Empirical Study on Contribution of Technical Innovation to Economic Growth in Eastern China

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Abstract By using Grey Relational Analysis (GRA) method and adopting some empirical data of invention patents application quantity and high technology industries added value, this paper comprehensively analyzes and compares contributions of technical innovation to economic growth of each region. These applied data come from some large-and-middle-scaled enterprises during the period from 2000 to 2005 of four regions in eastern China, namely, the Area Surrounding Bohai, Northeast Old Industry Base, Yangtze River Delta, Pearl River Delta. The results indicate that Northeast Old Industry Base has the highest synthetic correlation degree between invention patents application quantity and high technology industrial added value, and Yangtze River Delta and Pearl River Delta are secondary to it, and the Area Surrounding Bohai has the lowest synthetic correlation degree. Hereby we can conclude that the contribution of technical innovation to economic growth in the Area Surrounding Bohai is apparently lower than the other regions in eastern China; technical innovation in Yangtze River Delta and Pearl River Delta have comparatively stronger contribution to economic growth; the correlation between technical innovation and economic growth in Northeast Old Industry Base also seems comparatively stronger. This article further explains the generation of the above phenomena.
Key words technical innovation, economic growth, grey relational analysis, grey correlation degree

1 Introduction

The effect of technical progress to economic growth has been specially concerned by economists all the time. Although Neo-Classical Model of Economic Growth, represented by *Solow* regards technology as exterior variable of economic growth, he never denies the decisive effect of technologies to economic growth. The new growth theory, which arose in 1980s, pushed the study on relation between technical progress and economic growth to the climax. Unlike the Neo-Classical Growth Theory, which has a common model that is accepted by most economists, the new growth theory is just a loose aggregation formed by all sorts of growth model proposed by some economists, who have same or similar viewpoints. The common viewpoint of all models is: economic growth is not the results of effect of exogenous factor, but is determined by endogenous variable. According to the difference of technical endogenous process method, the endogenous growth model can be classified into two types: first type is the model represented by *Locus* (1988)[1], which is also called investment-based growth model; the second one is the model represented by *Romer* (1990) and *Grossman & Helpman* (1991) [2]-[3], which is also called R&D-based growth model.

A lot of empirical study before 2000 showed that technical innovation did not become the source for economic growth of China. In recent years, a lot of study on the relationship between technical innovation and economic growth in China came forth, such as: Chen Ying (2004) [4], Shang Jianchu (2005) [5], Wang Bangjun (2006) [6], Zhang Genqing (2007) and Huang Zhilin (2007) [7]-[8], etc. They either adopted cointegration theory and Granger causality test method, or adopted panel data model to carry out empirical study on the relationship between technical innovation and economic growth. Their study conclusions are fundamentally the same; that's to say: technical innovation and economic growth in China has remarkable positive relationship with each other and the technical innovation is the drive to boost economic growth in China.

According to the existing literature, the study on the relationship between technical innovation and economic growth in China was carried out on country level and there were few studies on the relationship between technical innovation and regional economic growth. However, China is a country with imbalanced economic development. That's why this article tries to do some empirical study on contribution of technical innovation to regional economic growth in China; this article hereby describes the difference of function and status of technical innovation activities to economic growth in different regions and proposes the corresponding countermeasures.

2 Indicators, Study Method and Source of Data

2.1 Selection of Indicators

2.1.1 Selection of measurement indicators for technical innovation capability

The measurement for effect of technical innovation to economic growth first involves the problem of selecting the measurement indicators for technical innovation capability. At the international field of vision, starting from the time when *Schmookler* (1966) creatively used patents data as technical innovation indicators to compare the status of technical innovation in all countries, the analysis on patents data had been believed to be an important method to evaluate all aspects of technical conversion all the time. Chen Guohong (2002) pointed out[9], the commonly used indicators to evaluate scientific and technical output efficiency in the world included: patents, scientific and technical paper, technology trade, capital investment, high technology products or technical dense products, etc. Comparatively speaking, the patents data is reliable and scientific. Additionally, the patent system itself is a type of encourage on technical innovation activities. Article 52 in European patent convention specifies that "European patent is conferred to any novel, creative invention that can be applied in industries"; article 22 of patent law in China specifies that "The invention and practical new model that obtained patent should have novelty, creativity and practicality". Therefore, among so many indicators of evaluating scientific and technical output, this paper selects the quantity of patent application as the indicators to evaluate regional technical innovation capability.

We need point out that why this paper selects the quantity of invention patent application as the measurement indicators for patent output, but not the quantity of conferred patents, this is because: 1. the quantity of conferred patents has strong linear correlation with the quantity of patent application and the information contained in quantity of patent application has covered the quantity of conferred patents to a big extent; 2. compared with quantity of patent application, the conferring of patents is quite lagged behind and the information may easily become untrue if the quantity of conferred patents is used for analysis indicators.

2.1.2 Selection of economic growth measurement indicators

In recent years, western countries adjusted their industrial structure one and another; they regarded development of high and new technology industries as the dominant industry direction and regard development of high and new technology as important measure to participating international competition and created one series policies and measures for this aim. The development level of high and new technology evidently represents the comprehensive economic strength of a country. What's more important is: it directly normalizes industrial standards and regulations, and also determines the development space of a country. In modern society, high and new technology can be industrialized in short term, so high and new technology industrialization plays an important role in economic development of a country. Based on the above analysis, this paper adopts regional high technology industrial production value as the standard for measurement of regional economic growth.

2.2 Study Method: Grey Relational Analysis

Grey Relational Analysis is one of the main content of grey system theory and is used to analyze the close degree of relationship between main factor and sub-factors in the system, so as to judge the primary factors and secondary factors that cause the development of the system. The basic idea of Grey Relational Analysis is to judge if the relation is close according to the similarity degree of geometric shape of sequence polygonal line. Compared with mathematical statistical method, this method can be applied no matter there are many or few samples or there is typical distribution rule or not. What's more, this method has simple calculation, so it has wide applicability. Grey Relational Analysis finally embodies to be the calculation of correlation degree. Correlation degree is a type of quantitative description on degree of correlation between factors. The main procedures of Grey Relational Analysis are as follows:

2.2.1 The original data sequence

Let main factor data sequence be:

$$X_0(k) = \{X_0(1), X_0(2), \cdots, X_0(n)\}$$

M pieces of comparative sequences are:

$$X_i(k) = \{X_i(1), X_i(2), \cdots, X_i(n)\} \qquad (k = 1,2,\cdots,n; \quad i = 1,2,\cdots,m)$$

2.2.2 Calculate absolute correlation degree

Let the difference sequence of reference sequence and comparison sequence be $X_0^{(0)}$ and $X_i^{(0)}$, then:

$$X_0^{(0)} = X_0(k) - X_0(1), \quad X_i^{(0)} = X_i(k) - X_i(1)$$

Assume:

$$|S_i| = \left| \sum_{k=2}^{n} X_i^{(0)}(k) + \frac{1}{2} X_i^{(0)}(n) \right|$$

The expression of absolute correlation degree is:

$$\varphi_{0i} = \frac{1 + |S_0| + |S_i|}{1 + |S_0| + |S_i| + |S_i - S_0|}$$

2.2.3 Calculate relative correlation degree

Carry out initial conversion of reference sequence and comparison sequence to get initialization sequence $X_0^{(0)}$ and $X_i^{(0)}$:

$$X_0^{'(0)}(k) = X_0(k) \Big/ X_0(1), \qquad X_i^{'(0)}(k) = X_i(k) \Big/ X_i(1)$$

Assume:

$$|S_i'| = \left| \sum_{k=2}^{n} X_i^{'(0)}(k) + \frac{1}{2} X_i^{'(0)}(n) \right|$$

The expression of relative correlation degree is:

$$\gamma_{0i} = \frac{1 + |S_0'| + |S_i'|}{1 + |S_0'| + |S_i'| + |S_i' - S_0'|}$$

2.2.4 Calculate synthetic correlation degree

The expression of synthetic correlation degree is:

$$\rho_{0i} = \theta\varphi_{0i} + (1-\theta)\gamma_{0i} \quad (i = 1,2,\cdots,m)$$

2.3 Data Source and Description

This article selects the related data of eastern China (13 provinces and cities) that has strong economic development and scientific and technology strength during the period from 2000 to 2005 and divides it into four regions: the Area Surrounding Bohai, Northeast Old Industry Base, Yangtze River Delta and Pearl River Delta according to the current national regional economic development planning. The data on indicators of invention patents application quantity and added value of high and new technical industry of large and middle scale enterprises in east regions comes from *China Statistical Yearbook* (issues from 2001-2006) [10]. Please see the specific data in table 1 and table 2.

Table 1 Patent Application Quantity of Large and Middle Scale Enterprises of All Regions in Eastern China Unit: Item

year	the Area Surrounding Bohai	Northeast Old Industry Base	Yangtze River Delta	Pearl River Delta
2000	610	191	553	663
2001	787	178	698	1154
2002	2056	254	938	1565
2003	3232	313	1961	2236
2004	4320	444	3632	3477
2005	4276	623	4415	6649

We need to point out that, as the science conversion capability of higher academies and scientific institutions is comparatively weak, from the angle of market to create value, the main body of science and technology innovation is mainly those enterprises with comparatively big scale and strong science and technology research capability. The basic object of enterprises is to pursue profit, while the patent application, especially for those invention patents with strong scientific content can ensure the competitive advantage of enterprises in market and guarantee them to obtain high profit. So it's common that enterprises have strong innovation motivation and their scientific and technology achievements are converted for market. Meanwhile, because of the transfer principium of technologies, the output of patents often results in increase of high and new technology industrial output. Hereby, Table 1 shows

the invention patent application quantity of large and middle scale enterprises of all regions in eastern China.

Table 2 High Technology Industries Added Value of All Regions in Eastern China Unit: RMB 100 Million

year	the Area Surrounding Bohai	Northeast Old Industry Base	Yangtze River Delta	Pearl River Delta
2000	577.56	179.58	669.34	811.62
2001	640.6	193.37	790.51	892.15
2002	767.77	222.26	935.38	1188.02
2003	855.44	240.53	1432.1	1787.95
2004	1123.1	261.3	1947.4	2180.1
2005	1423.39	323.77	2614.98	2683.59

Note: The Area Surrounding Bohai includes Beijing, Tianjin, Hebei Province and Shandong Province;
Northeast Old Industry Base includes Heilongjiang Province, Jilin Province and Liaoning Province;
Yangtze River Delta includes Shanghai, Jiangsu Province and Zhejiang Province;
Pearl River Delta includes Guangdong Province, Fujian Province and Hainan Province

3 Empirical Analysis

In the specific calculation process of data, this article used related modeling software to carry out Grey Relational Analysis on invention patent application quantity and high technology industries added value of large and middle scale enterprises of all regions in eastern China[11], where the invention patent application quantity of large and middle scale enterprises is behavioral sequence. The calculation results are shown in Table 3.

Table 3 Results of Grey Relational Analysis

	Grey Absolute Correlation Degree	Grey Relative Correlation Degree	Grey Synthetic Correlation Degree (θ=0.5)
the Area Surrounding Bohai	0.5766	0.5936	0.5851
Northeast Old Industry Base	0.7118	0.7607	0.7362
Yangtze River Delta	0.7447	0.7136	0.7292
Pearl River Delta	0.7124	0.6854	0.6989

The above calculation results show that the synthetic correlation degree of Northeast Old Industry Base, which is comparatively underdeveloped among the four regions in east coastal area of China, is the highest. Yangtze River Delta and Pearl River Delta are lower than it; the synthetic correlation degree of the Area Surrounding Bohai is the lowest.

The unexpected results are caused by the fact in some degree that the industrial structure of Northeast Old Industry Base is composed mainly by heavy industry and high technology industrial added value is low. On the other hand, large state-owned enterprises take comparatively big proportion in regional economy of Northeast Old Industry Base and the development of small-scale private enterprise with strong economic strength is comparatively backward. Most of invention patents need huge fund investment in prophase. Only large state-owned enterprises have enough motivation and strength for such investment and most of the private enterprises are not able to afford investment for invention patent. Therefore, the correlation degree between invention patent output and high technology industrial added value in Northeast Old Industry Base is comparatively strong.

As far as the Area Surrounding Bohai is concerned, the contribution of invention patent application quantity of large and middle scale enterprises to the high technology industrial added value of this region is apparently lower than other regions. Because there are a lot of higher academies, scientific institutions in Beijing-Tianjin region, whose density of scientific and technical talents is higher than national average level, the contribution of human capital to high technology industries is evidently higher than other regions and this pulls down the contribution of invention patents application quantity to the high technology industries added value in this region.

The correlation degrees of Yangtze River Delta and Pearl River Delta, which are the two most developed regions in eastern China, are comparatively close to each other, at about 0.7. This indicates that the invention patents of the two regions have strong contribution to high technology industries added value and enterprises there have strong self innovation capability. Meanwhile, the high technology industries develop quickly in the two regions. In year 2005, the high technology industrial added value of the two regions exceeded RMB 250 billion, which was far higher than Northeast Old

Industry Base and the Area Surrounding Bohai, and the added value amassed strong motivation and scientific reserves for sequential development.

4 Conclusions

The Grey Relational Analysis results of invention patent application quantity and high technology industrial added value of large and middle scale enterprises of all regions in eastern China shows that the contributions of technical innovation to economic growth in different regions have some difference. The contribution degree of technical innovation to economic growth in the Area Surrounding Bohai is evidently lower than other regions in eastern China; the contribution degree of technical innovation to economic growth is high in Yangtze River Delta and Pearl River Delta; the correlation between technical innovation and economic growth in Northeast Old Industry Base is comparatively strong. However, as a matter of fact, if compared with developed regions in eastern China, the absolute quantity of invention patent application and high technology industrial added value of Northeast Old Industry Base is far laggard behind and its technical innovation capability is comparatively weak. For this aspect, this article has following suggestions on policy:

The Area Surrounding Bohai should make full use of advantages of abundant talents in Beijing-Tianjin region, combine the innovative motivation of enterprises with the scientific and technical advantages of scientific institutions, enhance the total number of invention patent application and conferring, tries to convert technical innovation into practical economic growth as soon as possible.

Yangtze River Delta and Pearl River Delta, especially for Shanghai, Jiangsu province and Guangdong province, which have strong education and science strength, should strengthen the scientific and technical cooperation among academies, scientific institutions and enterprises, so as to accelerate the conversion of scientific achievements, such as invention patents, boost the development and industrial upgrade of high technology industries, fully exert the boosting effect of eastern China, or even China, and form the benign circulation of technical innovation boosting the development of high technology industries and high technology industries boosting science and technology innovation, especially for original invention patent application.

Northeast Old Industry Base should especially pay attention to the development speed of local high technology industries, cultivate more private enterprises with technical innovation capability and flexible organism, try to enhance the high technology industries added value of the whole region, and boost the economic development of the whole region.

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