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Nonlinear Effect of Financial Efficiency and Financial Competition on Heterogeneous Firm R&D: A Study on the Combined Perspective of Financial Quantity Expansion and Quality Development

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Abstract: Manufacturing firm data and district financial quantity and quality indicators for 2005–2007 combined with heterogeneous firm characteristics were used with a threshold panel to study the effect of financial inefficiency on firm R&D and the financial boundaries of efficiency improvement. The results show that: (1) extensive financial quantity expansion cannot support high innovation efficiency R&D (Research and Development) activities in private enterprises, low- and medium-technology enterprises, and underdeveloped area enterprises, as it causes financial inefficiency problems and a shortage of R&D inputs; and (2) financial efficiency and financial competition have nonlinear effects on firm R&D. Financial inefficiency and either low or excessive financial competition result in a lack of highly efficient firm R&D. Only improvements in financial efficiency and moderate competition can significantly promote firm R&D. The results of this study reveal an important way to improve the influence of financial inefficiency on firm R&D by moving away from simply expanding financial quantity to promoting quality instead.

Keywords: financial efficiency; financial competition; heterogeneity; threshold panel; sustainable finance; financial innovation

1. Introduction

Strengthening the decisive role of the market mechanism in resource allocation, promoting financial capital investments in the real economy, and supporting enterprise innovation and technological progress are keys to industrial upgrades, sustained economic growth, and avoiding China's "middle income trap". However, the financial sector has dual characteristics. First, as the core actor allocating modern economic resources, the financial sector's efficient operation is conducive to improving the development of the real economy. Second, both the rapid expansion of the financial scale and excessive speculation will result in a deviation from the original goal of financially serving the real economy. Financial development theory does not provide a clear answer at the micro level regarding how to invest limited funds in an enterprise's innovation and technological progress. After 2015, China's economic growth entered the "New Normal", and, during 2016–2020, the country's

potential gross domestic product (GDP) growth will range from 5.7% to 6.7%. In addition, an obvious L-type decreasing trend reveals that, driven by profit-seeking, industrial capital driven is pursuing short-term profits by infiltrating the financial sector, resulting in a lack of core technologies in the real sector, a declining investment rate, and unsustainable economic growth. China's financial development is relatively inefficient, even as it experiences a quantitative expansion. From this perspective, analyzing the impact of financial development on enterprise innovation therefore has significant theoretical value. However, current studies on the relationship between financial development and innovation investment—most of which focus on either financing constraints or the benefits and challenges of different financial structures—fail to integrate the level of quality of the financial sector caused by financial efficiency and financial competition. Especially in financial markets, different levels of quality will have different impacts, so the relationship between the variables may be nonlinear [1]. Thus, it is difficult to explain the need for the logical transformation of financial development from scale expansion to efficiency promotion. Thus, considering the important factor of heterogenous enterprise characteristics—i.e., total factor productivity—this paper takes the relationship among financial efficiency, financial competition, and micro-level firm R&D investments as its basic research object. Through empirical tests, we conclude that only improvements in financial efficiency and moderate competition can significantly promote firm R&D. To effectively reduce the impact of financial inefficiency on firm R&D in China, it is important to move from simple expansion to improved financial quality. The conclusions of this article have important practical significance in filling the gap in the existing literature on the relationship between financial development and firm R&D investment, focusing mostly on the aspect of financial scale and the inadequacy of nonlinear effects. It also enriches the study of financial efficiency in the Chinese context and introduces a modest competition mechanism for R&D investment.

2. Theoretical Analysis and Research Hypotheses

2.1. Financial Development and Heterogeneous Firm R&D

With the advent of research on the impact of financial development on the real economy, research on the financial development of micro-enterprises and economic innovation inputs has attracted widespread attention. From the financial structure perspective, we analyze the comparative advantage of promoting R&D inputs from financial structures dominated by banks, markets, and the inflow of foreign capital with the opening of the financial markets. According to studies on the financial structure dominated by banks, financial intermediation has an advantage in information gathering and processing, which is beneficial for both the allocation of resources and economic development. However, according to studies on market-dominated financial structures such as Gustav [2], financial markets can offer more flexible risk management tools and financial risk products; however, banks have a natural tendency to be cautious, which is not conducive to innovation and growth. With the deepening and opening of financial markets, the inflow of foreign capital has continuously improved the function of the domestic financial structure to promote investments in real economic innovation. Moreover, countries with high financial system efficiency export financial intermediation functions to countries with low efficiency, which helps these countries realize the functions of innovative capital allocation and risk diversification and increases firm R&D, as noted by Bertrand [3].

When studying the impact of financial development on firm R&D inputs, many studies have also considered the influence of a firm's characteristics on its R&D. Schumpeter's study on the impact of internal factors (ranging from scale to capital intensity, profit, age, and human resource differences) on firm R&D was the first in its field. However, these factors rarely include the core of firm heterogeneity: the level of productivity. Numerous studies have focused on the impact of R&D on firm productivity, but they fail to note that firm productivity often reflects contributions of non-productive factors, such as enterprises' technological progress or institutional environment [4]. Different productivity levels usually mean that there are significant differences in firms' technological

level or innovation efficiency, and innovation behavior is different for R&D. Furthermore, the response sensitivity to external factors is also different [5,6]. Yang used the three-stage ordinary least squares (OLS) method to integrate firm R&D [7], productivity, and exports into an overall analysis framework. The method shows that R&D promotion of enterprise productivity leads to a change in a firm's own R&D activities after excluding self-selection behavior. In other words, the higher the productivity level of the enterprise is, the stronger the R&D motivation, and the level of R&D input will improve accordingly [8,9].

When we combine an analysis of the impact of macro-financial development on firm R&D investment and the characteristics of heterogeneous firm R&D, we find that with the financial development of the economy, the financial sector should effectively deploy funds to firms with higher R&D power and efficiency to improve the innovation scale and promote the sustainable development of the real economy [10]. Therefore, determining whether China's financial development contributes to the flow of financial resources to high-efficiency enterprises is a matter of great significance. First, high-tech R&D projects involve significant complexity and uncertainty. Many SMEs [11], especially in the early stages of high-tech enterprises, lack collateral assets. In addition, a fundamental conflict exists between the demand for capital and banks' safe credit principles, making it difficult for firms to obtain bank financing. Second, given the background of information opaqueness and a lack of asset liquidity, financiers can rely on only their own special advantages and experience to intervene and guide the flow of the financial sector's resources. This phenomenon primarily relies on the reputation or security of the enterprise itself. Particularly in state-owned enterprises, the implicit guarantee of the government or the state has resulted in the adverse selection of R&D financing by state-owned financial institutions for non-state-owned enterprises [12,13], resulting in distorted capital prices and other financial repression phenomena that cause an inefficient allocation of financial capital. Therefore, this article proposes Hypothesis 1.

Hypothesis 1 (H1): *Expansion of the financial scale can lead to financing moving away from supporting R&D inputs for high-efficiency firms, thereby causing financial inefficiencies.*

2.2. Financial Efficiency, Financial Competition, and Firm R&D

From the perspective of the financial scale, quantitative growth does not automatically lead to an improvement in financial efficiency. However, financial efficiency plays a key role in the financing process to promote economic development. The level of financial efficiency determines the financial costs and the strength of the economy. Therefore, to a significant extent, financial efficiency determines the overall level of economic efficiency [14]. For transition countries, it is only by promoting growth in the real economy—in particular, firm R&D is needed to accelerate financial reform [15] and financial innovation to improve financial efficiency—that strong support mechanisms for the financial system can be truly established [16]. The core function of financial development relative to firm R&D lies in selecting the most innovative entrepreneurs and effectively allocating capital to support these entrepreneurs' innovation and entrepreneurship activities to achieve sustained economic growth [17,18].

However, the scale of frictional financial inefficiency caused by a financial structure dominated by China's large banks and SMEs' financing difficulties restricts these enterprises' financing scale, thus inhibiting the level of innovation and investment [19]. Financial capital flows to inefficient state sectors, making it difficult to improve the scale and efficiency of financial development [14,20]. The higher the proportion of government ownership in the Chinese banking sector is, the less significant (or even negative) the impact of credit inefficiency on SME innovation will be [21]. Therefore, in less efficient financial markets, simple financial expansion does not effectively promote more efficient businesses and may even suppress firm R&D in innovative and efficient enterprises that lack political or government guarantees. Therefore, this article proposes Hypothesis 2.

Hypothesis 2 (H2): *Financial efficiency has a threshold effect on firm R&D. Only when financial efficiency improves, together with enhancements to the quality of financial development, will promoting the R&D of more efficient enterprises be of assistance.*

Furthermore, it is important to improve and enhance financial efficiency—especially in transition economies and in China, with its high degree of banking monopoly. Only through a fully competitive financial market can the Pareto optimal allocation of financial resources—that is, financial efficiency—be realized. Even if a fully competitive state is difficult to achieve, a Pareto improvement in financial resource allocation can be achieved by encouraging competition and cultivating competitive financial markets. In the credit market, financial enterprises are the main bodies for organizing deposits and issuing loans, and these organizations compete to achieve their management goals and strengthen businesses. As funding providers, these enterprises also transport capital to the economic fields with the highest income and seek efficient capital allocation. The degree of competition in the financial markets is a qualitative financial development indicator that is parallel to the scale and efficiency of the development of financial intermediaries [14,20]. In the case of distortions in the financial structure, cooperation between FDI and private enterprises can encourage banks to provide loans to the private sector, which can compensate for distortions and help improve financial efficiency. However, whereas financial competition pushes the expansion of the financial system forward by improving financial efficiency and promoting innovation by real enterprises, excessive competition can result in blind, impulsive, and disorderly financial markets and may even lead to chaos in the country's macro-financial system and social and economic disorder. In particular, China is at a stage of transforming from old systems to new, with local government intervention hidden behind financial competition; this intervention has distorted the local financial structure as an exogenous force in the capital deepening process, causing it to deviate from the optimal financial structure determined by local factor endowments and resulting in a loss of financial efficiency in the capital deepening process [22,23]. Therefore, this article proposes Hypothesis 3.

Hypothesis 3 (H3): *Financial competition has a threshold effect on firm R&D inputs. Moderate financial competition can effectively improve inefficiencies in capital allocation toward innovation in the financial sector, thus increasing firm R&D.*

3. Research Design

3.1. Research Sample and Data Sources

This article uses enterprise data from the statistical "China Industrial Enterprise Database" (2005–2007), which is compiled and collected by the National Bureau of Statistics from all state-owned and non-state-owned enterprises. Financial development indicators (regional financial institution loan balances, regional financial efficiency indicators and regional financial competition indicators, among others) are collected from the "China Financial Yearbook" (2011) and "China's Marketization Index—The Relative Process of Marketization in Various Regions 2009 Report." This paper used the Access 2010 and Stata11.0 statistical software packages to perform the data processing by screening 35,859 firms, all with positive R&D inputs.

3.2. Selection and Definition of Variables

3.2.1. Definition and Measurement of Quantitative and Qualitative Indicators of Financial Development

(1) To select the scale of financial development (fd) indicators, Goldsmith (1969) proposed the concept of a financial correlation ratio: total financial assets to all physical assets—the value of national wealth—to measure the degree of financial development. However, Beck [14] noted that the quantitative differences among different qualitative items should not simply be compared. Therefore, this paper draws on Lu [24] and uses the ratio of total loans to GDP for the financial

institutions in each region instead of a quantitative scale of financial development to study its impact on firm R&D.

(2) The selection of financial efficiency indicators is based on Beck's [20] definition of financial efficiency and the financial efficiency indicators used by Ranjian [20]. (1) LDR (decre) bank loans have the strongest impact on investment growth in various regions; therefore, we use the year-end loan balance/year-end deposit balance for the financial institutions in each province to reflect the conversion efficiency of savings in the banking system, which represents the banking system's micro-efficiency. (2) The loan ratio of non-state-owned enterprises (credit) equals the loan amount of non-state-owned enterprises/total loan amount. Under a socialist market economy, market activities should make funds flow to more efficient industries [25]. Non-state-owned enterprises are active market players for their high operating efficiency, and such firms should obtain financial support commensurate with their contribution. This condition, which reflects the financial allocation efficiency of social resources, is an important aspect when examining the efficiency of macroeconomic financing [26].

The data are represented by the proportion of non-state-owned loans to all loans in China's market-oriented index report, including long-term loans, short-term loans, and loans provided by financial institutions to all non-state-owned enterprises. (3) With respect to the savings–investment conversion rate (dein), the savings of financial institutions can add value only if they are converted into capital and flow to the production sector. Under the premise of a high savings rate, the efficiency of saving for investment reflects the ability of regional finance to create wealth, which is an important aspect of financial development efficiency. Therefore, this article uses the ratio of total capital formation (the total amount of fixed capital and the value of inventory changes in a certain period) to the deposit balance of financial institutions in each region to represent the savings–investment conversion rate, which reflects micro-banks' effect on macroeconomic efficiency.

(3) For the selection of financial competition indicators, this paper draws on and supplements the method of Beck and Ranjian [14,20] and divides it into the following concepts. (1) We use the proportion of deposits absorbed by non-state-owned financial institutions to the deposits of all financial institutions to reflect the degree of competition in the domestic credit market, and the data are collected from the China market-oriented index report. (2) China's financial system reflects a banking monopoly that is opening up to the outside world through an influx of foreign capital. These changes will inevitably affect the competitive landscape for local financial institutions. Therefore, this paper uses the ratio of provincial foreign direct investment to GDP (FDI) to measure the degree of competition related to financial openness.

3.2.2. Selection of Control Variables

To prevent endogeneity problems in R&D investment caused by other factors, we added the following firm-level and industry-level control variables as well as industry and time dummy variables. The specific explanations are as follows.

(1) Enterprise innovation input level (R&D) [27,28] represents the percentage of enterprise innovation investment of the enterprises' total assets. (2) With respect to heterogeneous enterprise productivity (tfp), this paper uses the HTFP method to calculate a total factor productivity indicator for enterprises, the C-D production function as the research object, LnQ to represent the natural logarithm of enterprises' output Q, LnK to represent the natural logarithm of firm capital K, LnL to represent the natural logarithm of the labor force, and the logarithmic approximation of total factor productivity (LnTFP) to represent the residuals obtained by using OLS as a linear regression with no intercepts, that is, the enterprise's "Solow residual value". This paper then introduces the lagged variable of enterprise productivity as an explanatory variable into the model. (3) Regarding enterprises' internal cash flow (cf), this paper uses the ratio of an enterprise's net cash flow from operating activities and assets to measure internal cash flow [29], that is, net cash flow/assets. (4) Export (ex) represents the proportion of exports to total sales revenue. Because the export variables have many zero observations, to avoid estimation bias caused by having too many missing values, we introduce the form ln(1 + ex/sales).

To avoid endogeneity problems caused by enterprises' exports and R&D intensity [30,31], we introduce lagged export variables into the model as explanatory variables. (5) Enterprise capital intensity (k/l) is the ratio of an enterprise's total fixed assets to its total number of employees. (6) Industry concentration (HHI) uses the Herfindahl–Hirschman Index [32,33] to control for the competitive structure within the industry. (7) For enterprise size (Size) [34], we use the logarithm of sales revenue as the agency variable. (8) Enterprise age (Age) represents the time span from the enterprise's opening to the statistical year. (9) Industry (Industry) and year variables (Year) are also included as control variables [31,35].

4. Empirical Research

4.1. Descriptive Statistical Analysis of Variables

Table 1 reports the descriptive statistical analysis of the variables. To mitigate the effects of outliers, in Table 1 and in the following analysis, we use the winsorization method for all variables to eliminate extreme values at the 1% and 99% levels [36].

Table 1. Descriptive statistical analysis of the characteristics of each variable.

Variable		Average	Median	Standard Deviation	Minimum	Maximum
Financial scale	fd	1.092	0.962	0.365	0.612	2.234
Financial efficiency	dein	0.329	0.337	0.124	0.098	0.877
	decre	0.710	0.713	0.095	0.348	0.929
	credit	10.140	10.59	2.088	2.690	13.150
Financial competition	nonde	8.106	8.160	1.873	−3.980	11.010
	FDI	4.066	4.140	2.044	−0.010	9.390
R&D	RDI	0.021	0.006	0.052	4.04×10^{-7}	2.557
Heterogeneity	TFP	3.919	3.771	0.769	0.449	7.787
Control variables	CF	0.053	0.581	0.305	−13.870	23.955
	EX	4.811	0.011	5.340	0.000	19.014
	K/L	4.223	4.059	1.261	−3.215	14.058
	HHI	0.145	0.039	0.301	0.018	0.911
	SIZE	11.589	10.535	1.678	4.868	19.047
	AGE	14.698	7.000	16.097	0.000	407

Data sources: "China Industrial Enterprise Database" (2005–2007), "China Financial Yearbook" (2011) and provincial statistical yearbooks; each metric contains 35,859 firms.

4.2. Impact of Financial Development on Heterogeneous Firm R&D Research

4.2.1. Construction of Measurement Model

In this section, we study the impact of the quantitative expansion of financial development on heterogeneous firm R&D and further discuss the R&D allocation efficiency in heterogeneous firms. Therefore, we take firm R&D as the explained variable and the scale of financial development, firm heterogeneity characteristics (total factor productivity), and other variables as explanatory variables. We follow the standard academic modeling methods [37] to develop the following panel model:

$$R\&D_{it} = \beta_0 + \beta_1 FD_{it} + \beta_2 TFP_{it-1} + \beta_3 CF_{it} + \beta_4 EX_{it-1} + \beta_5 (K/L)_{it} + \beta_6 HHI_{it} \\ + \beta_7 SIZE_{it} + \beta_8 AGE_{it} + \sum Year_t + \sum Industry_j + \varepsilon_{it} \tag{1}$$

In Equation (1), *i* represents the enterprise, *t* represents the period, and *j* represents the industry category. See above for the definitions of the variables.

4.2.2. Empirical Results Analysis

Table 2 reports the results of the impact of the financial scale on heterogeneous firm R&D by enterprise ownership type, industry, and level of regional economic development. A Hausman test of the

panel model found that the *p* value rejects a random effect at a level less than 0.05; thus, we selected a fixed effect model for the study. (1) For state-owned and privately owned enterprises, financial quantitative development has a significantly positive impact on the former's (but not the latter's) R&D. This result shows that under China's state-owned bank monopoly, financial quantitative development has restricted banks' credit resources and assigned them to either the government or to elite state-owned enterprises closely linked with the government. (2) For high-, middle-, and low-tech enterprises, financial quantitative development has a significantly positive impact on high-tech enterprises, but not on middle- and low-tech enterprises. This result shows that, because China's high-tech industry is protected by local governments and national policies, the development of the banking system can promote the innovation activities of enterprises that rely more on external funds. (3) With regard to enterprises in developed and underdeveloped regions, financial quantitative development positively affects the former and negatively affects the latter because enterprises in underdeveloped regions are usually small and have relatively low rates of return. Moreover, it is difficult to obtain financing for innovation from large banks and financial markets. When the financial function is absent, funds cannot be effectively configured.

Table 2 also shows the impact of enterprises' productivity on their own innovation investments. In general, enterprises' total factor productivity positively affects their R&D under different types of ownership, in different industries, and in different regions, indicating that high-productivity enterprises have strong innovation power. In contrast, we find that enterprises' productivity has a more significant impact in the private sector, in low-tech industries, and in economically underdeveloped areas. Thus, such enterprises have a strong motivation to innovate and attempt to improve their competitiveness through innovation. However, these enterprises do not receive adequate innovation financing based on their own country's financial scale development and often face internal cash flow constraints.

Table 2. Impact of financial development on firms' R&D research.

	Divided by Ownership Type		Divided by Industry		Divided by Region	
Variable	State-Owned Enterprises	Private Enterprises	High-Tech Industries	Middle and Low-Tech Industries	Developed Regions	Underdeveloped Regions
fd	0.0040127 **	0.0011563	0.00494 ***	−0.0018923 ***	0.0034215 ***	−0.0012009
	(2.90)	(0.23)	(5.48)	(−3.03)	(4.89)	(−0.48)
tfp	0.0088791 ***	0.0331841 ***	0.0141752 ***	0.0177676 ***	0.0185776 ***	0.0117284 ***
	(10.77)	(21.38)	(28.31)	(25.36)	(28.77)	(21.72)
ex	0.0003967 ***	0.0002584 *	0.0002584 ***	0.0001246	0.0002265 **	0.0005444 ***
	(3.56)	(1.69)	(3.97)	(1.29)	(2.33)	(6.90)
cf	0.0003128	0.0028265 *	0.0016551	0.0024428 *	7.36×10^{-7}	0.0021157 *
	(0.35)	(1.91)	(1.51)	(1.72)	(0.45)	(1.77)
k/l	1.80×10^{-7} **	0.0000195 ***	3.40×10^{-6} ***	6.15×10^{-7} ***	7.70×10^{-7} ***	6.01×10^{-7} **
	(2.63)	(9.07)	(8.20)	(4.28)	(5.65)	(2.17)
HHI	−0.00421 *	−0.00417 *	−0.00438 *	−0.00455 *	−0.00468 *	−0.00472 *
	(−1.73)	(−1.68)	(−1.81)	(−1.92)	(−1.98)	(−2.04)
SIZE	0.0046862 ***	0.0069438 ***	0.0055577 ***	0.006587 ***	0.006202 ***	0.0064398 ***
	(11.84)	(7.05)	(20.91)	(19.08)	(18.70)	(23.77)
AGE	−0.0000763 ***	0.0000603	−0.0000567 ***	0.0000677 *	−0.0000445 **	0.0000267
	(−3.42)	(0.54)	(−3.06)	(1.99)	(−2.29)	(1.15)
cons.	0.0480681 ***	−0.0208204 *	0.0418401 ***	0.0317505 ***	0.0445082 ***	0.049962 ***
	(10.43)	(−1.92)	(14.32)	(7.09)	(7.29)	(12.67)
R²	16.95	17.36	15.56	14.58	14.54	15.87
statistic F	27.27 ***	76.6 ***	159.42 ***	115.78 ***	141.45 ***	133.57 ***
N	2565	6762	6322	5631	14862	4522

Notes: t statistics are in brackets. *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively. Each model includes the variables industry (Industry) and year (Year); to save space, these variables are not listed in the table. The definition of high-tech industries is based on the "Catalog of High-tech Industry Statistics" issued by the National Bureau of Statistics in 2006; see http://www.stats.gov.cn/tjbz/t20061123_402369836.htm. This paper defines the eastern part of China, including Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Joan, Liaoning and 11 other regions, as economically developed; central and western China are classified as economically underdeveloped regions.

4.3. Impact of Financial Efficiency and Financial Competition on Private Firm R&D Research

4.3.1. Measurement Model Construction and Inspection

In this section, we study the impact of qualitative improvements in financial development on firms' R&D and further discuss the impact of financial development on the allocation efficiency of

firms' R&D [37–43]. Therefore, we use firm R&D as the explained variable, the qualitative indicators of financial development (financial efficiency, financial competition) as the threshold variables of financial scale development, and enterprise heterogeneity (total factor productivity) and the other variables as explanatory variables [44–50]. Using the Hansen [51] modeling method, we create the following threshold panel model:

$$
\begin{aligned}
R\&D_{it} = {} & \alpha_0 + \alpha_1 TFP_{it-1} + \beta' control_{it} + \theta_1 FD_{it} \cdot I(q_{it} \leq \gamma_1) + \\
& \theta_2 FD_{it} \cdot I(\gamma_1 < q_{it} \leq \gamma_2) + \theta_3 FD_{it} \cdot I(q_{it} > \gamma_2) + \varepsilon_{it}
\end{aligned}
\tag{2}
$$

In Equation (2), *i* represents the enterprise and t represents the period. See above for the definitions of the variables. β' represents the coefficient vector of the control variable; *control*$_{it}$ represents the control variable vector, including enterprises' internal cash flow CF_{it}, exports EX_{it-1}, capital intensity K/L_{it}, industry intensity HHI, size $SIZE_{it}$, age AGE_{it}, and industry and year control variables; θ represents the coefficient of the threshold variable; $I(\cdot)$ is the indicator function; γ represents the specific threshold value; q_{it} represents a threshold variable (including various types of financial efficiency—the loan ratios of non-state-owned enterprises, LDR (decre) bank loans, the savings–investment conversion rate, and financial competition indicators—the proportion of deposits absorbed by non-state-owned financial institutions to deposits and foreign direct investment to GDP); and ε_{it} represents random disturbance items when $q_{it} \leq \gamma$, $I(q_{it} \leq \gamma) = 1$. In contrast, when $q_{it} > \gamma$, $I(q_{it} > \gamma) = 1$. Specifically, when financial efficiency is less than 1, financial development FD does not have a catalytic effect on R&D investment. When financial competition is less than 1 or greater than 2, financial development is also not conducive to R&D investment.

Equation (1) proves that financial development has asymmetric effects on firms' R&D investment in different categories and regions; thus, we use Equation (2) to explore how to optimize the financial efficiency and financial competition indicators to improve the impact of financial development on firm R&D. That is, we can prove that financial development can significantly influence different types of R&D only when financial efficiency and financial competition are nonlinear within a certain range.

Based on the panel threshold model estimation principle, in this paper, the measurement model is estimated under the assumption of no threshold effect, a threshold value, and two threshold values [48–51]. We also test the threshold effect of the explained variable at the 1%, 5%, and 10% significance levels, and Table 3 shows the results of testing the threshold effect. We find that, for the 95% confidence interval, financial efficiency has a single-threshold effect on firm R&D and financial competition has a double-threshold effect on firm R&D.

Table 3. Threshold effect test of each variable.

Indicator	Loans by Non-State-Owned Enterprises		LDR		Conversion of Savings to Investment		Deposits of Non-State-Owned Banks			Foreign Capital Inflow		
	Single/Double Threshold		Single/Double Threshold		Single/Double Threshold		Single/Double/Triple Threshold			Single/Double/Triple Threshold		
F value	9.43	2.97	13.83	3.41	11.51	3.33	19.02	8.76	1.84	6.33	6.29	3.15
p value	0.004	0.102	0.001	0.112	0.002	0.095	0.000	0.012	0.143	0.010	0.015	0.091
99%	8.16	8.46	8.25	8.87	8.33	8.75	7.19	7.94	8.85	6.22	6.44	6.51
95%	3.88	3.25	3.62	3.78	3.72	3.81	3.66	3.81	3.62	3.32	3.34	3.24
90%	2.64	2.55	2.33	2.62	2.45	2.71	2.82	2.91	2.39	2.27	2.31	2.25
Threshold value	11.05		0.78		0.51		(7.03, 10.51)			(3.34, 6.13)		

4.3.2. Empirical Results Analysis

Table 4 shows the results of the impact of financial qualitative indicators on private firm R&D. First, in general, the results of the impact of financial efficiency on firms' R&D show that each financial efficiency indicator has a negative impact on firm R&D on the side lower than the threshold value and a positive impact on the side higher than the threshold value. This result indicates that improvements in financial quality positively affect private firms with high levels of R&D, which is obviously a different result than the impact of simple financial quantitative development on firm R&D in Table 2. However, different financial efficiency indicators have different impacts on firm R&D. (1) The LDR indicator on the side higher than the threshold value does not significantly promote firm

R&D, which indicates that China's banking sector places more funds into the innovative financing of state-owned enterprises but limited funds in private enterprises. (2) The efficiency of the conversion of savings to investment on the side higher than the threshold value in the banking sector can promote private firm R&D, thus indicating that bank deposits positively affect private firm R&D when fixed assets are being formed throughout society because private enterprises are the main factor in social activity participation and an influential factor in efficiency improvements. (3) The loan ratio of non-state-owned enterprises throughout society on the side higher than the threshold value has a positive impact on private firm R&D. In other words, as the non-state-owned economy obtains more loans, private enterprises with higher innovation efficiency can obtain more financing, and macroeconomic efficiency becomes higher.

Second, regarding the impact of competition on firms' R&D: (1) The deposits that non-state-owned banks absorb represent the level of competition in the domestic credit market. However, when domestic credit market competition is lower than (6.03) or higher than (9.01) the threshold values, private firm R&D in inhibited. Only within the limits of the two thresholds can this competition significantly promote firm R&D. This result shows that when lower competition exists in domestic financial markets, the banking system monopoly makes it difficult to improve financial efficiency, and the credit market on the supply side spends more money on safer enterprises or projects. However, when the domestic financial market is more competitive, financial capital is not conducive to the innovation activities of enterprises, and the quantitative expansion of financial development caused by fierce competition requires banks to strongly consider more profitable investment projects. However, at this stage in China's development, the reason for this nonsignificant negative trend is that the country's financial marketization process is not deep, and financial competition has not reached a high level. Only when the level of financial competition in China is within a reasonable range can firm R&D be significantly promoted. (2) The inflow of foreign capital is effectively similar to credit competition in China, but it is not statistically significant on either side of the threshold. This result indicates that foreign investment participation in domestic financial markets and moderate competition can improve the innovation financing constraints of private firms, but foreign investment is not closely related to domestic enterprises.

Table 4. Impact of financial efficiency and financial competition on private firm R&D research.

Indicator	Efficiency Indicator			Competition Indicator	
Variable	Ratio of Loans by Non-State-Owned Enterprises	LDR	Conversion of Savings to Investment	Deposits of Non-State-Owned Banks	Foreign Capital Inflow
tfp	0.0317 ***	0.0315 ***	0.0315 ***	0.0308 ***	0.0318 ***
	(20.42)	(20.32)	(20.32)	(19.82)	(20.28)
ex	0.00034 *	0.00037 *	0.00035 *	0.00031 *	0.00032 *
	(1.74)	(1.77)	(1.75)	(1.63)	(1.65)
cf	0.00240 *	0.00246 *	0.00249 *	0.00233 *	0.00242 *
	(1.76)	(1.78)	(1.80)	(1.65)	(1.77)
k/l	0.0000173 ***	0.0000177 ***	0.0000182 ***	0.0000181 ***	0.0000185 ***
	(7.94)	(8.03)	(8.14)	(8.11)	(8.21)
HHI	−0.00428 *	−0.00436 *	−0.00441 *	−0.00425 *	−0.00429 *
	(−1.84)	(−1.96)	(−2.03)	(−1.79)	(−1.86)
SIZE	0.00868 ***	0.00862 ***	0.00865 ***	0.00852 ***	0.00892 ***
	(8.91)	(8.86)	(8.87)	(8.80)	(9.15)
AGE	0.00013	0.00016	0.00018	0.00011	0.00010
	(1.13)	(1.15)	(1.16)	(1.09)	(1.08)
fd ($q \leq \gamma 1$)	−0.0013	−0.0010	−0.0008	−0.0024 **	−0.0001
	(−1.58)	(−1.26)	(−1.20)	(−2.10)	(−0.16)
fd ($\gamma 1 < q \leq \gamma 2$)	0.0032 **	0.0021	0.0039 ***	0.0034 **	0.0011
	(2.67)	(1.53)	(3.13)	(2.71)	(1.30)
fd ($q > \gamma 2$)	—	—	—	−0.0015	−0.0011
	—	—	—	(−1.58)	(−1.28)
Sample size	6762	6762	6762	6762	6762

Notes: t statistics are in brackets *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively. Each model contains the variables industry (Industry) and year (Year); to save space, these variables are not listed in the table.

4.4. Robustness Examination

4.4.1. Impact of Financial Efficiency and Financial Competition on Middle- and Low-Tech Firm R&D Research

Table 5 shows the results of the impact of financial qualitative indicators on middle- and low-tech firms' R&D. The impact of financial efficiency and financial competition on firm R&D on either side of the different threshold values is similar to that shown in Table 4, but the specific impacts are slightly different. On the side of less than the threshold, the financial efficiency indicator, LDR, conversion of savings to investment, and the ratio of loans by non-state-owned enterprises have nonsignificant negative impacts on firm R&D, which shows that low financial efficiency is not conducive to middle- and low-tech firm R&D. On the side of higher than the threshold value, LDR and the conversion of savings to investment have significantly positive impacts on firm R&D, but the ratio of loans by non-state-owned enterprises has a nonsignificant impact. This result indicates that. when more bank deposits are converted into loans, which are then effectively converted into total social assets, middle- and low-tech firm R&D can benefit from the conversion because these enterprises enhance their competitiveness by buying advanced equipment or technology, thus manifesting advanced technological characteristics. The ratio of loans by non-state-owned enterprises on the side higher than the threshold value has a nonsignificant positive impact, which shows that the macroeconomic efficiency of the impact of China's financial system on middle- and low-tech firm R&D is not at an overall high level. For the financial competition indicator, credit competition in China that is either too low or too high has a significant inhibitory effect on middle- and low-tech firm R&D. However, moderate competition can actively promote innovation financing and innovation investment. Within a certain range, the inflow of foreign capital can also effectively promote firm R&D, while lower or higher foreign participation shows a negative impact on business innovation, but this result was not statistically significant.

Table 5. Impact of financial efficiency and financial competition on middle- and low-tech firm R&D research.

Indicator	Efficiency Indicator			Competition Indicator	
Variable	**Ratio of Loans by Non-State-Owned Enterprises**	**LDR**	**Conversion of Savings to Investment**	**Deposits of Non-State-Owned Banks**	**Foreign Capital Inflow**
tfp	0.0188 ***	0.0188 ***	0.0188 ***	0.0180 ***	0.0175 ***
	(19.62)	(19.68)	(19.67)	(18.67)	(17.94)
ex	0.00011	0.00012	0.00012	0.00012	0.00012
	(1.01)	(1.26)	(1.26)	(1.42)	(1.36)
cf	0.0023 *	0.0022 *	0.0022 *	0.0026 *	0.0025 *
	(1.69)	(1.68)	(1.68)	(1.77)	(1.76)
k/l	0.0000167 ***	0.0000171 ***	0.0000175 ***	0.0000179 ***	0.0000181 ***
	(7.58)	(7.83)	(7.96)	(8.03)	(8.10)
HHI	−0.00412 *	−0.00424 *	−0.00436 *	−0.00415 *	−0.00422 *
	(−1.75)	(−1.87)	(−1.93)	(−1.78)	(−1.83)
SIZE	−0.0068 ***	−0.0064 ***	−0.0064 ***	−0.0063 ***	−0.0061 ***
	(−14.63)	(−13.60)	(−13.59)	(−13.38)	(−13.07)
AGE	0.000061 *	0.000068 *	0.000071 *	0.000063 *	0.000061 *
	(1.67)	(1.75)	(1.79)	(1.69)	(1.67)
fd ($q \leq \gamma 1$)	−0.0001	−0.0002	−0.0001	−0.0021 ***	−0.0001
	(−1.05)	(−1.19)	(−1.08)	(−3.73)	(−0.23)
fd ($\gamma 1 < q \leq \gamma 2$)	0.0010	0.0012 *	0.0033 ***	0.0014 *	0.0017 *
	(1.60)	(1.68)	(4.57)	(1.74)	(1.88)
fd ($q > \gamma 2$)	-	-	-	−0.0011 *	−0.0008
	-	-	-	(−1.65)	(−1.52)
Sample size	5631	5631	5631	5631	5631
Threshold value	11.65	0.73	0.50	(7.4, 10.06)	(3.71, 7.21)

Note: t statistics are in brackets. *, and *** indicate significance levels of 10%and 1%, respectively. Each model contains the variables industry (Industry) and year (Year); to save space, these variables are not listed in the table.

4.4.2. Impact of Financial Efficiency and Financial Competition on Underdeveloped Region Firm R&D Research

Table 6 shows the results of the impact of financial qualitative indicators on underdeveloped region firms' R&D. The financial efficiency and financial competition indicators have negative effects on firm R&D on the side lower than the threshold value. This result indicates that lower financial

efficiency and a lower degree of financial competition are not conducive to enhancing firm R&D in these regions. On the side higher than the threshold value, the conversion of savings to investment and foreign inflow have significantly positive impacts on firm R&D. This result indicates that an increase in social fixed assets and foreign investment can effectively promote firm R&D in underdeveloped regions and can act as a strong embodiment of technological advances from foreign inflow spillovers. The impacts of the other indicators on the side higher than the threshold value are not significant.

Table 6. Impact of financial efficiency and financial competition on undeveloped region firms' R&D research.

Indicator	Efficiency Indicator			Competition Indicator	
Variable	Ratio of Loans by Non-State-Owned Enterprises	LDR	Conversion of Savings to Investment	Deposits of Non-State-Owned Banks	Foreign Capital Inflow
tfp	0.0110 ***	0.0109 ***	0.0104 ***	0.0108 ***	0.0106 ***
	(15.22)	(15.01)	(14.43)	(14.94)	(14.68)
ex	0.0003 **	0.0002 *	0.0003 **	0.0002 **	0.0003 **
	2.78	1.65	2.54	2.32	2.72
cf	0.0025 *	0.0023 *	0.0020 *	0.0023 *	0.0024 *
	(1.84)	(1.76)	(1.70)	(1.75)	(1.79)
k/l	−0.0000 ***	−0.0000 ***	−0.0000 ***	−0.0000 ***	−0.0000 ***
	(−3.62)	(−3.71)	(−3.59)	(−3.33)	(−3.52)
HHI	−0.00471 *	−0.00470 *	−0.00472 *	−0.00473 *	−0.00474 *
	(−1.98)	(−1.94)	(−2.05)	(−2.11)	(−2.13)
SIZE	−0.0045 ***	−0.0042 ***	−0.0043 ***	−0.0044 ***	−0.0044 ***
	(−12.41)	(−11.56)	(−11.85)	(−12.16)	(−12.25)
AGE	0.0001 *	0.0001 **	0.0001 *	0.0001 **	0.0001 *
	(1.79)	(2.17)	(1.69)	(2.28)	(1.96)
fd ($q \leq \gamma 1$)	−0.0016 ***	−0.0008 **	−0.0024 ***	−0.0009 **	−0.0009 **
	(−4.88)	(−2.37)	(−6.49)	(−2.64)	(−2.62)
fd ($q > \gamma 1$)	0.0006	0.0000	0.0011 ***	0.0004	0.0031 ***
	(1.39)	(0.11)	(3.55)	(1.09)	(8.01)
Sample size	4522	4522	4522	4522	4522
Threshold value	10.96	0.82	0.47	8.36	3.74

Note: t statistics are in brackets *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively. Each model contains the variables industry (Industry) and year (Year); to save space, these variables are not listed in the table.

5. Conclusions and Implications

This article uses a large sample of data on Chinese industrial enterprises and quantitative and qualitative indicators of regional financial development combined with the characteristics of enterprises based on panel data and the threshold panel method to analyze the impact of firm R&D. We make the following findings. (1) At this stage in China's economic development, the extensive growth of the country's finances cannot effectively support innovation, and financial inefficiency exists in the R&D activities of efficient private enterprises, middle-, and low-tech enterprises, and enterprises in underdeveloped regions. (2) The impact of financial efficiency at different thresholds on firm R&D is different. Low financial efficiency, particularly low macro efficiency, is an important reason that financial quantity development is not very effective in promoting firm R&D. (3) Financial competition at different threshold levels impacts firm R&D in different ways, and financial competition that is too high or too low adversely affects firm R&D. Only when financial competition is within a reasonable range can firm R&D be significantly promoted. The main problems in China are low levels of financial efficiency and financial competition, and the inefficiencies of firm R&D can be effectively improved by expanding the quantitative financial scale and improving financial qualitative indicators.

Based on our research in this paper, we make the following policy recommendations.

First, we provide suggestions to reform China's macro-financial development. China's financial system reforms have lagged behind its structural economic reforms, and, because of its extensive financial expansion, there remains much room for improved efficiency in China's financial system. Financial capital has not been properly optimized and configured, resulting in a waste of financial resources that is not conducive to changing China's economic growth mode and optimizing and upgrading the industrial structure. In particular, the financial development process in underdeveloped regions requires extensive effort to improve the efficiency of the financial system by improving the internal governance level of financial institutions and the cooperation among financial institutions in different regions to guarantee the balanced development of finance in each region. In the future,

China's financial system reforms therefore should focus on "qualitative" development, optimizing the financial structure, and improving financial functions to gradually improve the situation through adequate financial development but a lack of qualitative development.

Second, we provide suggestions for government agencies. The nonlinear relationship between the financial scale and financial system efficiency with respect to firm R&D shows that the contribution of future financial development to firm R&D is relatively dependent on the efficiency level. Therefore, policy-making departments and local governments should devote their full attention to efficiency. Considering the "threshold effect" in financial development, financial efficiency, and firm R&D processes, policy-making departments and local governments should formulate differentiated financial development strategies for each region. When financial expansion reaches a certain effective limit, it should be transformed to adjust the structure and improve efficiency, and attempts should be made to break through the bottleneck of the impact of the financial scale on firm R&D. In addition, a benign interaction mechanism should be developed to expand the financial scale, improve financial efficiency and R&D growth, prevent asset bubbles from falling into over-liquidity, and reduce the harm from excessive development of the financial scale, which results in deviations from the optimal R&D funding in the real economy.

Third, we provide suggestions for micro-financial sector reform. The construction of financial functions should be strengthened, and the technical level of financial practitioners should be improved. Because of the need to strengthen the risk-screening process for innovation projects, China cannot reduce the risk of allocating innovation funds through financial ownership discrimination. Social capital should be appropriately introduced, and the coordinated development of direct and indirect financing should be emphasized. Different measures must be adopted for different enterprises, especially for small- and medium-sized enterprises, to provide multi-level and multi-channel financing systems. The marketization of interest rates should be accelerated, and the original banks should be less concerned about becoming the new gods of the private sector, which will require a corresponding increase in banks' risk management levels.

Fourth, we provide suggestions for industries and firms. The capital return rate of enterprises in different industries and the innovation ability and production efficiency of firms should be improved. The government should create an atmosphere that encourages firms to make R&D investments and to innovate through channels such as tax reductions, fee reductions, and technical subsidies to narrow the gap in returns between corporate capital and financial capital and to guide financial capital to private enterprises, low- and medium-technology enterprises, and enterprises in underdeveloped regions with high productivity (heterogeneity) to make up for the inefficient allocation of financial capital.

Fifth, we provide suggestions for improving the construction of financial markets. The construction of financial markets should be improved, and the financial structure should be optimized. Both traditional manufacturing and new services or technology-driven enterprises need equity, but banks cannot supply equity, and the other financial institutions are under-supplied. On the one hand, China's trillions in bank deposits cannot be loaned out. On the other hand, the real economy urgently needs equity capital, but obtaining financing from the domestic capital market is difficult. If China cannot open up more channels for the use of funds, the price of the "limited supply of financial assets" will increase rapidly. A large-scale and deep financial market can ease the credit rationing problem caused by imperfect bank reforms, quickly absorb excess liquidity in the economy and prevent asset bubbles. In addition, the Chinese corporate bond market has certain problems, such as complex listing approval procedures, high thresholds, single nominal interest rates, and hidden fees for non-state-owned enterprises that increase costs. The reforms can include auditing aspects and canceling the traditional methods of first and second batches for the entire year and converting them to approval methods after maturation. Nevertheless, the risk control mechanism should be standardized appropriately by reducing the debt issuance threshold to increase the supply of corporate bonds. In terms of distribution, interest rates should be used as benchmarks and reflect companies' differential pricing. Moreover, the Chinese corporate bond market should enter a virtuous

development track based on market-oriented operations so that bonds can become an important part of the financial market.

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