** It is assumed that under the information asymmetry of the credit market, a firm can obtain loans only if its productivity is recognizable to financial institutions; otherwise, the firm cannot obtain any loan. Thus, the degree of information asymmetry in the credit market directly bears on the loan acquisition by firms. The higher the degree, the lower the probability of loan acquisition.

Let  $p \in [0, 1]$  denote the probability for a firm to obtain loans. The higher the probability of loan acquisition, the greater the value of  $p$ . Since information asymmetry makes it harder for a firm to obtain loans,  $p$  is a decreasing function of  $\phi$ :  $\partial p/\partial\phi < 0$ .

**2.4.3. Digital Finance and Loan Acquisition.** Digital finance development enhances the ability of financial institutions to recognize firm productivity, weaken information asymmetry, and thereby increase the loan acquisition probability of each firm. Therefore,  $p$  is an increasing function of  $\gamma$ . The expression is as follows:

$$\frac{\partial p}{\partial \gamma} = \left( \frac{\partial p}{\partial \phi} \right) \cdot \left( \frac{\partial \phi}{\partial \gamma} \right) > 0. \quad (6)$$

*Proof*

As  $\partial p/\partial\phi < 0$  and  $\partial\phi/\partial\gamma < 0$ , it is easy to infer that  $\partial p/\partial\gamma > 0$ . Q.E.D.

**2.5. Overall Equilibrium.** The central bank requires every financial institution to deposit a portion of its total deposit in the central bank as the reserves against deposits. The remaining of its total deposit can be used to issue loans. This portion is called the required reserve ratio (RRR).

Let  $\eta$  be the proportion of total loan to total deposit and  $1 - \bar{\eta}$  be the RRR. Since a financial institution must deposit  $1 - \bar{\eta}$  of its total deposit to the central bank, the maximum proportion of total loan to total deposit should not surpass  $\bar{\eta}$ .

The total demand for loans is the integral of the amount of loan acquired by a firm with productivity greater than  $\underline{z}$



multiplied by its loan acquisition probability. The total supply of loans is the total deposit of a financial institution subtracted by its reserves against deposits, that is, the total supply of loans of a financial institution is  $\bar{\eta}$  of its total deposit.

As shown in Table 1, the total loan of Chinese financial institutions in 2011–2013 took up about 70% of the total deposit; the RRR required by the central bank was 20%. Thus, about 10% of the total deposit was not loaned out. This means that the financial institutions have not fully unleashed their loaning ability; the total demand for loans is smaller than the total supply and equal to the total loan. In this case, the market is not equilibrium, leaving room for the total loan to grow further.

Digital finance development can enhance the ability of financial institutions to recognize firm productivity. Therefore, more firms with productivity greater than the critical value  $\underline{z}$  will be recognized and given loans. The ensuing growth in the total loan will elevate the ratio  $\eta$  of total loan in total deposit as follows:

$$\int \int_{\underline{z}}^{z_m} p(\gamma)k(a, z)dF(a, z) = \eta \int \int_0^{z_m} a dF(a, z). \quad (7)$$

$$\left\{ \int \int_{\underline{z}}^{z_m} \frac{[1 + \underline{z} - \delta]a}{(1 - \phi)(1 - \delta) + \underline{z} - \phi z} \frac{\partial p}{\partial \gamma} dF(a, z) \right\} d\gamma = \int \int_0^{z_m} a dF(a, z) d\eta. \quad (9)$$

Suppose  $A = \int \int_{\underline{z}}^{z_m} ([1 + \underline{z} - \delta]a)/((1 - \phi)(1 - \delta) + \underline{z} - \phi z) (\partial p/\partial \gamma) dF(a, z) > 0$  and  $B = \int \int_0^{z_m} a dF(a, z) > 0$ . It is apparent that  $A > 0$  and  $B > 0$ . Then, it can be solved that

$$\frac{\partial \eta}{\partial \gamma} = \frac{A}{B} > 0. \quad (10)$$

Therefore, before the total demand for loans surpasses the total supply (i.e.,  $\eta$  does not reach  $\bar{\eta}$ ), the credit market belongs to the non-equilibrium state of oversupply. The growing total demand for loans merely pushes up the ratio of total loan to total deposit and does not increase the market equilibrium interest rate  $r$  or critical value of firm productivity  $\underline{z}$ . Therefore, we have

$$\begin{aligned} \frac{\partial \bar{z}}{\partial \gamma} &= 0, \\ \frac{\partial r}{\partial \gamma} &= 0. \end{aligned} \quad (11)$$

It can be derived from formula (6) that the development of digital finance does not bring up  $r$  or  $\underline{z}$ . Since the incumbent firms in the market at least achieve the productivity of  $\underline{z}$ , by mitigating information asymmetry, digital finance development makes it more likely for the productivity of each incumbent firm to be recognized by financial institutions. In this way, all incumbent firms will be more likely to receive loans. Eventually, the firm exit rate will be reduced

TABLE 1: Deposit balance and loan balance of Chinese financial institutions in 2011–2013.

Index	2011	2012	2013
Total deposit of financial institutions	80.9368	91.7555	104.3847
Total loan of financial institutions	54.7947	62.9971	71.8961
Total deposit/total loan	0.6770	0.6865	0.6888
RRR of large financial institutions (%)	19.00	20.50	20.00

Unit: trillion yuan. Source: official website of Chinese National Bureau of Statistics.

Substituting  $r = \underline{z} - \delta$  into formula (7), the following can be derived:

$$\int \int_{\underline{z}}^{z_m} \frac{[1 + \underline{z} - \delta]a}{(1 - \phi)(1 - \delta) + \underline{z} - \phi z} p(\gamma) dF(a, z) = \eta \int \int_0^{z_m} a dF(a, z). \quad (8)$$

Finding the perfect differentials of  $\eta$  and  $\gamma$  on the two sides of formula (8), the following can be derived:

across the board. On this basis, the following hypotheses were presented:

*Hypothesis 1.* Digital finance development suppresses the overall firm exit probability.

*Hypothesis 2.* Digital finance development suppresses firm exit by alleviating financing constraints.

### 3. Research Design

*3.1. Model Setting.* First, the following equation was established to test the influence of digital finance development on firm exit:

$$ex_{it} = c + \beta_1 \text{digfin}_{it} + \sum_j \beta_j \text{control}_{it} + \mu_i + u_t + \varepsilon_{it}, \quad (12)$$

where  $ex_{it}$  is the dummy variable of firm exit,  $\text{digfin}_{it}$  is the development level of digital finance,  $\text{control}_{it}$  is the control variables affecting firm exit,  $\beta_j$  is the parameter to be estimated,  $\mu_i$  is the individual fixed effects,  $u_t$  is the time fixed effects, and  $\varepsilon_{it}$  is the residual term.

Since firm exit is a dummy variable, all the regressions in this research were implemented by the probit model. In the probit model, the explained variable  $Y$  is valued either zero or one, and the probability of the event depends on the explanatory variable, that is,  $P(Y = 1) = f(X)$ . In other words, the probability of  $Y = 1$  is a function about  $X$ , where  $f(X)$  obeys the standard normal distribution. In all regressions,

TABLE 2: Variable definitions and descriptive statistics.

Name	Definition	Sample size	Mean	Standard deviation
Firm exit	1 for the year of exit and 0 for other years	208,381	0.209	0.406
Digital finance	Acquired by a python web crawler	208,381	0.525	0.194
TFP	Obtained by Levinsohn–Pettrin (LP) method [22]	208,381	6.572	1.167
Firm scale	Logarithm of total asset	208,381	11.13	1.398
Firm age	Logarithm of firm age plus 1	208,381	2.142	0.689
Return on assets	Net profit divided by total asset	208,381	0.108	0.200
State ownership	1 for state-owned firm and 0 for non-state-owned firm	208,381	0.053	0.225
Asset-liability ratio	Total debt divided by total asset	208,381	0.545	0.264
Export density	Export delivery value as a proportion of total output	208,381	0.149	0.305
Government-firm relationship	1 for subsidized firm and 0 for nonsubsidized firm	208,381	0.151	0.358
Industry concentration	Measured by Herfindahl index	208,381	0.161	0.211
GDP growth rate	GDP growth rate of each city against the level of the previous year	208,381	0.115	0.057

the time-fixing effects, four-digit industry fixed effects, and urban fixed effects were under control; the standard deviations were clustered and adjusted on the individual level. The main variables were configured as follows.

**3.1.1. Explained Variables.** The explained variable is the two-dimensional (2D) selection variable of firm exit. Inspired by Brandt et al. [18], this paper regards the firms that are no longer included in the Chinese Industrial Enterprises Database after a certain year as exit firms. The firm exit variable was set to 1 in that year and 0 in the other years.

**3.1.2. Core Explanatory Variables.** The core explanatory variable is the development level of digital finance. Referring to Li and Song [19] and Jin et al. [20], text mining was adopted to determine the application level of financial technologies among banks in different cities. First, the five most popular technologies used in banks were selected as keywords: big data, artificial intelligence, cloud computing, blockchain, and internet of things. Next, these keywords were searched in combination with city names and banks; a python web crawler was employed to search for the news on each keyword in each year during 2011–2013; and the research results of all keywords of the same city were added into the total search amount. Finally, the logarithm of the total search amount was taken and divided by 10.

**3.1.3. Control Variables.** Referring to Jian et al. [21], the control variables include total factor productivity (TFP) of the firm, firm scale, firm age, state ownership, asset-liability ratio, return on assets, firm export density, government-firm relationship, industry concentration, and gross domestic product (GDP) growth rate. The calculation methods of all variables are given in Table 2.

**3.2. Data Sources.** Based on Chinese Industrial Enterprises Database, this paper constructs a non-balanced panel data of 2011–2013. Although the database is updated to 2015, the sample period was determined as 2011–2013 for two reasons:

TABLE 3: Regression results on digital finance and firm exit.

Explained variable: firm exit	(1)
Digital finance	-0.043*(-1.71)
TFP	-0.101***(-5.98)
Firm scale	-0.191***(-8.33)
Firm age	-0.194***(-12.17)
Return on assets	0.021(0.61)
State ownership	-0.074(-1.16)
Asset-liability ratio	0.198*** (2.70)
Export density	-0.245***(-10.03)
Government-firm relationship	-0.168***(-6.22)
Industry concentration	0.146*** (7.19)
GDP growth rate	1.041*(1.83)
Time, industry, and city-fixed effects	Yes
_cons	2.658*** (9.19)
N	208381
Pseudo $R^2$	0.1116

\*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

first, in the database, lots of samples lack the data of 2014 and 2015, making the data unsuitable for calculation of firm exit, and second, digital finance in China starts developing since 2011.

Referring to the approach of Brandt et al. [18], the authors removed the unreasonable sample data and the observations that lack key indices. Finally, 208,381 year-firm observations were obtained. The descriptive statistics of the main variables are given in Table 2.

## 4. Test Results and Analysis

**4.1. Benchmark Regression Analysis.** The influence of digital finance development on firm exit probability was first tested by formula (12). The regression results are listed in Table 3. In column (1), the coefficients of digital finance were all significantly negative, indicating that digital finance development greatly reduces the probability of firm exit. Therefore, Hypothesis 1 was proved to be valid.

Among the control variables, TFP, firm scale, firm age, and export density all had significantly negative coefficients. Therefore, the firms with a high TFP, a large scale, a long age, and a high export density are unlikely to exit the market. The

TABLE 4: Regression results on mechanism analysis.

Explained variable	Low financing constraint group (1)	High financing constraint group (2)
Digital finance	0.003 (0.08)	-0.068***(-2.63)
Control variables	Yes	Yes
Time, industry, and city-fixed effects	Yes	Yes
_cons	0.537**(2.12)	3.580*** (11.17)
N	100210	108168
Pseudo R <sup>2</sup>	0.0696	0.0950

\*\*\*, \*\*, and \* indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

coefficient of government-firm relationship was significantly negative, suggesting that the firms maintaining a good relationship with the government are not likely to exit the market. The coefficients of asset-liability ratio and state ownership were not significant, indicating that the two factors do not greatly affect firm exit probability. Industry concentration had a significantly positive coefficient, that is, the more concentrated the industry, the higher the exit probability of the firm. The coefficient of GDP growth rate was also significantly positive. Hence, the firms in a city with fast economic growth tend to exit the market.

**4.2. Mechanism Analysis.** Theoretical analysis shows that digital finance development eases the financial constraint on firms by facilitating their acquisition of loans and thereby reduces the probability of firm exit. This subsection further tests whether digital finance development affects firm exit via the channel of financing constraint.

The size-age (SA) index proposed by Hadlock and Pierce was adopted. Because it is fitted solely by the firm scale and age, the index has strong externality and thus gained popularity among researchers [23]. The SA index can be calculated by:  $SA = -0.737 \times \text{Size} + 0.043 \times \text{Size}^2 - 0.04 \times \text{Age}$ . The calculation result of the index is always negative. For convenience, the absolute value of the index was adopted. The greater the absolute value, the more severe the financing constraints on the target firm.

By the median of financing constraint, the samples were divided into a high financing constraint group and a low financing constraint group. Then, each group of samples was subject to regression. The regression results are recorded in Table 4. The coefficients of digital finance in column (1) were not significant, while those in column (2) were significantly negative. Hence, digital finance development can only suppress firm exit in the high financing constraint group. The empirical results support the expectation that digital finance development suppresses firm exit by alleviating financing constraint. Hence, Hypothesis 2 was proved valid.

## 5. Conclusions

Taking the Chinese industrial firms of 2011–2013 as samples, this paper discusses the influence of digital finance development on firm exit and summarizes the mechanism of that influence. The main conclusions are: digital finance development suppresses firm exit probability, and the suppression effect is realized by alleviating the financing constraint on firms.

Based on the conclusions, two important suggestions were given for policy-makers:

- (1) Encourage banks to apply digital techniques and improve their loan technology.

Banks are the primary source of loans to firms. The government should encourage banks to cooperate with financial technology firms. Through the cooperation, the banks can acquire the front desk consumer flow and online big data, which empower the application of big data in loaning.

- (2) Encourage firms to engage in e-commerce and reduce information asymmetry.

The government should establish an incubation mechanism for e-commerce firms. Measures such as setting up models, talent training, and financial subsidies could be implemented to guide firms to engage in e-commerce, accumulate transaction data on e-commerce platforms, and give signals about their good operation state.

## Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

## Conflicts of Interest

The authors declare that they have no conflicts of interest.

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