Research on Regional Human Capital and Technological Innovation of Enterprises—Empirical Based on the R&D Intensity

Jiao GUO, Ming-Hai YANG* and Xiang-Xiang MENG
Shandong University of Finance and Economics, Shandong, China
*Corresponding author

Keywords: Regional Human Capital, Technological Innovation Capability, R&D Intensity

Abstract. Ethnological innovation is inseparable from human capital. Regional human capital as an endogenous force can promote the technological innovation capability of enterprises. Lots of researches argue that regional human capital and the Technological innovation are positive linear, while ignoring the moderate effects by R&D intensity. This paper bases on the provincial panel data of 2009-2015 years in China to explore the impact of regional human capital on technological innovation of enterprises, furthermore, under the moderate effect of R&D intensity. It’s found that regional human capital can effectively enhance the technological innovation capability of enterprises. Besides, R&D intensity has a significant moderating effect on the relationship between regional human capital and enterprise technological innovation capability.

1. Introduction

Under New normal goals background, China's economy has changed from the stage of high-speed growth to the stage of high-quality development and in the key period of transforming the mode of development, optimizing the economic structure and transforming the driving force of growth. In the face of such a fierce external competitive environment, technological innovation has become the driving force for China's industrial transformation and upgrading [1]. However, the regional human capital is the main source of technological innovation. The structure and allocation of regional human capital will affect the innovation ability of a region and play a vital role in technological innovation. Regional human capital has become a key factor in promoting regional economic growth. In recent years, with the rapid development of the popularization of higher education, the China's per capital education years have been significantly improved, for example, from 7.60 years in 2001 to 9.08 years in 2015 and even in the eastern developed areas the average age of education has exceeded 10 years. Among them, Beijing has reached 12.15 years, it's 1.34 times the national average; the average education level per capital in Tianjin and Shanghai is 10.50 and 10.92 years, which is close to the level of developed countries. However, under the condition that the regional human capital represented by the per capita education level has been continuously improved. Whether the technological innovation of Chinese enterprises has improved or improved significantly? How can we effectively exert regional human capital accumulation and promote technological innovation? Therefore, it is particularly important to explore how to cultivate new technological competitive advantages with the change of regional human capital. The purpose of this study provides useful answers to this question.

2. Theoretical Hypothesis

2.1 Regional Human Capital for Technological Innovation of Enterprises

Looking at the relevant documents at home and abroad, many scholars have done a lot of related research and Corresponding researches. The relationship between human capital and different modes of technological innovation shows that human capital is very important for technological innovation. Human capital can promote progressive technological innovation and fundamental technological innovation of enterprises. From a large number of empirical studies, the differences of technological innovation progress in different countries and regions mainly depend on the
differences of R&D investment and regional human capital. Based on the theory of endogenous economic growth, Lucas (1988) incorporated human capital as an independent factor into the economic growth model, combining human capital with technological progress using a more micro-quantitative analysis method [2]. Xianzhong Wang (2015) holds that technological innovation plays an increasingly important role in social and economic development. The efficiency of technological innovation has become a key factor in determining the economic quality and international competitiveness of a country or region [3]. Technological innovation will become the main driving force for regional economic development and the realization of economic restructuring and sustainability in China. Liang and Zhang (2016) from the perspective of regional human capital of education reserve found that the western region of human capital of Education Reserve has a significant impact on technological innovation and more inclined to low-level technological innovation [4]. However, technological innovation is a gradual process. From the perspective of value chain, Yu and Liu (2013) divided the innovation process into three stages: knowledge innovation, scientific research innovation and product innovation, empirically analyzed the spillover effects of each stage [5]. Zhang, Liang and Xu (2016) divided the innovation process into two stages: knowledge innovation and product innovation, empirically analyzed the innovation efficiency of the Yangtze River Delta, Beijing-Tianjin-Hebei, five central provinces and seven western provinces and cities [6].

2.2 R&D Intensity and Technological Innovation Capability of Enterprises

Most of the research scholars are exploring the direct effect of R&D input intensity on innovation. From a theoretical point of view. Romer (1990) holds that endogenous technological progress is the decisive factor to ensure sustained economic growth [7]. Foreign scholars Crepon and Dugue (1998) studied the impact of R&D expenditure on innovation and productivity growth in French manufacturing enterprises. It is found that R&D capital intensity as an indicator of innovation output has a positive correlation with W European patent number [8]. R&D investment is a necessary condition for technological innovation and plays an important role in innovation output. Geiger and Makri (2006) based on resource-based theory, it is found that different redundant resources have different effects on exploratory innovation and exploitative innovation, In addition, R&D intensity plays a positive regulatory role in them [9]. R&D intensity is partly affected by technological innovation capability of enterprises. If an enterprise has a strong technological foundation, its decision-making may be bold and its R&D investment intensity is relatively large. With the rise of Dual innovation, Yang, Mei and Shi (2010) proposed that the more R&D investment, the greater R&D intensity and the more enterprises tend to choose mutative innovation, when R&D funds are sufficient, enterprises will pay more attention to long-term performance to improve the level of innovation input and choose mutative innovation [10]. From the above literature, a large number of theoretical and empirical studies have been conducted the relationship between R&D intensity and innovation. It can be seen that firms with different R&D intensities have a certain impact on innovation investment, so there is a close relationship between them which cannot be ignored.

![Figure 1. Model.](Image)
Most scholars have done a lot of research on the impact of regional human capital on technological innovation. However, there are still some controversies in the research methods. For example, the effect of regional human capital on technological innovation and whether there are effective mediators and moderators between them. Therefore, from the perspective of region, based on the availability and completeness of data, we introduce R&D intensity as moderator. This paper selects the provincial panel data of 30 provinces (except Tibet) from 2009 to 2015 to analyze the mechanism about the regional human capital on technological innovation of enterprises. The building model is shown in the following figure.

3. Data and Variable

Considering the accuracy and availability of the data, 30 provinces (autonomous regions and municipalities directly under the Central Government) in China from 2009 to 2015 were selected as the subjects, exploring the influence mechanism of regional human capital on technological innovation capability of enterprises in different regions.

There are many ways to calculate regional human capital, and there is no uniform definition yet, this paper uses the method of Liang and Zhang (2016) for reference and selects the average length of education per capita. Generally accepted by most scholars to measure regional human capital. It is generally believed that the longer the average age of education is the higher the level of regional human capital. The formula for calculating the average years of schooling of worker is as follows:

\[
Ed = \frac{ST_1*6+ST_2*3+ST_3*3+ST_4*3+ST_5*4+ST_6*3+ST_7*4}{N}
\]

Formula (1) shows the enrollment of primary school, junior high school, senior high school, university, bachelor's degree, master's degree and doctor's degree respectively, the figure is the academic year stipulated by the corresponding academic qualifications. Learning from previous scholars' research and combining with the stage characteristics of technological innovation. In this study, patent application volume (TC1) and new product sales revenue (TC2) were used to measure the level of manufacturing technology innovation. When patents are used as a measure of technological innovation, the amount of patent applications is used, because of the lag of 1 to 2 years between patent application and approval, so the number of patent applications can more accurately reflect the current innovation output. R&D intensity reflects the degree of investment in innovation mainly divided into R&D personnel input intensity and R&D funds input intensity. Quality of personnel is neglected, and the intensity of R&D input should be used to measure the intensity of R&D from the perspective of investment. As R&D expenditure intensity is also affected by the level of regional economic development. The study uses foreign investment level (FDI) and government support (GS) as control variables. Drawing lessons from previous scholars’ research, FDI is one of the important sources of innovation capital, expressed by the actual amount of foreign capital utilization. Government support uses the proportion of government funds in R&D funds.

4. Conclusions and Implications

Based on the above tests, this study takes regional human capital as the explanatory variable and enterprise technological innovation ability as the explanatory variable, respectively considering the time fixed effect model, regional fixed effect model and both regional fixed effect model and time fixed effect model, as shown in Table 1.
urbanization process, as time goes on, the level of urbanization gap between the eastern and central regions has narrowed. The fixed effect model (1), government support, foreign direct investment and urbanization control variables all played a good role in controlling, but in the regional capability of enterprises. In the time period, foreign direct investment, government support and urbanization play a significant role in controlling the positive impact of regional human capital on technological innovation capability of enterprises. The results show that regional human capital has a significant positive effect on the technological innovation ability of enterprises. Foreign direct investment, government support and urbanization play a significant role in controlling the positive impact of regional human capital on technological innovation capability of enterprises. In the time-fixed effect model (1), government support, foreign direct investment and urbanization control variables all played a good role in controlling, but in the regional fixed effect model (2) the urbanization level did not play a controlling role. Because with the gradual rise of the western economy, has narrowed the gap between the eastern and central regions, from the urbanization process, as time goes on, the level of urbanization gap between regions will narrow.

Table 1. Direct Impact of Regional Human Capital on Technological Innovation Capability of Enterprises.

| Explanatory variable | Ln|tc | Ln|tc1 | Ln|tc2 |
|----------------------|-------------------|-------------------|-------------------|-------------------|
|                      | Model(1)          | Model(2)          | Model(1)          | Model(2)          |
| Ln|ed | 7.055***         | 5.182***         | 3.666***         |
|                      | (0.689)           | (0.500)           | (0.774)           |
| ln|gs | -0.613***        | -0.847***        | -0.698***        |
|                      | (0.088)           | (0.197)           | (0.129)           |
| ln|fdi | 0.282***         | 0.145***         | 0.166**          |
|                      | (0.062)           | (0.033)           | (0.073)           |
| ln|urban | 0.896***       | -0.181           | 0.810***         |
|                      | (0.093)           | (0.387)           | (0.218)           |
| -cons | -5.728***      | -2.729*          | 2.727            |
|                      | (0.925)           | (1.646)           | (1.870)           |
| R^2_w | 0.8265          | 0.9789           | 0.6025           |
| F | 97.45***         | 591.27***        | 339.18***        |

Note: *, **, *** are at the level of 10%, 5% and 1% respectively, and standard errors in brackets.

Table 2. The Effect of R & D Intensity on the Regulation of Regional Human Capital on Technological Innovation Capability of Enterprises.

| Dependent variable | Ln|tc | Ln|tc1 | Ln|tc2 |
|-------------------|-------------------|-------------------|-------------------|-------------------|
|                    | Model(1)          | Model(2)          | Model(1)          | Model(2)          |
| Ln|ed | 14.347***         | 6.546***         | 10.638***        | 1.318            |
|                      | (2.972)           | (2.222)           | (2.889)           | (1.633)           |
| Ln|ri | -3.050**         | -1.969***        | -2.490**         | 0.312            |
|                      | (1.223)           | (0.696)           | (1.196)           | (0.524)           |
| ln|edri | 1.993***      | 0.959**          | 1.833***         | -0.066           |
|                      | (0.557)           | (0.400)           | (0.541)           | (0.240)           |
| ln|gs | -0.178**         | -0.800***        | 0.148           | -0.121           |
|                      | (0.088)           | (0.237)           | (0.188)           | (0.144)           |
| ln|fdi | 0.076*         | 0.102          | 0.119***        | -0.001           |
|                      | (0.044)           | (0.067)           | (0.036)           | (0.024)           |
| ln|urban | 0.992***       | 0.355           | 0.794***        | 0.535           |
|                      | (0.087)           | (0.355)           | (0.067)           | (0.361)           |
| -cons | -11.492*       | -3.961          | -6.510           | 7.936**         |
|                      | (6.192)           | (4.373)           | (6.094)           | (3.659)           |
| R^2_w | 0.902          | 0.641           | 0.950           | 0.882           |
| F | 180.69***        | 46.29***        | 171.10***        | 63.63***        |

Note: *, **, *** are at the level of 10%, 5% and 1% respectively, and standard errors in brackets.
On the basis of considering time and dual fixed effects of time and region respectively, a classical regression model is constructed to further verify the regulatory effect of R&D intensity on regional knowledge innovation and product innovation, as shown in table two.

Based on the analysis of the above results, it can be concluded that R&D intensity has a significant moderating effect on the impact of regional human capital on the overall technological innovation ability of enterprises, and can effectively promote the promotion of regional human capital on the technological innovation ability of enterprises. The level of urbanization and government support has played the most obvious role in this process. It shows that with the increase of R&D intensity, regional human capital can effectively promote the overall technological innovation capability of enterprises.

R&D intensity has a significant positive moderating effect on the relationship between regional human capital and enterprise's overall technological innovation ability, enterprise's knowledge innovation ability and enterprise's product innovation ability. Government support, foreign direct investment and urbanization level control variables have played a significant role in different fixed effect models, although the degree of impact is different. In addition, whether in the two-stage innovation of enterprise's overall technological innovation ability or enterprise's knowledge innovation and product innovation ability, the gradual accumulation of human capital and the increase of enterprise's R&D intensity are more conducive to absorb the knowledge spillover from the region, which can not only enhance the absorptive capacity of enterprises, but also enhance the absorptive capacity of enterprises. It can also improve the innovation ability of enterprises. Based on the above findings, the management implications of this study include the following points: First, the government should speed up the reform of educational system and mechanism so as to promote the innovation of personnel training mode. In addition, we should increase the investment in research and development funds and researchers, so as to enhance the existing human capital stock of enterprises, constantly improve the independent research and development capacity and absorptive capacity, and better speed up the transformation of scientific and technological achievements of innovative talents, so as to enhance the scientific and technological innovation capability of enterprises. Lastly, we should further speed up the construction of urbanization level. We should speed up the construction of new-type urbanization, increase investment in urban infrastructure, create a good hardware environment, narrow the level of urbanization gap between regions, so as to better attract foreign direct investment, speed up the operation of enterprise capital and elements, bring better development opportunities for enterprises, and help to enhance Technological innovation capability of enterprises.

References
[1] Schultz T W. Investment in Human Capital [J]. Economic Journal, 1961, 82(326):787.
[2] Lucas. Differential equation model [M]. National University of Defense Technology press, 1998.
[3] X. Z. Wang. Evaluation of regional technological innovation performance in six central provinces of China [D]. Jiangxi University of Finance and Economics, 2015.
[4] S. L. Liang, L. J. Zhang. Human capital, technological innovation and long-term economic growth-based on the analysis of Western China [J].Technological economy and management research, 2016 (11): 29-34.
[5] Y. Z. Yu, D.Y. Liu. Spatial Spillover Effect and Value Chain Spillover Effect of Regional Innovation Efficiency in China: Research on Multidimensional Spatial Panel Model from the Perspective of Innovation Value Chain [J].Management World, 2013 (7): 6-20.
[6] G. Zhang, Y. Liang, Y. Y. Xu. The Multidimensional Spillover Effect of Regional Innovation Efficiency from the Perspective of Ecosystem--Spatial Econometric Analysis of Panel Data[J].Progress and Countermeasures in Science and Technology, 2016,33(15): 30-37.
[7] Romer P M. Are Nonconvexities Important for Understanding Growth? [J]. American Economic Review, 1990, 80(2):97-103.

[8] CréPon B, Duguet E, Mairesse J. Research, innovation, and productivity [J]. 1998.

[9] Geiger S W, Makri M. Exploration and exploitation innovation processes: The role of organizational slack in R & D intensive firms [J]. Journal of High Technology Management Research, 2006, 17(1):97-108.

[10] J. J. Yang, X. F. Mei, L. J. Shi. Research on the Relationship among Ownership Concentration, Innovation Commitment and Innovation Style Choice [J]. Science and Technology Management, 2010 (1): 48-54.