Research on the Relationship Between Technological Innovation and Regional Economic Development

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Abstract. This article studies the correlation between the regional economic development and the technological innovation using the provincial and enterprise data of China from 2009 to 2018. Based on the results, we draw the following conclusions: Firstly, the most economically developed provinces generally have the highest technological innovation input and output. Secondly, the technological innovation input will efficiently increase the technological innovation output. Thirdly, the regional economic development is positively correlated with the technological innovation input. Fourthly, the efficiency of technological innovation makes a significantly positive contribution to the regional economic development. In summary, both the technological innovation input and efficiency have significantly positive impacts on the regional economic development. Moreover, the marginal utility of innovation efficiency is greater than the technological innovation input. Finally, technological innovation can efficiently improve the profitability of enterprises.

Keywords: Economic development · Technological innovation · Innovation efficiency · Innovation input · Innovation output

1 Introduction

Since the reform and opening-up, China's economy has maintained rapid growth. Economic rapid growth is inseparable from the input of production such as labor and capital. From the 1970s, the rate of births in China has been falling fast and the dependency ratio of families has been accordingly reduced. As the burden of family support has decreased, the capital accumulation rate of the economy has increased. At the stage, China presented the characteristics of unlimited supply of labor force in dual economic structure [1]. However, from the 2010, as the population has aged, the share of the workforce began to decline. With the disappearance of demographic dividend, labor-intensive industries lost their comparative advantages. Therefore, labor shortage and rising labor costs have become the structural problems that constraining China's economic development. The

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growth model that relies solely on increasing the quantity of factors of production is no longer sustainable.

From the macro level, labor shortage and the rising labor costs have led to a decline in manufacturing's share of China's economy. Premature deindustrialization will weaken the potential for economic growth in developing countries [2]. The economy faces the shortage of supply-side kinetic energy. From the medium level, the labor-intensive industries lose the comparative advantage because of the labor shortage and rising labor costs. In addition, the labor force of traditional manufacturing has been plundered by the services. From the micro level, in response to the labor shortage and rising labor costs, the enterprises choose capital deepening and technological innovation instead of labor.

According to the research of Zhou et al., China's economy has shifted from a labor-driven and capital-driven model to one driven by technological innovation [3]. To study the influence and transmission mechanism of fiscal expenditure and scientific research expenditure on high-quality economic growth, they found that increased government spending on technological innovation may reduce the steady output level of the economy in the short run, but in the long run, it is conducive to high-quality economic growth. In other words, the technological innovation, the industrial transformation and the upgrading are key to China's rapid and sustainable economic growth. Improving innovation efficiency is the driving force of high-quality economic development [4].

In terms of the correlation between the economic development and the technological innovation. Technological innovation can increase the resource utilization efficiency [5]. In high-income countries, the acceleration of economic growth is closely related to patent activity and there is a significant positive correlation between economic growth and patent application growth [6]. Moreover, there are significant regional differences in the driving effect of technological innovation on economic growth, and there are significant differences in innovation efficiency among different regions [7]. The competitive advantage of regions and their economic growth stem from their ability to produce and utilize complex technologies [8]. It can be seen that technological innovation has great influence on regional economic development, the innovation is important for the transformation and upgrading of companies and industries, the world's developed countries tend to have the largest number of patent applications and higher ratings [9].

2 Materials and Methods

This article aims to study the correlation between the regional economic development and the technological innovation using the following economic model [10]:

$$Y_{it} = \alpha X_{it-1} + \beta Z_{it-1} + \delta_t + \varepsilon_{it} \tag{1}$$

In the formula, i and t is respectively the province and the year. Y_{it} is the dependent variable which is the innovation output and the regional economic development. This article uses the number of valid invention patents to measure the innovation output, and the gross domestic product and its growth rate to measure the regional economic development. X_{it-1} is the independent variable which includes the innovation input and innovation efficiency. This article uses the research expenditure and personnel to measure the innovation input, and the DEA model to calculate the innovation efficiency.

Table 1. Definitions of variables

Variable	Symbol	Calculation method
Innovation output	Vpt	The Natural logarithm of the number of valid patents of province i in year t
Regional economic development	GDP	The Natural logarithm of the gross domestic product of province i in year t
	ΔGDP	$\Delta GDP_{it} = (GDP_{it} - GDP_{it-1})/GDP_{it-1}$
Innovation input	Exp	The Natural logarithm of the research and development spending of province i in year t − 1
	Peo	The Natural logarithm of the research and development personnel of province i in year t − 1
Industry structure	Ind	The ratio of tertiary industry GDP of GDP in province i in year t − 1
Degree of openness	Trd	The ratio of total import and export of GDP in province i in year t − 1
Degree of government intervention	Gov	The ratio of fiscal expenditure of GDP in province i in year t − 1

In addition, Z_{it-1} is the control variable which includes the industry structure, the degree of openness, the degree of government intervention. Finally, ε_{it} is the residual term that measures the other factors which have impacts on the dependent variable. The detailed variable definitions are shown in Table 1.

Table 2 is the descriptive statistics of the variables. From the results, we can see that the mean of ΔGDP is 0.101, which illustrates that the average economic growth of provinces in China is 10.1%. Moreover, the mean of Ind is 0.452, which shows that the average ratio of tertiary industry GDP of GDP in Chinese province is 45.2%. Finally, the mean of Gov is 0.191 illustrating that the average ratio of fiscal expenditure of GDP in Chinese province is 19.1%.

Table 2. Descriptive statistics of variables

Variable	Obs	Mean	SD.	Min	Max
Vpt	275	8.528	1.723	3.466	12.702
GDP	275	9.619	0.991	6.090	11.485
ΔGDP	275	0.101	0.058	−0.224	0.263
Exp	275	13.834	1.678	7.401	16.741

(*continued*)

Table 2. (*continued*)

Variable	Obs	Mean	SD.	Min	Max
Peo	275	10.320	1.652	3.091	13.033
Ind	275	0.452	0.095	0.293	0.810
Trd	275	0.272	0.314	0.017	1.549
Gov	275	0.191	0.119	0.041	0.938

To achieve the research purpose, we take the following steps to conduct empirical research. Firstly, we use the descriptive statistics to analyze the technological innovation in all provinces in China. Secondly, we apply the model (1) to measure the impact of innovation input on the output and the regional economic development. Thirdly, we use the DEA model to calculate the innovation efficiency, and the model (1) to measure the impact of the innovation efficiency on the regional economic development.

3 Results and Discussion

This part is the analysis of empirical results. The first step is the descriptive analysis. From Fig. 1, 2, 3 and 4, we found that Zhejiang Province has the largest number of research projects, Guangdong Province has the largest number of research expenditure and personnel. In addition, Guangdong Province, Jiangsu Province, Shandong Province and Zhejiang Province are higher than other provinces in terms of the number of research projects, personnel and expenditure. Correspondingly, these four provinces are also the most economically developed provinces in China. We can speculate that the regional economic development is positively correlated with the innovation input and output.

Table 3 shows the regression results of the innovation output and the regional economic development to the innovation input. From the column (1), we find that the coefficient of Exp and Peo is respectively 4.255 and 0.140 with the t-value is respectively 4.94 and 4.38, which illustrates that the innovation output is positively correlated with the innovation input. In addition, from the results in column (2) and (3), we find that the innovation input affects the regional economy and its growth rate positively. The

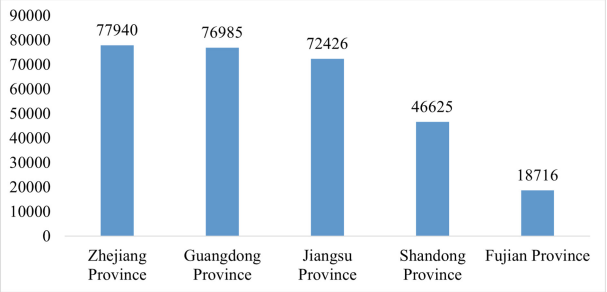

Fig. 1. Number of research and development projects

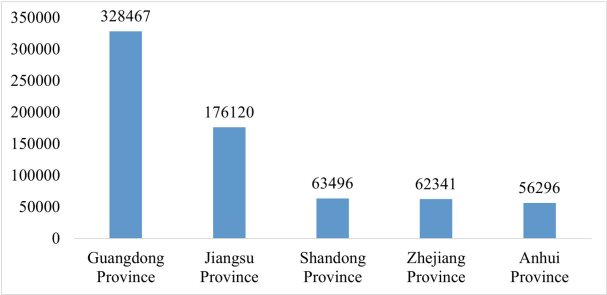

Fig. 2. Number of valid invention patents

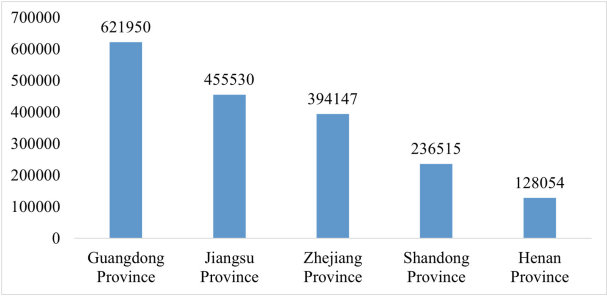

Fig. 3. Number of research and development personnel

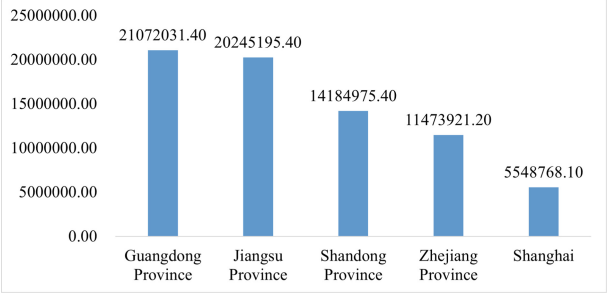

Fig. 4. Research and development expenditure

regression coefficients of independent variables are both significant at the 1% confidence level.

According to the results in Table 3, we can draw the following conclusions: Firstly, there is a significantly positive correlation between the number of the valid invention patents and the innovation input. Secondly, the regional economic development level is positively correlated with the innovation input. Thirdly, the regional innovation input has a significantly positive contribution to improving the economic growth rate. In summary, the innovation input is beneficial to the regional economic development.

Table 3. Economic development and R&D input

	OLS (1)	OLS (2)	OLS (3)
	Vpt	GDP	ΔGDP
Exp	4.255*** (4.94)	0.298*** (4.69)	0.051*** (4.83)
Peo	0.140*** (4.38)	0.272*** (4.62)	0.044*** (3.97)
Ratio		−0.248** (−2.02)	−0.069 (−1.41)
Trd		−0.040 (−1.15)	−0.024* (−1.80)
Gov		−0.056 (−0.24)	−0.009 (−0.26)
Year Fixed Effect	Yes	Yes	Yes
Adj-R^2	0.7625	0.9342	0.1378
Obs	279	275	275

Note: *, ** and *** indicate significance at 10%, 5% and 1% levels. T-values are in parentheses.

Table 4 is the regression results of the regional economic development to the innovation efficiency. From the column (1), we find that the coefficient of DEA is 0.551 with the t-value is 9.94, which shows that the GDP is positively correlated with the DEA. Also, according to the results in column (2), the coefficient of DEA is 0.060 with t-value is 5.35, which illustrates that the DEA has a significantly positive impact on the regional GDP growth rate.

In summary, we can draw the following conclusions based on the results in Table 4: Firstly, the efficiency of the technological innovation has a significantly positive impact on the regional economic development. Secondly, the innovation efficiency also has a beneficial impact on the regional economic growth rate. In other words, technological innovation will promote the regional economy.

At the micro level, in order to further verify the role of technological innovation in promoting economic development. We use the enterprise data and apply the following model (2) to study the impact of technological innovation on enterprise profitability.

$$Y_{ijt} = \alpha X_{ijt-1} + \beta Z_{ijt-1} + \delta_t + \gamma_j + \varepsilon_{ijt} \quad (2)$$

In the formula, i, j and t is respectively the enterprise, industry and the year. Y_{ijt} is the dependent variable which is the profitability of the enterprises. This article uses the return on assets (ROA and ROE) to measure the profitability. X_{ijt-1} is the independent variable which is the research and development expenditure of the enterprises (RD_exp). In addition, Z_{ijt-1} is the control variable which includes the enterprise scale (Size), the year of registration (Age), the asset-liability ratio (Lev), the tobin-q (TQ), the ownership concentration (Equity) and the nature of equity (Nature). δ_t and γ_j is respectively time

Table 4. Economic development and innovation efficiency

	OLS (1)	OLS (2)
	GDP	ΔGDP
DEA	0.551*** (9.94)	0.060*** (5.35)
Exp	0.359*** (5.17)	0.051*** (4.39)
Peo	0.240*** (3.73)	0.045*** (3.78)
Ratio	−0.574*** (−5.77)	−0.100** (−1.97)
Trd	−0.162*** (−4.65)	−0.033** (−2.30)
Gov	−0.132 (−0.77)	−0.037 (−1.18)
Year Fixed Effect	Yes	Yes
Adj-R^2	0.9434	0.6783
Obs	275	275

Note: *, ** and *** indicate significance at 10%, 5% and 1% levels. T-values are in parentheses.

fixed effect and industry fixed effect. Finally, ε_{ijt} is the residual term that measures the other factors which have impacts on the dependent variable.

Table 5 shows the regression results of the subsequent profitability and the innovation input of the enterprises. From the results, we can find that the coefficient of RD_exp is respectively 0.421 and 0.839 in column (1) and (2). Then, the t-values are both more than 10. This result indicates that the subsequent profitability of enterprise is significantly and positively correlated with the innovation input.

In summary, according to the results in Table 5, we can conclude that the technological innovation of enterprises can significantly improve the subsequent profitability. This result also fundamentally explains that why the technological innovation can promote the high-quality development of regional economy.

Table 5. The innovation efficiency of the enterprises

	OLS (1)	OLS (2)
	ROA	ROE
RD_exp	0.421*** (10.64)	0.839*** (10.67)

(*continued*)

Table 5. (*continued*)

	OLS (1)	OLS (2)
	ROA	ROE
Size	0.017*** (24.58)	0.037*** (25.06)
Age	0.003 (1.28)	0.006 (1.46)
Lev	−0.145*** (−32.36)	−0.229*** (−20.02)
TQ	0.009*** (15.10)	0.014*** (12.67)
Equity	0.071*** (16.51)	0.127*** (15.15)
Nature	−0.009*** (−5.67)	−0.016*** (−4.83)
Year Fixed Effect	Yes	Yes
Industry Fixed Effect	Yes	Yes
Adj R^2	0.2587	0.1642
Obs	20118	20118

Note: *, ** and *** indicate significance at 10%, 5% and 1% levels. T-values are in parentheses.

4 Conclusions

This article uses the economic models to study the correlation between the regional economic development and the technological innovation. According to the results, we can draw the following conclusions: Firstly, in China, the economically advanced provinces tend to have higher innovation input and output. Secondly, the innovation output is positively correlated with the innovation input. Increasing research expenditure and personnel can significantly increase the patents output. Thirdly, the regional economic development is positively correlated with the innovation input. The provinces that spend more on researching tend to have higher GDP and growth rate. Fourthly, the regional economic development is positively correlated with the innovation efficiency. Higher innovation efficiency brings higher regional GDP and growth rate. Finally, the technological innovation promotes the regional economic development by improving the profitability of regional enterprises.

In summary, the results show that the technological innovation has significantly positive impact on boosting the regional economy. Improving the efficiency of technological innovation is very important to promote the regional economic development. In addition, compared with the research input, the efficiency of technological innovation contributes more to the economic growth.

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