Factors on the Transformation of Scientific and Technological Achievements under IUR cooperation

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Keywords: IUR, cooperation, Achievement Transformation, R&D

Abstract: As a new system mode to promote technological innovation, the model of IUR (Industry-University Research) cooperation is one of the important ways to improve the rate of technology transfer. In order to study the influencing factors of scientific and technological achievements in the mode of IUR cooperation, this paper uses social benefits and economic benefits to measure the transformation of scientific and technological achievements, and uses the university scientific research capacity, the benefits of enterprises, the absorptive capacity of enterprises, the close degree between IUR subjects, and the external environment of IUR cooperation to measure the influencing factors of transformation of scientific and technological achievements, besides, we select some more detailed latent variables to construct the structural equation. The results show that all these five factors will affect the transformation of scientific and technological achievements, but the impact of economic efficiency is small, which can only improve social benefits; In addition, the influence of university scientific research ability on social benefits is the largest while the effect of enterprise absorptive capacity on economic benefits is the largest.

Introduction

With the advent of the new century, innovation has become the theme of social development. The contribution rate of science and technology to economic growth has increased significantly, which has risen to about 80%. The importance of technological innovation is self-evident, but the rate of technology transfer in China is far lower than that in the developed countries while the transformation of scientific and technological achievements is considered to be the form of technological innovation, which has become the bottleneck of technological innovation and development.

Some scholars put forward that the mode of IUR cooperation is one of the important ways to promote technological innovation and improve the rate of technology transfer from the perspective of technological innovation. IUR cooperation refers to the enterprises, universities, research institutions and other units to work together to carry out a series of product technology innovation activities. Now how to give full play to the advantages of universities/research institutes and enterprises, realize the deep cooperation between these main subjects and improve the rate of technology transfer, and promote scientific and technological innovation under the mode of IUR cooperation has already become a hot topic in academic research.

This paper intends to use the empirical research method to find the factors that affect the transformation of scientific and technological achievements in the IUR cooperation, and provide reference for improving the efficiency of China's IUR cooperation.

Review of the Study

IUR cooperation refers to an advantage-complementary, risk-sharing, benefit-sharing, common-developing, formal but non-merging relationship which is built to achieve a common vision, get the best interests and comprehensive advantages, or seize new market opportunities on the basis of the developing strategy objectives and strategic intent of the government, enterprises, universities, research institutes and other parties (Xueyuan Wang, 2006). The core appeal of IUR cooperation is to promote the transformation of scientific and technological achievements as a new system mode.

The transformation of scientific and technological achievements is affected by many factors. At present, domestic and foreign research has found: the tightness of both parties (Santoro, 2000), external policy environment (Weili Xia et al., 2009), new product development funding, technology services, government funding support (Jiashu Liu et al., 2010) and many other factors will affect the rate and performance of technology transfer. Besides, there are some literatures use theoretical research methods to study the factors affect the transformation of scientific and technological achievements from the perspective of IUR cooperation, but very few people use empirical methods to study it.

Research Methods

In this paper, the Structural Equation Model (SEM) is used to study the factors influencing the transformation of scientific and technological achievements in the mode of IUR cooperation. The SEM can estimate the relationship between potential variables and the size of the path parameters between the measured variables and potential variables simultaneously, that is, integrate both factor analysis and path analysis at the same time.

Assuming that there are latent independent variables ($\boldsymbol{\xi_1}$) and latent dependent variables ($\eta_1 \sim \eta_m$), relationships between the independent variables ($\gamma_1 \sim \gamma_n$), and relationships between the variables(β_{ij}) in the SEM, as shown in Eq.1.

$$\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \cdots\\ \eta_m\end{bmatrix}=\begin{bmatrix}0 & 0 & 0 & 0 & 0\\ \beta_{21} & 0 & 0 & 0 & 0\\ \beta_{31} & \beta_{32} & 0 & 0 & 0\\ \cdots & \cdots & \cdots & 0 & 0\\ 0 & 0 & 0 & \beta_{mn} & 0\end{bmatrix}\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \cdots\\ \eta_m\end{bmatrix}+\begin{bmatrix}\gamma_{11}\\ \gamma_{12}\\ \gamma_{13}\\ \cdots\\ 0\end{bmatrix}\xi_1+\begin{bmatrix}\varepsilon_{\eta 1}\\ \varepsilon_{\eta 2}\\ \varepsilon_{\eta 3}\\ \cdots\\ \varepsilon_{\eta m}\end{bmatrix} \quad (1)$$

There are two requirements in the form of structural equation coefficients, the elements on the diagonal are 0 and it is a lower triangular matrix, which can be different from Eq.1, and the number of independent variables and dependent variables can be determined according to the content of the study. The following is a general description of vectors and matrices.

Assuming that there are m dependent variables in the model, which can be expressed as η_1, η_2,…, η_m by column vectors, and denoted as η_k, independent variables, which can be expressed as ξ_1, ξ_2,…,ξ_k by column vectors, and denoted as **ξ;** The coefficient matrix of **η** is a m-order square matrix and denoted as **B**; The coefficient matrix of ξ is m×k-order matrix and denoted as **Γ**; the residual terms are expressed as ε_1,ε_2,...,ε_m by column vectors and denoted by ε_η, so the structural model in the above equation can be extended to

$$H = B\eta + \Gamma\xi + \varepsilon_\eta. \quad (2)$$

In addition to the structural model, the interaction between the latent variable and the observed variable can also be expressed by the equation, and there are two ways to express if we distinguish causal paths. Suppose that there are S(t) observed variables corresponding to the independent variable ξ_t, and they are denoted as x_{tj}, j = 1, 2, ..., S(t); L(i) observed variables corresponding to the dependent variable η_i, and they are denoted by **y**, j = 1, 2, ...,L(i). Therefore, the latent variables can be expressed by the observed variables in the observed equations, as is shown in Eq. 3 and Eq.4.

$$\xi_t = \sum_{j=1}^{s(t)} \psi_{tj} x_{tj} + \varepsilon_{\xi t}, t=1,2,\ldots, k \quad (3)$$

$$\eta_i = \sum_{j=1}^{L(i)} w_{ij} y_{ij} + \varepsilon_{\eta i}, i=1,2,\ldots, m \quad (4)$$

If the observation vector is denoted as $x_t=(x_{t1},x_{t2},\ldots)'$,t=1,2,…,k and $y_i=(y_{i1},y_{i2},\ldots)'$, i=1,2,…,m; Assuming that $v_t=(v_{t1},v_{t2},\ldots,v_{tj})'$, $\lambda_i=(\lambda_{i1},\lambda_{i2},\ldots,\lambda_{ij})'$, then the equations can be extended to:

$$x_t = v_t\xi_t + \varepsilon_{xt}, t=1,2, \ldots, k. \quad (5)$$

$$y_i = \lambda_i\eta_i + \varepsilon_{yi}, i=1,2, \ldots, m. \quad (6)$$

Index Selection

The purpose of this paper is to study the factors influencing the transformation of scientific and technological achievements under the mode of IUR cooperation. Therefore, we select the indicators to measure the transformation of scientific and technological achievements and its influencing factors at first. Based on the existing literature review and statistical data, this paper uses social benefits and economic benefits to measure the transformation of scientific and technological achievements, and uses the university scientific research capacity, the benefits of enterprises, the absorptive capacity of enterprises, the close degree between IUR subjects, and the external environment of IUR cooperation to measure the influencing factors of transformation of scientific and technological achievements. Moreover, each indicator is measured by more detailed indicators, as shown in Table 1.
According to the selected indicators, we collect the corresponding data from 2009 to 2015 of China's 31 provinces, municipalities and autonomous regions (Hong Kong, Macao, Taiwan excluded). After removing the sample without data, a total of 4160 available data were obtained.

Table 1 Indicators and the influencing factors

Dimension	Indicator	Index code
Economic benefits	Sales of new products	Y1
	Number of patent licenses	Y2
Social benefits	The number of scientific papers included in the three major search tools in China	Y3
	Labor productivity	Y4
University Scientific research capacity	Technology manpower	GX1
	Research funding	GX2
	Research institutions	GX3
	Science and technology projects	GX4
	Outputs	GX5
Benefits of enterprises	Per capita profit	QY1
	Operating margin	QY2
	Total assets contribution rate	QY3
Absorptive capacity of enterprises	Enterprise R D personnel equivalent to full time equivalent	XH1
	Corporate R&D expenses	XH2
The close degree between IUR subjects	The domestic higher education expenditure in enterprise R&D external expenditure	ZT1
	The domestic enterprise expenditure in higher education R&D external expenditure	ZT2
External environment of IUR cooperation	Number of Intermediary Service Organizations	WB1
	Government funding for science and technology	WB2
	Government cooperation policy	WB3
	Science and technology expenditure	WB4

Hypothesis and Model

This paper measures the transformation of scientific and technological achievements from 2 dimensionalities-social benefits and economic benefits, and measures the factors influencing the transformation of scientific and technological achievements from 5 aspects- the university scientific research capacity, the benefits of enterprises, the absorptive capacity of enterprises, the close degree between IUR subjects, and the external environment of IUR cooperation, therefore, there are 2×5 hypothesis in this paper in total. We make the following hypothesis based on the analysis of other scholars' research results:

Hypothesis 1: The university scientific research ability has a positive impact on the economic benefits of the transformation of scientific and technological achievements.

Hypothesis 2: The university scientific research ability has a positive impact on the social benefits of the transformation of scientific and technological achievements.

Hypothesis 3: The benefits of enterprises has a positive impact on the economic benefits of the transformation of scientific and technological achievements.

Hypothesis 4: The benefits of enterprises has a positive impact on the social benefits of the transformation of scientific and technological achievements.

Hypothesis 5: The absorptive capacity of enterprises has a positive impact on the economic benefits of the transformation of scientific and technological achievements.

Hypothesis 6: The absorptive capacity of enterprises has a positive impact on the social benefits of the transformation of scientific and technological achievements.

Hypothesis 7: The close degree between IUR subjects has a positive impact on the economic benefits of the transformation of scientific and technological achievements.

Hypothesis 8: The close degree between IUR subjects has a positive impact on the social benefits of the transformation of scientific and technological achievements.

Hypothesis 9: The external environment of IUR cooperation has a positive impact on the economic benefits of the transformation of scientific and technological achievements.

Hypothesis 10: The external environment of IUR cooperation has a positive impact on the social benefits of the transformation of scientific and technological achievements.

Results and Analysis

In order to test whether or not the data meets the condition of structural equation. At first, make descriptive statistical tests and adjust the outliers, and then test the reliability and validity of these data. The results show that these two tests has been passed, therefore, the data can be used to estimate the structural equation. The model can be revised when it's necessary.

The overall fitness of the initial estimation of the model is not very well, and the correlation between benefits of enterprises and the economic is not significant. In reality, the ultimate goal is realizing the transformation of scientific and technological achievements, while only converting it into a commodity can bring economic benefits through the transformation mechanism. However, it will produce some social benefits during the study of scientific research in the IUR cooperation, such as publishing papers related to the research part. Therefore, there is a phenomenon that the results are not be transformed into commodity successfully and bring about economic benefits in the process of transformation, but produced social benefits in the research process. So in order to modify the model, remove the path between the benefits of enterprises and economic benefits of transformation of scientific and technological achievements, and results of the modified model are shown in table 2.

Table 2 Standardized regression results for the modified model

Path relationship	Estimate	P
Economic benefits<---University scientific research capacity	0.129	0.007
Social benefits<---University scientific research capacity	0.766	***
Economic benefits<---Absorptive capacity of enterprises	0.760	***
Social benefits<---Absorptive capacity of enterprises	0.100	***
Economic benefits<---The close degree between IUR subjects	0.189	***
Social benefits<---The close degree between IUR subjects	0.170	0.035
Economic benefits<---External environment of IUR cooperation	0.608	***
Social benefits<---External environment of IUR cooperation	0.105	0.049

In addition, this paper examines the indirect effects of the path and the total effect that include the direct and indirect effects between the variables. The total effect of the model after the normalization is shown in the table 3.

Table 3 The overall impact of standardization

	External environment of IUR cooperation	The close degree between IUR subjects	Benefits of enterprises	University scientific research capacity	Absorptive capacity of enterprises
Social benefits	0.105	0.170	0.217	0.766	0.100
Economic benefits	0.608	0.189	0.000	0.129	0.760
Labor productivity	0.059	0.096	0.122	0.433	0.057
The number of scientific papers included in the three major search tools in China	0.105	0.169	0.216	0.765	0.100
Number of patent licenses	0.553	0.172	0.000	0.117	0.691
Sales of new products	0.285	0.089	0.000	0.060	0.356

The Research Capacity and the Transformation of Achievements

The university scientific research capacity has a positive effect on the transformation of scientific and technological achievements, and has an impact on its economic and social benefits. The effect of standardized effect is 0.129 and 0.766 respectively. On the whole, the greater the university scientific research capacity, the greater the economic and social benefits of the transformation of scientific and technological achievements. Specifically, the university scientific research capacity has influences on the number of patent licenses, sales of new products, the number of scientific papers and the labor productivity. The university scientific research capacity mainly has a great impact on the number of scientific papers (0.765) and labor productivity (0.433).

The Benefit of Enterprises and the Transformation of Scientific and Technological Achievements

The improvement of the benefit of enterprises will promote the transformation of scientific and technological achievements, but it only affects the social benefits and its effect of standardized effect is 0.217. Specifically, the effect that the benefit of enterprises on the number of scientific papers (0.216) is greater than the impact on labor productivity (0.122).

The Absorptive Capacity of Enterprises and the Transformation of Scientific and Technological Achievements

The enhancement of the absorptive capacity of enterprises has a positive effect on the transformation of scientific and technological achievements, and it has an impact on its economic benefits and social benefits. The effect of standardized effect is 0.760 and 0.100 respectively. On the whole, the improvement of enterprises' absorptive capacity will promote the transformation of scientific and technological achievements. Specifically, the absorptive capacity of the enterprise has influences on the number of patent licenses, sales of new products, the number of scientific papers and the labor productivity. The absorptive capacity of the enterprises mainly affects the amount of patent authorization (0.691) and the sales income of new products (0.356).

The Close Degree between the Subjects and the Transformation of Scientific and technological Achievements

The close degree between the subjects in the IUR cooperation has a positive effect on the transformation of scientific and technological achievements and has an impact on its economic and social benefits. The effect of standardized effect is 0.189 and 0.170 respectively. Specifically, the degree of close relationship between the subjects has influences on the number of patent licenses, sales of new products, the number of scientific papers and labor productivity. It can be seen from the size of the coefficient that it mainly affects the number of patent licenses (0.172) and the number of scientific papers (0.169).

The External Environment of IUR Cooperation and the Transformation of Scientific and Technological Achievements.

The external environment of IUR cooperation has a positive effect on the transformation of scientific and technological achievements and has an impact on its economic and social benefits. The effect of standardized effect is 0.608 and 0.105 respectively. Specifically, the external environment of IUR cooperation has influences on the number of patent licenses, sales of new products, the number of scientific papers and the labor productivity. The external environment of the cooperation mainly affects the number of patent licenses (0.553) and sales of new products (0.285).

Conclusion

The university scientific research capacity has a positive impact on the transformation of scientific and technological achievements. The stronger the scientific research capacity, the greater the social and economic benefits bring about by the transformation of scientific and technological achievements. Moreover, the impact of scientific research capacity on the social benefits is the greatest; The correlation between research funding and university research is the strongest.

The benefits of enterprises have a positive impact on the social benefits, while have no effect on the economic benefits. This result shows that enterprises mainly contribute to the stages of transformation, which may associate with the situation that the economic benefits of China's industrial enterprises are less optimistic.

The absorptive capacity of enterprises has a positive impact on the transformation of scientific and technological achievements, the stronger the absorptive capacity, the greater the social and economic benefits bring about by the transformation of scientific and technological achievements. Moreover, the impact of corporate absorptive capacity on the economic benefits is greatest, the absorptive capacity of enterprises is essential to the transformation of scientific and technological achievements. Fifth, the close degree between IUR subjects has a positive impact on the transformation of scientific and technological achievements, the closer the relationship between the subjects, the greater the social and economic benefits bring about by the transformation of scientific and technological achievements.

The external environment of IUR cooperation has a positive impact on the transformation of scientific and technological achievements. The good external environment is also one of the factors that promote the transformation of scientific and technological achievements.

Acknowledgement

This research was financially supported by the Foundation of Beijing Education Commission for the project ‘Management System of Cooperative Innovation Center for Rail Traffic Safety”.

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