The Information Technology and Corporate Innovation: Evidence from China's Listed Companies

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Abstract—In the past few years, the digital economy and digital finance have developed rapidly in China and have had a far-reaching impact on enterprises. By constructing a linear model, this paper evaluates this impact from the perspective of enterprise innovation. The study found that, on average, increasing the coverage of digital finance by one unit will increase the R & D expenditure of enterprises by 0.91%. Heterogeneity analysis found that compared with large-scale enterprises, the development of digital finance has a greater impact on the R & D expenditure of small and medium-sized enterprises.

Keywords-Digital Finance; Innovation; empirical research

1 INTRODUCTION

Due to the inherent limitations of the economic system driven by the market, it is difficult for individuals and small and micro enterprises with high credit risks to obtain financial support from commercial banks. In addition, affected by the "dual" economic structure prevailing in urban and rural areas, it is still difficult for rural families to enjoy convenient financial services [1]. Inclusive Finance allows these marginalized populations to diversify their sources of capital and overcome the challenges of difficult financing and excessive financing costs. Inclusive finance has the potential to extend the range and depth of financial services while simultaneously promoting the long-term sustainability of financial institutions. As a result, the rapid development of inclusive financial services promotes social equity, promotes the growth of small and micro enterprises, reduces rural poverty, improves the economic and social status of farmers, creates a more reasonable financial ecological environment, and ultimately leads to economic development and social well being. Despite the strategic necessity of Inclusive Finance for social and economic development, due to the instinct of commercial banks to pursue profits, the development of Inclusive Finance still needs to be promoted under the public policy led by the government. Its main core tasks are: first, to promote the financial authorization of vulnerable groups; second, to enhance the competition in the financial market.

In the past five years, with the popularization and implementation of China's inclusive financial policies, the inclusive financial functions of commercial banks have been further improved, and the inclusive financial business represented by large state-owned commercial banks has achieved

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unprecedented development [2]. In 2017, large state-owned commercial banks completed the establishment of the inclusive finance division, among which the industrial and Commercial Bank of China established 230 small and micro-financial business franchise institutions; the Bank of communications established the mechanism of "franchise team + traditional network" and gradually promoted the modes of business division system assignment; The Agricultural Bank of China has implemented the two-wheel-drive mode of "agriculture, rural areas and farmers + inclusive"; Bank of China established Inclusive Finance Division Based on Bank of China fudeng village bank. With the establishment of more inclusive financial departments of joint-stock banks and the continuous innovation of financial formats on Internet platforms such as P2P and equity crowd funding, the supply of financial services for "agriculture, rural areas and farmers" and small, medium and micro enterprises has been greatly improved. In novel corona virus pneumonia, inclusive finance played an important role, providing financial support for a large number of small and micro businesses to tide over difficulties. According to statistics published by the People's Bank of China, the balance of inclusive small and micro loans at the end of 2020 was 15.5% 10 trillion yuan, a year-on-year increase of 30.5% 30%, an increase of 3.5% in the whole year 52 trillion yuan, an increase of 1.5% over 2019 43 trillion yuan. Inclusive financial business is bound to be an important growth point for commercial banks in the future [3].

Furthermore, as the digital economy has grown, emerging technologies such as artificial intelligence (AI), cloud computing, block chain, and big data have become a powerful driving force for financial digitization, expanding the breadth and depth of financial service companies [4]. As an important driving force of credit science and technology, digital finance continues to play an important role in enabling finance with science and technology to serve the real economy and help banks build their independent capacity of digital credit. Inclusive Finance is an important field and focus of digital transformation and application of commercial banks. Digital transformation will promote the innovation of customer acquisition channels, marketing methods, customer service, credit rating, and risk control means of inclusive financial business, and solve the practical difficulties in customer acquisition cost, risk management, and product design in the inclusive financial business to a certain extent. Digital inclusive finance was created with the use of digital technology. Everything that can promote the growth of Inclusive Finance through financial technology is referred to as digital inclusive finance. At the moment, all state-owned commercial banks are making significant progress in the second stage of digital inclusive finance development.

While digital technology provides convenience and real-time advantages for inclusive financial services, it also brings a series of new problems such as data competition, data security, technical specifications, and so on [5-6]. Digital Inclusive Finance is not only the growth point of commercial bank business development but also the main carrier to realizing its social responsibility. Due to this connotation and characteristics of digital Inclusive Finance, its business expansion has inherent deficiencies. For a long time, digital inclusive finance still needs policy support. From the standpoints of technology, economy, and management, the integrated development of digital technology and inclusive finance should continue to be developed and enhanced.

Technological innovation is a new driving force and new growth point of economic growth in various countries [7]. As a key element of China's economic system, the technological innovation ability of small and medium-sized enterprises is directly related to the healthy and stable development of society and the market economy [8]. However, due to the structural imbalance

of China's traditional financial system and the restrictive characteristics of enterprises, most enterprises are easy to fall into financing difficulties when developing new technologies. In theory, digital finance can significantly improve the inclusive nature of financial services [8]. It is an effective tool to help enterprises solve financing problems and speed up technological innovation. However, in practice, there is no clear conclusion on whether digital finance can promote enterprises break through the financing bottleneck and carry out technological innovation activities.

This article explores the impact of the development of digital finance on enterprise innovation, based on the aforementioned context. This paper's structure is as follows: The research design introduces the data source, variable definition, and model specification; the empirical results include benchmark regression results and heterogeneity analysis; the robustness test is the fourth element; and the conclusion is the fifth part.

2 RESEARCH DESIGN

2.1 Data Source

This paper uses two databases. The data of Shanghai and Shenzhen A-share enterprises comes from China Stock Market & Accounting Research Database (CSMAR). CSMAR is an economic and financial database developed by Sishma to the needs of academic research, drawing on the processing methods of CRSP (the Center for Research in Security Prices), Compustat, and other international well-known databases, and combined with China's actual national conditions. The database is current China's most complete, accurate, and comprehensive financial and economic database. In recent years, more than 60000 high-quality academic papers using the CSMAR series research database and its research services have been published in first-class journals at home and abroad, and these academic papers have been cited by subsequent researchers. Domestic includes Economic Research, Accounting Research, Financial Research, etc., while foreign countries include the Journal of Finance, Journal of financial economics, Journal of business, Journal of accounting research, etc. This paper filters the data according to the following process: (1) Excluding the sample of companies in the financial industry; (2) Eliminate the samples of companies subject to ST and *ST; (3) Eliminate samples with missing values of variables; (4) Considering the influence of extreme values, the method of winsorize is used to deal with the main continuous variables by 1% level.

The digital inclusive finance index comes from the digital finance research centre of Peking University. The Peking University Digital Finance Research Center and ant financial group established a joint research group to build this set of "Peking University Digital Inclusive Finance Index" using ant financials' massive data on digital Inclusive Finance to empirically and accurately describe the development status of China's digital Inclusive Finance. There are two periods in the index. The first era spans 2011-2015, while the second spans 2016-2018. The "Peking University Digital inclusive finance index," which is the subject of this paper, is in its second phase. The spatial span of the index includes three levels: provincial, city, district, and county. The time period is based on the first phase, which runs from 2011 to 2015, and is supplemented by data from 2016 to 2018. This set of indexes reflects many dimensions of digital

Inclusive Finance, such as coverage, depth of usage, and degree of digitization, as well as sub-indexes of payment, insurance, monetary fund, credit services, investment, credit, and other businesses, in addition to the overall index. In particular, to maintain the vertical consistency and comparability of the index, the research group strives to stabilize the index system and index calculation method when compiling the second index; But at the same time, it also takes into account the reality of further innovation of digital finance and adds a small number of indicators reflecting the latest business trends.

2.2 Model Specification

This paper uses a linear model and OLS estimation to investigate the impact of digital finance coverage on enterprise innovation. The model is as follows:

$$R\&D_i = \alpha_0 + \alpha_1 \times coverage\ breadth_i + \boldsymbol{x_i'\beta} + \varepsilon_i \quad (1)$$

Where the dependent variable is the logarithm of enterprise R & D expenditure. α_0 is constant. $coverage\ breadth$ is the core independent variable. According to previous literature, $\boldsymbol{x_i'}$ is control variable, including listing age, total asset, total debt, the shareholding ratio of the largest shareholder, the nature of ownership (state-owned enterprises and foreign-funded enterprises, dummy variables), the board size, the number of independent directors, executive salary and rate of the asset [9-10]. The variable definition is shown in table 1.

Table 1 Variable Definition

variables	type	definition
Coverage Breadth	Core independent variable	Please see the Peking University Digital Finance Inclusive Index 2018
R&D	Dependent variable	Research and development expenses
Asset, unit: 10000 Yuan	Control variables	Total asset at year-end
Debt, unit: 10000 Yuan		Total asset at year-end
Age		Listing age
top1		The shareholding ratio of the largest shareholder
SOE=1		Stated-owned enterprises=1, otherwise 0
Foreign=1		Foreign-funded enterprises=1, otherwise 0
Board Size		The number of directors
No. of Independent Director		The number of independent directors
Salary, unit: 10000 Yuan		Executive salary
ROA, %		Rate of asset

2.3 Summary Statistics

In this set of data, the average value of coverage breadth is 193.23. The minimum value is -10.49. The maximum value is 290.31. Later, we can find that the average value of his total assets at the end of the period is 1309503, but his total liabilities at the end of the period are indeed 802120.3, which indicates that the company may be losing money. The data mentions that their maximum board size is 15 but their maximum number of independent directors is 5, which suggests that many board members may not have actual rights. The data shows that their average salary is370.87 but the maximum salary is indeed 2411.1, indicating that the company's salary distribution may not be reasonable.

Table 2 Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
Coverage Breadth	193.2397	60.7071	-10.49	290.3175
R&D, unit: 10000 Yuan	10130.243	22917.993	0	148001.8
Asset, unit: 10000 Yuan	1309503	4177095.3	18657.975	45434239
Debt, unit: 10000 Yuan	802120.3	2967420.7	3627.572	33624640
Age	9.5128	7.2835	0	25
top1	35.082	15.2319	.29	99
SOE=1	.3766	.4845	0	1
Foreign=1	.0482	.2141	0	1
Board Size	8.6247	1.7189	5	15
No. of Independent Director	3.1852	.5694	2	5
Salary, unit: 10000 Yuan	370.8776	357.9202	15.7712	2411.08
ROA, %	4.4138	6.3487	-32.8121	23.4179

3 EMPIRICAL RESULTS

3.1 Benchmark Regression

In this part, this paper employs unbalanced panel data from 2011 to 2018, and the OLS estimation method and benchmark regression are shown in table 3. The independent variable in Column (1) only includes the coverage breadth of digital finance. Estimation results in column (2) contain control variables. The complete model is shown in column (4), which includes both control variables, time fixed-effect, and industry fixed-effect.

The coefficient reported in column (1) is 0.0258 and significant at 1% level, which shows the statistical correlation between enterprise R & D expenditure and the coverage breadth of digital finance. From the complete model in column (4), increasing the coverage of digital finance by one unit will increase the R & D expenditure of enterprises by 0.91%.

This paper holds that the continuous innovation and upgrading of digital finance can provide better financial services for enterprise technological innovation. Although there are significant hazards associated with the digital digital finance model's innovation process, generally, digital

finance has effectively supported the improvement of traditional financial services using current information technology. On this foundation, digital finance can offer a wider range of financial services tailored to the needs of small and medium sized businesses, lower enterprise financing costs through digital technology, expand financing channels for technological innovation, and encourage small and medium-sized businesses to actively promote technological innovation. Compared with traditional finance, digital finance can comprehensively assist enterprises to obtain more technology R & D funds and effectively enhance the innovation level of enterprises from the aspects of financing channels, service threshold, risk prevention, financing efficiency, and credit investigation system.

Table 3 Benchmark Regression

	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
VARIABLES	Ln R&D	Ln R&D	Ln R&D	Ln R&D
Coverage Breadth	0.0258***	0.0244***	0.0101***	0.0091***
	(0.0009)	(0.0009)	(0.0017)	(0.0016)
Age		-0.1564***		-0.2116***
		(0.0284)		(0.0220)
Age-sq		-0.0070***		0.0014
		(0.0012)		(0.0009)
Ln asset		1.7617***		1.6555***
		(0.1254)		(0.1034)
Ln debt		-1.1338***		-0.5429***
		(0.0919)		(0.0759)
top1		-0.0316***		-0.0045
		(0.0037)		(0.0030)
SOE=1		-0.9702***		-0.1931*
		(0.1465)		(0.1139)
Foreign=1		-0.6303***		-0.5563***
		(0.1980)		(0.1796)
Board Size		0.0259		0.0712*
		(0.0452)		(0.0372)
No. of Independent Director		0.0156		-0.1199
		(0.1413)		(0.1149)

Ln salary		0.5311***		0.6030***
		(0.0840)		(0.0655)
ROA, %		0.0021		0.0079
		(0.0083)		(0.0070)
Constant	8.8712***	-10.0314***	10.3617***	-20.8228***
	(0.1910)	(1.3019)	(0.3764)	(1.1248)
Observations	18,854	18,854	18,854	18,854
R-squared	0.0454	0.1729	0.4494	0.5042
Data	Unbalanced	Unbalanced	Unbalanced	Unbalanced
Industry Dummy	No	No	Yes	Yes
Year Dummy	No	No	Yes	Yes

3.2 Heterogeneity Analysis

The development and promotion of digital Inclusive Finance, as a type of financial infrastructure, not only compensates for the shortcomings of traditional finance, but also provides a foundation for small and medium-sized businesses to alleviate financing constraints and promote technological innovation. As a result, in this section, the research explores the varied effects of the development of digital finance on enterprise R&D innovation. Specifically, this paper regards the enterprises with total assets above the 50th percentile as large-scale enterprises, and the dummy variable is 1, otherwise 0. To investigate the heterogeneity, the model needs to include the coverage of digital finance, dummy variables, and the interaction between them. The estimated results of heterogeneity analysis are shown in Table 4. From the estimation results, it can be found that the interactive term coefficient is negative, the estimation coefficient of the impact of digital financial development on R & D expenditure of small and medium-sized enterprises is 0.0083, and the impact on large-scale enterprises is 0.0045 (0.0083-0.0045). Therefore, the impact of the development of digital Finance on Enterprise R & D innovation has a significant scale effect.

Table 4 Heterogeneity Analysis

	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
VARIABLES	Ln R&D	Ln R&D	Ln R&D	Ln R&D
Coverage Breadth	0.0256***	0.0233***	0.0104***	0.0083***
	(0.0010)	(0.0009)	(0.0018)	(0.0017)
Dummy	8.5796***	11.6583***	1.9957	1.3779
	(1.6271)	(1.6292)	(1.2859)	(1.2541)
Dummy × Coverage Breadth	-0.0315***	-0.0399***	-0.0045***	-0.0038***
	(0.0064)	(0.0063)	(0.0006)	(0.0009)

Constant	8.8740***	-8.4235***	10.4426***	-19.6573***
	(0.1965)	(1.3519)	(0.3772)	(1.1657)
Observations	18,854	18,854	18,854	18,854
R-squared	0.0466	0.1767	0.4529	0.5050
Data	Unbalanced	Unbalanced	Unbalanced	Unbalanced
Controls	No	Yes	No	Yes
Industry Dummy	No	No	Yes	Yes
Year Dummy	No	No	Yes	Yes

4 ROBUSTNESS TEST

To check whether the conclusion of this paper is robust, in this part, this paper uses balanced panel data and fixed effect regression to re-estimate the model (1). The estimation results are shown in Table 5, and the conclusion of this paper is robust.

Table 5 Robustness Test

	(1)	(2)	(3)	(4)
	Panel FE	Panel FE	Panel FE	Panel FE
VARIABLES	Ln R&D	Ln R&D	Ln R&D	Ln R&D
Coverage Breadth	0.0294***	0.0440***	0.0048***	0.0080***
	(0.0010)	(0.0015)	(0.0006)	(0.0003)
Constant	8.1464***	-6.2133**	12.0149***	-11.7888***
	(0.2411)	(2.8862)	(0.5965)	(2.5665)
Observations	13,344	13,344	13,344	13,344
Number of id	1,668	1,668	1,668	1,668
Controls	No	Yes	No	Yes
Data	Balanced	Balanced	Balanced	Balanced
Year Dummy	No	No	Yes	Yes

5 CONCLUSION

This article finds that the development of digital finance stimulates enterprise R&D and innovation, based on data from A-share listed companies in Shanghai and Shenzhen and the digital inclusive financial index. Furthermore, the impact of digital finance on enterprise R&D innovation has a large-scale effect. As a result, the following suggestions are made in this paper:

First, guide enterprises to allocate assets reasonably and avoid "emphasizing falsehood over reality" of assets. On the one hand, enterprises should establish a correct investment concept, reasonably allocate the proportion of financial assets and operating assets, and avoid entering the trap of speculative arbitrage due to excessive financing constraints. On the other hand, relevant

departments should actively guide and support the development of new financial services, improve the efficiency and level of financial services, establish multi-level and diversified financing channels, and enhance the financial inclusive effect.

Second, encourage enterprises to accelerate digital transformation. Firstly, facing the increasingly fierce market competition, enterprises should strengthen the transformation of digital consciousness and digital management, and upgrade the digital transformation to the strategic level of the company; Secondly, enterprises should pay attention to technological innovation.

Third, we should vigorously develop digital Inclusive Finance to boost the construction of innovative countries. The 14th Five Year Plan period is the initial stage of China's new journey of building a socialist modern country. The digital economy provides effective support for better improving the benefits of economic growth. Driven by digitalization, China's innovative technologies and products are moving towards globalization, further implementing the new development concept of accelerating the construction of an innovative country, leading new drivers of economic growth, and providing a steady stream of innovative vitality for the real economy.

Fourth, strengthen the support of digital Inclusive Finance and help the development of financing vulnerable enterprises. In terms of financial scope, enhance the digital finance infrastructure, give full play to the Internet platform's driving role in the digital transformation of vulnerable enterprises, overcome the time and space restraints of traditional financial business, improve financial coverage, enhance vulnerable enterprises' ability to expand their online business, and promote the inclusive finance process. We use digital technologies like 5G, cloud computing, artificial intelligence, and the Internet of Things to build diverse financial service formats, reduce credit risk, improve fund utilization efficiency, provide more convenient and lower-cost financial services for businesses, and improve the quality and efficiency of real-economy development.

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