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The Influence of Financial Development on Regional Technological Innovation

Wenjun Liu

School of Business, University of York, York, United Kingdom
shjili@163.com

Abstract: *Firstly, this paper defines the connotation of financial development from four aspects: financial scale, banking industry structure, financial structure, and financial ecological environment. It interprets the technological innovation ability of each province using the national patent authorization quantity. Secondly, according to the "Seven-Five Plan", China's 31 provinces are divided into three parts: east, central, and west. Static panel models are established for each region to compare the influence of financial development on the level of technological innovation in different regions. The research results show: (1) China's financial development has significant regional differences in its impact on technological innovation. (2) The level of technological innovation in the eastern region is decreasing its reliance on the financial market. In contrast, the western region urgently needs to improve the function of the financial market further, and the central region needs to make adjustments to the financial market.*

Keywords: *Financial development; Regional technology; Panel data*

1. Introduction

1.1. Research Background

Technology serves as the prime mover of economic growth. Over the past four decades, China has witnessed robust development, ascending to become the world's second-largest economy. By capitalizing on the advantages of inexpensive land and labor costs, and adopting a model of technology absorption, digestion, and re-creation, China has swiftly risen to prominence as the global manufacturing epicenter. Nonetheless, as the technological gap narrows and core industry technologies face monopolistic barriers, China confronts challenges in industrial upgrading. To ensure sustainable development, China has unequivocally opted to prioritize technological innovation, propel the advancement of high-tech industries, explore new frontiers, and safeguard the quality and efficacy of economic development.

1.2. Research Objectives and Significance

According to relevant literature, there exists pronounced regional heterogeneity in both the levels of technological innovation and financial development across various regions in China. Regional disparities primarily manifest in the concentration of technological activities and the prevalence of labor-intensive industries.

For instance, the western regions, typified by Sichuan and Shaanxi, alongside the eastern coastal area and southern regions encompassing the Yangtze River Delta, Pearl River Delta, and the Bohai Rim area, emerge as pivotal hubs for the electronic information industry. Aircraft manufacturing gravitates towards northern locales such as Liaoning, the Beijing-Tianjin area, and the southern reaches of eastern China, notably the Yangtze River Delta and the Bohai Rim area. Similarly, the integrated circuit industry focuses in the Pearl River Delta, the Yangtze River Delta, and the Shandong Peninsula. Meanwhile, the software and electronic computer service sectors adopt an urban-centric structure, primarily concentrating in major metropolitan clusters such as Shanghai, Beijing, Nanjing, Shenzhen, and Chengdu, characterized by rapid developmental trajectories and iterative advancements.

Consequently, knowledge-intensive industries in China predominantly cluster in the eastern regions, with nominal dispersion in central and southwestern areas, notably accentuated in the Pearl River Delta and the Yangtze River Delta regions. Moreover, viewed through the lens of financial development, an

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overarching paradigm emerges, encapsulated by the adage "the east leads, the west develops, the central region ascends, and the northeast revitalizes."

Hence, a preliminary inference suggests that the eastern regions exhibit elevated economic prowess and accelerated financial maturation, thereby harboring forefront capabilities in technological innovation. To refine this thesis, this study endeavors to gauge the influence of financial development on regional technological innovation through mathematical modeling.

2. Literature Review

2.1. Research on Financial Development

Gurley and Shaw (1956) first proposed the theory of financial development, suggesting that the evolution of financial development from simplicity to complexity can be demonstrated through a financial development model, thereby determining the positive correlation between economic development and the level of financial development. Raymond W. Goldsmith (1969) introduced the "financial structure theory" in his work, which combines financial ratios with financial structure to analyze a country's financial development status. By empirically establishing models, he demonstrated that different stages of economic development lead to the formation of distinct financial structures, thereby illustrating the phased nature of financial development. Ronald I. McKinnon (1973) argued that the monetary and financial systems of developing countries have certain distinct characteristics compared to developed countries. They advocated for financial liberalization and deepening reforms in developing countries, rather than policies that suppress financial development. LaPorta (1998) introduced a legal perspective to financial development theory, suggesting that a country's legal system's ability to safeguard investors' rights correlates with its level of financial development. This theory offered a novel angle to studying financial development.

In China, research on the evaluation system of financial development has shown an upward trend. Initially, scholars mainly assessed the level of financial development using single indicators such as financial ratios (Tan, 1999) or the M2/GDP ratio (Zhou, 2003), which were somewhat one-sided and lacked a regional perspective. Subsequently, some scholars attempted to establish evaluation indicator systems for financial development (Li et al., 2007; Lei, 2009; Dong, 2010), focusing on static analysis without addressing the overall regional variations in financial development. Later, Yin and Sun (2010) conducted multidimensional evaluations of financial development levels from economic, scale, depth, and efficiency perspectives using 33 indicators. While the richness of indicators increased significantly, there were some redundancies in indicator selection.

Subsequently, scholars were devoted to figuring out the indicator of financial development. Lin (2014) argued that both quantity and quality are crucial factors in financial development. Quantity refers to the increase in the variety and number of financial institutions and financial derivatives. Quality requires improvements in the financial development structure and efficiency. Lin also pointed out that a rapid increase in the quantity of financial development can lead to a large amount of capital flowing into the virtual economy and financial investment sectors, potentially causing financial structure mismatches and reducing resource allocation efficiency and surplus assets. Xia (2014) primarily assessed the degree of development from three dimensions: financial scale, financial structure, and financial efficiency. Overall, a larger financial scale can increase social savings and provide stronger support for the real economy. Additionally, financial structure composition and financial efficiency are crucial factors. Higher financial efficiency regions have stronger capabilities to convert regional savings into investments and achieve higher output efficiency.

Cao and Tang (2016) adopted a financial market perspective, selecting three major financial markets—the inter bank market, securities market, and the insurance market. They constructed a 12-functional indicator system, including risk management, information production, and savings mobilization, to measure the degree of financial development in 31 provinces and cities nationwide.

Sun (2018) put forward the theory of financial ecosystems, illustrating that the financial entities within a country or region and their surrounding environment constitute an interconnected organic entity. The level of financial development is influenced by multiple factors, including the extent of economic openness, legal framework, governmental administration, and social credit environment.

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2.2. Research on the Impact of Financial Structure on Technological Innovation

The financial structure can be delineated into three principal categories. The first category entails a system predominantly governed by commercial banks. Some scholars posit that such a structure can effectively bolster technological innovation endeavors of enterprises (Fang 2016). Conversely, opposing views suggest that an overbearing dominance of commercial banks might stifle innovation activities.

The second category accentuates capital markets as the cornerstone of the financial structure. Capital markets are deemed capable of mitigating various shortcomings stemming from market governed by commercial banks, thereby facilitating a more efficient allocation of funds and resources to innovative enterprises. In China, the stock market commands a substantial portion of the financial capital market, offering substantial support for financing endeavors in technology-intensive industries characterized by lengthy R&D cycles and robust growth prospects. Additionally, venture capital plays a pivotal role in alleviating funding constraints for small technology firms.

The third category advocates for a dynamic equilibrium between commercial banks and capital markets. Given the protracted innovation cycle, distinct financing mechanisms are necessitated at different stages. Commercial banks and capital markets exhibit varying degrees of involvement across different phases of the R&D cycle. Early-stage funding predominantly relies on angel investment and venture capital, with stock markets stepping in during the mid-term as technology research and development trajectories become clearer. Similarly, Mi (2016) espouses analogous perspectives, suggesting that both stock markets and credit markets can significantly elevate technological innovation levels to a certain extent. Moreover, the developmental impact of the credit market is pronounced and remains unaffected by enterprise ownership dynamics.

2.3. Financial System Scale and Financial Efficiency on Technological Innovation

Luo (2013) conducted panel vector autoregression analysis to derive two conclusions. Firstly, amplifying the scale of financial investment facilitates the augmentation of research and development (R&D) initiatives. Secondly, optimizing the efficiency of financial structure plays a pivotal role in fostering technological innovation, thus mitigating the inadequacies in working capital and research funding encountered by technology innovation entities. From the respect to the finance scale, the increment of financial scale constantly improves the level of technology innovation (Ma et.al. ,2022). Zhou(2019)found that financial efficiency can be measured in two ways: on the one hand, the directed output of finance, on the other hand the undirected output of finance when it indeed influences the economy.

2.4. Financial ecological environment

2.4.1. Government Management.

It is an subject of ongoing debate that the impact of governmental management practices on technological innovation. According to Sun and Hu (2014), governments primarily enhance innovation effectiveness through three main avenues:

1) Supportive Path: This involves government financial investment in R&D and providing technological support for innovation. Meanwhile, the government tends to provide fiscal and tax incentive.

2) Guiding Path: This entails establishing innovative platforms, such as technology research platforms and financial support platforms. It also includes fostering an innovative environment by promoting a societal atmosphere conducive to innovation and encouraging entrepreneurship among university students.

3) Protective Path: This primarily focuses on bolstering intellectual property protection. Within protective policies, the efficiency of the judicial system is considered a critical measure of technological innovation, as it can catalyze progress in the innovation environment across various domains.

However, critics argue that excessive government intervention in scientific research and development may dampen technological innovation. This stems from concerns that some researchers may overly focus on government-promoted focal areas, leading to disorganization and redundancy

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among relative project researchers.

2.4.2. Openness

The degree of openness is typically gauged through the practical utilization of foreign direct investment (FDI). Scholars, drawing from nationwide (excluding Hong Kong, Macao, and Taiwan) sample statistics, have observed that FDI tends to impede the advancement of innovation levels. However, FDI has a positive effect when the average level of human capital surpasses 0.52 years. This phenomenon stems from the concern that an excessive inflow of foreign capital into low-end manufacturing sectors could tether China to lower echelons of industrial development, thereby hindering technological innovation. Nonetheless, the aggregation of high-caliber human resources, to some extent, can safeguard for technological innovation endeavors (Guo Shuhua et al., 2016).

2.4.3. Credit Environment.

The concept of the credit environment comprises both narrow and broad dimensions. The narrow perspective focuses on institutional aspects related to commercial credit management, to foster trustworthiness and discourage dishonest practices. On the other hand, the broad perspective encompasses a multitude of factors influencing the credit environment, such as educational and legal frameworks, cultural norms, and economic conditions. This paper adopts a preference for the narrow perspective of the credit environment.

3. Methodology

3.1. Data Source

This research employs annual provincial-level data from 2008 to 2017, gathered from the National Bureau of Statistics and the Wind Database. Due to data limitations in specific areas, an unbalanced panel regression model is utilized for statistical analysis. To delineate regional divisions, adhering to the guidelines outlined in the national "Seventh Five-Year Plan," the 31 provincial-level administrative districts are segmented into three main regions, excluding the territories of Hong Kong, Macau, and Taiwan.

3.2. Indicator Setting and Principles

Drawing upon extant scholarly literature, this study examines the impact of financial development on regional technological innovation across four key dimensions: financial efficiency, financial structure, financial scale, and financial ecological environment.

(1) Financial efficiency is operationalized through the ratio of financial input (deposits) to financial output (loans). The smaller the index, the higher the efficiency of capital operation number of financial

(2) Financial structure is elucidated via the ratio of aggregate loan volumes to total financing, encompassing both loan disbursements and equity financing. This choice is informed by the predominant role of the commercial bank in China.

(3) Financial scale is gauged by the ratio of aggregate deposits and loans held by financial institutions to the Gross Domestic Product (GDP).

(4) Financial environment encompasses three dimensions: government regulatory metrics are epitomized by the ratio of fiscal outlays to GDP, indicative of governmental oversight and regulatory authority within a given region; creditworthiness is appraised through the ratio of non-performing loans to regional GDP; and the level of economic openness is quantified by the ratio of actual foreign capital utilization to GDP.

(5) Technological innovation prowess is assessed through regional patent application and authorization volumes.

In conclusion, all of the indicators should be presented in Table 1:

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Table 1: Indicator system

predicted variable	technological innovation	
explanatory variable	financial efficiency	
	financial structure	
	financial scale	
	financial environment	government regulatory
		creditworthiness
		economic openness

4. Results

As the initial data did not meet the criteria for stationarity, a logarithmic transformation was applied in this research. The transformed model is formulated as follows:

$$\ln Y = \mu_{i,t} + \alpha_1 \ln E_{i,t} + \alpha_2 \ln S_{i,t} + \alpha_3 \ln G_{i,t} + \alpha_4 \ln CRE_{i,t} + \alpha_5 \ln K_{i,t} + \alpha_6 \ln STR_{i,t}$$

In this context, Y denotes the count of patents granted, while E represents financial efficiency, S denotes financial scale, and G signifies government management. Additionally, CRE stands for the credit environment indicator, and STR denotes financial structure. The subscript i pertains to various provinces, and t refers to different years, spanning from 2008 to 2017. The term μi,t denotes mutually independent random disturbances across diverse cross-sections.

4.1. Unit Root Test and Cointegration Test

The primary aim of conducting unit root tests is to mitigate the risk of spurious regression. In order to ensure a comprehensive evaluation, this study employs two distinct methodologies for unit root testing.: the Fisher-ADF test for disparate roots and the LLC (Levin-Lin-Chu) test for akin roots. The results of the unit root tests for the explanatory variables are presented in Table 2. These results indicate that each variable passes the unit root test at the 1% significance level. Hence, it can be inferred that the processed data exhibits stationarity and series demonstrate congruent orders of integration.

Table 2: Unit root test results

	Eastern Region		Central Region		Western Region	
	LLC	ADF	LLC	ADF	LLC	ADF
LNY	0.0000***	0.0000***	0.0000***	0.0011***	0.0000***	0.0012***
LNE	0.0000***	0.0001***	0.0003***	0.0342**	0.0160**	0.0012***
LNS	0.0000***	0.0008***	0.0003***	0.0230**	0.0001***	0.0021***
LNG	0.0000***	0.0012***	0.0001***	0.0224**	0.0000***	0.0001***
LNCRE	0.0000***	0.0002***	0.0000***	0.0046***	0.0000***	0.0010***
LNK	0.0000***	0.0002***	0.0000***	0.0022***	0.0000***	0.0009***
LNSTR	0.0000***	0.0092***	0.0000***	0.0000***	0.0000***	0.0000***

Note: *, **, * ** represent at 10%, 5%, 1% significance levels

4.2. Cointegration Test

The processed data meets the criterion of possessing the same order of integration, thus facilitating the application of the Kao test method for cointegration analysis. The primary purpose of this test is to examine whether a linear combination of two or more non-stationary series forms a stationary series. As depicted in Table 3, the p-values of the Kao test results for the panel models of the Eastern, Central, and Western regions are all less than 1%, indicating the presence of cointegration among the variables. Consequently, subsequent panel estimations can be conducted.

Table 3: Cointegration test results

region	t-Statistic	P-value
eastern	-5.536413	0.0000***
middle	-4.382783	0.0000***
western	-5.017444	0.0000***

Note: *, **, * ** represent at 10%, 5%, 1% significance levels

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4.3. Model regression

In model selection, panel data typically involves three model forms: fixed effects model, random effects model, and mixed effects model. In this study, each of these forms was estimated, and it was observed that the fixed effects model yielded higher goodness of fit.

4.3.1. Eastern Region

As depicted in Table 4, financial efficiency and financial scale exhibit significant impact on the technological innovation capability with coefficients of 1.383027 and 1.383927, respectively. Meanwhile, financial structure and the credit environment exert significant positive, while government management and the level of economic openness exert inhibitory effects on the enhancement of technological innovation capability. Moreover, both the R2and adjusted R2 values of the model exceed 70%, and the p-value corresponding to the F-statistic test is 0.00, indicating that the model demonstrates a strong explanatory power for the dependent variable, technological innovation level.

Table 4: Eastern Region

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	3.808985	2.166135	1.758424	0.0820
LNE	1.383927	0.654257	2.115265	0.0371
LNS	1.848352	0.370773	4.985131	0.0000
LNG	-2.096687	0.444555	-4.716368	0.0000
LNCRE	0.601580	0.088581	6.791311	0.0000
LNK	-0.339481	0.156963	-2.162811	0.0331
LNSTR	181.94648	90.55798	2.009171	0.0474
R-squared	0.747239	Adjusted R-squared		0.730932
F-statistic	45.82274	Prob(F-statistic)		0.000000

4.3.2. Central Region

As illustrated in Table 5, financial efficiency, financial structure, and government management exhibit significant negative effects on the technological innovation level in the Central region. The credit management indicator fails to pass the significance test, indicating an unclear impact on technological innovation. Surprisingly, the level of economic openness demonstrates a significant positive effect on the Central region, with a one percent increase leading to approximately a 0.7% increase in technological innovation level. Furthermore, both the R2 and adjusted R2 values of the model are around 50%, indicating that the model does not exhibit strong explanatory power for the dependent variable, technological innovation level.

Table 5: Central Region

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	4.696023	4.065319	1.155143	0.2524
LNE	-4.136112	1.103627	-3.747745	0.0004
LNS	1.423312	0.648671	2.1941970	0.0319
LNG	-1.242557	0.732924	-1.695344	0.0949
LNCRE	0.296316	0.145539	1.280173	0.0460
LNK	0.734238	0.240869	3.048295	0.0034
LNSTR	-451.0800	170.7330	-2.642020	0.0104
R-squared	0.529419	Adjusted R-squared		0.484602
F-statistic	11.81285	Prob(F-statistic)		0.000000

4.3.3. Western Region

As depicted in Table 6, government management and financial structure exert significant negative effects on the technological innovation capability in the Western region. Both the coefficients of the financial scale and the credit environment pass the test and have positive effects, with the financial scale having a larger impact on technological innovation. Specifically, a one percent change in the scale indicator results in approximately a 4.69% change in technological innovation capability. Similar to the Central region, the Western region experiences a positive effect of economic openness on technological innovation capability. Furthermore, both the R2 and adjusted R2 values of the model are around 80%,

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and the p-value corresponding to the F-statistic test is 0.00, indicating that the model demonstrates strong explanatory power for the dependent variable, technological innovation level.

Table 6: Western Region

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-11.82266	1.912327	-6.182340	0.0000
LNE	1.158413	0.405011	2.860201	0.0051
LNS	4.698787	0.409873	11.46402	0.0000
LNG	-3.580761	0.347687	-10.29882	0.0000
LNCRE	0.212530	0.063691	3.336912	0.0012
LNK	0.191550	0.089276	2.145593	0.0341
LNSTR	-78.780332	38.92758	-2.023766	0.0454
R-squared	0.838730	Adjusted R-squared		0.830013
F-statistic	96.21468	Prob(F-statistic)		0.000000

5. Conclusions

5.1. Financial Efficiency

Financial efficiency exhibits a negative impact on the Central region while having a positive effect on the Western region and Eastern region. This suggests that the technological innovation activities in the three regions of China are at different organizational stages. It is diminishing that reliance on financial institutions to enhance innovation levels in the eastern region, which is associated with the concentration of most universities in the region. Thus, many researchers can achieve accessible support from the university, resulting in stable funding sources. The negative impact observed in the Central region indicates that financial institutions indeed stimulate the development of innovation, suggesting a higher risk preference can be given. In the Western region, due to its remote geographical location and lower level of economic development, improvement of financial efficiency cannot effectively contribute to innovation.

5.2. Financial Scale

Financial scale has a significant positive impact in all three regions, indicating that larger total loans and deposits by financial institutions are more conducive to enhancing the level of technological innovation at any stage of development.

5.3. Financial Structure

Excepting from the Eastern region, the financial structure indicator has a negative impact in the central and western region, indicating that a banking-dominated financial system is not conducive to technological innovation. This result corroborates the research theory of some scholars, which suggests that an excessively concentrated banking asset structure is detrimental to the improvement of technological innovation levels. This is because banks in the current economic environment prefer to undertake industries with shorter cycles, lower risks, and higher collateral qualifications, such as lending to some state-owned enterprises and real estate businesses with a large number of collateralized assets. Therefore, overall, the current financial structure in China does not play a crucial role in enhancing the level of technological innovation.

5.4. Financial Ecological Environment

From the perspective of government management, government intervention in technological activities has negative influence on all regions, indicating that it has interfered with the direction of technological innovation activities and led to important technological innovation achievements not being fully realized. From the perspective of economic openness, attracting foreign investment is conducive to promoting the development of technological levels in the Central and Western regions. However, for the Eastern region, foreign investment may inhibit the improvement of technological innovation levels. Considering the recent China-US trade war, the United States primarily targeted China's high-tech industries for attack. The initiation of this trade war demonstrates that China's

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maturity in related industries is comparable to international leaders. Therefore, for the Eastern region where high-tech industries are densely distributed, foreign investment may not yield good results, but may instead prolong the cycle of technological innovation research and development, inhibiting the development of technological innovation potential. From the perspective of credit management, credit management in all regions has a promoting effect on the improvement of innovation levels, indicating that a sound credit management system can reduce information asymmetry problems, safeguard the rights and interests of investors, and benefit innovation activities.

6. Suggestions

For the Eastern region, it is necessary to first reduce government intervention in technological innovation activities and purify the environment for technological innovation. Secondly, enhance the current credit management system. It is not only necessary to credit enterprises but also to strengthen the improvement of the personal credit system, promoting the formation of a good integrity atmosphere in society.

For the Central region, diversifying financial institutions and increasing the scale of finance are recommended. Therefore, it is necessary to promote the emergence of various financial institutions, increase the total financial scale, and ensure sufficient funding guarantees for technological innovation activities at any stage.

For the Western region, strengthening the function of the financial market is the primary task. From the empirical results, the Western region is greatly influenced by the level of financial development. Therefore, it is necessary to strengthen the development of the securities market, reduce the monopoly of large banks, and increase the activity of the financial market.

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