INTELLECTUAL PROPERTY RIGHTS AND SCIENCE AND TECHNOLOGY INNOVATION IN CHINA: EVIDENCE AND THEORY *

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ABSTRACT

This paper adopts the Panel Data Model based on the combination of time sequence and data of cross sections and does research on data of seventeen institutes in the Chinese Academy of Sciences. It makes empirical analysis of the Intellectual Property Rights (IPR) authorization and the relationship between R&D input and R&D scientific and technological output. Research results show that the role played by the Intellectual Property Rights Authorization in scientific and technological growth is notable and positively correlated.

Keywords: Scientific research income, Intellectual property rights, Panel Data Model

1 INTRODUCTION

As the strategic goal of building a prosperous society and an economic development model that follows a new road to industrialization is proposed, IPR exploration and protections have become an important part of China's independent innovation strategy. In essence, IPR belongs to the area of scientific and technological innovation. The scope of science and technology is wide, and a most fundamental and valuable part of the core is Intellectual Property Rights. In the past, within the field of IPR, the main concern was with the introduction, digestion, and absorption of high-tech achievements. After entering the new century, with respect to the questions of how science and technology can be developed to a higher level, how to focus on the most important and fundamental concepts, how to faster and better enhance the competitiveness of science and technology, a significant entry point and focal point is IPR because its successful application can directly and remarkably bring forth the enormous wealth brought by the transformation of science and technology to advanced productive forces, which is the most wonderful manifestation of " Science and technology are the primary productive forces" (Deng, 1994). During recent years, more and more research related to the quantitative analysis of IRP has appeared and have achieved very good results. However, owing to the lack of IPR statistical data for China's science and technology, empirical research pertaining to the relationship between science and technology input and IPR authorization is not sufficient.

The Chinese Academy of Sciences, as a major scientific and technological force in China, is primarily engaged

* *Funded projects: National Natural Science Fund Project "Based on the Ecological Rebuilding of Basin Scale Control Model of Water Resources" (No. project approved: 40601038).*

in basic, strategic, and forward-looking research on scientific and technological innovation. On June 9, 1998, Zhu Rongji presided over the first meeting of the National Leading Group in Science, Technology, and Education and, in principle, examined and approved *Chinese Academy of Science Knowledge Innovation Project* (Chinese Academy of Sciences, 1998). In this conference, CAS was selected to be the experimental unit of the national new-system construction, and it has taken the lead in implementing the experimental unit work of knowledge innovation projects. Since the implementation of knowledge innovation, in order to meet the fierce competition of IPR at home and abroad, all institutes in CAS have been placing great significance on intellectual property rights work, which is related to the overall situation of knowledge innovation throughout the whole institute. They have attached great importance to the application of IRP and have already achieved good results. This paper selects seventeen representative institutes in CAS and makes a Panel Data analysis based on the combination of IPR authorization, science and technology input, and its output.

The structure of this paper is as follows: the second part focuses on factors affecting scientific and technological growth; the third part proposes theoretical models; the fourth part makes statistical analysis of the basic data and demonstrates the results; and the fifth part is the conclusion and policy recommendations.

2 ANALYSIS OF FACTORS AFFECTING SCIENTIFIC AND TECHNOLOGICAL GROWTH

In this paper, the so-called scientific and technological growth is referred to in its narrow sense; in other words, it is the output of scientific and technological research and exploration. In reality, it generally consists of worker quality, enhancement of equipment technology levels, reform in process flow, improvement in the management levels, optimization of economic structure, etc. From the perspective of economics, it refers to the common contribution of all other factors apart from the increase in the amount of input of capital and labor in the economic growth, which is generally called the "Solow Residual" (Solow, 1956). According to the definition of "Solow Residual," factors affecting technological development are various and complicated. Based on general studies made by economists, scientific and technological growth it made up of the following factors: R&D input, human capital, and IPR analysis. Each is discussed below.

2.1 R&D input

The new economic growth theory holds that technical progress is the ultimate source of economic growth, and R&D input is the most direct factor promoting this technical progress. R&D input can be divided into two parts: the first is data from theoretical studies aimed at the achievements of scientific and technological effects; the second regards such aspects as technological transformation and innovation with a view to economic and social benefits. The function of the productive forces of R&D input is realized through the enhancement of the efficiency of material capital and human power capital. It can raise its efficiency of material capital in three aspects: the first is to reduce production costs by ensuring the use-value of the material capital; the second is to increase the use-value of material capital under the condition that production costs are not changed; and the third is not only to reduce the production costs but also to increase the use-value of material capital, which, in common analysis, is called capital input.

2.2 Human capital

The awareness of economists concerning the establishment of the important position of human power capital is gradually developing along with economic progress and growth. Human resources are the fundamental basis of national wealth, and capital and natural resources are the passive production factors. Human beings are the initiating force in accumulating capital, exploring natural resources, establishing a social economy and political organization, and promoting national development. In the era of a knowledge-based economy, the core position of human capital is more important. As a result, actively cultivating and effectively utilizing human capital will be most significant to our economic development and sustained growth. This paper calls this manpower input.

2.3 IPR authorization

IPR is a series of principles and rules to protect intellectual achievements, whose goal is to endow an organization with the authority or legal position to encourage knowledge production, promote scientific and technological progress and innovation, and finally accelerate the national economic growth. Quantitatively calculating the relationship between IPR and scientific and technological growth is both necessary and difficult. Seen from the historical perspective, after adopting different levels of IPR protection measures, some countries have achieved high-speed economic growth. Within an international scope, IPR, especially the relationship between patent and economic growth, has been explicitly demonstrated; however, the obvious relationship between IPR and economic growth and the notable effect exerted by IPR upon economic operations have not been discovered. For instance, Goodall and Gruben (1996) have connected the rate of many countries' economic growth with variables showing patent force and found that patent rights have no influence upon economic growth. When we measure the interaction of patent rights and the trade openness index, no obviously correlated relationship appears. Park and Jennet (1997) have studied the way in which IPR affects economic growth, and they too have not found a direct relationship between patent rights and economic growth, yet patent rights obviously and actively influence visible investment and exploration, which accordingly increases the rate of economic growth. However, some scholars in our country have made a direct connection between IPR authorization and economic growth with regression statistical analysis, achieving good results. This paper also attempts to analyze the placement of IPR authorization as an important response variable in scientific and technological progress and to find the relationship between IPR authorization and economic growth.

3 RESEARCH MODEL

Analyses made in this paper are based upon the data combination of "Institutes— Time," and the established model is the panel data model. Compared with the single cross-section data model or time-sequence data model, this model not only can describe the rules of sample data collected in each institute during a certain period but also can describe each institute's rules as they change over time. In addition, it can best reflect the interrelationship among institutes.

The research model in this paper selects the total factor production rate evolved from Cobb-Douglas' production function model, which can be specified as Equation (1) (Meeusen & van Den Broeck, 1977).

$$Y = AK^{\alpha}L^{\beta}I^{\gamma} \qquad (1)$$

Take logarithms from the above equation and add time (t) and research target (i) as Equation (2).

$$\ln Y(i,t) = \alpha \ln K(i,t) + \beta \ln L(i,t) + \gamma \ln I(i,t) + e_i \qquad (2)$$

In the equation,

(1) Y(i,t) is the R&D output of the (i)th institute in the period of t

(2) K(i,t) is the R&D input of the (i)th institute in the period of t

(3) L(i, t) is the number of R&D personnel in the period of t

(4) I(i, t) is the IPR authorization of the (i)th institute at the period pf t

α, β, and γ, respectively refer to the demand elasticity of scientific research input R&D, scientific research personnel number, and the contribution made by IPR authorization to scientific and technological output.

4 BASIC DATA AND EMPIRICAL RESULTS

This paper has selected the Chinese Academy of Sciences as its research target and done empirical research based upon the combination of the seventeen institutes in the CAS's new knowledge innovation project. The institutes studied in this paper are the Shanghai Institute of Optics and Physics(SIOM), the Dalian Institute of Chemical Physics(DICP), the Shanghai Institutes for Biological Sciences(SIBS), the Institute of Metals Research(IMR), the Changchun Institute of Optics, Fine Mechanics, and Physics (CIOMP), the Changchun Institute of Applied Chemistry(CIAC), the Institute of Chemistry, the Chinese Academy of Sciences(ICCAS), the Institute of Process Engineering(IPE), the Technical Institute of Physics and Chemistry (IPC), the Institute of Mechanics(IMECH), the Lanzhou Institute of Chemical Physics(LICP), the Institute of Coal Chemistry(ICC), the Shenyang Institute of Automation(SIA, the Institute of Acoustics(IOA), the Institute of Theoretical Physics(ITP), the Shanghai Institute of Technical Physics(SITP), the Xi'an Institute of Optics and Precision Mechanics(XIOPM).

The relevant basic data stem from the *Statistical Yearbook of China's Science and Technology,* 2002 to 2004 and the *Statistical Yearbook of Chinese Academy of Sciences*. The source of each type of data is as follows:

(1) R&D input: data taken from the "*Scientific Research Income*" list in the *Sum Income of Public Institution* table in the *Statistical Yearbook of Chinese Academy of Sciences.*

(2) R&D output: data taken from the "*Career Output*" list in the *Expenditures of Scientific Research Institution* table in the *Statistical Yearbook of Chinese Academy of Sciences*.

(3) Labor force of R&D input: data taken from the "*Professional and Technical Personnel*" list in the *Situation of Regular Employees and Retired Workers in the Public Institution* table in the *Statistical Yearbook of Chinese Academy of Sciences.*

(4) IPR authorization: data taken the from *Authorization of Patent of Invention* list in the *Acceptance and Authorization of Patent Application* table in the *Statistical Yearbook of Chinese Academy of Sciences.*

First of all, we will describe the samples and their major variables. Table 1 contains the statistical attributes of each sample.

Table 1. R&D output (Y), R&D input (K), Labor Force of R&D (L), and IPR authorization
Descriptive Statistics of Sample Data

	Number of Observations	Minimum	Maximum	Mean	Std. Dev.
Y	51	252	14227	5080	3543
K	51	182	500	14039	9770
L	51	46	146	486	324
I	51	2	111	36	23

(Note: Taking into account the actual meanings of economic variables, we take the units of all the data from their logarithm figures.)

As can be seen from the table, the number of observed values in each area is 51 in every case. The differences among the institutes in the samples are relatively large. For example, the data reveals that the institute with the largest value is 70 times greater than the one with the smallest. Meanwhile, there is also a relatively big difference between scientific and technological input, scientific and technological human resources, and authorization data of patents. The statistical software E-VEWS 3.1 applied to these studies can be used to make model estimations. Based on formula (2), results are shown in Table 2.

Table 2. Common weighted least-squares procedure

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	0.251569	0.432781	0.581285	0.5638
LnK	0.199263	0.054223	3.674893	0.0006
LnL	0.950822	0.057730	16.47018	0.0000
LnI	0.118743	0.062678	1.894496	0.0643
Weighted Statistics				
R-squared	0.994250	Mean dependent var		11.35336
Adjusted R-squared	0.993883	S.D. dependent var		5.249858
S.E. of regression	0.410594	Sum squared resid		7.923616
F-statistic	2709.031	Durbin-Watson stat		0.995791
Prob(F-statistic)	0.000000			
Unweighted Statistics				
R-squared	0.776770	Mean dependent var		8.230422
Adjusted R-squared	0.762521	S.D. dependent var		0.894949
S.E. of regression	0.436125	Sum squared resid		8.939630
Durbin-Watson stat	0.631593			

As the table shows, the elasticity of the entire capital input in the equation is 0.2, the elasticity of labor force L is 0.95, and the elasticity of patent authorization is 0.12. This indicates that the most important part of China's scientific and technological output stems from labor force input and that the contributions of patent authorization and capital input are not as important when compared to the fixed effects method (Cheng, 2003). See Table 3.

Table 3. Fixed Effects Method

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LnK	0.153312	0.054220	2.827584	0.0081
LnL	0.180689	0.163994	1.101799	0.2790
LnI	0.271535	0.034796	7.803624	0.0000
Fixed Effects				
SIOM	4.987292			
DICP	5.026490			
SIBS	5.372923			
IMR	5.085843			
CIOMP	5.689865			
CIAC	4.795346			
ICCAS	4.599439			
IPE	4.273815			
IPC	4.654253			
IMECH	4.191329			
LICP	4.404226			
ICC	4.496192			
SIA	4.838335			
IOA	5.849091			
ITP	2.901898			
SITP	5.826641			
XIOPM	4.978259			
Weighted Statistics				
R-squared	0.999523	Mean dependent var		13.31912
Adjusted R-squared	0.999230	S.D. dependent var		8.462168
S.E. of regression	0.234758	Sum squared resid		1.708455
F-statistic	32467.91	Durbin-Watson stat		2.677495
Prob(F-statistic)	0.000000			
Unweighted Statistics				
R-squared	0.952651	Mean dependent var		8.230422
Adjusted R-squared	0.923630	S.D. dependent var		0.894949
S.E. of regression	0.247320	Sum squared resid		1.896182
Durbin-Watson stat	2.379860			

As the equation shows, when the specific analysis of each institute is separated, the elasticity K's quotient of capital input is 0.15, the elasticity of the labor force is 0.18, and the elasticity of patent authorization is 0.27. We can see that the difference among institutes when analyzed by the fixed effects method is relatively important, and the contribution made by patent authorization is relatively obvious as also shown by using the random effects method (Chung, 2004). See Table 4.

Table 4. Random Effects Method

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	0.587326	0.879550	0.667758	0.5076
LnK	0.196776	0.053145	3.702613	0.0006
LnL	0.864521	0.125274	6.901067	0.0000
LnI	0.197767	0.068480	2.887944	0.0058
Random Effects				
SIOM	0.137835			
DICP	-0.149542			
SIBS	-0.210385			
IMR	-0.079340			
CIOMP	0.093035			
CIAC	-0.294791			
ICCAS	-0.154200			
IPE	-0.074809			
IPC	0.133062			
IMECH	-0.409018			
LICP	-0.192713			
ICC	-0.155706			
SIA	0.018273			
IOA	0.785212			
ITP	-0.357084			
SITP	0.697625			
XIOPM	0.212546			
GLS Transformed Regression				
R-squared	0.917059	Mean dependent var		8.230422
Adjusted R-squared	0.911765	S.D. dependent var		0.894949
S.E. of regression	0.265839	Sum squared resid		3.321501
Durbin-Watson stat	1.533898			
Unweighted Statistics including Random Effects				
R-squared	0.941273	Mean dependent var		8.230422
Adjusted R-squared	0.937525	S.D. dependent var		0.894949
S.E. of regression	0.223693	Sum squared resid		2.351815
Durbin-Watson stat	2.166345			

As equation (3) shows, when the specific analysis of each institute is separated, the elasticity of K's quotient of capital input is 0.19, the elasticity of the labor force L is 0.86, and the elasticity of patent authorization is 0.19. It can be found that the difference between institutes found by the random effects method is relatively important, and the contribution made by the labor force is relatively obvious.

5 CONCLUSION

This paper illustrates that the difference between institutes is relatively large. For instance, the statistical data from scientific and technological data shows that the institute with the largest number is 70 times bigger than the one with the smallest number.

The elasticity K's quotient of the entire capital input in the equation is 0.2, the elasticity of labor force L is 0.95, and the elasticity of patent authorization is 0.12. This indicates that a most important part of China's scientific and technological output emanates from the labor force, and the contributions of patent authorization and capital input are not quite important. Meanwhile, there is also a relatively large difference between scientific and technological input, scientific and technological human resources, and authorization data of patents. When the specific analysis of each institute is separated, elasticity K's quotient of capital input is 0.15, the elasticity of labor force is 0.18 and elasticity of patent authorization is 0.27. We can see that the difference among institutes based upon an analysis of the fixed effects method is relatively important, and the contribution made by patent authorization is relatively obvious. When a random effects method is adopted, the elasticity K's quotient of capital input is 0.19, the elasticity of labor force L is 0.86, and the elasticity of patent authorization is 0.19. Thus, the differences among the institutes based on the random effects method are also relatively important, and the contribution made by labor force is relatively obvious.

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