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Research on the Impact of FinTech on Technological Innovation in Small and Medium-Sized Enterprises

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Abstract: As a vital engine for supporting technological innovation in Small and Medium-sized Enterprises (SMEs), FinTech provides diversified solutions for corporate innovation financing and risk management by deepening financial model innovation and optimizing the supply of financial products. Using a sample of companies listed on the SME Board from 2016 to 2020, combined with the Peking University Digital Financial Inclusion Index, this paper empirically examines the impact of FinTech on technological innovation in SMEs. The results show that the development level of FinTech has a significant positive effect on SMEs' technological innovation. This conclusion remains robust after a series of tests, including substituting explanatory variables and altering the study period. From the perspective of firm ownership, the promoting effect of FinTech on technological innovation is more pronounced in non-state-owned enterprises. From the perspective of firm size, the effect is particularly prominent for smaller enterprises, highlighting the differentiated value of FinTech in enhancing technological innovation across different types of enterprises.

Keywords: FinTech; Technological Innovation; Small and Medium-Sized Enterprises; Financing Constraints.

1. Introduction

As a key component of China's economic system, Small and Medium-sized Enterprises (SMEs), with their vast numbers, serve as the main force in national economic development. Their technological innovation capabilities are directly related to the healthy and stable development of society and the market economy. The report of the 20th National Congress of the Communist Party of China emphasized the need to "improve the transformation and industrialization of scientific and technological achievements, strengthen the dominant position of enterprises in scientific and technological innovation, and create a favorable environment for the growth of technology-based SMEs." However, due to their small size, weak risk resilience, and structural imbalances in China's financial market, financing difficulties remain a key bottleneck constraining their innovative development. Limited by their own scale, insufficient information disclosure, and imperfect governance mechanisms, SMEs find it difficult to raise funds directly in capital markets, making bank loans their primary channel for debt financing [1]. Historical fluctuations in the credit environment have also led banks to reduce or withdraw loans from SMEs, worsening their financing conditions. Against this backdrop, empowering finance with technology to build a more effective financial market, alleviating corporate financing constraints, and reducing information asymmetry are of great significance for stimulating the innovation vitality of SMEs and enhancing the nation's overall innovation capacity.

The structural mismatch observed in traditional financial services supporting the real economy requires innovative financial models to correct it. In recent years, with the rapid development of technologies such as the Internet, big data, cloud computing, and artificial intelligence, FinTech has demonstrated enormous potential and application space [2]. The state has successively issued policy documents like the "Guiding Opinions on Promoting the Healthy Development of Internet Finance" and the "Action Outline for Promoting Big Data Development" to foster the deep integration of digital technology and financial services. Since 2016, China has gradually transitioned from internet finance to technology-driven finance. The rapid development of technology-driven finance helps alleviate information asymmetry between banks and enterprises, broaden the coverage of financial services, promote the diversification of financing tools, and effectively reduce corporate financing costs and transaction costs [3]. The 2023 Central Financial Work Conference further proposed to excel in the "Five Major Areas of Finance: Technology Finance, Green Finance, Inclusive Finance, Pension Finance, and Digital Finance," aiming to provide higher-quality financial services for the real economy. As an important supplement to the traditional financial system, FinTech is gradually becoming a key force supporting enterprise technological innovation.

Domestic and international research generally indicates that FinTech can effectively alleviate financing constraints for SMEs and positively incentivize corporate innovation [4]. Beyond market-oriented FinTech services, policy tools represented by government R&D subsidies also play a crucial role in promoting corporate innovation, particularly in compensating for insufficient R&D investment in non-state-owned enterprises [5]. Based on the externality characteristics of innovation activities, this paper focuses on SMEs precisely because this group faces particularly prominent financing constraints during the technological innovation process and relies more heavily on external financing, which aligns well with the "inclusive" and "targeted" nature of FinTech services [6].

Therefore, this paper selects listed companies on the SME Board from 2016 to 2020 as the research sample, combined with the provincial-level Peking University Digital Financial Inclusion Index, to empirically examine the impact of FinTech on SME technological innovation and its underlying mechanisms. Furthermore, this paper conducts heterogeneity analysis from the perspectives of ownership nature and firm size, revealing the differential effects of FinTech on the innovation behavior of different types of enterprises,

providing theoretical reference and practical insights for understanding how FinTech aligns with the development patterns and financing characteristics of SMEs [7].

2. Theoretical Analysis and Research Hypotheses

2.1. FinTech and SME Technological Innovation

In the current context of intertwined technological revolution and industrial transformation, technological innovation has become the core driving force for SMEs to achieve high-quality development and the fundamental guarantee for building competitive market advantages [8]. However, SME innovation activities are typically characterized by long cycles, high uncertainty, and severe information asymmetry, which require sustained and stable external financial support. In reality, SMEs generally face severe financing constraints, placing them in the "long-tail market" that traditional finance, following the "80-20 rule," struggles to cover effectively [9]. FinTech deeply integrates digital technologies like big data, AI, and cloud computing into the financial system. By empowering financial services, upgrading financial products, and optimizing business processes, it can effectively narrow the service blind spots of traditional finance and improve the efficiency of financial resource allocation to SMEs. More importantly, FinTech can, through the mining and analysis of multi-dimensional data, more accurately identify SME innovation projects with development potential and investment value, thereby directly enhancing their probability and efficiency of innovation success. Based on the above analysis, this paper proposes the first research hypothesis:

H1: The development of FinTech has a significant promoting effect on technological innovation in SMEs.

2.2. Heterogeneity Analysis

The preceding analysis establishes the overall effect and core mechanism through which FinTech influences SME technological innovation. However, different types of enterprises vary in their resource endowment, ownership background, and operating environment, leading to differing degrees of financing constraints and sensitivity to FinTech [10]. Therefore, the innovation-promoting effect of FinTech is likely to be heterogeneous.

2.2.1. Heterogeneity Based on Ownership Nature

State-Owned Enterprises (SOEs), with their inherent "political connections," find it easier to obtain stable credit support from the traditional financial system, and thus face relatively lighter financing constraints. Non-State-Owned Enterprises (non-SOEs), however, often suffer from "ownership discrimination" due to a lack of collateral and public credit records, facing more severe external financing difficulties. FinTech, relying on data-driven risk control models, can weaken the dependence on a firm's "identity" and focus more on its actual operating conditions and development potential, thereby providing a relatively fair credit access channel for non-SOEs. In contrast, the innovation decisions of SOEs may be influenced more by non-market factors (such as administrative goals, soft budget constraints), and thus may be less sensitive to FinTech as a market-oriented tool [11]. Therefore, this paper proposes:

H2: The promoting effect of FinTech on technological innovation is more significant in non-state-owned enterprises than in state-owned enterprises.

2.2.2. Heterogeneity Based on Firm Size

Firm size is a key factor affecting its financing capacity and innovation model. Small-sized enterprises typically lack internal funds, have insufficient collateral assets, and face the most prominent information opacity problems, thus confronting the strongest financing constraints [12]. The broadening of financing channels and reduction in costs brought by FinTech have the greatest marginal effect for small-sized enterprises. Conversely, large-sized enterprises possess stronger internal financial resources, more complete credit records, and smoother access to financing from traditional financial institutions, resulting in naturally lower dependence and sensitivity to FinTech. Therefore, this paper proposes:

H3: The promoting effect of FinTech on technological innovation strengthens as firm size decreases, meaning the incentive effect is most significant for small-sized enterprises.

3. Data Description, Variable Selection, and Model Design

3.1. Data Sources and Variable Description

This paper selects companies listed on the SME Board from 2016 to 2020 as the research sample. The relevant financial data for listed companies primarily come from the CSMAR (China Stock Market & Accounting Research) database. The FinTech level data uses the provincial-level "Digital Financial Inclusion Index" provided by the "Peking University Digital Financial Inclusion Index (2011–2022)." Furthermore, this paper filters the original sample data as follows: (1) Retain companies with at least three consecutive years of data; (2) Exclude financial and insurance industry companies from the listed companies; (3) Exclude all companies delisted before the end of 2020; (4) Remove ST and ST* company samples to ensure all variables are complete. Continuous variables were winsorized at the 1% and 99% levels to effectively reduce the interference of extreme factors. The final dataset consists of 4,615 effective firm-year observations. This study uses Excel software for data organization and Stata18.0 for regression analysis and testing.

3.1.1. Explanatory Variable

This paper uses the FinTech level (Fintech) as the explanatory variable. Following the method of Guo et al. (2020), the article uses the Digital Financial Inclusion Index published by the Peking University Digital Finance Research Center (2011–2022) for comprehensive measurement. The Digital Financial Inclusion Index calculation includes 33 indicators across three dimensions: coverage breadth, usage depth, and digitization level, comprehensively reflecting the overall development and changing trends of technology-empowered finance.

3.1.2. Explained Variable

This paper uses the technological innovation level (RD) of SMEs as the explained variable. Currently, relevant literature primarily measures corporate technological innovation level from the perspectives of innovation input and output. Comparatively, the connotation of innovation input is relatively straightforward and objective. It can not only truly reflect the importance a firm places on technological innovation but also most directly and objectively reflect the

firm's subjective willingness to engage in technological innovation R&D. Therefore, referencing the measurement method of Nie Xiuhua (2020), the article uses R&D intensity to assess the technological innovation level of SMEs, expressed as the ratio of total R&D expenditure to operating revenue. To ensure the robustness of the results, this paper uses both the ratio of R&D investment to operating revenue (RD) and the logarithm of R&D investment (RD_in) to measure the technological innovation level of SMEs.

3.1.3. Control Variables

Since the inherent attributes of SMEs also affect their innovation activities, firm characteristics such as firm size (Size), firm age (Age), Return on Assets (ROA), Leverage ratio (Lev), Fixed asset ratio (Fix), Ownership concentration (Top1), and Firm growth (Growth) are controlled for.

The variable descriptions are shown in Table 1 below.

Table 1. Variable Definitions

Variable Type	Variable Name	Variable Symbol	Variable Definition
Explained	SME Technological Innovation Level	RD	R&D Investment / Operating Revenue
		RD_ln	ln(R&D Investment)
Explanatory	FinTech Level	Index	Composite Peking University Digital Financial Inclusion Index (2011–2022)
	Coverage Breadth	Coverage	
	Usage Depth	Usage	
	Digitization Level	DL	
Control Variables	Firm Age	Age	ln(Observation Year- Establishment Year + 1)
	Firm Size	Size	Ln(Total Assets)
	Return on Assets	ROA	Net Profit / Average Total Assets
	Leverage Ratio	Lev	Total Liabilities / Total Assets
	Fixed Asset Ratio	Fix	Net Fixed Assets / Total Assets
	Ownership Concentration	Top1	Shareholding Percentage of the Largest Shareholder
	Firm Growth	Growth	(Current Operating Revenue - Previous Operating Revenue) / Previous Operating Revenue

3.2. Model Construction

To study the impact of FinTech on SME technological innovation, the empirical model is set as follows:

$$RD_{it} = \alpha_0 + \alpha_1 Fin_{mt} + \beta Controls + Year_t + Ind_j + \epsilon_{it}$$

Where, i, t, and m represent the firm, year, and region, respectively. RD represents the SME technological innovation level, Fin represents the regional FinTech level, Controls represents the control variables, Year represents year fixed effects, Ind represents industry fixed effects, and ε is the random error term.

4. Empirical Results Tests and Analysis

4.1. Descriptive Statistics

Based on data from some SMEs listed on the Shenzhen Stock Exchange's SME Board from 2016 to 2020, this study collected a total of 4,615 valid observations. Table 2 reports the descriptive statistics of the main variables. For the explained variables, the mean of SME technological innovation level (RD) is 6.022, and the median is 4.540, indicating a right-skewed distribution of R&D investment among sample firms. The minimum value is 0.140 and the maximum is 27.33, reflecting significant differences in R&D investment levels among different firms. The mean of the logarithmic value of R&D investment (RD_in) is 18.06, with a standard deviation of 1.098, indicating a relatively concentrated distribution. For the explanatory variables, the regional FinTech level indicators show different characteristics: the mean of FinTech level (Fin) is 321.4, the median is 327.4, with a relatively balanced distribution; the mean of Coverage breadth (Coverage) is 300.5; the mean of Usage depth (Usage) is 330.2, with a standard deviation of 63.47, indicating relatively high volatility; the mean of Digitization level (DL) is 374.7, the median is 396.0, indicating a relatively high FinTech development level for most firms. For the control variables, the mean of Firm size (Size) is 8.047, with a standard deviation of 0.926, indicating moderate size variation among sample firms; the mean of Firm age (Age) is 3.231, with a small standard deviation, suggesting relatively concentrated establishment times for sample firms. Among the financial indicators, the mean Return on Assets (ROA) is 4.6%, reflecting good overall profitability of sample firms; the mean Leverage ratio (Lev) is 35.6%, indicating a reasonable debt level; the mean Fixed asset ratio (Fix) is 18.4%, consistent with the light-asset characteristics of SMEs. In terms of corporate governance, the mean shareholding of the largest shareholder (Top1) is 31.24%, indicating moderate ownership concentration; the mean Firm growth (Growth) is 18.9%, showing good development potential of sample firms. In summary, the distribution ranges of all variables are reasonable, standard deviations and extreme values are within normal ranges, and there are no obvious outlier issues, meeting the data requirements for subsequent empirical analysis.

4.2. Correlation Analysis

Table 3 reports the results of the correlation analysis among the variables. Regarding the relationship between explanatory and explained variables, all dimensions of the regional FinTech level indicators show a significant positive correlation with the SME technological innovation level. Specifically, the correlation coefficient between FinTech level (Fin) and technological innovation level (RD) is 0.104, and with the logarithmic R&D investment (RD_in) is 0.231, both significant at the 1% level; the correlation coefficients

between Coverage breadth (Coverage) and RD and RD_in are 0.113 and 0.233, respectively; the correlation coefficients between Usage depth (Usage) and the two are 0.093 and 0.216, respectively; the correlation coefficients between Digitization level (DL) and the two are 0.073 and 0.194, respectively, all passing the 1% significance test. These results preliminarily indicate a positive association between FinTech and corporate technological innovation, which will be further verified by subsequent regression analysis.

Table 2. Descriptive Statistics

Variable	N	Mean	p50	SD	Min	Max
RD	4615	6.022	4.54	4.862	0.14	27.33
RD_ln	4615	18.06	18.02	1.098	15.19	21.09
Fin	4615	321.4	327.4	52.79	217.7	431.9
Coverage	4615	300.5	305.9	52.14	188.8	397
Usage	4615	330.2	329.9	63.47	199.2	488.7
DL	4615	374.7	396	49.4	295.1	462.2
Size	4615	8.047	8.002	0.926	6.216	10.54
Age	4615	3.231	3.219	0.166	2.833	3.638
ROA	4615	0.046	0.047	0.069	-0.271	0.227
Lev	4615	0.356	0.345	0.169	0.056	0.765
Fix	4615	0.184	0.166	0.12	0.006	0.525
Top1	4615	31.24	29.68	12.92	9.07	66.56
Growth	4615	0.189	0.136	0.334	-0.43	1.866

Regarding control variables, Firm age (Age) is significantly negatively correlated with both R&D indicators, indicating that older firms have relatively conservative R&D investments; Ownership concentration (Top1) is significantly negatively correlated with R&D investment, suggesting that dispersed ownership may facilitate innovation decisions. Overall, the correlation analysis results provide preliminary support for subsequent empirical research, and the relationships between variables align with theoretical expectations.

Table 3. Correlation Analysis

	RD	RD ln	Fin	Coverage	Usage	DL	Size
RD	1						
RD ln	0.314***	1					
Fin	0.104***	0.231***	1				
Coverage	0.113***	0.233***	0.990***	1			
Usage	0.093***	0.216***	0.959***	0.924***	1		
DL	0.073***	0.194***	0.853***	0.833***	0.718***	1	
Size	-0.161***	0.704***	0.154***	0.154***	0.139***	0.144***	1
Age	-0.086***	-0.037**	-0.005	-0.004	-0.008	0	0.015
ROA	-0.081***	0.059***	-0.131***	-0.133***	-0.105***	-0.152***	-0.008
Lev	-0.242***	0.302***	0.115***	0.117***	0.099***	0.112***	0.452***
Fix	-0.262***	-0.078***	-0.098***	-0.107***	-0.101***	-0.030**	0.021
Top1	-0.095***	-0.038***	-0.104***	-0.107***	-0.093***	-0.090***	-0.002
Growth	-0.071***	0.086***	-0.170***	-0.171***	-0.136***	-0.198***	0.094***
	Age	ROA	Lev	Fix	Top1	Growth	
Age	1						
ROA	-0.036**	1					
Lev	-0.015	-0.277***	1				
Fix	0.055***	-0.011	0.069***	1			
Top1	-0.045***	0.158***	-0.009	0.102***	1		
Growth	-0.049***	0.305***	0.067***	-0.049***	0.016	1	

Note: *, **, *** represent significance levels of 10%, 5%, and 1%, respectively.

Furthermore, this paper incorporates different FinTech level indicators into four separate models in the regression analysis. To more objectively test for multicollinearity, this paper conducted Variance Inflation Factor (VIF) tests for the four models respectively, with results reported in Table 4. The test results show that the VIF values for all variables in the

four models are far below the critical threshold of 10. Specifically, the VIF for FinTech level (Fin) in model (1) is 1.090, for Coverage breadth (Coverage) in model (2) is 1.100, for Usage depth (Usage) in model (3) is 1.070, and for Digitization level (DL) in model (4) is 1.090. The tolerance (1/VIF) for all variables is far greater than the critical value of 0.1, further confirming the absence of multicollinearity issues. Therefore, the variable settings in each model are reasonable, the research design is feasible, and the regression results are reliable.

Table 4. VIF Test Results

	Modle(1)		Modle(2)		Modle(3)		Modle(4)	
Variable	VIF	1/VIF	VIF	1/VIF	VIF	1/VIF	VIF	1/VIF
Fin	1.09	0.915						
Coverage			1.1	0.912				
Usage					1.07	0.935		
DL							1.09	0.918
Size	1.31	0.764	1.31	0.764	1.3	0.767	1.31	0.765
Age	1.01	0.99	1.01	0.99	1.01	0.99	1.01	0.99
ROA	1.28	0.781	1.28	0.781	1.28	0.782	1.28	0.779
Lev	1.43	0.7	1.43	0.7	1.43	0.7	1.43	0.7
Fix	1.03	0.967	1.04	0.965	1.03	0.967	1.02	0.977
Top1	1.05	0.953	1.05	0.952	1.05	0.954	1.05	0.954
Growth	1.18	0.85	1.18	0.85	1.16	0.859	1.18	0.845

4.3. Benchmark Regression Analysis

Table 5. Benchmark Regression Analysis

	(1)	(2)
	RD	RD_ln
Fin	0.007***	0.003***
	-0.002	0
Size	-0.043	0.865***
	-0.08	-0.014
Age	-2.239***	-0.238***
	-0.356	-0.062
ROA	-9.411***	1.171***
	-1.283	-0.183
Lev	-7.357***	0.03
	-0.484	-0.08
Fix	-4.791***	-0.305***
	-0.566	-0.099
Top1	-0.008**	-0.001
	-0.004	-0.001
Growth	-0.265	0.003
	-0.231	-0.035
_cons	15.562***	10.968***
	-1.462	-0.257
N	4615	4615
r2_a	0.29	0.623
Industry	Y	Y
Year	Y	Y

Note: *, **, *** represent significance levels of 10%, 5%, and 1%, respectively; t-values are in parentheses; Y indicates control for Industry and Year. The same applies to the following tables.

The benchmark regression results are shown in Table 5. Column (1) shows that the regression coefficient of FinTech level (Fin) on technological innovation level (RD) is 0.007, significantly positive at the 1% statistical level, indicating that the development of FinTech can significantly promote the technological innovation level of SMEs. Column (2) uses the

logarithm of R&D investment (RD_in) as the dependent variable for regression; the coefficient of FinTech level (Fin) is 0.003, also significantly positive at the 1% level, further verifying the positive promoting effect of FinTech on SME technological innovation. The regression results confirm the research hypothesis, suggesting that further promoting the development of regional FinTech levels will help stimulate the innovation vitality of SMEs and drive the high-quality development of China's real economy.

The adjusted R^2 for the two models are 0.290 and 0.623, respectively, indicating good model fit, especially for the RD_in model which has stronger explanatory power. All regressions control for industry and year fixed effects. In summary, the benchmark regression results robustly support the core conclusion that FinTech promotes SME technological innovation, laying the foundation for subsequent analysis.

4.4. Robustness Tests

4.4.1. Substituting Explanatory Variables

This paper conducts robustness tests by substituting the explanatory variable. In the benchmark regression, FinTech level (Fin) is used as the core explanatory variable. To test the robustness of the results, we respectively use Coverage breadth (Coverage), Usage depth (Usage), and Digitization level (DL) as different measurement indicators for FinTech level and re-run the regression analysis. Table 6 reports the regression results after substituting the explanatory variables.

It can be seen that in column (2), using Coverage breadth (Coverage) as the explanatory variable, its coefficient on technological innovation level (RD) is 0.008, significantly positive at the 1% level, and its coefficient on the logarithmic R&D investment (RD_ln) is 0.003, also significant at the 1% level. In column (3), using Usage depth (Usage) as the explanatory variable, its coefficient on RD is 0.004, significant at the 5% level, and its coefficient on RD_in is 0.002, significant at the 1% level. In column (4), using Digitization level (DL) as the explanatory variable, its coefficient on RD is 0.007, significant at the 10% level, and its coefficient on RD_ln is 0.002, significant at the 1% level.

The above results indicate that when using different regional FinTech level measurement indicators, the impact of FinTech on SME technological innovation level still exists. Although the significance levels of some coefficients change, the results overall support the conclusions of the benchmark regression, confirming the robustness of the research findings.

Table 6. Regression Results with Substituted Explanatory Variables

	(1)	(2)	(3)	(4)	(5)	(6)
	RD			RD_ln		
Coverage	0.008***			0.003***		
	-0.002			0		
Usage		0.004**			0.002***	
		-0.002			0	
DL			0.007*			0.002***
			-0.004			-0.001
Size	-0.046	-0.04	-0.04	0.864***	0.866***	0.867***
	-0.08	-0.08	-0.08	-0.014	-0.014	-0.014
Age	-2.242***	-2.239***	-2.248***	-0.240***	-0.237***	-0.242***
	-0.355	-0.356	-0.357	-0.062	-0.062	-0.063
ROA	-9.406***	-9.423***	-9.354***	1.173***	1.161***	1.188***
	-1.282	-1.284	-1.283	-0.183	-0.183	-0.184
Lev	-7.360***	-7.368***	-7.342***	0.028	0.028	0.03
	-0.484	-0.484	-0.485	-0.08	-0.08	-0.08
Fix	-4.736***	-4.864***	-4.910***	-0.295***	-0.319***	-0.360***
	-0.566	-0.567	-0.567	-0.1	-0.099	-0.099
Top1	-0.008**	-0.008**	-0.008**	-0.001	-0.001	-0.001
	-0.004	-0.004	-0.004	-0.001	-0.001	-0.001
Growth	-0.265	-0.27	-0.275	0.002	0.004	-0.002
	-0.231	-0.231	-0.231	-0.035	-0.035	-0.035
_cons	15.351***	16.684***	15.243***	11.022***	11.225***	11.240***
	-1.45	-1.378	-1.845	-0.249	-0.247	-0.335
N	4615	4615	4615	4615	4615	4615
r2_a	0.291	0.289	0.289	0.624	0.623	0.619
Industry	Y	Y	Y	Y	Y	Y
Year	Y	Y	Y	Y	Y	Y

4.4.2. Changing the Study Period

To enhance the robustness of the basic conclusions, we continue testing by changing the study period. In the benchmark regression, the study period is the full sample from 2016-2020. Considering the potential impact of changes

in the macroeconomic environment and the COVID-19 pandemic in 2019-2020, this paper excludes samples from these two years and re-runs the regression analysis using the 2016-2018 sub-sample. The results are reported in Table 7.

From the full sample regression results, it can be seen that the coefficient of FinTech level (Fin) on R&D investment (RD) is 0.007, significantly positive at the 1% level; the coefficient on the logarithmic R&D investment (RD_in) is 0.003, also significant at the 1% level. After using the 2016-2018 sub-sample, the coefficient of FinTech level (Fin) on RD is 0.008, significant at the 5% level; the coefficient on RD_in is 0.003, still significant at the 1% level.

The above results indicate that after excluding the interference of the special period of 2019-2020, the impact of FinTech on SME technological innovation still exists. Although the significance level of Fin for RD changes from 1% to 5%, it still supports the conclusion of the benchmark regression overall.

Table 7. Regression Results with Changed Study Period

	Full Sample		Sub-sample	
	RD	RD_ln	RD	RD_ln
Fin	0.007***	0.003***	0.008**	0.003***
	-0.002	0	-0.003	-0.001
Size	-0.043	0.865***	-0.137	0.847***
	-0.08	-0.014	-0.101	-0.018
Age	-2.239***	-0.238***	-2.147***	-0.219***
	-0.356	-0.062	-0.45	-0.08
ROA	-9.411***	1.171***	-8.407***	1.680***
	-1.283	-0.183	-1.723	-0.273
Lev	-7.357***	0.03	-6.865***	0.111
	-0.484	-0.08	-0.622	-0.101
Fix	-4.791***	-0.305***	-4.677***	-0.176
	-0.566	-0.099	-0.697	-0.124
Top1	-0.008**	-0.001	-0.006	-0.002*
	-0.004	-0.001	-0.005	-0.001
Growth	-0.265	0.003	-0.24	-0.033
	-0.231	-0.035	-0.302	-0.041
_cons	15.562***	10.968***	15.508***	10.861***
	-1.462	-0.257	-1.856	-0.331
N	4615	4615	2769	2769
r2_a	0.29	0.623	0.287	0.613
Industry	Y	Y	Y	Y
Year	Y	Y	Y	Y

4.5. Heterogeneity Tests

4.5.1. Perspective of Ownership Nature

The previous sections have basically demonstrated that FinTech has a significant promoting effect on SME technological innovation. This section, based on ownership heterogeneity, divides the overall sample into two sub-samples: state-owned enterprises and non-state-owned enterprises, and conducts regression analysis separately. The results are reported in Table 8.

From the regression results, it can be seen that the impact of FinTech support on R&D investment differs significantly between the two types of enterprises. For the SOE sample, the coefficient of FinTech level (Fin) on technological innovation level (RD) is 0.007 but not significant, while the coefficient on the logarithmic R&D investment (RD_In) is 0.004, significantly positive at the 1% level. For the non-SOE sample, the coefficients of FinTech level (Fin) on RD and RD_In are 0.009 and 0.003, respectively, both significantly positive at the 1% level.

The above results indicate that the promoting effect of FinTech on SME technological innovation is more significant and stable in non-state-owned enterprises, while in state-owned enterprises, it primarily manifests as an effect on increasing R&D investment intensity. This may stem from non-SOEs' higher dependence on market-based financial resources, while SOEs' innovation investments are influenced more by institutional factors.

4.5.2. Perspective of Firm Size

This section, based on firm size heterogeneity, divides the overall sample into three sub-samples according to the tertiles of firm size (Size): small-sized, medium-sized, and large-sized enterprises, and conducts regression analysis separately. The results are reported in Table 9. From the regression results, it can be seen that the impact of FinTech on technological innovation varies significantly among firms of different sizes. For small-sized enterprises, the coefficients of FinTech level (Fin) on technological innovation level (RD) and the logarithmic R&D investment (RD_in) are 0.023 and 0.004, respectively, both significantly positive at the 1% level. For medium-sized enterprises, the coefficients of Fin on RD and RD_in are 0.006 (significant at the 10% level) and 0.003 (significant at the 1% level), respectively. For large-sized

enterprises, the coefficients of Fin on RD and RD_in are - 0.006 (insignificant) and 0.001 (insignificant), respectively.

Table 8. Heterogeneity Test Results by Ownership Nature

	SOEs		Non-SOEs	
	RD	RD_ln	RD	RD_ln
Fin	0.007	0.004***	0.009***	0.003***
	-0.008	-0.001	-0.003	0
Size	1.005***	0.948***	-0.210**	0.851***
	-0.24	-0.042	-0.087	-0.014
Age	-3.246***	-0.27	-2.058***	-0.236***
	-0.908	-0.177	-0.382	-0.064
ROA	-11.521***	1.906***	-9.472***	1.096***
	-4.228	-0.718	-1.337	-0.188
Lev	-10.034***	-0.483**	-7.135***	0.034
	-1.301	-0.22	-0.525	-0.085
Fix	-8.789***	-0.061	-4.234***	-0.290***
	-1.548	-0.316	-0.609	-0.105
Top1	-0.031**	-0.004*	-0.007	-0.001
	-0.013	-0.002	-0.004	-0.001
Growth	0.325	0.077	-0.249	0.004
	-0.678	-0.117	-0.247	-0.037
_cons	13.262***	10.218***	15.481***	11.086***
	-4.575	-0.738	-1.558	-0.268
N	485	485	4130	4130
r2_a	0.388	0.705	0.295	0.62
Industry	Y	Y	Y	Y
Year	Y	Y	Y	Y

Table 9. Heterogeneity Test Results by Firm Size

	Small-sized		Medium-sized		Large-sized	
	RD	RD_ln	RD	RD_ln	RD	RD_ln
Fin	0.023***	0.004***	0.006*	0.003***	-0.006	0.001
	-0.004	-0.001	-0.004	-0.001	-0.004	-0.001
Size	-1.051***	0.725***	0.222	0.923***	0.578**	0.887***
	-0.312	-0.039	-0.442	-0.073	-0.242	-0.046
Age	-3.121***	-0.223***	-1.996***	-0.031	-1.744***	-0.466***
	-0.676	-0.082	-0.574	-0.092	-0.662	-0.138
ROA	-13.623***	0.878***	-8.199***	0.556**	-6.664***	1.959***
	-2.285	-0.262	-2.107	-0.282	-2.311	-0.408
Lev	-8.945***	0.297***	-6.703***	-0.101	-6.211***	-0.054
	-0.88	-0.104	-0.77	-0.131	-0.906	-0.177
Fix	-5.040***	-0.268*	-5.529***	-0.490***	-4.742***	-0.237
	-0.989	-0.145	-0.951	-0.164	-1.041	-0.201
Top1	-0.011	-0.001	-0.007	-0.004***	-0.013*	0.002
	-0.009	-0.001	-0.006	-0.001	-0.007	-0.002
Growth	-0.161	0.06	-0.531*	0.031	-0.083	-0.044
	-0.458	-0.054	-0.293	-0.059	-0.436	-0.062
_cons	21.774***	11.370***	12.585***	9.957***	11.779***	12.014***
	-3.299	-0.456	-3.796	-0.676	-3.724	-0.643
N	1539	1539	1537	1537	1538	1538
r2_a	0.305	0.382	0.312	0.311	0.245	0.447
Industry	Y	Y	Y	Y	Y	Y
Year	Y	Y	Y	Y	Y	Y

These results fully demonstrate that the promoting effect of FinTech on SME technological innovation is most significant in small and medium-sized enterprises. As firm size increases, this promoting effect gradually weakens and even becomes insignificant in large-sized enterprises. This may stem from the stronger financing constraints faced by small-sized enterprises, where the marginal effect of financial support on their innovation activities is greater, while large-sized enterprises have stronger internal financial resources and relatively lower dependence on financial support.

5. Research Conclusion and Policy Implications

5.1. Research Conclusion

Against the backdrop of the deep integration of digital technology and financial services, FinTech is providing new momentum for SME technological innovation by reshaping financial service models and optimizing resource allocation efficiency. Based on data from listed companies on the SME Board from 2016 to 2020, combined with the Peking University Digital Financial Inclusion Index, this paper empirically tests the impact of FinTech on SME technological innovation and its heterogeneous characteristics. The main research conclusions are as follows:

First, the development level of FinTech has a significant positive promoting effect on SME technological innovation. The benchmark regression results show that the improvement of regional FinTech levels can effectively drive the increase in corporate R&D intensity. This conclusion remains valid after a series of robustness tests, including substituting core explanatory variables (coverage breadth, usage depth, digitization level) and changing the study sample period.

Second, the technological innovation promotion effect of FinTech exhibits significant heterogeneity. From the perspective of internal firm characteristics, in terms of ownership nature, the promoting effect of FinTech is more significant and stable in non-state-owned enterprises; in terms of firm size, its incentive effect on technological innovation strengthens as firm size decreases, with the most prominent positive impact on small-sized enterprises. This indicates that the service effectiveness of FinTech accurately benefits enterprise groups that are relatively disadvantaged in resource acquisition.

5.2. Policy Implications

The conclusions of this study provide clear policy implications for how to leverage FinTech to stimulate the innovation vitality of SMEs and promote high-quality development of the real economy. Based on the above findings, the following recommendations are proposed:

First, strengthen technological empowerment and deepen the structural reform of the financial supply side. Continuous support should be given to the research, development, and application of underlying FinTech technologies such as big data, artificial intelligence, and blockchain. Traditional financial institutions should be encouraged and guided to undergo digital transformation. By building more accurate corporate credit profiling models and automated approval processes, the financial system's ability to identify and serve innovative SMEs can be fundamentally enhanced, expanding the coverage breadth and service depth of inclusive finance.

Second, build a favorable ecosystem and optimize the innovation environment for SMEs. Policy formulation should focus on building an ecosystem conducive to the synergistic development of FinTech and SME innovation. On the one hand, cooperation between financial institutions and technology companies should be encouraged to develop financial products suitable for the characteristics of SMEs. On the other hand, digital infrastructure construction should be strengthened to create convenient conditions for SMEs to utilize FinTech tools.

Finally, implement targeted strategies to enhance policy effectiveness. Given the structural differences in the impact of FinTech, relevant policies should avoid a "one-size-fits-all" approach. For the non-state-owned enterprise group, efforts should be made to improve the legal and credit reporting environment supporting FinTech, safeguarding their right to fair access to financial resources. For small-sized enterprises, consider providing specialized support for FinTech popularization, lowering the threshold for using advanced financial tools, and maximizing the boosting effect of FinTech on their innovation.

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