

Research on the Impact of Digital Finance on Innovation and R & D of Technology-Based SEMs —Moderating Role Based on Financial Flexibility

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Abstract

Digital finance can effectively ease corporate financing constraints and enhance corporate R & D innovation capabilities. Taking the financial data of technology-based SMEs on the Growth Enterprise Market from 2013 to 2020 as a sample, the fixed effect model is used to empirically test the impact of digital finance and financial flexibility on enterprises' R & D investment from the external environment and internal mechanism. The results show that digital finance has a significant positive impact on the R & D investment of technology-based SMEs through the breadth of coverage, depth of use and degree of digitization; Financial flexibility is positively correlated with R & D investment of technology-based SMEs, and has a positive moderating effect on the relationship between digital finance and R & D investment; Further heterogeneity analysis shows that the impact of digital finance on the R & D investment of enterprises is heterogeneous due to the different life cycles and regions of enterprises. Therefore, technology-based SMEs should focus on the coordination of internal and external financial resources based on their own characteristics, and effectively support innovative R & D activities.

Keywords

Digital Finance, Financial Flexibility, R & D Investment, Technology-Based SMEs, Heterogeneity

1. Introduction

It is an important part of the "14th Five-Year Plan" outline to improve the market-oriented mechanism of technological innovation, strengthen the dominant position of enterprises in innovation, and promote the concentration

of various innovation elements in enterprises, thereby strengthening the support for innovation of Small and Medium-sized Enterprises (SEMs). Under the guidance of various national policies, the number of technology-based SEMs has grown rapidly, which have gradually become an important body to promote the construction of China's modern economic system, support the development of the knowledge economy, cultivate new momentum, and promote high-quality development. It is also an important force to promote the national innovation strategy and strengthen the dominant position of enterprises in innovation. Therefore, only through continuous R & D investment can technology-based enterprises continuously improve their innovation capabilities and realize the transformation from "followers" to "leaders" in technological innovation.

According to the Statistical Bulletin of National Science and Technology Funding Investment in 2020, the expenditure on research and experimental development of enterprises was 1867.38 billion yuan, an increase of 10.4% over the previous year. In the context of fighting against the new crown pneumonia epidemic, the R & D expenditure of enterprises can still maintain a moderate growth rate, which shows that the status of Chinese enterprises as the main body of innovation is constantly being consolidated. However, innovation is an activity with strong uncertainty, high risk and high cost, and the stable resources required for it are constrained by financing (Seker, 2012). Due to the limitation of information channels, weak guarantee ability and high operating risks, the problems of financing difficulties and high financing costs for SEMs are more prominent. The role of financial means can effectively alleviate this problem (Zhuang & Si, 2021). A good external financial environment can change the efficiency of resource allocation, directly affect the supply channels of corporate funds, and facilitate corporate innovation. Based on its own digital, intelligent and networked characteristics, digital finance realizes the integration of digital technology and financial services, breaks the traditional "two eight rules", and has outstanding performance in terms of service radius, service depth and service availability. It is a powerful supplement to traditional finance. With the help of Internet big data and cloud computing platforms, it can accurately locate customers, reduce the risk of resource mismatch, and play a significant role in alleviating the financing constraints of technology-based SMEs and enhancing innovation capabilities (Jiang et al., 2022). However, at the same time, due to the need for technical confidentiality and the uncertainty of the transformation of scientific and technological achievements, technology-based SMEs have exacerbated the information asymmetry between banks and enterprises, resulting in high due diligence costs, high risks and low enthusiasm for banks. In this case, to ensure investment in innovation, it is more dependent on its own financial reserves. Heath, who first proposed the concept of financial flexibility, believes that financial flexibility is an emergency ability for enterprises to avoid financial distress by quickly adjusting cash flow (Heath, 1978). Gamba and Triantis, from the

perspective of investment and financing costs, believed that financial flexibility is the ability of enterprises to obtain new financing sources at low financing costs (Gamba & Triantis, 2008). At this time, enterprises with strong financial flexibility can replace the financing constraints to a large extent to ensure the R & D investment of enterprises.

At the same time, digital finance is a new type of financial service channel. In the process of orderly development, there are also problems such as arbitrage by some financial institutions and disrupting the financial capital market, which brings hidden risks to the stable development of the financial industry (Zhao et al., 2021). Therefore, does digital finance really benefit the innovation investment of technology-based SMEs? This issue remains to be further confirmed. At present, research on digital finance is mostly related to macroeconomics and national livelihood. Research shows that digital finance plays a role in promoting rural economic development, increasing residents' income and consumption, promoting industrial structure upgrading, and enhancing environmental governance and high-quality urban development (Lu & Wang, 2021; Sun & Xu, 2021; Zhu & Zhang, 2022). However, the research on micro-enterprises mostly starts from the theoretical mechanism, and analyzes the effect of digital finance on enterprise value and investment efficiency by alleviating corporate financing constraints and reducing information asymmetry (Yang, 2019; Li et al., 2021; Cai et al., 2020). These literature provides a useful reference for the study of "Digital Financial Environment—Enterprise Innovation Investment".

The possible innovations of this paper lie in: 1) R & D capability, as an important element to maintain the vitality of enterprises, has attracted extensive attention, but the current research perspective on its impact is relatively simple. This paper introduces two variables, digital finance and financial flexibility, from the internal and external environment, to analyze their impact on the R & D investment of technology-based SMEs; 2) Technology-based SEMs have become an important force to promote economic development, but at present, few research perspectives focus on technology-based SEMs. This study enriches the research in this field and provides a reference for improving the R & D capacity of technology-based SEMs; 3) The impact of digital finance on enterprise innovation based on the life cycle perspective is less. The heterogeneity analysis based on the life cycle and regional perspective provides references for the development of enterprises' R & D investment at different stages.

The structure of the article is as follows: This chapter analyzes the research background and purpose, and the second chapter sorts out the relevant theories and puts forward the hypothesis of this article on this basis; Chapter 3 introduces the data source, variable selection and model setting of this study; Chapter 4 uses fixed effect model to empirically test the analysis of this paper and make a robustness analysis; Chapter 5 further discusses the heterogeneity of this study based on the life cycle perspective and regional perspective; Finally, Chapter 6 gives the conclusion and countermeasures.

2. Theoretical Analysis and Research Assumptions

2.1. Digital Finance and R & D Investment of Technology-Based SMEs

The point of view of functional finance theory points out that a good financial system helps to optimize the allocation of economic resources across time and space. The existing literature shows that the innovation activities of enterprises are affected by fiscal and tax policies, market reform, financial environment and other factors at the macro level, and the continuous optimization of the external environment can promote the R & D investment of technology-based enterprises (Li & Wang, 2021; Habib & Hasan, 2015; Sun, 2021). Meng Weifu also pointed out that the optimization of the external financing environment will promote the change of the subject's concept and guide enterprises to develop innovative business (Meng & Liu, 2021).

Digital finance is a new generation of financial services that combines the Internet, big data and other technologies with the financial industry. On the one hand, the unbalanced supply of resources left by traditional financial institutions and the financial market makes the funding needs of technology-based SMEs unmet. Digital finance broadens the breadth of financial coverage and provides a financing platform for technology-based SMEs; On the other hand, digital finance uses its own big data platform to accurately screen massive data at a lower cost, monitor the progress of innovation projects of the applicant enterprises through cost and regulatory advantages (Berg et al., 2020), and reduce the hidden risk of adverse selection through the comprehensive collection of information, increase innovation investment and improve the depth of use of digital finance by easing the financing constraints of technology-based SMEs. At the same time, digital transformation can promote SMEs to improve operational efficiency, and improve the level of innovation. Based on this, the hypothesis 1 of this paper is proposed:

H1: The development of digital finance can enhance the innovation input of technology-based SMEs.

2.2. Financial Flexibility and R & D Investment of Technology-Based SMEs

Many internal factors such as management's decision-making power, corporate governance, financial flexibility and so on can have an impact on the innovation management of enterprises. According to the financing priority theory, equity financing will increase the financing cost of enterprises, spread the bad business information of companies, and enterprises are more inclined to endogenous financing under general conditions. Relevant research shows that financial flexibility can provide a basis for internal financing of enterprises. The R & D investment of enterprises with strong financial flexibility will increase significantly.

Financial flexibility refers to the ability to consider the idle funds and liabilities of an enterprise and analyze whether it can adapt to changes in the economic environment and take advantage of investment opportunities. The measurement

of cash capacity is mainly reflected in the comparison of cash flow revenue and expenditure. When the enterprise's income cash flow is greater than the cash required for payment, it shows that the enterprise has surplus cash to deal with emergencies, so that it has better cash reserves for R & D investment. Generally speaking, it is unwise for an enterprise to rely solely on equity financing, which makes it unable to obtain the advantages of debt financing, and excessive debt will lead to financial risks, so it is necessary to keep the debt at a reasonable level. Maintaining appropriate financial flexibility is a necessary condition for enterprises to use financial leverage flexibly. At the same time, enterprises with financial flexibility can use the retained debt capacity to finance externally in order to support the capital required for innovation activities (DeAngelo & DeAngelo, 2007). Based on this, this paper proposes Hypothesis 2:

H2: Financial flexibility is significantly positively correlated with innovation input of technology-based SMEs.

2.3. Financial Flexibility Adjusts the Relationship between Digital Finance and Corporate R & D Investment

The development of digital finance has placed technology-based SMEs in a situation where opportunities and risks coexist. On the one hand, due to the characteristics of the digital industry and insufficient financial supervision, some digital financial institutions use their own conditions to commit financial fraud, aggravating the instability of the financial market. The confidentiality of innovative research and development is also high, which poses a serious threat to the information security of technology-based SMEs. On the other hand, due to the differences in financial environment and financial infrastructure, even if enterprises in areas with limited financial resources conduct financing through online channels, it is difficult to give full play to the scale advantages and innovation effects of digital finance (Gomber et al., 2018).

Therefore, the internal financial reserves and planning of technology-based SMEs are particularly important. As enterprises become more sensitive to changes in the external environment, more and more technology-based SEMs have put reasonable reserves of their own internal funds on the agenda, and their management has become more mature. When external financing cannot act as a driving force for enterprise R & D, enterprises with higher financial flexibility will be more capable of raising and mobilizing funds to provide sufficient financial support for R & D innovation. Relevant studies have shown that financial flexibility plays a role between corporate innovation and zero-leverage strategy (Denis & McKeon, 2012), and there is also a significant moderating effect between internal control quality and corporate innovation management. When the external financial environment is good, the internal financial flexibility management will play a "supplementary" role while the technology-based SMEs obtain external financing; on the contrary, when the external financial environment is not ideal, it is more difficult to carry out innovative activities through external financing, the internal financial flexibility management will play a "fo-

reseeing” role. Based on this, this paper proposes Hypothesis 3:

H3: Financial flexibility plays a moderating role in the effect of digital finance on the R & D investment of technology-based SMEs.

3. Study Design

3.1. Sample Selection and Data Sources

In order to ensure the authenticity, continuity and easy availability of the research data, combined with the research objects, and referring to Xiao Xiang in his research on the selection of samples of technology-based SMEs (Xiao et al., 2022), this paper selects the 2013-2020 China Growth Enterprise Market Listed company data. The enterprise level data is from CSMAR, and the digital financial level data is from the website of the Digital Finance Research Center of Peking University. The data screening is as follows: due to the particularity of financial data of financial enterprises, listed financial enterprises are excluded; since the consistency of financial data of ST enterprises cannot be guaranteed, non-ST enterprises are selected as samples; the microscopic variables were processed by 1% and 99% WINSOR, and 3216 observations were obtained. Then use EXCEL, SPSS, STATA software to process the data.

3.2. Definition of Main Variables

3.2.1. Core Explanatory Variable: Digital Financial Environment (DIF)

It is measured by the Peking University Digital Financial Inclusion Index and analyzed from three dimensions: coverage ratio (COV), depth of use (DEP) and digitization (DIG). This paper matches the prefecture-level city data of the financial index with the office addresses of listed companies to represent the digital financial environment of companies.

3.2.2. Explained Variable: Enterprise R & D Investment (Input)

There are usually two methods for evaluating the R & D investment of enterprises. One is measured by the ratio of R & D investment to total assets, and the other is measured by the ratio of R & D investment to operating income (Mura & Mariamileresa, 2010). In this paper, in the empirical research, the second method is used to measure, and the first method is used in the robustness test.

3.2.3. Adjustment Variable: Financial Flexibility (Fin)

There are generally three methods for measuring financial flexibility. First, single indicator measurement, the most widely used indicator is cash holdings; The second is the combination of double indicators, specifically the combination of financial leverage and cash holding level; The third is the comprehensive measurement of multiple indicators. This paper constructs an indicator system as shown in Table 1 from three levels: cash, leverage and financing costs.

3.2.4. Control Variables

This paper selects control variables from two levels of company operation and corporate governance. The specific indicators are shown in Table 2.

Table 1. Enterprise financial flexibility test.

target	first-level indicator	Secondary indicators	measurement method
financial flexibility	cash indicator	Cash holdings	(Money Funds + Trading Financial Assets)/Average Total Assets
		Cash Dividend Coverage Multiple	Net operating cash inflow per share/cash dividend per share
		Reinvested Cash Ratio	Net cash flow from operating activities/(fixed assets + long-term investment + other funds + working capital)
	Leverage Indicator	Unused Debt Capacity	1-Asset-liability ratio
		Long-term gearing ratio	Non-current liabilities/(non-current liabilities + shareholders' equity)
	Financing Cost Indicator	Z-score	Interest-bearing debt ratio
			Z = 1.2M1 + 1.4M2 + 3.3M3 + 0.6M4 + M5, where, M1 = working capital/assets; M2 = retained earnings/assets; M3 = earnings before interest and taxes/assets; M4 = market value/book value of liabilities; M5 = sales revenue/assets

Source: Based on the research results of scholars and the theoretical assumptions of this paper.

Table 2. Control variables.

category	variable name	symbol	measurement method
Company operations	enterprise size	Size	Total assets log
	business age	Age	Ln (1 + years of listed companies)
	corporate profitability	Nps	Net profit/operating income
	business growth	Growth	(Total operating income of the current period – total operating income of the previous period)/total operating income of the previous period
	enterprise risk level	Lev	Total liabilities at the end of the year/total assets at the end of the year
Corporate Governance	ownership concentration	Owner	Sum of shareholding ratio of top ten shareholders
	equity balance	Bal	Whether the top ten shareholders are related (existence = 1; others = 0)
	Two-weight separation ratio	Separ	The difference between the control right and ownership of the listed company owned by the actual controller
	Work of Independent Directors	Indep	Statistics on the consistency of working places of independent directors and listed companies (consistency = 1; others = 0)
	Integration of two positions	Interg	Concurrent positions of chairman and general manager (yes = 1; others = 0)

Source: Control variables selected from current research.

3.3. Model Settings

In order to examine the impact of digital finance and financial flexibility on the R & D investment of technology-based SMEs, a benchmark regression model of formulas (1) and (2) was constructed. In order to test whether financial flexibility plays a moderating role between digital finance and corporate R & D invest-

ment, the regression model of formula (3) is constructed.

$$\text{Input}_{it} = \beta_0 + \beta_1 \text{DIF}_{it} + \beta_2 \text{Controls} + \sum \text{Year} + \sum \text{Industry} + \varepsilon_{it} \quad (1)$$

$$\text{Input}_{it} = \beta_0 + \beta_1 \text{Fin}_{it} + \beta_2 \text{Controls} + \sum \text{Year} + \sum \text{Industry} + \varepsilon_{it} \quad (2)$$

$$\begin{aligned} \text{Input}_{it} = & \beta_0 + \beta_1 \text{DIF}_{it} + \beta_2 \text{Fin}_{it} + \beta_3 \text{DIF} * \text{Fin}_{it} \\ & + \beta_4 \text{Controls} + \sum \text{Year} + \sum \text{Industry} + \varepsilon_{it} \end{aligned} \quad (3)$$

3.4. Model Selection

This paper first conducts the Hausman test on the sample data. The results show that “prob > chi²” is significant at 1%, indicating that the null hypothesis is rejected, so a fixed-effects model is selected. Secondly, by testing the correlation of variables, the results show that the correlation coefficients between the variables are less than 0.7, indicating that there is no problem of collinearity.

4. Empirical Analysis

4.1. Descriptive Statistics and Correlation Analysis

Descriptive statistics of each variable are shown in **Table 3**. It can be seen that the average value of innovation investment is only 7.14%, and the maximum and minimum values are 32.2% and 0.45%, respectively, which indicates that the innovation investment level of technology-based SEMs is generally not high, and the differences between enterprises are large. The overall average level of digital finance and its three dimensional variables is good, but there are also regional differences. Among the control variables at the corporate governance level, the ownership concentration ratio has a large difference in the sample among groups but the average value is high, indicating that the shares of enterprises are generally concentrated in the hands of the top ten shareholders; The mean value of the separation rate of two weights is low but has prominent values, and the mean value and standard deviation of other variables are at the median level. The standard deviation of the control variables at the company’s operation level

Table 3. Descriptive statistics.

variable	size	mean	sd	min	max	variable	size	mean	sd	min	max
Input	3216	7.142	5.667	0.450	32.20	interg	3216	0.432	0.495	0	1
DIF	3216	228.4	42.90	131.9	303.0	indep	3216	0.578	0.494	0	1
COV	3216	226.5	40.14	122.9	290.3	age	3216	2.313	0.278	1.609	2.639
DEP	3216	226.3	53.37	123.2	325.7	size	3216	21.26	0.817	19.66	23.55
DIG	3216	238.8	50.72	144.6	329	growth	3216	0.232	0.375	-0.469	1.935
owner	3216	61.63	12.95	29.33	98.40	nps	3216	0.103	0.187	-1.074	0.433
separ	3216	2.978	5.750	0	24.48	lev	3216	1.114	0.502	-0.0196	4.276
bal	3216	0.773	0.419	0	1	Fin	3216	-0.00199	0.473	-1.240	1.640

Source: according to the running results of the stata software on the samples.

is small, and the difference between groups of each variable is small.

4.2. Benchmark Regression Analysis of the Effect of Digital Finance on Corporate Innovation Investment

The test of the impact of digital finance on innovation input of technology-based SMEs is shown in columns (1)-(4) of **Table 4**. Column (1) shows that the impact of digital finance on enterprise innovation input is positive, and the correlation coefficient is 0.049, passing the 1% significance test, indicating that the improvement and optimization of digital finance as an external financial environment will play a positive role in promoting the innovation input of technology-based SMEs. Columns (2)-(4) are tested from the three dimensions of digital finance. It can be seen that the three dimensions of digital finance have a positive impact on innovation investment, among which coverage is the most obvious, indicating that the innovation investment of technology-based SMEs is affected by the external financial environment in many ways. The lower the concentration of equity and the higher the separation rate of two rights, the more beneficial to the innovation activities of SMEs, thus avoiding the behavior of large shareholders who use their power to seek benefits and reduce the innovation efficiency of enterprises. The higher the degree of integration of two roles, the more innovative enterprises will be because they can better allocate the resources of enterprises to serve the innovation activities. The longer the enterprise is, the more resources it can accumulate for innovation activities; The smaller the size of the enterprise, the more investment in innovation, which further illustrates the characteristics of technology-based SMEs; The growth and risk of enterprises have a negative effect on R & D investment, while the profitability has a positive effect. That is, after rapid growth, enterprises do not have enough power to support R & D activities. The stronger the profitability, the higher the net operating profit rate, the enterprises have enough funds to engage in R & D activities. To sum up, the hypothesis 1 that digital finance can enhance enterprise innovation investment has been verified.

4.3. Benchmarking and Moderating Effects of Financial Flexibility on Innovation Input

The test results of the impact of financial flexibility on innovation input of technology-based SMEs are shown in column (5) of **Table 4**. The impact of financial flexibility on innovation input is significantly positive at the level of 1%, and the correlation coefficient is 2.812, indicating that, except for the external digital financial environment, the internal financial reserves and planning of technology-based SMEs have a positive role in promoting innovation input. In addition, by comparing the correlation coefficient, it can be found that compared with digital financial variables, financial flexibility has a stronger impact on enterprise innovation investment, which indicates that in the more complex activity of innovation, technology-based SEMs have limited external financing for various reasons, internal financial planning is more important, and the external economic

Table 4. Regression results.

	Input					
	(1) DIF	(2) COV	(3) DEP	(4) DIG	(5) Fin	(6) Fin (mo)
DIF	0.049*** (9.44)					0.049*** (9.75)
COV		0.041*** (10.44)				
DEP			0.021*** (5.04)			
DIG				0.015** (2.19)		
Fin					2.821*** (12.66)	
DIF*Fin						0.009** (2.05)
owner	-0.030*** (-3.48)	-0.031*** (-3.65)	-0.027*** (-3.20)	-0.026*** (-3.07)	-0.025*** (-2.99)	-0.028*** (-3.37)
separ	0.031** (2.05)	0.038** (2.50)	0.022 (1.41)	0.023 (1.47)	0.028* (1.88)	0.036** (2.43)
bal	-0.292 (-1.33)	-0.267 (-1.22)	-0.304 (-1.37)	-0.329 (-1.48)	-0.369* (-1.70)	-0.365* (-1.72)
interg	0.393** (2.19)	0.370** (2.07)	0.496*** (2.74)	0.574*** (3.17)	0.568*** (3.22)	0.383** (2.20)
indep	0.191 (0.99)	0.137 (0.71)	0.456** (2.36)	0.645*** (3.39)	0.637*** (3.44)	0.179 (0.95)
age	1.112** (2.43)	1.131** (2.48)	1.061** (2.29)	1.053** (2.27)	-0.123 (-0.27)	-0.077 (-0.17)
size	-0.890*** (-6.57)	-0.898*** (-6.65)	-0.850*** (-6.21)	-0.814*** (-5.93)	-0.277** (-1.98)	-0.330** (-2.38)
growth	-1.328*** (-5.32)	-1.374*** (-5.52)	-1.312*** (-5.19)	-1.342*** (-5.29)	-0.879*** (-3.52)	-0.871*** (-3.54)
nps	2.377*** (3.60)	2.432*** (3.70)	2.365*** (3.55)	2.458*** (3.67)	-0.665 (-0.95)	-0.828 (-1.21)
lev	-1.123*** (-6.02)	-1.099*** (-5.90)	-1.219*** (-6.47)	-1.289*** (-6.83)	-0.808*** (-4.31)	-0.663*** (-3.58)

Continued

Constant	16.748***	18.272***	19.952***	20.020***	13.582***	7.412**
	(5.53)	(6.12)	(6.56)	(6.22)	(4.50)	(2.45)
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
N	3216	3216	3216	3216	3216	3216

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Source: according to the running results of the stata software on the samples.

environment is stable in most cases, which is “inclusive” for all enterprises. At this time, the enterprise’s internal “particularity” and risk prevention and tolerance will play an important role in its R & D investment. Therefore, hypothesis 2 is verified.

This paper uses a regression model with a product term to test whether financial flexibility has a moderating effect between digital finance and technology-based SMEs’ innovation investment. The results are shown in column (6) of **Table 4**. The interaction term DIF * Fin is significantly positive at the 5% level, and the correlation coefficient is 0.009, indicating that financial flexibility has a positive moderating effect. It can be seen that while technology-based SMEs rely on external finance to carry out innovation activities, the accumulation of internal financial flexibility funds will play a “supplementary” or “foreseeing” role in the innovation activities of enterprises to a large extent. Hypothesis 3 is verified.

4.4. Robustness Test

The above model test controls the year and industry effects, but there may be some missing variables at the individual level. Therefore, the fixed effects at the individual level are controlled and tested again. The results are shown in column (1) of **Table 5**. After controlling the fixed effect at the individual level, the estimated coefficient of the impact of digital finance on enterprise innovation input is 0.019, passing the 10% significance test. The robustness test adopts the replacement variable method. The results of replacing R & D input variables are shown in columns (2)-(4) of **Table 5**, which are consistent with the empirical analysis results in this paper.

5. Further Analysis

5.1. Heterogeneity Analysis from the Perspective of Life Cycle

According to Li Yunhe’s criteria for the division of enterprise life cycle (Li et al., 2011), the sample enterprises are divided by using the three-way method to assign values to the four variables, namely, sales revenue growth rate, capital expenditure rate, retained earnings rate and enterprise age. The test results are shown in **Table 6**. The impact of digital finance and financial flexibility on the R

Table 5. Robustness test results.

	Input		Input*	
	(1)	(2)	(3)	(4)
DIF	0.019*	0.0002***		0.0002***
	(1.76)	(10.13)		(10.18)
Fin			0.003***	
			(3.18)	
DIF*Fin				0.00004**
				(2.30)
Constant	2.190	0.099***	0.113***	0.088***
	(0.36)	(8.45)	(9.44)	(7.32)
Company FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	3216	3216	3216	3216

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Source: according to the running results of the stata software on the samples.

Table 6. Regression results of life cycle heterogeneity.

	Input								
	Growth period			Mature period			Recession period		
DIF	0.035***		0.033***	0.056***	0.056***	0.048***		0.051***	
	(3.34)		(3.19)	(7.98)	(8.30)	(4.03)		(4.29)	
Fin		2.187***			3.599***			1.510***	
		(5.49)			(11.44)			(3.49)	
DIF*Fin			0.010		0.012**				-0.002
			(1.06)		(2.00)				(-0.15)
Constant	25.639***	26.016***	21.285***	13.962***	8.451**	0.803	12.527	12.372	10.711
	(4.46)	(4.69)	(3.73)	(3.23)	(1.97)	(0.19)	(1.58)	(1.55)	(1.37)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	870	870	870	1899	1899	1899	447	447	447

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Source: according to the running results of the stata software on the samples.

& D investment of technology-based SMEs is significantly positive at the level of 1% in all three life stages, and the effect is more obvious in the mature stage. For enterprises in the mature period, financial flexibility has a significant moderat-

ing effect, but it has no moderating effect on enterprises in the growth and recession periods, and has a negative correlation with the effect in the recession period.

Specifically, technology-based SEMs have developed rapidly in the growth period, pursuing economies of scale, and are strongly constrained by financing, so there is a large gap in enterprise financing. Digital finance provides possibility for external financing of enterprises through advanced technology and weakening information asymmetry of enterprises. At this time, the internal cash reserves of the enterprise may only meet the current needs to support R & D investment, while the internal and external resource coordination for the enterprise to carry out innovation activities has not been considered, so there is a result that the financial flexibility itself is significant and the regulatory role is not significant. Mature technology-based SMEs have not only achieved some achievements in innovation, but the profits accumulated by these achievements have brought sufficient cash flow to the enterprise. Looking for external financing under the current state, the accumulation of internal cash makes the financial flexibility of the company more abundant at present and in the future, and for companies that are seeking new profit growth points at this time, their R & D investment must also be sufficient. After entering the recession period, the financial deterioration of enterprises leads to bankruptcy risk. The financial flexibility has shown a negative regulatory effect between the external financial environment and R & D investment. The possible explanation is that technology-based SMEs no longer have the ability to innovate.

5.2. Heterogeneity Analysis from the Perspective of Region

Due to the regional differences in China's economic development level, the external infrastructure conditions that digital finance relies on have significant advantages in the eastern region. As shown in **Table 7**, the impact of digital finance on R & D investment of technology-based SMEs is significantly positive correlated at the level of 1% in the eastern and central regions, but not significant in the western regions; The impact of financial flexibility on R & D investment of enterprises is significantly positive correlation in the eastern and western regions; the moderating effect of financial flexibility only passes the 5% significance test in the eastern region.

Specifically, the eastern region has a better digital development relying on the advantages of economy, location and infrastructure, which makes digital finance a high substitute for traditional finance; In addition, there are a large number of technology-based SEMs. Driven by the competitive power, they have a high demand and enthusiasm for innovative activities. Compared with the eastern region, the innovative financing of enterprises in the central region mostly depends on the external digital financial environment. The possible explanation is that the rapid development of digital finance makes many enterprises want to take the "tailwind" of external financing, so R & D investment mostly comes from external financing. However, due to the immaturity of enterprise development and

Table 7. Regression results of regional heterogeneity.

	Input								
	Eastern region			Central region			Western region		
DIF	0.047*** (7.39)	0.047*** (7.57)	0.086*** (6.52)	0.085*** (6.46)	0.018 (0.67)	0.028 (1.14)			
Fin		2.773*** (10.96)		0.738 (1.31)		4.157*** (5.27)			
DIF*Fin			0.010** (2.04)		0.010 (0.88)				-0.008 (-0.54)
Constant	19.212*** (5.30)	14.256*** (3.93)	7.828** (2.13)	12.774** (2.03)	17.700*** (2.66)	11.722* (1.82)	5.387 (0.44)	3.338 (0.30)	1.619 (0.14)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	2548	2548	2548	417	417	417	251	251	251

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Source: according to the running results of the stata software on the samples.

insufficient attention to internal financial reserves, financial flexibility naturally did not play an active role in regulation. Due to the weak level of local economic development and low coverage of digital infrastructure, the impact of digital finance on enterprises' R & D investment in western China is not significant. However, under the constraint of external financing, enterprises can attach importance to internal financial planning. But due to the lack of effective coordination and cohesion between the internal and external, and the constraints of their own economic development, financial flexibility plays a negative role in the regulation, but it is not significant.

6. Conclusion and Enlightenment

Based on the financial data of listed companies on the Growth Enterprise Market from 2013 to 2020, this paper conducts an empirical study on the relationship between digital finance, financial flexibility and R & D investment of technology-based SMEs, and draws the following conclusions: 1) Digital finance has a positive effect on R & D investment of technology-based SMEs; 2) Financial flexibility has a positive effect on the innovation input of technology-based SMEs, and plays a positive regulatory role between digital finance and enterprise R & D investment; 3) Digital finance has a positive effect on R & D investment of enterprises in different life cycles, which is more effective in the mature period, but the regulatory role of financial flexibility is heterogeneous for enterprises in different life cycles; 4) The impact of digital finance on enterprise innovation investment is heterogeneous among regions, but not significant in the western

region; The impact of financial flexibility on enterprise innovation input is not significant in the central region, and there is also heterogeneity among the three regions.

The conclusions of this paper have the following policy implications: 1) We should steadily promote the development of the external digital financial environment, promote a more effective balanced flow of financial resources among regions, improve the financial hardware facilities and networking construction in underdeveloped regions, weaken the digital financial development gap between regions, and provide good financing conditions for the innovative investment of technology-based SMEs; 2) Technology-based SEMs should maintain a reasonable matching level of cash, debt and external financing capabilities to ensure that enterprises can quickly and cheaply obtain adequate financial resources when responding to external emergencies and strategic adjustments. They should develop flexible financial policies and budget management levels by ensuring reasonable financial flexibility to improve their ability to deal with risks; 3) Pay attention to the coordination of internal and external resources. The R & D investment of technology-based SMEs should not only give play to the conditions brought by external financial resources, but also play the role of their own financial flexibility. The two should cooperate to predict and perceive the combination of resources, so as to better play a supporting role in innovation activities; 4) The government should vigorously develop a multi-level capital market, so that enterprises at different stages of development can obtain the resources needed for innovation activities, enhance enterprise value under the role of innovation, and open up new paths for enterprise operation.

Project Source

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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