The Impact of Financial Technology on Corporate Innovation

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Introduction

Innovation is the key to high-quality development of an enterprise. However, the large demand for funds for innovation projects, high uncertainty, and inherent information asymmetry can also induce problems such as adverse selection and moral hazard, making corporate innovation activities face serious external financing difficulties.

In recent years, science and technology have contributed to the development of the financial market. It has focused on distributed computing technology led by cloud computing and blockchain, security technology led by biometrics and digital encryption technology, and big data driven by emerging technologies such as artificial intelligence, financial technology has ushered in explosive growth. Through cutting-edge digital technology, fintech can obtain more information about borrowers, give birth to new financial service models, expand the coverage of financial services, and broaden the channels for companies' reefs, which may effectively promote the production of companies. **Therefore, clarifying the impact of financial technology development on corporate innovation and its mechanism has important practical significance for innovation to drive the high-quality development of the Chinese economy and enhance the function of financial services in the real economy.**

The possible marginal contributions of this article are as follows: **1. Based on the Internet big data search engine, we propose an index for the development of financial technology. 2. We incorporate financial technology into the analysis framework of corporate innovation, and enrich existing research on corporate innovation.**

Economic Mechanism

The development of financial technology can ease the financing constraints of enterprises by reducing the information asymmetry between banks and enterprises, thereby promoting enterprise innovation. Huang et al. (2018) used Alibaba's data and found that when reviewing loans, Ant Financial will use non-financial information other than traditional loan review information, including sales information, to assist in loan review, which not only reduces The information asymmetry between the two parties has been improved, and the quality of financial services has been improved, which has further promoted the development of the real economy including innovation.

The development of financial technology can also speed up the credit approval process, thereby alleviating financing constraints and reducing financing costs. Fuster et al. (2019) used US housing credit data to control a series of factors that may affect the mortgage loan approval

process, and found that fintech has increased the loan approval speed by 20% without increasing the loan default risk.

Fintech makes external financing inclusive and lowers the financing threshold of the financial market. Under the traditional financial service model, banks and other financial institutions pay more attention to the hard assets that companies can mortgage, while ignoring technology and innovation capabilities, making it difficult for companies with fewer hard assets but greater growth potential to obtain financing, thus hindering companies Innovation. Fintech uses big data, artificial intelligence, blockchain and other advanced technologies to conduct a comprehensive analysis of various financial service entities, form an ecological map of the technology industry, expand the coverage of financial services, and lower the entry barriers for the credit market.

Fintech is also conducive to the efficient implementation of corporate innovation incentive policies by thousands of governments. The high investment in innovation projects and the uncertainty of innovation results make it difficult for government departments to obtain information about enterprise innovation and distinguish the advantages and disadvantages of innovation projects. Fintech uses big data technology to comprehensively evaluate the characteristics of enterprises so that the government can effectively identify enterprises with innovative potential, which is conducive to the government's fiscal and tax policies to alleviate the financing difficulties of enterprises, thereby stimulating the innovative vitality of enterprises.

Data Sources

This article takes the listed companies on the New Third Board as the research object. The reasons for choosing NEEQ companies are mainly based on the following considerations: 1. Innovative entities are mainly small and medium-sized enterprises; 2. There are many listed companies, more than 11,000, and they are widely distributed in all provinces across the country, covering regions with different development levels of financial technology; 3. Useful external audited financial data.

The patent data of NEEQ listed companies used in this article comes from the patent database of Baiteng.com; the development level of financial technology at the prefecture-level city or municipality level comes from the number of results of relevant keywords in Baidu news advanced searc; the data on the level of regional financial development comes from the Chinese banking industry Commercial bank branch data published by the Supervision and Management Committee; financial data, board-related data, and research and development data of the NEEQ companies come from the CSMAR database and WIND database; the relevant data on the city characteristics of the company comes from the "China City Statistical Yearbook."

In order to make the sample data more representative, this article processes the sample data as follows: 1. Eliminate the samples of financial listed companies such as banks, securities, insurance, etc.; 2. Eliminate the samples with missing data in the main variables; 3. Eliminate the book value of owner’s equity Negative company samples; 4. Cut 1% double-sided tailing for continuous variables in order to eliminate the interference of outliers on the results of this paper. After the above

processing, the final sample involved 23558 company-annual observation values from 2011 to 2016.

Model Construction

With reference to Nanda and Rhodes-Kropf (2013), this paper constructs the following regression model to analyze the impact of financial technology development on enterprise innovation output:

$$\boldsymbol{Patent_{i,t} = \alpha + \beta Fintech_{m,t} + \gamma Controls + \delta_i + \theta_{t,j} + \epsilon_{i,t}}$$

The dependent variable $\boldsymbol{Patent_{i,t}}$ is the innovation output of company $\boldsymbol{i}$ in year $\boldsymbol{t}$, which is measured by the number of company patent applications; the explanatory variable $\boldsymbol{Fintech_{m,t}}$ represents the financial technology development level of the city $\boldsymbol{m}$ where company $\boldsymbol{i}$ is located in year $\boldsymbol{t}$; ***Controls*** are other control variables that represent the characteristics of the individual enterprise and the city level, including enterprise size (***Size***), asset-liability ratio (***LEV***), enterprise growth (***Growth***), capital expenditure ratio (***CapEx***), fixed assets Ratio (***PPE***), board independence (***Indep***), urban GDP (***GDP***), urban population (***Population***), etc.; $\boldsymbol{\delta_i}$ represents the company's individual fixed effects. Since the regional fixed effects will be absorbed by the company's individual fixed effects, this article essentially controls Regional fixed effects; $\boldsymbol{\theta_{t,j}}$ represents the year-industry fixed effects to control unobservable factors that change over time at the industry level. The subscript $\boldsymbol{t}$ represents the year and j represents the industry. The fixed effects controlled in this article are more stringent than the existing literature; $\boldsymbol{\epsilon_{i,t}}$ represents random Errors. The coefficient $\boldsymbol{\beta}$ of the key explanatory variable $\boldsymbol{Fintech_{m,t}}$, represents the impact of financial technology development on enterprise innovation. According to the research hypothesis in this article, the coefficient $\boldsymbol{\beta}$ is expected to be significantly positive.

Variable Construction

Patent. The innovation measurement of an enterprise is divided into innovation input and innovation output. Since the R&D expenditures of NEEQ companies are relatively large, this article mainly uses the natural logarithm of the total number of patent applications by companies to measure the innovation of companies. Considering that the number of annual patent applications of many sample companies is 0, and the distribution of the number of patent applications has an obvious thick tail, it is necessary to add 1 to the number of patents and take the natural logarithm.

Fintech. This article extracts key words related to financial technology based on important news and conferences. Match these keywords with all prefecture-level cities or municipalities in China, search for prefecture-level cities or municipalities + keywords in Baidu News Advanced Search by year, such as searching for "Beijing + Blockchain", Baidu News Advanced Search can give you 2011 -The number of news pages containing both "Beijing" and "blockchain" in 2016. Using web crawler technology, extract the number of search results, and add up the number of search results for all keywords at the same prefecture-level city or municipality level to get the search volume (***Fintech_R***). Because the distribution of this indicator has a significant right-skewedness, this

article makes a logarithmic transformation of this indicator as an indicator to measure the level of financial technology development (***Fintech***) at the prefecture-level city or municipality level.

Size. Enterprise size is an important factor affecting innovation. The larger the enterprise, the stronger the production capacity and the higher the reputation. For the sustainable development of the enterprise, the more inclined it is to make long-term investment and improve the enterprise's risk management ability through innovation and other methods. This article selects the logarithm of total assets to measure the size of the enterprise.

LEV. The debt-to-asset ratio represents the company's capital structure and solvency, and reflects the company's ability to borrow money. When the leverage faced by the enterprise is low, continuous R&D investment can be guaranteed, so the innovation ability is stronger. This article uses the ratio of year-end liabilities to year-end total assets to measure the debt-to-asset ratio (***LEV***).

Growth. Enterprise growth has an important influence on innovation behavior. Companies with strong growth tend to have greater growth potential. When investment in innovative projects is not optimistic, good market expectations enable them to respond to related risks. This article uses the year-end growth rate (***Growth***) of total assets to measure the growth of a company.

CapEx. The capital expenditure ratio is an incremental concept, which usually refers to all expenses that can increase the value of fixed assets. Since fixed assets can reflect the production and technical conditions of an enterprise to a certain extent, the larger the capital expenditure ratio, the better the production and technical conditions of the enterprise, and the higher the innovation enthusiasm of the enterprise. This article uses the ratio of the total cash paid for the purchase and construction of fixed assets, intangible assets and other long-term assets to the total assets at the end of the year to measure the capital expenditure ratio (***CapEx***).

PPE. The higher the proportion of fixed assets, the better the production technology conditions of the enterprise and the stronger the profitability. At the same time, fixed assets can also be used as collateral to improve the financing capacity of enterprises and provide more abundant funds for enterprise innovation projects. Therefore, the more fixed assets a company has, the stronger its innovation capability. This article uses the ratio of total fixed assets to total assets at the end of the year to measure the ratio of fixed assets (***Growth***).

Indep. As an important supervisory force for corporate governance, independent directors are able to make more independent judgments on the company’s innovation and other matters when it comes to major decisions of the company. While playing an important role in internal governance, independent directors can be more neutral and in line with small and medium shareholders. Opinions of interest. Therefore, the higher the independence of the board of directors, the stronger the innovation capability of the enterprise. This article uses the ratio of the number of independent directors to the total number of board members to measure the independence of the board of directors (***Indep***).

In addition, the innovation output of a company is not only the input structure of the company's

unilateral R&D resources, but also has a close relationship with the city where it is located. Cities with high levels of economic development and large populations often have abundant economic resources and a large number of high-quality talents, and the conditions for enterprise innovation are more abundant. Therefore, this article also adds the city's economic development level (***GDP***), population (***Population***) and other factors that control the city level into the control variables.

Table 1: Brief Summary of Main Variables

VarName	Definition	Source	Time
Patent	the natural logarithm of ***Patent_R***	Baiteng.com	2011-2016
Patent_R	the number of annual patents	Baiteng.com	2011-2016
Fintech	the natural logarithm of ***Fintech _R***	Baidu advanced search	2011-2016
Fintech_R	the search volume of keywords	Baidu advanced search	2011-2016
Size	the size of the enterprise	CSMAR & WIND	2011-2016
LEV	the debt-to-asset ratio	CSMAR & WIND	2011-2016
Growth	year-end growth rate of total assets	CSMAR & WIND	2011-2016
CapEx	the capital expenditure ratio	CSMAR & WIND	2011-2016
PPE	the ratio of fixed assets	CSMAR & WIND	2011-2016
Indep	the independence of directors	CSMAR & WIND	2011-2016
GDP	economic development level	City Statistical Yearbook	2011-2016
Population	population	City Statistical Yearbook	2011-2016

Estimation Approach

Benchmark regression. We use a fixed-effect model of financial technology development on enterprise innovation as a baseline. The regression includes control variables at the enterprise and city levels, and controls the fixed effect of year-industry.

Endogenous problems. The development level of regional financial technology may be affected by the innovation behavior of a single enterprise, and there is a reverse causality. In addition, the results may be biased due to omission of indexing or financial technology measurement errors, which may cause endogenous problems.

Instrumental variable method. This article further uses the instrumental variable method to weaken this endogenous problem. Drawing on the ideas of Chong et al. (2013), this article manually sorts out the neighboring cities of all cities and uses the average value of the financial technology development level of all neighboring cities in the same year. This instrumental variable meets the two constraints of relevance and exogeneity: 1. Neighboring prefecture-level cities usually have similar economic development levels, and financial technology development levels are similar; 2. There is geographical segmentation of financing by Thousand Credit The level of regional financial technology development is difficult to influence the innovation of local enterprises through financing channels.

Descriptive Statistics

Table 2 reports the basic statistical characteristics of the main variables. The median of the total number of patents without logarithm (***Patent_R***) is 0, indicating that most companies do not have patent applications; the average annual number of patent applications is only 3.19, indicating that the overall innovation of the NEEQ companies is not strong. This may be because the NEEQ companies mainly come from less innovative industries such as consumer services and public utilities, and it also reflects insufficient innovation of Chinese companies. The average value of the total number of patents without logarithm is much larger than the median, indicating that patent applications have obvious right-skewed characteristics. Therefore, it is reasonable in this paper to do a logarithmic transformation of ***Patent_R*** (***Patent = ln(1 + Patent_R)***) to calculate the enterprise innovation index ***Patent***. Table 2 also reports the statistical characteristics of ***Fintech_R*** without logarithm. The average value of ***Fintech_R*** is 5303, which is much larger than the median of 99, indicating that ***Fintech_R*** also has serious right-skewing characteristics. Therefore, in this paper, the logarithmic change of ***Fintech_R*** (***Fintech = ln(1 + Fintech_R)***) is also reasonable to calculate the Fintech development indicator ***Fintech***.

Table 2: Statistical Characteristics of Main Variables

VarName	Obs	Mean	SD	Min	Median	Max
Patent	23558	0.7055	1.0227	0.0000	0.0000	6.0845
Patent_R	23558	3.1945	9.1892	0.0000	0.0000	438.0000
Fintech	23558	4.5459	1.2975	0.0000	4.6052	15.7756
Fintech_R	23558	5303.2491	1.91e+05	0.0000	99.0000	7.10e+06
Size	23558	18.1074	1.1901	15.4521	18.1071	21.1009
LEV	23558	0.4252	0.2176	0.0326	0.4191	0.9498
Growth	23558	0.0789	0.7250	-5.6888	0.1477	0.8564
CapEx	23558	0.2121	0.1863	0.0014	0.1635	0.7590
PPE	23558	0.1643	0.1587	0.0010	0.1129	0.6639
Indep	23558	0.0193	0.0804	0.0000	0.0000	0.4286
GDP	23558	18.1814	0.9768	15.7329	18.3380	19.4567
Population	23558	6.5266	0.6462	4.7314	6.5813	8.1195

Table 3 reports the changes in the development of financial technology (***Fintech***) in different years and regions. It can be seen that with the popularization of new-generation information technologies such as big data, blockchain, and artificial intelligence, the level of financial technology development has basically shown an upward trend year by year. Through a horizontal comparison of different regions at the same time, the NEEQ listed companies are more distributed in the eastern region during the sample period. The eastern region also has a higher level of financial technology development than the central and western regions due to economic development and rapid technological progress.

Table 3: The Development of Fintech Changes in Different Years and Regions

Year	Eastern Region		Central Region		Western region	
	Obs	Mean	Obs	Mean	Obs	Mean
2011	573	3.6270	113	2.2682	61	3.0210
2012	581	3.7708	110	3.0388	60	3.2448
2013	1625	3.8010	384	2.7896	180	3.1362
2014	4072	4.3094	968	3.3295	471	3.6983
2015	5330	4.9314	1243	3.9742	607	4.4512
2016	5330	5.4967	1243	4.2808	607	4.9168

Empirical Results and Discuss

Benchmark regression. **Table 4** reports the regression results of the fixed-effect model of the development of financial technology on the total output of enterprise innovation. The empirical results show that the coefficients of ***Fintech*** are significantly positive in the regression, indicating that the financial technology development index constructed in this paper is significantly positively correlated with the innovation output of China's new third board listed companies. In an economic sense, considering that the average value of ***Patent_R*** for innovation output without logarithm is 3.19, for every 1% increase in the city's financial technology development level, the number of patent applications by local companies will increase by about 0.17 on average (that is, 3.19x0.0543= 0.17). The possible reason is that the use of big data technology in the development of financial technology has reduced the information asymmetry between banks and enterprises, increased the speed of credit approval, and enabled financial services to accurately target small and medium-sized enterprises that lack collateral but have innovative potential. This solves the problem of the shortage of corporate innovation funds.

The relationship between the control variables in the regression results and corporate innovation behavior has basically reached theoretical expectations: the coefficient of corporate size (***Size***) is positive, and reaches a significance level of 1%, indicating that large companies have stronger innovation capabilities; assets and liabilities The coefficient of ***LEV*** is significantly negative at the 1% level, indicating that debt management is not conducive to corporate innovation; the coefficient of independence of the board of directors (***Indep***) is significantly positive, indicating that better corporate governance can promote corporate innovation.

In addition, we used Python and Stata to implement a fixed-effect model at the same time. In theory, despite using different programming languages, the regression coefficients of the two should be exactly the same, but the fact is not the case. **The reason is that we added 276 dummy variables that control the year-industry effect in the regression. Too many control variables cause the problem of multicollinearity, and Python and Stata handle it differently. In Python, we introduce the generalized inverse solving coefficients, while in Stata, the variables that cause the multicollinearity problem are deleted by default.** But we can see by comparison that the signs

of all coefficients, the significance of most of the coefficients, and the difference of most of the coefficients are not much different.

Table 4: Benchmark Regression Results

	(Stata)	(Python)
	Patent	***Patent***
Fintech	0.0543***	0.1116***
	(3.2356)	(6.3017)
Size	0.1208***	0.1490***
	(6.8222)	(7.4874)
LEV	-0.2607***	-0.3085***
	(-5.9162)	(-6.1714)
Growth	-0.0065	-0.0220*
	(-0.6504)	(-1.8014)
CapEx	-0.1269	-0.1388
	(-1.1205)	(-0.9539)
PPE	0.2718*	0.3111*
	(1.8883)	(1.7311)
Indep	0.4477**	0.5043**
	(2.4451)	(2.3017)
GDP	0.2183	0.8545***
	(1.4186)	(6.2174)
Population	-0.1082	-0.1951
	(-0.3948)	(-0.6407)
Entity_effect	Yes	Yes
Year*Industry	Yes	Yes
N	23558	23558

t statistic in parentheses, * p < 0.1, ** p < 0.05, *** p < 0.01

Instrumental variable method. Table 5 shows the regression results of the instrumental variables. After considering the possible endogenous problems between financial technology and corporate innovation, the coefficient of financial technology development is still positive, indicating that the development of financial technology can significantly promote corporate innovation output. The previous results are exactly the same.

Table 5: Instrumental Variable Regression Results

	(Stata)	(Stata IV)	(Python IV)
	Patent	***Patent***	***Patent***
Fintech	0.0543***	0.6585*	0.2999
	(3.2356)	(1.6683)	(1.1513)
Size	0.1208***	0.0994***	0.1002***
	(6.8222)	(3.1120)	(2.7500)
LEV	-0.2607***	-0.0585	-0.0716**
	(-5.9162)	(-1.6025)	(-2.1614)

Growth	-0.0065	-0.0008	-0.0008
	(-0.6504)	(-1.6034)	(-1.3705)
CapEx	-0.1269	-0.1313	-0.1468
	(-1.1205)	(-1.1811)	(-1.0258)
PPE	0.2718*	0.2640	0.2850
	(1.8883)	(1.5965)	(1.6222)
Indep	0.4477**	0.4576***	0.4637**
	(2.4451)	(2.7248)	(2.1145)
GDP	0.2183	0.0773	0.3078
	(1.4186)	(0.1810)	(0.3202)
Population	-0.1082	-0.7488	-0.4215
	(-0.3948)	(-1.1780)	(-1.4376)
Instrumental variable	No	Yes	Yes
Entity_effect	Yes	Yes	Yes
Year*Industry	Yes	Yes	Yes
N	23558	23484	23484

t statistic in parentheses, * p < 0.1, ** p < 0.05, *** p < 0.01

Future research work

The research conclusions of this article show that the development of regional financial technology has promoted the innovation process of enterprises, which is manifested in the increase in the number of patent applications. In order to further explore the mechanism of financial technology's impact on corporate innovation, in the future, external financing can be considered as an entry point, mainly from the perspectives of mitigating financing constraints and improving the efficiency of the use of some external funds.

Appendix

The data and code are found in the Advanced Econometrics repository in my GitHub. CharlieSCC/Advanced-Econometrics (github.com)

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