Study on Regional Technical Innovation Efficiency Discrepancy and Its Influential Factors

Hu Xiaomian
School of Economics, Huazhong University of Science & Technology, Wuhan, P.R.China, 430074
(E-mail: huxiaomian@126.com)

Abstract Based on the method of DEA, this paper evaluates the technical innovation efficiency of Chinese regions from 1997 to 2004, and analyzes the influential factor using the Tobit random model. The main conclusions are as follows: regional innovation efficiency in east is significantly higher than the middle and west; industry structure and enterprise scale have notable effect to regional technical innovation efficiency, but the enterprise system factor is not notable influential factor. Further analysis indicates that only higher education has a favorable effect on regional technical innovation efficiency.
Key words Regional economy; Technical innovation efficiency; DEA; Tobit model

1 Introduction

With increasingly fierce competition in the global economic development and shortcomings of traditional regional development model gradually emerged, people paid more and more attention on the concept of regional innovation systems (Enright, 2001). This has led to rediscover the importance of regional scale as well as regional resources in stimulating innovation capability and competitiveness company and regions (David and Saeed, 2005).

Since reform and opening, China's economy maintained a fast growth rate, but the economic gap between regions become increasing obviously. In addition to regional differences in geographical location and natural resources, the regional technological innovation efficiency differences is also an important factor which lead to regional economic development gap more greater. Technological innovation as the major driving force and source of a region to maintain sustainable economic development, the innovation efficiency is significantly affect regional economic development. This leads to the questions that are there significant differences in technological innovation efficiency in all regions of China? What factors affect the regional technological innovation efficiency?

The study on the efficiency of regional technological innovation in china can be basically divided into two categories: focused on the efficiency of regional innovation measurement (Huang Lucheng, 2000; Liu Xielin, 2002), or on the influencing factors of the technological innovation efficiency (Chi Rengyong and Yu Xiaofen 2004, Lin Yun 2008).

Based on previous research, this paper employs DEA method to study 30 provincial administrative regions of China (except Tibet). The regional technology innovation efficiency was measured and compared the efficiency between these areas, and panel Tobit model was used to further analyze influential factors on regional technology innovation efficiency.

2 The Model

Data envelopment analysis is a non-parametric method to evaluate decision making unit (DMU) relative efficiency, developed on the basis of Farell measure by the U.S. operational researcher A. Harnes (1978). This method is based on decision making unit Pareto optimal concept, employing real decision making unit in a production system, using linear programming to construct convex efficient production frontier border, compared to this frontier, can identify inefficiencies decision-making units and the efficiency value, and then get the relative efficiency as well as the scale information of decision making units.

Limited dependent variable model is used to study the influential factors of regional technical innovation efficiency using, and Tobit model for further estimate and analysis .

The basic structure of Tobit model is as follows:

$$Z_i = \begin{cases} \beta^T X_i + \varepsilon_i, & \beta^T X_i + \varepsilon_i > 0, \\ 0, & \beta^T X_i + \varepsilon_i \le 0, \end{cases}$$

Z_i is the value of efficiency, X_i is the explanatory variable vector, β^T is vector of unknown parameters, $\varepsilon_i \sim N(0, \quad \zeta^2)$.We use maximum likelihood method to estimate.

3 Positive Analysis

3.1 The measurement of regional innovation efficiency

In accordance with scientific principle, comparability principle and feasibility principle, taking into account the availability of indicator data, in reference to other researchers, this paper selected research and experimental development (R&D) expenditures, research and experimental development (R&D) full-time equivalent staff, technology flow in technology market as a regional innovation efficiency investment indicators, three kinds of granting patent applications, technology market contract transaction amount, number of Chinese scientific papers included in key foreign search tools as output indicators (see Table 1).

Table 1 The Regional Innovation Efficiency of Index System

Input indicators	Unit	Output indicators	Unit
R&D expenditures	Thousand Yuan	Number of Chinese scientific papers included in key foreign search tools	Piece
R&D full-time equivalent staff	Per person per year	Technology market contract transaction amount	Million Yuan
Technology flow in technology market	Million Yuan	Three kinds of granting patent applications	Item

We select 30 regions data in China (because of missing data, Tibet and Hong Kong, Macao and Taiwan regions are not analyzed), using DEA method calculates the 1997-2004 regional innovation efficiency, and received the mean ranks as follows.

Table 2 Mean Regional Innovation Efficiency

Provinces	Average technological innovation efficiency	Provinces	Average technological innovation efficiency	Provinces	Average technological innovation efficiency
Beijing	1	Tianjin	0.9065	Inner Mongolia	0.7315
Zhejiang	0.9967	Hubei	0.8867	Henan	0.7243
Guangdong	0.9895	Fujian	0.8772	Shandong	0.7225
Shanxi	0.9797	Gansu	0.8495	Guizhou	0.7051
Anhui	0.9791	Jiangsu	0.8306	Jiangxi	0.6219
Hainan	0.9750	Guangxi	0.8301	Ningxia	0.6060
Jilin	0.9653	Liaoning	0.8191	Shanxi	0.5302
Chongqing	0.9609	Xinjiang	0.79	Qinghai	0.4304
Shanghai	0.9529	Hebei	0.7766	the East	0.9706
Heilongjiang	0.9400	Sichuan	0.7622	the Middle	0.9141
Hunan	0.9343	Yunnan	0.7494	the West	0.8541

Note: in the table, the east including Beijing, Zhejiang, Guangdong, Hainan, Shanghai, Tianjin, Fujian, Jiangsu, Guangxi, Liaoning, Hebei, Shandong; Central including: Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan ; western including: Chongqing, Sichuan, Guizhou, Yunnan, Shanxi, Gansu, Qinghai, Ningxia, Xinjiang.

The mean of regional technological innovation efficiency in 1997-2004 shows that for 8 years, technical innovation efficiency of Beijing is always 1, means DEA efficient. Which indicate that since 1997, based on its current output Beijing has been achieved optimal input level.

According to the interpretation of the NDRC, China's eastern, central and western division is the policy division rather than administrative divisions, nor the geographical division. The east coast is the first implementation of open door policy and the provinces and cities of higher levels of economic development; middle is the sub-developed economic areas; the west refers to the western underdeveloped economy regions. There can be seen more significant differences among three regions from DEA efficiency scores. Judging from the economic development, the east is also much stronger than the middle and the west, which means that in China's economy, more developed regions have higher technological innovation efficiency. In addition, there are five regions in the east have the DEA efficiency scores above 0.9, only two regions of the west reach the basic DEA effective. The less technology innovation efficient regions, which DEA efficiency scores less than 0.7, these areas must be rationally reallocate the innovate resources.

This situation indicates that China's Eastern and Central areas are developed more balanced, the within innovation efficiency gap is smaller than the western; all the DEA efficiency in the western

region was low, and internal disparities is significant. To make western region out of the innovation plight as soon as possible, keep up and exceed the development of central and eastern. The combinations and number of the inputs must be found to maximize innovation outputs on the basis of the available resources.

3.2 Regional technical innovation efficiency factors

In order to analyze the influential factors of regional technology innovation efficiency, the technological innovation efficiency value of year 1997 to 2004 is interpreted as a dependent variable, the panel Tobit random effect model is used to estimate. The paper mainly examines the effects of enterprise systems, enterprise size, industry structure and human capital on regional technological innovation. In which the proportion of state-owned and collective enterprises in total industrial output value (state), and the share of R&D expenditure in research institutions of total expenditure (rd) represent the enterprise system factors; the proportion of large enterprises account in total industrial output value (large) to measure firm size; the proportion of heavy industry sector output in industrial output (hea) to represent the characteristics of industrial structure; the average years of schooling is used to represent human capital. The stock of human capital (edu) calculated as: primary school proportion × 6 + junior school proportion× 9 + high school proportion× 12 + the proportion of college and above × 16.

To further examine different impact of human capital levels on technical innovation efficiency, this paper use the ratio of primary, secondary, and higher education students relative to total population to measure regional human capital structure, under normal circumstances, higher level of education means stronger learning ability and creativity, and can be more effectively integrate various social resources to achieve maximum output in the process of technological innovation.

The Tobit random effect regression model used in regional innovation efficiency is as follows:

$$Y_{it} = + {}_{1\mathrm{it}} state + {}_{2\mathrm{it}} hea + {}_{3\mathrm{it}} edu + \mu_{\mathrm{i}} + \xi_{\mathrm{it}} \zeta^{2} \quad (1)$$

Among them, α is the constant term, β_{i} (i = 1, 2, 3, 4) is the coefficient of each factor respectively, μ_{i} is the effect of the cross section can not be observed, $\varepsilon_{\mathrm{it}}$ is the random interference terms. Get the other three models by replacing human capital stock in model (1) with the primary, secondary and higher education.

Using Stata software (ver10.0), results of the Tobit random effects regression were calculated in the following table.

Table 3 Regional Technical Innovation Efficiency Factors

	Model 1	Model 2	Model 3	Model 4
state	-0.0711（0.444）	-0.0359（0.701）	-0.0751（0.419）	-0.0270（0.774）
rd	0.0173（0.839）	0.0302（0.718）	0.0171（0.841）	0.0246（0.767）
large	0.2064（0.048）	0.2423（0.020）	0.2083（0.046）	0.2350（0.025）
hea	-0.3091（0.004）	-0.4324（0.000）	-0.3075（0.005）	-0.4084（0.000）
edu	0.0085（0.402）			
edu1		-0.68574（0.019）		
edu2			0.0781（0.519）	
edu3				1.3900（0.011）
constant	0.8843（0.000）	1.2216（0.000）	0.9130（0.000）	0.8944（0.000）
Log llikelihood	122.780	125.152	122.637	125.570
LR test of σu2	0.000	0.003	0.000	0.001

Note: p value in brackets (2-tailed).

Most variables coefficients are statistically significant and the direction of the symbols basically in line with our expectations. In the model 1 to model 4, the heavy industrial output value proportion has a negative effect on regional technology innovation efficiency; large enterprises output value proportion is positively affect the technological innovation efficiency; primary education hinder the improvement of the regional innovation efficiency, meanwhile higher education promote it. Finally, the enterprise system factors and the average years of schooling have no significant role in promoting or hindering technical innovation efficiency in the statistical sense.

According to the regression results, the larger enterprises proportion can promote innovation efficiency in the region. Therefore, to improve the regional innovation efficiency, a large number of strong innovation capability, scaled and medium-sized enterprises and enterprise groups should be founded, with a certain financial technological innovation support, fundamentally promote regional

innovation efficiency.

Although the enterprise system factors was not statistically significant, but the coefficient is negative, indicating that when the state-owned enterprises and collective enterprises proportion of total industrial output value too large, will still hinder regional technical innovation.

In the regression model 1, we see that the average years of school education is not significant. The regression 2 results with a number of empirical results, as primary education has a negative effect on efficiency, can explain to a certain extent why Chinese primary education is not favor for improving the regional technology innovation efficiency.

The results of Model 4 also show that university education has a positive effect on the regional technology innovation, but secondary education are not so significantly positive effect, people with the primary and secondary education levels have limited technology absorptive and innovation capacity. The majority of a region has received primary education, will inevitably hinder the technological innovation efficiency, and difficult to digestion and absorption the introduced technology.

4 Conclusions

In this paper, DEA technology is used to measure China's regional technology innovation efficiency in 1997 to 2004, the results show that the technological innovation efficiency in Beijing as the lead every year, the eastern region, is better than central and the western, in which the western region is the least efficient regional.

The analysis of Panel Tobit random effects model indicates: increase the large-scale enterprises number and develop light industry can promote regional innovation efficiency. At the same time the average years of schooling has no significant impact on the regional technological innovation efficiency; but further analysis shows that: only with higher education can improve the regional technology innovation efficiency.

Therefore, to improve the regional technological innovation efficiency, on the one hand, region's leading enterprises must be developed, government should support a number of large potential and prospects companies to expand scale; on the other hand, while increasing innovation investment funds the government should also concern about innovation talents, make full use of innovation human capital. Education can not just stop at the current universal primary stage, higher coverage of education should also be enhanced to increase the overall region's culture quality, thereby promoting the regional innovation efficiency.

Of course, this paper is only preliminary, there are still some defects. First, because of data availability, a number of input and output indicators had to give up in measuring the regional technology innovation efficiency with DEA, so the DEA efficiency value may be has some gaps whit the real situation; Second, regional innovation efficiency factor is not limited to the several aspects of the paper mentioned, in the future I will further look for other possible factors.

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