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Analysis of Incentive Effects of Government R & D Investment on Technology Transaction

Yufeng Zhong

School of Economics, Jinan University, Guangzhou, China
Email: 397160827@qq.com

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Abstract

With panel data of 25 provinces from 2009 to 2014 and the internal expenditure of R & D derived from the government as the measure of the government's R & D input in the region, the fixed effect model is adopted to analyze the influence of the government R & D investment on technology transaction. Empirical results show that technology transaction will be promoted significantly with the increase of government R & D investment. Therefore, the technology transaction can be effectively stimulated by adding the R & D investment from government to make more technological innovation achieve the transfer and commercialization.

Keywords

Government R & D Investment, Technology Transaction, Fixed Effect Model

1. Introduction

Over the past thirty years, the economy of China has experienced a rapid growth stage, but with the increasingly competitive global economy and technological innovation playing a more and more important role in the competition, extensive economic growth in China over the years relying on investment and export is not sustainable. In recent years, China's economic slowdown is very clear. According to the statistical bulletin of the national economic and social development in 2015 from the National Bureau of Statistics, in 2011, the GDP growth is 9.5%; in 2012, 7.8%; in 2015, drops to the lowest point with only 6.9%.

Facing the severe challenge of entering the new normal, it is more urgent for China to build an innovative country. To drive economic growth by technological innovation and change the way of economic development, China put forward the strategy of independent innovation and development as early as 2006. On May 8 2015, the State Council formally put forward the concept of "Made in

China 2025", and adhered to the basic principle of "innovation, quality first, green development, structure optimization, talent oriented", so China once again stressed the crucial role of technological innovation in economic development. On July 5 2016, the National Bureau of Statistics released the announcement on the reform of R & D expenditure accounting method as well as the revision of GDP accounting data. The R & D expenditures that are able to bring economic benefits to the owner are no longer considered as intermediate consumption, but classified as fixed capital. This reform will better reflect the contribution of technological innovation to economic growth, the implementation effect of "public entrepreneurship, innovation" and the role of technological progress in economic development, so as to encourage investment in R & D as well as promote the development of technological innovation. However, at present, technological innovation of China has not played an effective role in the development of economy in China, and the technological innovation ability of China is unsatisfactory. Although the number of published papers and patent applications by Chinese grows rapidly, which means China has come out in front in these two aspects, the rate of China's technological achievements which can be applied to industry and market is less than 10% [1]. Now, many Chinese even go to other countries to buy foreign milk powder, close tool and electric cooker regardless of long distance. The phenomenon that Chinese are keen on overseas purchasing shows that the transformation motivation of technology achievement is insufficient in China. As an important way of technology transfer and commercialization, technology transaction is an important part of the commercialization of technological innovation achievements and the realization of its economic value. According to the data of Annual Report of National Technology Market Statistics in 2016, in 2015 the number of Chinese technology transfer contract is 12787, accounting for only 4.16% of all kinds of technical contract in China; the amount is 146.653 billion RMB, accounting for 15% of that of the country.

Though the government plays an important role in the technological innovation, financing and investment in technological innovation from the government in China are insufficient. The fiscal expenditure on science and technology in China increases at a relative high speed every year. According to National Bureau of Statistics of the People's Republic of China, in 2010, R & D funds of China reach 706.26 billion RMB; in 2011, R & D funds of China reach 868.7 billion RMB; in 2012, R & D funds of China are 1029.84 billion RMB; in 2013, R & D funds of China are 1184.66 billion RMB and in 2014, R & D funds of China are 1301.56 billion RMB. And the growth rates are 21.7%, 23%, 18.5%, 15% and 9.9%. But there is a large gap between per capita fiscal expenditure on science and technology in China and that of western countries. R & D spending and the proportion of it in gross domestic product (GDP) have become the general international measure indexes of science and technology activity scale and investment in science and technology. At present, there is still a gap between the proportion of R & D spending from government funding in gross domestic product

in China and that in western countries. As shown in Figure 1, in Organization for Economic Co-Operation and Development (OECD) countries, the proportion of R & D spending in GDP reached 2.37% on average. In contrast, R & D spending accounted for only 2.09% of gross domestic product in 2014 in China, so the Chinese government's R & D input was still relatively insufficient. In an era when China enters a New Normal with a high economic downward pressure, no matter from the perspective of theory and reality, it is significant to study how to expand the technology transaction in China and make more technological achievements realize technology transfer and commercialization. It is self-evident that the government plays an important role in technological innovation and technology transaction in China. So, does the government R & D investment have a significant impact on the commercialization of technological innovation? Can the increase of government R & D investment enhance the technology transaction? This is what this paper attempts to study.

2. Literature Review

Technological innovation activities have positive externalities, and individuals engaged in technological innovation cannot obtain the full benefits of the activities, so in technological innovation activities individual income is less than social benefits. Therefore, if there is no government intervention and the role in the market, the supply of technological innovation activities is less than the optimal level. Arrow believes that in the full market without government intervention, the resource investment of the R & D activities will be insufficient. Public goods being the property of technological innovation activity, the government's financial investment in science and technology has become an important part of the investment in technological innovation. R & D activities are the core of technological innovation, so the western countries finance these activities in

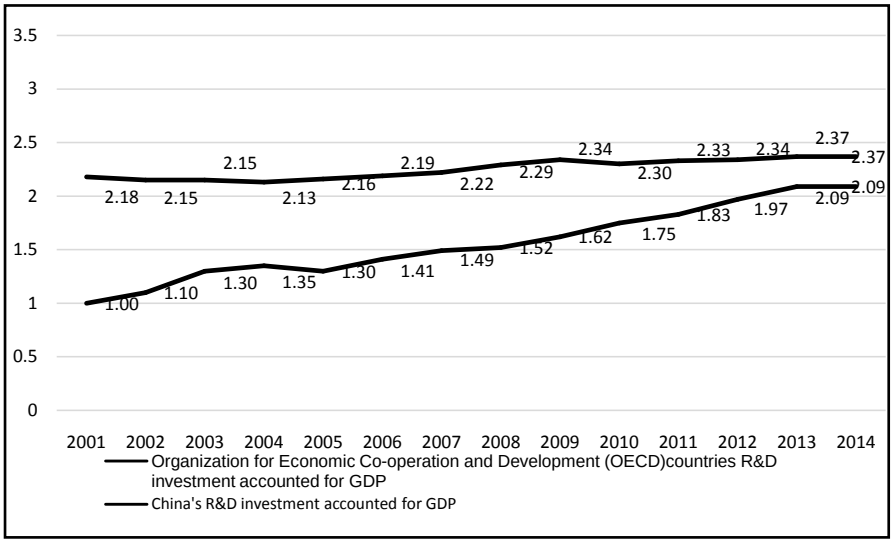

Figure 1. 2001-2014 the OECD countries and China's R & D accounting for GDP proportion (%) [2] [3]. Datasources: OECD (https://data.oecd.org), National Annual Statistical Bulletin of China (http://www.stats.gov.cn/tjsj/tjgb/ndtjgb/index.html).

different ways, such as general subsidies, purchasing products, funding activities, tax incentives and funding activities in R & D.

At the end of 1990s, many scholars began to study the function and efficiency of government investment in science and technology. By studying seven western countries, Capron found that the government's long-term financing can effectively motivate R & D activities of enterprises; Nadri and Mamuneas' research into American manufacturing also suggests that the government's long-term funding R & D of the enterprise has an incentive effect on R & D activities [4]. Many scholars study the influence of R & D input on technology transfer. In an empirical research from the point of micro industry and enterprise Deolalikar [5] and Braga [6] found that R & D activity has a significant incentive for technology transfer, so as to improve the productivity; Muscio [7] believes, through his research, that the personnel quality of R & D has an important impact on the technology transfer in enterprise; the research of Bolli [8] shows that science and technology funds input promotes the technology transfer activities of institutions of higher learning.

There are also lots of Chinese scholars studying the role government financial investment plays in science and technological innovation from various aspects. Yao Yang and Zhang Qi [9], through their research into the effectiveness of Chinese government's R & D input, think that most of the R & D activities are conducted by research institutions and universities in China, and put forward that more R & D activities should be conducted by the enterprises. By empirical test Xu Zhi and Shi Ping [4] confirm the impact of the government's investment in science and technology on R & D activities of enterprise. The results show that the government's investment in science and technology has a positive incentive effect on enterprise R & D expenditure. Chinese scholars have studied scale and structure of fiscal expenditure on science and technology in China. Liu Chunjie and Liu Shiyu [10] analyzed the relevant data of China between 1980 and 2004, compared them with those of other countries, thought that it is difficult to meet the requirements of China's technological innovation that China's fiscal expenditure on science and technology in terms of size and structure, and put forward that China should increase government investment in science and technology and adjust the structure of fiscal expenditure on science and technology. Chinese researchers also pay attention to the contribution of financial expenditure on science and technology to the economic growth of China. Bestowing China's fiscal expenditure on science and technology and GDP data and applying empirical test the result of Hu Xinran and Lei Lianghai's research [11] shows that the fiscal expenditure on science and technology is one of the causes of economic growth. And Zhu Yuancheng and Wang Lei [12] concentrate on empirical analysis of the relationship between enterprise R & D investment and enterprise technology transaction. The results show that the investment of R & D will cause the increase of technical requirements and technical achievements, which will eventually lead to the increase of the technical market. Using national data in an

empirical research, Wang Fang and Li Hua [13] analyzed the relationship between the structure of R & D and the technological transaction scale, and the results show that it is clear that R & D investment has an effect on the technological transaction scale, both government and enterprise R & D investment have a strong correlation with technological transaction, and the government R & D investment has a more encouraging effect on the technological transaction scale.

While many scholars study the role of government R & D investment in technological innovation and economic development, there are few scholars that are concerned about the impact of government R & D investment on the commercialization of technological innovation achievements in the commercial stage. Technology transaction is an important part of the commercialization of technological innovation achievements and the realization of its economic value. The research on the influence of the government R & D investment on technology transaction is even rarer. On the basis of previous studies, this paper tries to use the panel data of 25 provinces of China to analyze the incentive effect of R & D investment on technology transaction in China, and puts forward some relevant suggestions.

3. Study Design

3.1. The Sample Selection and Data Sources

The data in this paper comes from the data about 25 provinces, *i.e.* Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Chongqing, Sichuan, Yunnan, Shaanxi and Xinjiang from 2009 to 2014 in "China Statistical Yearbook on Science and Technology" and "China Statistical Yearbook". The reason why the other 6 provinces in Chinese mainland, *i.e.* Tibet, Guizhou, Ningxia, Qinghai, Hainan and Gansu are not included mainly lies in that in these underdeveloped areas (by and large, the 6 provinces are the most backward areas in China), the efficiency of the government R & D investment funds is low, and the increase of investment may not be an effective incentive of technological innovation and technology transaction. In these underdeveloped areas with a low degree of marketization, independent research and development investment to improve the technological innovation and obtaining technology from the market have to bear competitive opportunity cost and high risk for enterprises, and most of the enterprises take the shortcut by imitating innovation and "bringing" technology. In the areas with relatively developed economy, because of the high level of intellectual property protection and the fierce competition between enterprises, the investment in research and experimental development can promote technological innovation and trade. Therefore, in order to improve the accuracy of the model and consider the continuity and accessibility of data, this paper selects 25 economically developed provinces and areas in China and removes the extreme values of 6 provinces mentioned above.

3.2. Variables Selection

1) Explained variable: the regional transaction volume of technical market.

There are many indexes to measure the technology transfer and commercialization, such as the transaction volume of technical market, the number of the concluded contracts in technical market, the number of the technology output contract in technical market and the technology output value in technical market and so on. The number of the concluded contracts in technical market and the number of the technology output contract in technical market only reflect the number of technological transaction, so the accuracy of the two indexes is relatively low. Therefore, we elect the regional transaction volume in technical market to measure technological transaction. The transaction volume in technical market in one area reflects the value of technological transaction in this area, the transaction technology may come from the region, may also come from other areas, and the technology may be output from the area, and may also enter the area. But whether the technology is introduced into or output from the area, it is a part of the region's technological transaction.

2) Explanatory variable: the internal expenditures of regional R & D funds from the government.

The sources of R & D funds, the main method to measure the investment in science and technology, include government funds, enterprise funds and foreign funds, etc. And the regional R & D expenditures include internal and external expenditure. According to the interpretation of China Science and Technology Statistical Yearbook index, the internal research and development expenditure is the actual expenditures of the regional investigation units used to carry out research and experimental development, including direct expenditures for research and development projects and indirect expenditures for the research and development activities such as the management fee, service charge, the basic construction expenditure for research and experimental development and external processing fee; the regional external R & D expenditure includes the expenditure used by regional investigation units to fund Chinese research institutions, Chinese institutions of higher learning, Chinese enterprises and overseas institutions. Considering that at present the majority of expenditures of regional R & D funds in China are internal expenditures, and the continuity and accessibility of data, this paper elects the internal expenditures of regional R & D funds from the government as the regional government R & D investment. The internal expenditures of regional R & D funds from the government include the financial allocation for science and technology from regional investigation units, science foundation, operating expenses of education and other departments and the actual expenditure out of budget of government departments, etc.

3) Other control variables.

The R & D investment of the government is the capital investment aimed at technological innovation, and the factors affecting the technological innovation also include human capital input. Human capital input does stimulate technological innovation so as to promote technological transactions. In this paper, the

human capital input of research and development is measured by the full time equivalent of the test development staff, which we choose as a control variable. R & D staff full time equivalent, an internationally common index used to compare the indicators of scientific and technological human input, is the sum of the workload of the full-time staff whose working time used for R & D takes up at least 90 percent of all their working time and the converted workload of non-full time staff according to their actual work. In addition, the number of R & D institutions subjects in each area is a reflection of the intensity of the regional science and technology input, and high technology industry is an important field of technology innovation and application. Both the number of R & D institutions subjects and high technology industry can affect the activity of the regional technological innovation and technological transactions. Therefore, the number of R & D institutions subjects and the operating profit level of high-tech industry are quoted as control variables in this paper.

3.3. Descriptive Statistics

Table 1 gives descriptive statistics of the explained variable, explanatory variable and other control variables. The results of pro, ft, per, pr and y in the table are the results after taking the logarithm of the variables.

4. Model, Estimation and Result Analysis

4.1. Model

In order to investigate the effect of government R & D investment on technological transaction, this paper takes the regional transaction volume in technical market as the dependent variable, and the internal expenditures of regional R & D funds from the government as the independent variables. At the same time, the factors influencing technological transaction includes human capital input, the number of R & D institutions subjects and the operating profit level of high-tech industry. The paper takes research and development human capital, the number of regional R & D institutions subjects and regional high-tech industry operating profit level as control variables, and sets up the econometric model.

Table 1. Descriptive statistics of each variable.

Variable	Meaning	Observed	Mean	Standard	Min	Max
y	Technological transaction	150	13.4723	1.4726	9.3991	17.2614
ft	Government R & D investment	150	13.0667	0.9760	11.0478	15.7615
per	Regional R & D personnel full time equivalent	150	11.3386	0.8355	9.4458	13.1360
pr	Number of regional R & D institutions subjects	150	7.3773	0.8025	5.9636	10.2141
pro	Regional high tech industry operating profit level	150	13.9186	1.3292	8.8537	16.5988

$$\ln y_{it} = \beta 1 \ln ft_{it} + \beta 2 \ln per_{it} + \beta 3 \ln pr_{it} + \beta 4 \ln pro_{it} + \alpha_i + \varepsilon_{it}. \quad (1)$$

y_{it} signifies the technological transaction, and the regional technological transaction is measured with the regional transaction volume in technical market; ft_{it} signifies the government R & D investment in the region, which is measured with the internal expenditures of regional R & D funds from the government; per_{it} stands for the human capital input of R & D investment, which is measured with the regional R & D personnel full time equivalent; pr_{it} is the number of regional R & D institutions subjects; pro_{it} is the management condition of regional high tech industry, which is measured with regional high tech industry operating profit level. The factors peculiar to some provinces that do not change with time but have not been observed yet, such as the legal environment, resource endowment, the higher education level, are the random disturbance.

4.2. Estimation Method and Result Analysis

Fixed effect model and randomized effect model are the most commonly used estimation method of panel data. For short panel data, this paper adopts the fixed effect model, takes the lny as the dependent variable, lnft as the independent variable, and lnper, lnpr and lnpro as control variables. Stata 12.1 Software is used in the empirical analysis of this article, and "region" is used as the cluster robust standard deviation of cluster variables to analyze the fixed effect regression. Table 2 shows the results of the model related commands.

The estimated results show that the F value of the model is 31.26 and the P value is 0.0000, so the model is very significant on the whole. Model group R is 0.5772 (within = 0.5772), so the change ratio of interpretation within the unit is 57.72%; model group R is 0.7719 (between = 0.7719); general R model is 0.7505 (overall = 0.7505), indicating that the explanatory ability of the model is still relatively strong.

Table 2. The incentive effects of government R & D on technological transaction.

Variables	OLS	FE	FE (robust)
$lnft_{it}$	1.111322***	0.8157182***	0.8157182***
	(0.0943642)	(0.2320385)	(0.2393094)
$lnper_{it}$	0.3214107*	0.6666111**	0.6666111**
	(0.1755193)	(0.3191131)	(0.3226723)
$lnpr_{it}$	−0.0260883	0.0008086	0.0008086
	(0.0914454)	(0.0773812)	(0.0406603)
$lnpro_{it}$	0.0242155	0.1925514**	0.1925514**
	(0.0960837)	(0.0925855)	(0.0852718)
adjusted R-squared	0.7835	0.7505	0.7505

1) The numbers in parentheses are the standard deviation of the estimated coefficients, and **** and * signify the level of 1%, 5% and 10% respectively.

The significant P value of each variable coefficient in the observation model is generally significant. The government R & D investment has a significantly positive correlation with technological transactions at the level of 1%, so increasing the government R & D investment can effectively motivate technological transaction scale; R & D investment of human capital has a significantly positive correlation with technological transactions at the level of 5%, indicating that the increase in scientific research personnel can effectively increase the local technological transaction scale; the number of regional R & D institutions subjects has no significant impact on technological transactions possibly because the application of China's scientific research in research institutions is not strong, and the research results cannot increase the demand of technological transactions effectively; high technology industry operating profit has a significantly positive correlation with technological transactions at the level of 5%, indicating that in the areas with developed high-tech industry, the demand for technological innovation and technological transaction is relatively large, so the technological transaction scale in the regions with developed high technology industry is larger. From the above analysis, we can get the fitting equation of the fixed effect model:

$$\ln y_{it} = 0.8157 \ln ft_{it} + 0.6666 \ln per_{it} + 0.0008 \ln pr_{it} + 0.1926 \ln pro_{it} - 7.4309.$$

Using ordinary standard deviation to carry on the fixed effect regression analysis, we can see the results of F test (F test that all u_i = 0: F (24, 121) = 19.22 Prob > F = 0.0000) in the result window of the main interface in the statistical software significantly rejected the original assumption that all samples have no their own intercept, so we can think of each individual (on provincial level) for different intercepts. The fixed effect model is superior to the ordinary least squares regression model to some extent.

4.3. The Robustness Test

We examine the robustness of the above results further. In the above analysis, the technological transaction is measured with the regional transaction volume in technical market. Here through the method of principal component factor, we reduce the dimension of the four indexes (technological transaction volume in technical market, and the number of concluded contracts, technological output value, and the technological output contracts in technical market) and integrate these four indexes into one factor to measure the regional technological transaction. In the KMO test of factor analysis, the overall KMO value is 0.6487, and the KMO value of each variable is greater than 0.6, which indicates that the selected four variables are suitable for factor analysis. The chi square value of the model LR test is 996.07, the P value is 0.0000 and the model is very significant. After rotating the factor structure, we finally obtain a common factor (Table 3). From Table 3, we know that among the four common factors, only the eigen value of the first factor is greater than 1, and its variance contribution rate reaches 91.95%, so the first factor is the only common factor. We name the common factor as technological transaction factor. We reestimate the model with this technological transaction factor as the dependent variable. The results are shown

in Table 4.

The estimated results of Table 4 show that both the government R & D investment and R & D investment in human capital have passed the test of significance and both have a significantly positive correlation with the technological transactions.

5. Conclusions

This paper, with the provincial panel data from 2009 to 2014, measures the regional technological transaction with the regional transaction volume in technical market, and analyzes the incentive effect of the government R & D investment on the technological transaction with fixed effect model. The empirical results show that the government R & D investment can significantly promote the scale of the technological transactions; compared with the R & D human capital input, the government R & D investment has a greater role in promoting the scale of the technological transactions. Therefore, R & D investment of Chinese government needs to be further strengthened to promote more technological achievements to achieve commercialization.

Table 3. The results of factor analysis and comprehensive score 1).

Factors	Eigen value	Difference	Cumulative	x1	x2	x3	x4
1	3.67799	0.9195	0.9195	0.25546	0.26705	0.25874	0.26147
2	0.17909	0.0448	0.9643				
3	0.12897	0.0322	0.9965				
4	0.01395	0.0035	1.0000				

1) x1 ~ x4 in turn signify the technological transaction volume in technical market, the number of concluded contracts in technical market, the number of technological output value in technical market and the number of technological output contracts in technical market. The corresponding figures are the comprehensive score of the four indexes.

Table 4. The robustness test of the incentive effect of government R & D investment on technological transaction 1).

Variable	OLS	FE	FE (robust)
$\ln ft_{it}$	0.68518***	1.10271***	1.10271***
	(0.0811839)	(0.2183893)	(0.3414492)
$\ln per_{it}$	0. 4540596***	0.8617949**	0.8617949**
	(0.1755193)	(0. 3003419)	(0 .3741921)
$\ln pr_{it}$	0. 0941317	0.0344967	0.0344967
	(0. 0786728)	(0. 0728294)	(0. 0523836)
$\ln pro_{it}$	−0.1189368	0.0572579	0.0572579
	(0. 0826632)	(0. 0871393)	(0. 1491593)
Adjusted R-squared	0.7048	0.6715	0.6715

1) The figure in parentheses are the standard deviation of the estimated coefficient, ***, ** and * signify the level of 1%, 5% and 10% respectively.

To be specific, the expansion of the scale of technological transactions can be carried out from the following four aspects: the first one is to increase the intensity of government R & D investment. China's R & D investment mainly concentrates on enterprises, but at present, the intensity of enterprise R & D investment is still not enough, no matter in terms of fund or impetus. As the main source of investment in R & D, the government should play its role in technological innovation and technological transactions, and improve the government R & D investment in enterprises to promote more technological achievements to achieve commercialization. The second step is to adjust the structure of government financial investment in science and technology and government R & D investment. As can be seen from the empirical results, compared with R & D human capital input, the government R & D investment has a greater role in promoting the scale of the technological transactions. So on the one hand, the mechanism should be formed to stimulate the researchers to devote themselves to research. On the other hand, the government should adjust the proportion of the financial investment in science and technology and put more funds into enterprises. In addition, basic research is an important way to improve the ability of original innovation and accumulate intellectual capital, which has an important impact on the scale of technological transactions. So the government should increase the support and funding for basic research. The third one is to strengthen the protection of intellectual property rights. The level of intellectual property protection in a region has an important impact on the smooth operation of the technical market in the region. Only when the rights of both sides in technical market can be well protected, and the seller and the buyer in technical market benefit more than cost, the transaction is likely to occur. Therefore, it is urgent to make and improve laws and regulations related to intellectual property protection, increase law enforcement and safeguard the legitimate rights and interests of both parties. The last is to strengthen the policy incentives to the commercialization of enterprise innovation achievements, expand the benefit area of commercialization of innovation achievements, allow all technological transaction income to enjoy tax incentives and cancel the examination and approval of the technology transfer in China.

The inadequacies of the article are following two points: this paper adopts the fixed effect model, while because of hysteresis of technological innovation, many scholars apply instrumental variables to the empirical analysis of technological innovation, and use regression method with the explanatory variables included on some lagged variables, so it is necessary to attempt a further study with a more effective model; this paper analyzes the incentive effect of government R & D investment on technology transaction from a macro perspective, and the structure and field of government R & D investment may be the future research direction.

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