



Fintech and Enterprise Digital Innovation - Evidence from Patent Text Information

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Abstract. In today's digital economy age, the principal propellant of China's economic progression is the innovation of digital technology. This study explores China's extent of digital innovation by reviewing the digital patents from Shanghai and Shenzhen A-share listed enterprises between 2012 and 2021. It investigates the impact of regional fintech development on enterprise digital innovation. The study reveals a meaningful and positive correlation between the progress in fintech and the digital innovation of enterprises. This result has been confirmed in the robustness test using instrumental variables, system GMM, and replacement of core variables. Furthermore, the subsequent research has also discovered whether the development of regional fintech can alleviate the issue of information asymmetry between banks and enterprises, thus reducing the credit rationing and financing constraints imposed on businesses, indicating "information effect" and "resource effect". Therefore, during China's economic transition, We ought to perpetually drive fintech progression, employ contemporary technology in financial utilities, enhance the service of finance to the tangible economy, and hence, spur digital innovation within enterprises.

Keywords: Fintech; Enterprise Digital Innovation; Patent Text Information.

1 Introduction

The Twentieth National Congress of the Communist Party of China pointed out that insisting on innovation is the driving force for new momentum under our country's trend of intelligent development. To strengthen the power of independent innovation, financial technology plays a core role and helps ease the resource mismatch between financial and technological companies. By providing necessary financial assistance to tech companies, fintech can fill the funding gap in the stage of technological innovation and advance technological innovation practices. The fund injection offintech accelerates R&D innovations and motivates corporate technology's continuity and application. This holds substantial significance in promoting top-tier economic progression and elevating a country's technological aptitude.

This study examines the influence of fintech development on corporate digital innovation by selecting data from listed companies in China's Shanghai and Shenzhen A-share markets from 2012 to 2021. The findings indicate that fintech development has a significant positive impact on corporate digital innovation. Additionally, further analysis suggests that regional fintech development can help reduce information asymmetry between banks and enterprises, leading to a decrease in credit allocation and financing constraints for businesses. This can be attributed to the "information effect" and "resource effect".

The innovations are mainly reflected in: Firstly, this research employs the count of fintech firms as an innovative metric for gauging the degree of regional fintech evolution. This new indicator can more comprehensively and reflect a region's fintech development level. Secondly, referring to the research methodology of Huang Bo and others(2023) [1], the count of digital technology patents applied by a firm serves as an indicator of its level of corporate digital innovation. This approach precisely mirrors the digital innovation prowess of the enterprise and delineates the effect of fintech on the digital innovation journey of the enterprise. Also, from the perspective of the "information effect" and "resource effect", fintech is included in the analytical framework of corporate digital innovation, revealing the mechanism of fintech's impact on corporate digital innovation.

2 Theoretical Analysis and Research Hypotheses

2.1 Fintech "Empowering " Traditional Financial Institutions

The swift advancement of financial technology has delivered significant hurdles and transitions to conventional financial establishments. Initial studies have suggested that the primary influence of fintech on the conventional financial system occurs in two distinct manners: technological spillover and competitive effects. Technological spillover denotes the strategy where fintech firms leverage their IT prowess to enhance the capabilities of conventional financial establishments, alleviating information asymmetry, reducing loan costs and improving the efficiency of credit allocation (Lin et al., 2013[2]; Huang et al., 2018) [2] [3] . With digital technology, big data, and artificial intelligence, fintech companies can provide more convenient and efficient financial services, thus improving the corporate financing environment. Competitive effects are reflected when fintech companies release innovative financial products and services to compete with traditional financial institutions, squeezing their market share, which may lead to lower profits, increased operational risks, and pressure to deepen reforms to enhance service efficiency and quality (Dai Guoqiang and Fang Pengfei, 2014) [4] . However, in China, fintech companies rarely conduct lending activities due to financial license controls, so competitive effects are limited. Therefore, the impact of fintech on the real economy is mainly manifested in the technological spillover effect, i.e., by providing "empowerment" to traditional financial institutions.

2.2 Fintech and Corporate Digital Innovation

Yang Tao (2019) [5] proposed that in the process of development of financial technology, balance needs to be found between innovation and security. In addition, it is necessary to establish financial technology regulatory concepts suitable for the characteristics of China, offering support for corporate innovation and considering both the demand for financial innovation and financial stability (Xu Duoqi, 2018)[6]. Lv Tu (2020) [7] found that technology finance has a significant impact on regional green innovation efficiency. Fintech extends the scope and type of financial services, attracting more investors to participate in corporate technology innovation projects, and providing more convenient financing channels. Additionally, Li Chuntao et al. (2020) [8] also pointed out that with the support of emerging technologies, fintech has optimized financial services, enriched corporate financing methods and expanded the coverage of financial services. Meanwhile, fintech can help the government to implement fiscal and taxation policies more effectively, further promoting enterprise technological innovation. Lastly, a study by Wang Rong et al. (2022) [9] analyzed the influence of fintech on corporate innovation is significant, with the progression of fintech potentially enabling companies to find funding via various avenues, thereby increasing R&D investment, and stimulating active innovation within the enterprise.

In conclusion, these research findings illustrate that fintech positively influences the burgeoning of corporate technological novelty, offering a myriad of mechanisms to elucidate its role. The ensuing research conjectures are thereby suggested:

H1: The evolution of fintech has the potential to minimize information disparity, thereby fostering advancements in corporate digital innovation.

H2: Fintech progression can help ease corporate financial restrictions, thereby enhancing the caliber of corporate digital innovation.

3 Research Design

3.1 Model Setting and Variable Selection

In this paper, a fixed-effect model is adopted to evaluate the impact of urban fintech development on corporate digital technology innovation, and the benchmark model is set as follows:

$$\text{innovi}_{i,t} = a + \beta \text{fintech}_{j,t} + \sigma \gamma X_{i,t} + \delta c + \theta t + \epsilon_{i,t} \quad (1)$$

The explained variable $\text{fintech}_{i,t}$ represents the level of fintech development in city j in year t . Specifically, this paper refers to the research approach of Song

Min et al. (2021) [10], first searches the keywords such as “fintech”, “cloud computing”, “big data”, “blockchain”, “artificial intelligence”, and “Internet of Things” on the “Tianyancha” website, to obtain the business registration information of all related companies. Then it weeds out shell companies and companies with abnormal operating status. Ultimately, the annual count of fintech companies in prefecture-level cities serves as a measure of the degree of regional fintech

development, with superior numerical values denoting a more pronounced level of fintech evolution.

The to-be-explained variable $innov_{i,t}$ represents the level of digital technological innovation of company i in year t . To frame this paper's perspective, we have applied Huang Bo et al. (2023) [1] research methodology, which uses the annual number of digital technology patent applications a company files as a representation of the company's digital innovation. Predominantly, we have used the "Classification of Core Industries in the Digital Economy and Reference Relationship with International Patent Classification (2023)" as the basis. We paired relevant digital innovation IPC classifications with the invention patents and utility model patents' IPC classifications found in the China Research Data Service Platform (CNRDS) database. This approach enabled us to determine the number of digital technology patent applications the company submitted. Towards the conclusion, we uniformly added 1 to the digital patent data and then took its natural logarithm for simplified interpretation..

$X_{i,t}$ refers to some factors that may affect the innovation of digital technology in companies, including the size of the company (Size), the company's age (age), return on assets (roa), cash flow (cash), leverage (lev), growth potential (growth), property rights of the company (soe), etc. at the company level, and also includes the city's economic development (eco) and financial development(fin), the number of fintech firms within 200km except the one in the prefecture-level city(fin_200). In addition, δ_c 、 θ_t and $\varepsilon_{i,t}$ respectively represent industry fixed effects, year fixed effects, and residual terms.

3.2 Data Source and Descriptive Statistics

The sample for this investigation comprises Chinese A-share listed corporations from 2012 to 2021. The fundamental characteristics and fiscal figures for these firms are obtained from the CSMAR database, while the count of FinTech enterprises at the prefecture level city stems from the "Tianyancha" site. The research data are further processed in the following ways: Firstly, in order to overcome the impact of extreme conditions on regression results, all continuous variables involved in the model have undergone a two-sided 1% level tail reduction. Secondly, research samples with severe data lack, less than three years of listing time, or abnormal operation have been excluded. Thirdly, sample companies from industries such as finance and insurance have been removed. Finally, we have a total of 20,061 company-annual observations. Table 1 exhibits the statistical summary of the principal variables. The explained variable - the number of a company's digital patent applications (innov) - has a mean of 1.0706 and a standard error of 1.3596, indicating a significant discrepancy in the level of digital innovation among different companies. For the explanatory variable, the development of urban FinTech (fintech), the mean is 3.3133, with the maximum and minimum values being 9.1513 and 0 respectively, suggesting a gap in the level of FinTech development across different regions. Additionally, the control variables also present varying degrees of differences, which is consistent with existing literature.

Table 1. Descriptive statistics

Variables	Observations	Average	Standard Deviation	Min	Max
innov	20,061	1.0706	1.3596	0	8.1271
fintech	20,061	3.3133	2.1445	0	9.1513
roa	20,061	0.0427	0.0466	-0.1175	0.1934
age	20,061	10.7060	6.6966	1	25
lev	20,061	0.4286	0.2108	0.0483	0.8830
size	20,061	22.1082	1.2881	19.730	26.0543
cash	20,061	0.4286	0.0698	-0.1639	0.2347
growth	20,061	0.2235	0.5126	-0.4859	3.7051
soe	20,061	0.4918	0.5900	0	1
eco	20,061	0.0939	0.0260	0.035	0.173
fdi	20,061	0.3770	0.1813	0.0244	0.8127
fin 200	20,061	4.7035	1.8188	0.6931	9.3209

4 Empirical Results Analysis

4.1 Benchmark Regression Results and Parallel Trends Test

Table 2 presents the benchmark regression results of the impact of city fintech development on corporate digital technology innovation. In column (1), no control variables and fixed effects are included. In column (2), it controls for time and industry fixed effects based on column (1). The core explanatory variable is significantly positive in the above two situations. Column (3) and column (4) further control for corporate and regional feature variables based on column (2), and The computed coefficients of the primary determinant variable, fintech, exhibit significant positivity at the 1% level. This shows that the development of fintech has significantly promoted corporate digital innovation. It may be because fintech "empowers" traditional financial institutions, easing the information asymmetry between banks and companies, which can alleviate the problems of financing constraints and capital allocation imbalances in the process of digital technology innovation, and thereby enhance the level of corporate digital innovation.

Table 2. Baseline regression results

VARIABLES	(1)	(2)	(3)	(4)
	innov	innov	innov	innov
FintechN	0.1457*** (0.0120)	0.0848*** (0.0116)	0.0675*** (0.0101)	0.0657*** (0.0103)
roa			0.8380** (0.3280)	0.6875** (0.3278)
age			-0.0053* (0.0031)	-0.0051 (0.0031)
lev			-0.0631 (0.1005)	-0.0373 (0.1038)
size			0.3321***	0.3342***

			(0.0218)	(0.0218)
cash			-0.0271 (0.1696)	0.0295 (0.1666)
growth			-0.0079 (0.0189)	-0.0109 (0.0190)
soe			-0.0803* (0.0450)	-0.0848* (0.0451)
eco				1.6090** (0.7101)
fdi				-0.2007** (0.0991)
fin_200				0.0129 (0.0106)
Constant	0.5899*** (0.0417)	0.7907*** (0.0395)	-6.3965*** (0.4687)	-6.5794*** (0.4816)
Year FE	NO	YES	YES	YES
Industry FE	NO	YES	YES	YES
Adjusted R2	0.0527	0.3715	0.4501	0.4510
Observations	20,061	20,061	20,061	20,061

4.2 Robustness Test

4.2.1. Instrumental Variable Method.

Despite the efforts to control some factors that may affect regional fintech development and corporate digital innovation in the benchmark regression, there may still be endogeneity problems due to omitted variables, measurement errors, or reverse causality. Hence, this article further adopts the instrumental variable estimation method. Specifically, following the methodology from Song Min, et al. (2021)^[10], the average level of fintech development of the three prefecture-level cities within the corporate domicile province with the closest GDP to its registered office, is used as an Instrumental Variable (IV) for the fintech development in the company's location. Table 3 columns (1) and (2) report the results of two-stage regression by using this instrumental variable. Column (1) reveals that the coefficient estimate of the IV is 1.0807 and is significantly positive at the 1% level. This demonstrates that in a province, if the fintech development level of three GDP-comparable cities is high, it is expected to see a mirroring high level of fintech in the area. This confirms the pertinence of our instrumental variable assumption. Column (2) shows the coefficient of fintech is 0.0634 and is close to the benchmark regression estimate, and is significantly positive at the 1% level, further demonstrating that fintech can significantly promote corporate digital technological innovation. Besides, the paper also tests for the problem of weak instrumental variables, and the results indicate there is no such issue.

4.2.2. GMM Dynamic Panel Analysis.

Corporate-level innovation activities have certain persistence characteristics, i.e., they are series correlated. To address this issue, following Song Min et al. (2021)

[10], this article further employs system GMM regression to test the robustness of the previous conclusions.

The results in column (3) of Table 3 shows that the coefficient of Fintech is 0.0254, significantly positive at the level of 10%, signifying that fintech's positive effect on corporate digital innovation persists even after considering the feature of series correlation of corporate digital innovation and its control variable (L.innov and its resulted endogeneity).

Table 3. Robustness test results I

VARIABLES	(1) FintechN	(2) dinnov	(3) dinnov
IV	1.0807*** (0.0199)		
FintechN		0.0634*** (0.0151)	0.0254* (0.0151)
L.dinnov			1.0058*** (0.0239)
Constant	0.4760 (0.5071)	0.4760 (0.5071)	0.0212 (1.3339)
Observations	10,360	10,360	12775
Adjusted R2	0.7054	0.1298	0.3345
Year FE	YES	YES	YES
Industry FE	YES	YES	YES

4.2.3.Replacement of Core Variables.

For the core explanatory variable, this article uses the coverage index (cover) and usage index (usage) of provincial-level digital inclusive finance as alternative measures. According to the regression results of columns (1) and (2) in Table 4, the previous results still hold. In addition, considering that the patent application to authorization process involves robust scrutiny procedures, the authenticity and scientific rigour of innovation results are more reliable. Hence, the number of approved digital patents ($\ln(1+\text{innov}2)$) is employed as a replacement for the number of digital patent applications to better reflect the actual situation of enterprise digital innovations. As shown in column (3) of Table 4, the estimated results are still robust.

4.2.4.Considering the Interference of the Municipalities Directly under the Central Government.

Considering the economic and administrative uniqueness of Beijing, Shanghai, Tianjin, and Chongqing, the article re-examines the regression by excluding the samples from these cities. As indicated by the results in column (4) in Table 4, the estimated coefficient of fintech is still significantly positive at the 1% level, reconfirming the fundamental conclusions of this paper are robust.

Table 4. Robustness test results II

VARIABLES	(1) innov	(2) innov	(3) innov2	(4) innov
cover	0.4371* (0.2572)			
usage		0.1934* (0.1024)		
FintechN			0.0324*** (0.0071)	0.0657*** (0.0103)
Constant	-6.2691*** (0.5109)	-7.6397*** (0.7417)	-3.8874*** (0.3793)	-6.5794*** (0.4816)
Observations	13,939	14,421	15,761	15,761
Adjusted R2	0.4418	0.4450	0.1983	0.4510
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

5 Further Analysis

Next comes a critical question: What is the potential mechanism of regional financial technology development affecting corporate digital technology innovation? This paper further explores whether regional financial technology development can alleviate the information asymmetry between banks and companies, and then significantly reduce the credit rationing and financing constraints of companies, that is, showing a “information effect” and “resource effect” .

5.1 Information Effect

Intense information disparity is a significant factor causing variations in innovation efficiency among corporations. As the weak side of information, external stakeholders face the problem of adverse selection and moral hazard. Financial technology can enhance the capabilities of traditional financial institutions by integrating technologies such as big data and artificial intelligence. This allows for centralized processing of huge amounts of data, leading to deeper insights into user information and therefore diminishing the information asymmetry between banks and corporations (Lin et al., 2013; Huang et al., 2018) [2] [3]. Referring to Yu Wei et al. (2012) [11], this study develops a surrogate marker for the extent of information disparity, drawing upon the financial market microstructure research and meticulous individual equity transaction data. That is, by isolating the initial principal element of the liquidity ratio, non-liquidity ratio, and reversal indicator, we establish this proxy variable for information disparity. Tagged as ASY, a larger value for this metric suggests a more severe information asymmetry. The subtext further evaluates if the presence of financial technology can moderate this information asymmetry between corporations and banks, thereby enhancing the companies’ digital innovation aptitude. As presented in Table 5 column (1), there is a markedly negative coefficient for FintechN, significant at the 1% level. This denotes that advancements in financial technology can substantially trim down the magnitude of information asymmetry

between companies and their external investors. This could be stated differently without altering the word count. According to the estimated result of column (2), the estimated coefficient of the interaction term $ASY \times FintechN$ is significantly negative at the 1% level, indicating that in companies with lower information asymmetry, the role of financial technology in promoting corporate digital innovation is more pronounced. That is, the development of financial technology can alleviate the information asymmetry between traditional financial institutions and companies through the “information effect”, and thus improve the level of corporate digital technology innovation. Hypothesis 1 holds.

Table 5. Results of Mechanism Analysis and Heterogeneity Analysis

VARIABLES	(1)	(2)	(3)	(4)
	ASY	innov	SA	innov
FintechN	-0.0097*** (0.0035)	0.0515*** (0.0098)	-0.0028* (0.0014)	0.0989*** (0.0350)
ASY		-0.0920* (0.0533)		
$ASY \times FintechN$		-0.0537*** (0.0109)		
SA				-0.0823 (0.0969)
$SA \times FintechN$				-0.0638*** (0.0138)
Constant	6.3044*** (0.1873)	-4.7341*** (0.4681)	- (0.0990)	-5.1759*** (0.8218)
Observations	15,736	15,736	15,738	15,738
Adjusted R2	0.5976	0.4624	0.9363	0.4553
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

5.2 Resource Effect

A large amount of existing literature points out that financing constraints are an important constraint factor hindering companies from carrying out various types of innovation activities. Due to information asymmetry, “credit discrimination” and “scale discrimination” are common in credit markets. Therefore, banks need to inspect and supervise companies during the financing process in order to adjust “credit policy” in time and reduce default risk. Financial technology can alleviate information asymmetry, correct the pricing bias of credit funds, and thereby reduce the financing constraints of companies by means of technology spillover. Referring to Song Min et al. (2021) [10], Xiong Lingyun et al. (2020) [12], Li Wei’an et al. (2020) [13] and Hadlock and Piere (2010) [14], this paper uses the formula- $0.737 \times size + 0.043 \times size^2 - 0.04 \times age$ to calculate the SA index of companies in the observed year, and takes the absolute value of it as the measurement indicator SA for financing constraints. The SA index is negative, the larger the value, the higher the financing constraints. The regression result of column (3) in Table 5 shows that the

estimated coefficient of financial technology on financing constraint is significantly negative, indicating that the regional financial technology development can significantly reduce the financing constraints of companies. According to the regression result of column (4), the coefficient of the interaction term $SA \times FintechN$ is significantly negative at the 1% level, indicating that in companies with lower financing constraints, the role of financial technology in promoting corporate digital innovation is more pronounced. In other words, advancements in financial technology mitigate corporate financing constraints via the “resource effect”, which in turn boosts the level of digital technology innovation within corporations. Hypothesis 2 holds.

6 Conclusion and Suggestions

6.1 Conclusion

This paper employs the fixed effects model to evaluate the influence of city’s fintech development on corporate digital technology innovation. The research findings suggest that fintech development significantly stimulates corporate digital innovation, with the results remaining robust after the application of instrumental variables, system GMM and substitution of key variables. A deeper inspection of the mechanisms reveals that regional fintech development alleviates information asymmetry between banks and enterprises, significantly reduces corporate credit allocation and financing constraints, namely manifesting as “information effects” and “resource effects” .

6.2 Suggestions

Firstly, it is crucial to promote and support fintech development to meet financing needs for corporate digital innovation. There is a need to enhance top-level design to provide a reasonable and flexible policy environment for fintech policy creation and implementation. By leveraging the guidance of fintech, corporate digital innovation projects’ financing channels can be expanded. Fintech could remove traditional financial geographical and temporal limitations via information technology and the internet. Employing big data analysis and technological innovation, fintech can more effectively evaluate corporate credit risk.

Secondly, the advantages of digital technology in resolving information asymmetry and enhancing financial service capabilities should be utilized . However, the development and application of digital technology also bring the issues of data security and digital divide.

Thirdly, due to the diverse impacts of fintech on different regions, it is necessary to explore region-specific solutions to financing constraints of corporate digital innovation activities. Moreover, regional policies should be encouraged to improve public financial services and innovate fintech products and services.

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