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Liqin LIU
*School of Business Administration, Changchun University of Technology*, liuliqin2002@xinhuanet.com

Yuehong LIU
*School of Business Administration, Changchun University of Technology*

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# The Evaluation of the Regional Technology Innovation Ability Based on Grey Relational Analysis

*Liqin LIU*[*], *Yuehong LIU*
School of Business Administration, Changchun University of Technology, China

**Abstract:** Based on the set of an indicator system and the grey relational analysis model, the regional technology innovation ability of China is evaluated. It shows that the regional technology innovation ability of China is improving gradually; the level of technology input and the environment of technology innovation are promoting the development of the technology innovation ability of China, the level of technology output and the mechanism of the technology innovation are restricting the development of the technology innovation ability of China. In order to accelerate the regional technology innovation ability of China, some measures should be taken: the level of technology input should be increased, the level of technology output should be enhanced, the environment of technology innovation should be optimized, and the mechanism of the technology innovation should be perfected.

**Key words:** Grey Relational Analysis, Regional Technology Innovation Ability, Evaluation

## 1. INTRODUCTION

The regional technology innovation ability is the ability of outputting technology product with the technology input, technology innovation environment and technology innovation mechanism.[1][2][3] The meaning of regional technology innovation ability involves four aspects[4][5][6]: the first aspect is the input of regional technology innovation. The more output of technology innovation need more input of technology person and more technology innovation investment. The second aspect is the ability of regional technology innovation output which represented by the scale and level of the technology product. The third aspect is the environment of technology innovation. The new knowledge and new product are brought from the interrelation process of technology innovation subject and technology innovation environment, so the regional technology innovation is controlled and conditioned by technology innovation environment. The forth aspect is the mechanism of the technology innovation. The good stimulation mechanism of technology innovation can improve the innovative active of technology innovation persons and enhance the output efficiency of the technology investment; the good transformation mechanism can promote the technology output to turn into the productivity of developing regional economic.

## 2. ESTABLISHING APPRAISAL INDICATOR SYSTEM OF REGIONAL TECHNOLOGY INNOVATION

Based on the meaning of regional technology innovation and the comprehensive, universal and practical evaluation principle, the paper chooses four kinds of indicators which represent the level of technology innovative input, the level of technology innovative output, innovative environment and innovative mechanism to evaluate the technology innovative ability. Each kind indicator subsystem consists of several indexes [7][8][9] (see table 1).

[*] Corresponding author. Email: liuliqin2002@xinhuanet.com

**Table 1. Appraisal Indicator System of regional technology innovative ability**

| The first layer index | The second layer index | The third layer index | The forth layer index |
|---|---|---|---|
| Regional technology innovative ability U | The level of technology input $U_1$ | Personal input $S_1$ | Full-time Equivalent of R&D personnel(1000 man-years)$L_1$ |
| | | | R&D Personnel in Enterprises and Institutions(person)$L_2$ |
| | | Capital input $S_2$ | Proportion of Intramural Expenditure on R&D to GDP(%)$L_3$ |
| | | | Proportion of Intramural Expenditure for Science and Technology to GDP(%)$L_4$ |
| | | | Proportion of Intramural Expenditure for Science and Technology to Local Government Intramural Expenditure(%)$L_5$ |
| | | | Expenditure on New Products Development(100 million yuan)$L_6$ |
| | The level of technology output $U_2$ | Industrial output $S_3$ | Gross Value of New Products in High-tech Industry(10000 yuan)$L_7$ |
| | | | Gross Value in High-tech Industry(10000 yuan)$L_8$ |
| | | | Sales Profits of New Products in High-tech Industry(10000 yuan)$L_9$ |
| | | | Total Value of Export of High-tech(100 million yuan)$L_{10}$ |
| | | Scientific research output $S_4$ | Number of Inventions Patents Application Accepted(piece)$L_{11}$ |
| | | | Number of Inventions Patents Application Granted(piece)$L_{12}$ |
| | | | Number of National Scientific and Technological Progress Prizes Awarded(item)$L_{13}$ |
| | | | Number of Major Achievements in Science and Technology(item)L14 |
| | The environment of technology innovation $U_3$ | Informative level $S_5$ | Capacity of Mobile Telephone Exchanges(10000 subscribers)$L_{15}$ |
| | | | Length of Long Distance Optical Cable Lines(Km)$L_{16}$ |
| | | Educational level $S_6$ | Proportion of Population with Junior College and Above to Regional Population(%)$L_{17}$ |
| | | | Proportion of Intramural Expenditure for Education to(%)L18 |
| | The mechanism of technology innovation $U_4$ | transformation mechanism $S_7$ | Transaction Value in Technical Market(10000 yuan)$L_{19}$ |
| | | | Growth Rate of Transaction Value in Technical Market(%)$L_{20}$ |
| | | stimulation mechanism $S_8$ | Average Wage of Employed Persons in Scientific Research, Technical Services(yuan)$L_{21}$ |

## 3. GREY RELATIONAL ANALYSIS OF REGIONAL TECHNOLOGY INNOVATION ABILITY EVALUATION

The regional technology innovation ability is a complicated grey system. Many factors affect regional technology innovation ability, and some factors have obvious relation with the regional technology innovation, the others have no obvious relation with it. Only the primary index can be chosen to evaluate the regional technology innovation ability, which makes the regional technology innovation ability system become grey with incomplete information. The grey system theory can study and handle complicated system and apply to studying the system with complex mechanism, many layers which is difficult to be accurate measured, so the grey system have an obvious advantage to the small sample. This paper try to use the grey correlative analysis method coming from the grey system theory to establish the sequential evaluate model of regional technology innovation ability.[10]

### 3.1 Building the data column

Building the data column is the basis of the grey relational analysis. The comparative data column is built by annual 21 observed values in order to evaluate sequentially the regional technology innovative ability of m years. The comparative data column is recorded as:

$$x_i=\{x_{i(1)},\ x_{i(2)},\cdots x_{i(21)}\}\quad (i=1,\ 2,\cdots m) \tag{1}$$

Since the meaning and unit of each index is different and the difference of value of each index is great, the index should be dealt dimensionless. The index dealt is recorded as :

$$x'_{ij}=x_{ij}/\max(|x_{1j}|,\ |x_{2j}|,\ |x_{3j}|,\ \cdots,\ |x_{mj}|)(\ i=1,\ 2,\ \ldots,\ m;\ j=1,\ 2,\ \ldots,\ 21) \tag{2}$$

The optimum data column is built according to the comparative data column. For all the index is efficiency index, the optimum data column is recorded as:

$$X_{0j}=\max\{x'_{1j},\ x'_{2j},\ x'_{3j},\ x'_{4j},\ \cdots\ x'_{mj}\}\quad (j=1,\ 2,\ \cdots,\ 21) \tag{3}$$

### 3.2 Determining the weight of each index

The weight of each layer index is determined based on the influence extend on the higher layer index. The thesis think every index have equal influence on the higher layer index [11]. The weight of second layer index ($U_1$, $U_2$, $U_3$, $U_4$) to the first layer U is A=(0.25, 0.25, 0.25, 0.25). The weight of the third layer index ($S_1$, $S_2$)to the second layer index $U_1$ is $B_1$=(0.5, 0.5), the weight of the third layer index ($S_3$, $S_4$)to the second layer index $U_2$ is $B_2$=(0.5, 0.5), the weight of the third layer index ($S_5$, $S_6$)to the second layer index $U_3$ is $B_3$=(0.5, 0.5), the weight of the third layer index ($S_7$, $S_8$)to the second layer index $U_4$ is $B_4$=(0.5, 0.5). The weight of the forth layer index ($L_1$, $L_2$)to the third layer index $S_1$ is $E_1$=(0.5, 0.5), the weight of the forth layer index ($L_3$, $L_4$, $L_5$, $L_6$)to the third layer index $S_2$ is $E_2$=(0.25, 0.25, 0.25, 0.25), the weight of the forth layer index ($L_7$, $L_8$, $L_9$, $L_{10}$)to the third layer index $S_3$ is $E_3$=(0.25, 0.25, 0.25, 0.25), he weight of the forth layer index ($L_{11}$, $L_{12}$, $L_{13}$, $L_{14}$)to the third layer index $S_4$ is $E_4$=(0.25, 0.25, 0.25, 0.25), the weight of the forth layer index ($L_{15}$, $L_{16}$)to the third layer index $S_5$ is $E_5$=(0.5, 0.5), the weight of the forth layer index ($L_{17}$, $L_{18}$)to the third layer index $S_6$ is $E_6$=(0.5, 0.5), the weight of the forth layer index ($L_{19}$, $L_{20}$)to the third layer index $S_7$ is $E_7$=(0.5, 0.5), the weight of the forth layer index ($L_{21}$)to the third layer index $S_6$ is $E_6$=(1).

### 3.3 Establishing the model of correlative coefficient

Broaden matrix is built with the comparative data column and the optimum data column, which is recorded as:

$$X^*=(\ x'_{ij})_{(m+1)}\times 21\qquad (\ i=0,\ 1,\ 2,\cdots,\ \ m;\ j=1,\ 2,\cdots,\ 21) \tag{4}$$

The optimum vector is the comparative vector and the other vectors are the compared vector.

The grey correlative coefficient of $x'_{ij}$ and $x'_{0j}$(i=1，2，3，…，m；i=1，2，3，…，21)is calculated by the formula (5).

$$r_{ij}=\frac{\min_i\min_j|x'_{0j}-x'_{ij}|+\rho\max_i\max_j|x'_{0j}-x'_{ij}|}{|x'_{oj}-x'_{ij}|+\max_i\max_j|x'_{0j}-x'_{ij}|} \tag{5}$$

$\rho$ is coefficient, and the value of which is 0.5 usually.

The matrix which consists of grey correlative coefficient is recorded as:

$$R=r_{ij}\ \ (i=1,\ 2,\ \cdots,\ m;\ \ j=1,\ 2,\ \cdots,\ 21) \tag{6}$$

The column vector of R is the grey correlative coefficient vector of the forth index.

### 3.4 Calculating the degree of grey correlation

The degrees of grey correlation of the third layer index are calculated by the grey correlative coefficient of the forth layer index and their corresponding weight. The degrees of grey correlation of the second layer index are calculated by the grey correlative coefficient of the third layer index and their corresponding weight. The

degrees of grey correlation of the first layer index are calculated by the grey correlative coefficient of the second layer index and their corresponding weight. The formula which calculates the degree of grey correlation is formula (7).

$$y_i = \sum_{j=1}^{n} r_{ij} w_j \quad (i= 1,2,\ldots,m) \tag{7}$$

$y_i$ is the degrees of grey correlation of the first, second, third layer index, $r_{ij}$ is the grey correlative coefficient of the second, third, forth layer index, n is the number of the sub indicators of every layer index, $w_j$ is the corresponding weight of $r_{ij}$.

## 4. THE PRACTICAL STUDY OF TECHNOLOGY INNOVATIVE ABILITY IN CHINAT

### 4.1 Obtaining data

The data come from the <China statistical yearbook 2009>. Considering the obtaining and changing of data, the thesis chooses the data from 2001 to 2010.

### 4.2 Analysis of the technology innovative ability in China

Eleven comparative columns are set up with the index of eleven years. The grey correlative degree matrixes are calculated by the grey correlative analysis. The grey correlative degrees of every index delegate the level of the index. (See table 2)

**Table 2. the Grey Correlative Degree of the Second Index and the First Index**

| | The level of technology input | The level of technology output | The environment of technology innovation | The mechanism of technology innovation | Regional technology innovative ability |
|---|---|---|---|---|---|
| 2001 | 0.548 | 0.406 | 0.485 | 0.438 | 0.469 |
| 2002 | 0.565 | 0.421 | 0.528 | 0.409 | 0.481 |
| 2003 | 0.590 | 0.445 | 0.569 | 0.476 | 0.520 |
| 2004 | 0.591 | 0.500 | 0.607 | 0.495 | 0.548 |
| 2005 | 0.645 | 0.497 | 0.702 | 0.469 | 0.578 |
| 2006 | 0.704 | 0.521 | 0.644 | 0.502 | 0.593 |
| 2007 | 0.700 | 0.572 | 0.722 | 0.592 | 0.647 |
| 2008 | 0.749 | 0.669 | 0.784 | 0.646 | 0.712 |
| 2009 | 0.895 | 0.743 | 0.921 | 0.687 | 0.811 |
| 2010 | 0.917 | 0.992 | 0.992 | 1.000 | 0.975 |

### 4.3 Analysis of the result

The regional technology innovative ability from 2001 to 2010 is evaluated with the grey correlative coefficient of the first layer index and the second layer index. In order to getting the clear result, the thesis uses figure to show the grey correlative coefficient of technology innovative ability, the level of technology input, the level of technology output, the environment of technology innovation and the mechanism of technology innovation. (See figure 1)

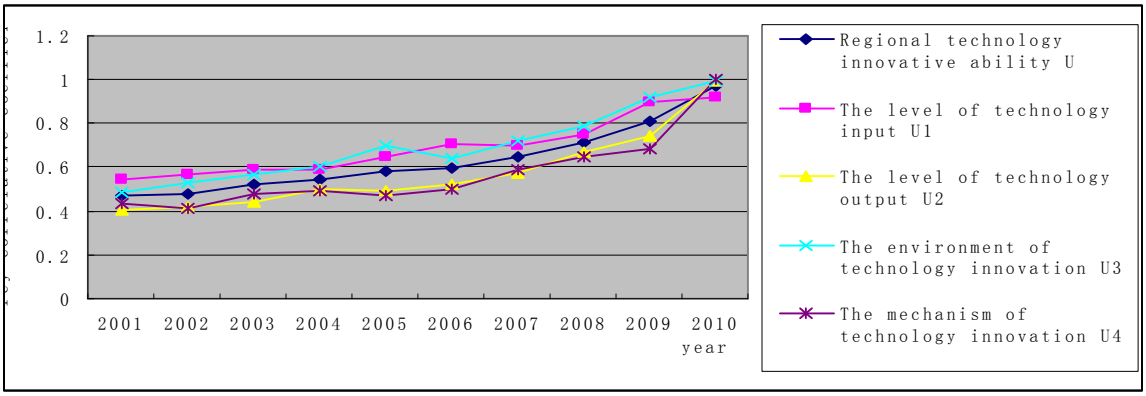


**Figure 1 the sequential change of the technology innovatiove ability in China from 2001 to 2010**

The compressive level of technology innovative ability in China from 2001 to 2010 has a rising tendency on the influence of the level of technology input, the level of technology output, the environment of technology innovation and the mechanism of technology innovation, and the change of the technology innovative ability can divide into slow rise stage which is from 2001 to 2007 and fast rise stage which is from 2008 to 2010.

The level of technology input in China from 2001 to 2010 has a clear rise tendency except 2007(curve $U_1$). The curve representing the level of technology input lies above the curve representing the level of technology innovative ability, which shows that technology input has a positive effect on the technology innovative ability. The level of the technology input is under the level of technology innovative ability in 2010, which shows that technology input has a negative effect on the technology innovative ability.

The curve of technology output level (curve $U_2$) has a tendency of rising from 2001 to 2010. The curve $U_2$ is under the curve U which representing the compressive level of technology innovative ability, which shows the level of technology output is lest and has a few contribution on the technology innovative ability. The level of technology output is higher than the level of technology innovative ability in 2010, which shows that the influence of the technology output on the technology innovative ability is enhanced.

The level of the technology innovative environment (curve $U_3$) is rising in every year from 2001 to 2010. The curve $U_3$ is on the curve U which shows that the technology innovative environment is well and benefits the technology innovative ability.

The curve $U_4$ representing the technology innovative mechanism in China has a rising tendency from 2001 to 2010. The technology innovative mechanism from 2001 to 2009 is under the technology innovative ability, which shows that the technology innovative mechanism is not perfect, and the technology innovative mechanism limits the development of technology innovative ability. The technology innovative mechanism is higher than the technology innovative ability in 2010, which reflects that the technology innovative mechanism becomes well in 2010.

## 5. CONCLUSION AND SUGGESTION

### 5.1 Conclusion

After the evaluation with the grey correlative analysis, the thesis draws the conclusion: the technology innovative ability in China is more enhance year by year and the rate of rise is growing; the technology input level and the technology innovative environment promote the development of the technology innovative ability; the technology output level and the technology innovative mechanism limit the development of technology innovative ability.

### 5.2 Suggestion

In order to improving the technology innovative ability in China, some suggestion should be taken:

5.2.1 Increasing the level of technology input

The capital should be raise by many channels to support the technology innovation. The technology innovative input mechanism should be formed which is comprised with governments, enterprises, financial institutions and members of the public. The technology innovation human capital should be strengthened; human capital can be not only cultured at home but also introduced at abroad. The talent management and encourage mechanism should be formed.

5.2.2 Enhancing the level of technology output

The government should support the high-tech industry with capital and policy and encourage the high-tech enterprise to produce goods with new technology. The scientific research equipment should be complete in enterprises and research organization and the scientific research personnel should be encouraged, which can promote the technology output. The communication platform should be built to strengthen the communication and cooperation of the research organizations and the high-tech enterprises in different region.

5.2.3 Optimizing the environment of technology innovation

Information is the development condition of technology innovation, so information infrastructure such as the internet and telecommunication network should be perfected. The educational input should be added; the colleges should culture the technology innovative talent. The role of technology innovative service should be strengthened in governments and agencies; the good market environment should be set up.

5.2.4 Perfecting the mechanism of the technology innovation

The transformation mechanism and the stimulation mechanism should be perfected. The transformation platform of technology achievement should be established and the transformation mechanism should be development with the influence of market mechanism. The stimulation mechanism should be development which consists of money and job award; the research organizations, universities and the research persons should be encourage transforming their research theories into products. The government should promote the cooperation of enterprise, research organizations and universities support the innovative enterprises to transform their research achievement to products with capital, credibility, and guarantee.

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