

The Impact of Financial Structure on Technical Innovation

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Abstract

We employed the fixed effects model to examine (1) the relationship between China's financial structure and technical innovation and (2) the impact of China's financial structure on heterogeneous technical innovation. This study was conducted using China's provincial panel data from 2004 to 2016. Results show that the market-oriented financial structure had an incentive effect that led to improvement in the level of technical innovation. Furthermore, we found that financial structure had different impacts on heterogeneous technical innovation. Specifically, the market-oriented financial structure significantly enhanced the improvement in the output level of regional original technical innovation; however, it had no significant impact on imitative technical innovation.

Keywords: financial structure, technical innovation, empirical research

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1. Introduction

With China entering a new normal in economic development in recent years, high-quality development will become an important direction for the country's socio-economic development for years to come. In this context, technical innovation is an important engine for high-quality development. According to Romer (1990), capital accumulation alone is not sufficient to support sustained economic growth. Rather, he argued that the fundamental driver of economic growth lies in technical innovation. Currently, China's financial structure is mainly reliant banks, making it difficult for technical innovation activities that have higher risks and a longer cycle of investment return to obtain sufficient financial support. In this paper, we ask: Through what mechanism does financial structure affect technical innovation, and in what direction? As the innovation value of different patented techniques is different, what is the relationship between financial structure and heterogeneous technical innovation? Thus far, the existing literature has not produced consistent conclusions. It is still not clear whether the current financial structure promotes or inhibits technical innovation in China, the world's largest economy in transition. Furthermore, the relationship between financial structure and technical innovation has become an important research topic, and such an investigation is necessary for achieving high-quality economic development in China.

After reviewing the existing literature, we found that there are mainly two main viewpoints regarding the impact of financial structure on technical innovation. A first, group of scholars argue that the relationship between bank-oriented financial structure and technical innovation is complicated. According to Brown *et al.* (2017), the credit market is more conducive to supporting innovation in capital-intensive industries, while it has no significant impact on technical innovation in high-tech industries. In their research based on the GMM dynamic panel, Mengnan and Xinmiao (2018) found that the relationship between credit market development and innovation displayed an inverted U-shaped nonlinear characteristic. Likewise, Jianhua and Lu (2019) conducted research based on different financing channels. They found that debt financing had a weaker positive effect on promoting enterprise innovation activities than equity financing. However, in their empirical study, Nanda and Nicholas (2014) found that the development of intermediary banks played an important supporting role in technical innovation. Junsheng, Xiaobo, and Shu (2017) argue that the financing function of capital market is not perfect and that it hinders technical innovation to a certain extent, while the credit market greatly stimulates technical innovation.

Second, scholars have argue that the market-oriented financial structure can motivate technical innovation to a certain extent. Jie and Sijing (2015) found that the capital market scale could improve the technical innovation capacity of the manufacturing industry. According to Yilin, Qiang, and Zhao (2016), the equity market can offer sustained and stable cash flow to enterprises, so it is more suitable than banks to support enterprise innovation. The study by Shancheng, Laiqun, and Huihong (2019) employed the dynamic GMM and dynamic threshold models. They found that that the capital market had a stronger promoting effect on enterprise innovation and financing activities in developed countries with a sound legal system. Hall and Lerner (2010) found that the financial market could significantly reduce the external financing costs of economic actors through the reasonable deployment of resources and effective supervision of technical innovation activities, thereby providing energy for technical innovation. Orman (2015) argued that a perfect capital market can reduce the risk of technical innovation to promote innovation professionalism, thereby leading to more technical innovation projects for enterprises. According to Durusu-Ciftci *et al.* (2016), only the capital market can support diversified venture investment decision-making within enterprises.

While relationship between financial structure and technical innovation has been deeply studied by academics, there is still room for further expansion in two ways. Firstly, the conclusions of existing research on the relationship between financial structure and technical innovation are not consistent. This relationship needs further study in China, the world's largest economy in transition. Secondly, the impact of financial structure on heterogeneous technical innovation remains unclear. If we consider greater differences in heterogeneous technical innovation due to different innovation value, the impact of financial structure on heterogeneous technical innovation may also vary. In this paper, therefore, technical innovation was subdivided into imitative technical innovation and original technical innovation. We then studied the influence of financial structure on heterogeneous technical innovation. This not only clarifies the relationship between financial structure and technical innovation, but also has practical significance for China. Specifically, this study can inform decision makers on how to optimize China's financial structure to achieve greater advances in science and technology.

2. Model setting, variable description and data source

2.1 Model setting

To study the impact of financial structure on technical innovation in China, the following basic regression equation was set (1):

$$\ln tech_{it} = \beta_1 fs_{it} + \beta_2 X_{it} + u_i + \varepsilon_{it} \quad (1)$$

In this equation (1), i represents the province, t represents the year, and ε_{it} is the random error term not related to X_{it} . u_i represents the individual fixed effect, $\ln tech_{it}$ is the explained variable, technical innovation (the technical innovation level of i province in t year). fs_{it} is the core explanatory variable, namely the financial structure. X_{it} is the control variable. Based on existing studies, 6 control variables (the infrastructure level in_{it} , economic development level $lnpgdp_{it}$, industrial structure is_{it} , opening degree $open_{it}$, fixed capital stock K_{it} and intellectual property protection ipr_{it}) were incorporated in the model, and then equation (2) was obtained:

$$\ln tech_{it} = \beta_1 fs_{it} + \beta_2 in_{it} + \beta_3 \ln pgdp_{it} + \beta_4 is_{it} + \beta_5 open_{it} + \beta_6 K_{it} + \beta_7 ipr_{it} + u_i + \varepsilon_{it} \quad (2)$$

To reduce the influence of heteroscedasticity and reduce the data fluctuation, the variables expressed as absolute values were subjected to logarithmic processing.

2.2 Variable description and data sources

2.2.1 Explained variable: technical innovation (*Intech*)

The technical innovation capability mainly depends on the output level of technical innovation. Therefore, it is more effective to measure the output of technical innovation through the number of patents based on the output method. Since patent applications cannot be granted without permission, technical innovation was measured using the number of patents granted. At the same time, this paper explored whether there were differences in the impact of financial structure on heterogeneous technical innovation. Considering that patents can be divided into three types (utility model patents, design patents and invention patents) according to the difference in innovation value, utility model patents and design patents were classified as imitative technical innovation, while invention patents were classified as original technical innovation. Imitative technical innovation is the result of processing and transformation of existing technologies, while original technical innovation is the result of development of new technologies. All patent data were obtained from the 2005-2017 *China Patent Statistics Yearbook*.

2.2.2 Core explanatory variable: financial structure (*fs*)

Following Wenxiang and Jiangjun (2020), we measured the financial structure using the entropy method from the financial scale and the financial efficiency measure. The financial scale was determined using the ratio of the total stock market value to the total loans to financial institutions. Financial efficiency was measured using the loan-to-deposit ratio, and in several steps. Firstly, the original indexes were non-dimensionalized to obtain standardized indexes. Then, the weight of each index was calculated and the entropy was determined. Next, the corresponding variation coefficient and weight were calculated. Finally, the weight and index value were multiplied using the weighting method to obtain a comprehensive index. The larger comprehensive index value for financial structure indicates that the financial structure of the region is mainly oriented by the market; otherwise, it is oriented by banks. The data required for calculating the financial structure were obtained from the 2005-2017 *China Finance Yearbook* and from the *Wind* database.

2.2.3 Control variables

The control variables we added to the model include:

- Infrastructure level (*in*): an increase in infrastructure construction can provide favorable production conditions for enterprises and raise the production efficiency, thereby promoting technical innovation within enterprises. In this paper, the infrastructure level was expressed as the ratio of the mileage of roads and railways to the land area. The data required for calculation of the infrastructure level were from the 2005-2017 *China Statistical Yearbook*.
- Economic development level (*lnpgdp*): Improving the economic development level is conducive to

- absorbing advanced production technology and high-end talents in China and surrounding, thereby stimulating technical innovation within enterprises. The regional economic development level in China is usually measured by regional GDP per capita. Therefore, we used regional GDP per capita to indicate the country's level of economic development. The data required for calculating the GDP per capita were obtained from the 2005-2017 *China Statistical Yearbook*.
- Industrial structure (*is*): The continuous optimization and upgrading of the industrial structure are conducive to raising the efficiency of resource allocation, thereby lowering the production and operation costs of enterprises, and creating a good environment for technical innovation. In this paper, the ratio of the sum of the output value of secondary and tertiary industries to GDP was used to indicate the industrial structure. The data required for calculating of the industrial structure were obtain from the 2005-2017 *China Statistical Yearbook*.
 - Opening degree (*open*): The increase in the degree of opening will help accelerate the factor flow among regions, thereby contributing to the introduction of technology and labor input, and encouraging technical innovation within enterprises. In this paper, the opening degree was expressed as the ratio of regional import turnover to GDP. The data required for calculation of the opening degree were taken from the 2005-2017 *China Statistical Yearbook*.
 - Fixed capital stock (*K*): Enhancing fixed capital investment can strengthen the configuration of production facilities, and further increase research and development (R&D) activities within enterprises, thereby enhancing the technical innovation level. In this paper, we followed Haojie (2008) and calculated the fixed capital stock based on a stationary depreciation rate of 10.96% using the perpetual inventory method with 2000 as the base period. The data required for calculation of the fixed capital stock were obtained from the 2005-2017 *China Statistical Yearbook*.
 - Intellectual property protection (*ipr*): Enhanced intellectual property protection is helpful in creating a favorable external environment and institutional assurance for enterprise R&D, thereby inspiring enterprises to innovate. In this paper, the intellectual property protection level was measured through one minus the intellectual property infringement rate was based on the method developed by Zhongqiang (2011). The data required for calculation of the intellectual property protection level were taken from the 2005-2017 *China Statistical Yearbook*.

2.3 Statistical description of variables

Considering the availability of data, we conducted our empirical analysis using panel data from 30 provinces in mainland China (except for the Tibet Autonomous Region) from 2004 to 2016. The statistical description of each variable is shown in Table 1. As we can see, the results of the multicollinearity test show that the variance inflation factor (VIF) of all variables did not exceed 10, indicating there is no multicollinearity among the variables.

Table 1: Statistical description of variables

Variable	N	Mean	SD	Min.	Max.	VIF
<i>ln_{tech}</i>	390	8.965	1.621	4.248	12.51	—
<i>fs</i>	390	0.155	0.164	0.0292	0.966	2.72
<i>in</i>	390	0.810	0.486	0.0404	2.190	2.00
<i>lnpgdp</i>	390	10.25	0.676	8.346	11.68	2.87
<i>is</i>	390	0.835	0.212	0.372	1.825	1.19
<i>open</i>	390	0.158	0.240	0.00411	1.338	3.52
<i>K</i>	390	9.774	0.943	7.190	11.76	2.93
<i>ipr</i>	390	-1.119	3.029	-19.87	1	1.24

Data source: according to the calculated variable data in Stata15.0 regression.

3. Analysis of empirical results

Due to the absence of relevant data of The Tibet Autonomous Region in mainland China, the empirical analysis of mainland China does not include The Tibet Autonomous Region. Based on the ordinary least square method, the impact of China's financial structure on technical innovation was subjected to empirical research using panel data from 30 provinces in mainland China from 2004 to 2016. We conducted the Hausman test in our regression analysis to determine whether a fixed effects model or a random effects model was more effective.

3.1 Empirical analysis of the impact of the financial structure on technical innovation

The regression results of the impact of the financial structure on technical innovation are shown in Table 2. Model1 represents the regression result of the pooled least square model under all explanatory variables. Model2 and Model3 represent the regression results of the fixed effects model and the random effects model with the core explanatory variable incorporated into the regression equation. Model4 and Model5 represent the regression results

of the fixed effects model and the random effects model under all explanatory variables. The Hausman test result shows that the null hypothesis of the random effects model was rejected by the model at a significance level of 1% (P=0.0000). Therefore, the regression results of the fixed effects model, namely Model5, were selected and observed. The clustered robust standard errors were used to ensure the robustness of the estimated results.

In Model5, the influence coefficient of financial structure on technical innovation was significantly positive at the level of 10%. This indicates that technical innovation is likely to be promoted when the financial structure tends to be oriented by the market. A possible reason is that, for enterprises, there is no demand for collateral for direct financing through the financial market, which reduces the financing costs of enterprise R&D. At the same time, the funds obtained via direct financing are irreversible, so the enterprises have no financial pressure to repay capital with interest on time, which can further encourage enterprises to improve technical innovation capacity. Moreover, the risks are more likely to be spread for both parties in investment and financing. Sufficient financial support can be provided for enterprises while enabling investors to share greater benefits through the risk-sharing and benefit-sharing mechanisms of the financial market, thus encouraging enterprises to innovate. As a result, more imitative technical innovation enterprises are mobilized to improve the technical innovation level and transform into original technical innovation enterprises, thereby raising the output level of regional technical innovation. In sum, the market-oriented financial structure leads to an improvement in the level of regional technical innovation.

Table 2: Regression results of the impact of financial structure on technical innovation

Explanatory variable	Model1	Model2	Model3	Model4	Model5
<i>fs</i>	0.068 (0.268)	-2.751*** (0.856)	-3.465*** (0.827)	0.683** (0.328)	0.680* (0.346)
<i>in</i>	0.617*** (0.078)			0.626*** (0.228)	0.452** (0.206)
<i>hpgdp</i>	-0.093 (0.067)			0.581*** (0.209)	1.086*** (0.263)
<i>is</i>	-0.270* (0.138)			-0.662 (0.612)	-0.801 (0.924)
<i>open</i>	1.006*** (0.209)			-0.353 (0.327)	-0.844*** (0.270)
<i>K</i>	1.348*** (0.049)			0.761*** (0.171)	0.360 (0.217)
<i>ipr</i>	0.036*** (0.010)			0.016* (0.009)	0.013 (0.010)
<i>_cons</i>	-3.654*** (0.500)	9.390*** (0.245)	9.500*** (0.128)	-4.415*** (0.934)	-5.338*** (1.098)
<i>Method</i>	Pooled-OLS	RE	FE	RE	FE
<i>Hausman</i>			17.971***		69.309***
<i>N</i>	390	390	390	390	390
<i>R²</i>	0.896		0.062		0.909
<i>F</i>	469.586		17.551		123.493
<i>p</i>	0.000	0.001	0.000	0.000	0.000

Note: according to the calculated variable data in Stata15.0 regression. ***, **, *: significant at the levels of 1%, 5% and 10%, respectively. The values in brackets are the clustered robust standard errors of the regression coefficients.

3.2 Empirical analysis of the impact of the financial structure on heterogeneous technical innovation

According to the technical revolution process, with the continuous increase in innovation level, the technical innovation development of a country transforms from imitative technical innovation to original technical innovation. However, during such a transformation, differentiated financing demands are very likely to be generated among heterogeneous technical innovation enterprises due to the differences between imitative technical innovation and original technical innovation. This can result in differential impacts of the financial structure on heterogeneous technical innovation. In this paper, technical innovation was classified into imitative technical innovation and original technical innovation, according to the difference in innovation value. It was then substituted into the model in the form of explained variables for this empirical research.

The regression results showing the impact of the financial structure on heterogeneous technical innovation are presented in Table 3. Model6 and Model7 represent the regression results of the fixed effects model and the random effects model of the impact of financial structure on original technical innovation under all variables.

Model8 and Model9 represent the regression result of the fixed effects model and the random effects model of the impact of financial structure on imitative technical innovation under all variables. The Hausman test result revealed that the null hypothesis of the random effects model was rejected at a significance level of 1%. Therefore, the regression results of the fixed effects models, namely Model7 and Model9, were selected for further analysis. In Model7, the financial structure and original technical innovation were significantly and positively correlated with each other at the level of 1%. This suggests that the market-oriented financial structure is more effective at improving the original technical innovation level. A possible reason is that the funds obtained via direct financing through the financial market are long-term, which matches the longer R&D cycle of original technical innovation products, thereby encouraging enterprises to engage in original technical innovation. Moreover, the financial market delivers effective signals through the value discovery function and feedback mechanism, thereby reducing the information asymmetry between the parties in investment and financing. At the same time, the higher R&D risk of original technical innovation is spread horizontally through the asset portfolio. This improves the efficiency of resource allocation and guides the flow of funding into original technical innovation enterprises with a high technical innovation capability, thereby promoting original technical innovation. In Model9, the influence coefficient of the financial structure on imitative technical innovation was positive, but it did not pass the significance test. That is, the market-oriented financial structure had no significant impact on imitative technical innovation. A possible explanation is that imitative technical innovation enterprises have sufficient tangible assets as collateral, and they manufacture incremental innovation products with a shorter R&D cycle and a lower R&D risk. Therefore, imitative technical innovation enterprises are often able to get financial support successfully from the banks. Besides, the financial market guides most of the funds to original technical innovation enterprises with a high technical innovation level by optimizing the resource allocation. This crowds out part of the financing toward imitative technical innovation enterprises, putting them in a relatively disadvantaged position. In sum, the market-oriented financial structure has no significant impact on imitative technical innovation.

From the above, we found that the market-oriented financial structure could significantly stimulate original technical innovation, but that it had no significant impact on imitative technical innovation. That is to say that financial structure had different impacts on heterogeneous technical innovation.

Table 3: Regression results of the impact of financial structure on heterogeneous technical innovation

Explanatory variable	Model6	Model7	Model8	Model9
<i>fs</i>	1.731*** (0.546)	1.561*** (0.557)	0.523 (0.333)	0.564 (0.364)
<i>in</i>	0.752*** (0.249)	0.619** (0.239)	0.616*** (0.233)	0.434* (0.213)
<i>lnpgdp</i>	0.418* (0.233)	0.659 (0.409)	0.606*** (0.219)	1.177*** (0.268)
<i>is</i>	-0.290 (0.413)	-0.523 (0.940)	-0.742 (0.674)	-0.892 (1.000)
<i>open</i>	-0.473 (0.387)	-1.087** (0.457)	-0.351 (0.342)	-0.833*** (0.278)
<i>k</i>	1.027*** (0.180)	0.841** (0.329)	0.720*** (0.180)	0.265 (0.224)
<i>ipr</i>	0.005 (0.010)	-0.002 (0.010)	0.019** (0.010)	0.016 (0.010)
<i>_cons</i>	-7.892*** (1.104)	-8.130*** (1.258)	-4.337*** (0.953)	-5.408*** (1.134)
<i>Method</i>	RE	FE	RE	FE
<i>Hausman</i>		33.482***		22.095***
<i>N</i>	390	390	390	390
<i>R²</i>		0.897		0.898
<i>F</i>		83.772		103.465
<i>p</i>	0.000	0.000	0.000	0.000

Note: according to the calculated variable data in Stata15.0 regression. ***, **, *: significant at the levels of 1%, 5% and 10%, respectively. The values in brackets are the clustered robust standard errors of the regression coefficients.

4. Conclusion

Using a fixed effects model, we analyzed the relationship between China's financial structure and technical innovation, as well as the impact of China's financial structure on heterogeneous technical innovation. Our analysis was conducted using China's provincial panel data from 2004 to 2016. The results indicate that the market-oriented financial structure promoted technical innovation. That is, direct financing through the financial market could better meet the financing demands of enterprises in innovative activities, thereby helping improve the output level of regional technical innovation. At the same time, technical innovation was further divided into original technical innovation and imitative technical innovation, according to its innovation value. We found that the market-oriented financial structure could significantly enhance the output level of original technical innovation, but that it had no

significant impact on imitative technical innovation. In other words, the market-oriented financial structure promoted technical innovation mainly by improving the original technical innovation level.

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