The Analysis of the Function about Regional Innovation Effectiveness Based on the RMI ——Taking Liaoning and Zhejiang Province as an Example

KAN Shuang & GUO Fu & Xu Jie Northeastern University, China

ABSTRACT: For self-similar system, the final system output linked to system self-products. Selecting the R&D input-structure as the input variables, citation and GDP as the output variables, the paper attempts to evaluate the effectiveness of innovation .First, using the power-law function to test whether the regional system is a system with self- similar attribute. Second, based on RMI coefficient built by the Canadian scholar KATZ, the paper constructs the mathematical model of efficiency. The model not only can be applied to compare the output elasticity of different objects, also can be of the same object .This paper takes Liaoning province and Zhejiang Province as an example, analyses and certifies their innovative effectiveness. KEYWORD: Self similar system; Scale-independent indicator

1 INTRODUCTION

The development of systems theory has shown that innovation systems are complex, and the relationships between the elements of the system and the relationship between specific indicators is not a simple linear relationship but rather a complex nonlinear relationship characterized by exchange emerging force and power of self-organization [1]. Methods of evaluation based on the input-output principle require validation of the independence of the indexes.

For example, it is not clear whether the manner of determining the ratio is affected by scale and time when the ratio of two indicators is used as evaluation indicator, how the effects of correlations between indicators on the results can be eliminated, how heterogeneous regional innovation systems (e.g. systems with different scales or different remuneration) can be evaluated, how innovative behavior (including management innovation, system innovation, etc.) can be confirmed as effective and efficient. The input-output principle evaluation method of performance described in this may solve these problems.

2 RESEARCH IDEAS AND MODELS

In 1997, May published a paper "Evaluation on National Science prosperity" in Science. He conducted statistical analysis of a great deal of

scientific data from the major developed countries collected from 1981-1994. After comparison and contrast, he proposed, "for some countries, scientific output may have a Matthew positive effect threshold"[2]. Katz combined the features of selfsimilar systems, which are widespread in nature, and conducted a rigorous mathematical deduction in subsequent studies. The expression of power-law function in the mathematics is $Y=AX^{\alpha}$, α is the scaling factor for both. The scaling relationship between two factors must be confirmed. The ratio of indexes Y/X can affect the results of the evaluation if the scaling relationship exists, and the ratio becomes more distorted over time. In order to eliminate the correlation interference from the ratio (Y/X) of scaling relationship Y-X, Katz constructed an RMI (relative magnitude indicator) index, which is a method of measurement involving using the ratio of the statistical data and the expected value to measure the relative influence. Mathematical expression of RMI is $RMI = Y / Y^E$ (Y is the actual data value, Y^E is the expected value obtained by power law function)[3-5]. These are used to evaluate the real effect of the independent variable X on the dependent variable Y.

Using input-output indicators and confirm that these indicators have a scaling relationship can give RMI more space to expand. Then, according to the construction principles of RMI, a relative performance indicator (RPI) for this self-similar system can be built as follows:

$$RPI = P/f(X) \tag{1}$$

(P: the actual value of a dependent variable; X: an independent variable; f(X) is the output expectation of a self-similar system obtained with a power-law function)

The actual value P is a statistical result at a specific point in time point in a complex system. The function is the expected output, which was established based on the performance of the system over time, the changes in output value was obtained by subtracting one value from another, that measures under the system's consistent output capacity whether the actual output brought by innovation is greater than or smaller than that which the system puts out by its own ability. In self-similar systems, new innovative activities bring changes in output, if the change in output is positive, the innovation activities of the system are effective. If innovation activities cause the actual output to become lower than the self-output of the system (output expectations obtained by power-law function), then the innovation activities are invalid.

In this way, Equation 2 can be obtained from Equation 1:

$$R = RPI - 1 \tag{2}$$

The meaning of the model described above is that if a system is self-similar, the innovative relative performance of the system can be determined by calculating the ratio of the final output to the selfoutput of the system. If the innovation relative performance RPI is greater than 1, then the final output of the system is greater than its self-output, then the innovation activities caused a positive output, and the innovation is effective and the innovative validity index is a positive number. The more effective the system is, the bigger the effectiveness index. However, if the innovation is invalid, the innovative validity index is a negative number. The stronger the invalid index is, the less effective the system is.

3 EFFECTIVENESS OF INNOVATION INLIAONING PROVINCE AND ZHEJIANG PROVINCE

3.1 Evaluation indicator system for evaluation of innovation performance

Liaoning Province and Zhejiang Province here served as examples, the statistics date were the

relevant information of these two provinces from the China Statistical Yearbook, China Science and Technology Statistical Yearbook (2001–2013), and the Chinese HowNet (http://www.cnki.net). The names of statistical indicators used in this article are consistent with the names of the statistical data given above. The years listed in this paper are years of publication.

3.2 Verification of C, GDP, and K/FTE scaling relationships

Assumption 1: C and K/FTE in Zhejiang Province have a scaling relationship.

Assumption 2: C and K/FTE in Liaoning Province have a scaling relationship.

Assumption 3: GDP and K/FTE in Zhejiang Province have a scaling relationship.

Assumption 4: GDP and K/FTE in Liaoning Province have a scaling relationship.

With the help of EXCEL software, the following conclusions were reached (Table 1). And assumptions 1-4 were established.

The Power-law function between the input structure from 2001–2010 and citations outputs from 2003–2012 in Zhejiang Province is as follows: $P_C=18.2(K/FTE)^{2.497}$. The independent variable K/FTE and the dependent variable C showed goodness of fit ($R^2=0.956$) in the form of power-law function. This indicates that there is a scaling relationship with a power-law function between these two variables. The economic significance of scale factor 2.497 is that although the innovation system in Zhejiang Province was complex, the data collected from 2001-2011 showed there to be a simple relationship between the number of citations and the investment structures in this complex system - if the innovation investment structure in Zhejiang Province increased a fold (two times of the original), then the volume of citation output must be 5.64 times of the original. According to this, if the input structure is n-fold the original, the citation output will be 2.4967 times the original. The magnitude of the corresponding scaling relationship in Liaoning Province was less pronounced than that of Zhejiang Province.

Table 1: C-K/FTE and GDP-K/FTE scaling relationships in Liaoning Province and Zhejiang Province (2001–2012)

	C-K/FTE scaling relationship		GDP—K/FTE scaling relationship		
	α	\mathbb{R}^2	α	\mathbb{R}^2	RPI ²⁰¹³
Liaoning	1.935	0.939	0.965	0.952	1.634
Zhejiang	2.497	0.965	2.048 (2001-12)	0.914	1.281
			1.469 (2001-07) 3.528 (2008-12)	0.980 0.944	

In studying GDP scaling relationship during 2001–2012 in Liaoning Province, the test data showed that the resulting power-law function between GDP and K/FTE obtained by fitting is HPR =27.96(K/FTE)^{0.965}, and intends to be goodness of fit (R^2 =0.952), therefore, we can accept there was scaling relationship between GDP-K/FTE. The economic significance of the scale factor, 0.884, indicates that if the value of innovation structure in Liaoning Province is two-fold of the original, the province's GDP will be 1.953 times the original. The value of this scaling factor in Zhejiang Province was 4.136, indicating that the effect of Liaoning Province innovation investment on GDP was less pronounced than that of Zhejiang Province.

In the current study of the GDP scaling relationship in Zhejiang Province, the province's economic development showed periodic trends from 2001–2012, but Liaoning Province did not clearly show such periodic trends.

3.3 *Evaluation of the effectiveness of* innovation based on construction principles of RMI

The relative innovation performance of GDP in Liaoning Province and Zhejiang Province in 2013 can be determined using Formula 2, and relevant statistical data from 2013 (RPI²⁰¹³ in Table 1).

The effectiveness of innovation in Liaoning Province in 2013 (I=0.6340) indicated that the innovation activities in Liaoning Province were effective in that year, more so than between 2001 and 2012, and the new innovation activities in 2013 increased GDP significantly. The growth rate was 63.4%. Analysis of the specific reasons was performed with respect to development of science and technology in the equipment manufacturing industry cluster, which is the leading industry of Liaoning Province. It has been supported by the state in recent years, from 2010 on Liaoning Province has been awarded the National Science and Technology Support Program, the national "985" plan, and other key scientific development projects. There has been investment in the construction of a number of national. provincial, and municipal public technology service centers, and a number of provincial and local industrial and fiscal policies have been made. There may be further improvement of the innovation investment structure, but also enhanced collaboration in technology transfer, and technology synchronization may lead to a substantial increase in the 2013 GDP.

The effectiveness of innovation in Zhejiang Province in 2013 has also been verified: the growth rate of GDP output brought by innovation was 28.14%. Although the magnitude of the relative contribution of innovation was lower than in Liaoning province, Zhejiang showed an average of nearly 10% increase GDP from 2001–2012, the innovation activities in 2013 has brought more than 25% performance improvement at a higher development base, indicating that innovation activities in 2013 had a long-term and fruitful viability.

4 CONCLUSIONS AND IMPLICATIONS

Power-law function tests showed that from 2001-2012, the innovation systems in Liaoning Province and Zhejiang Province had self-similar properties between CK and FTE, and between GDP-K and FTE two groups of variables. Taking C-K/FTE as an example, the scaling factors for Liaoning Province and Zhejiang Province were 1.935 and 2.497, respectively, indicating that if the investment structure variable K/FTE was n times of the original, the citation output (C) of both provinces will be 0.939 and 0.965 times the respective originals. Such self-similarity feature of a system has nothing to do with the size of the system or the size of the dependent variable, it is a self-replicating feature and will go through automatic dynamic continuation in the absence of external interference.

Self-similar systems have Matthew effects and the scale factor indicates the nature of this Matthew effect. If the scaling factor α was bigger than 1, then there is a rich-getting-richer Matthew positive effect; conversely, a poor-getting-poorer Matthew negative effect. From the scaling factor, the two Provinces both showed a positive Matthew effect in terms of output. In the GDP-K/FTE citation scaling relationship, GDP output in Liaoning Province had a negative Matthew effect, and GDP output in Zhejiang Province had a negative Matthew effect. This shows that the innovative structures in the two provinces were not roughly equally enhanced to two times the original values. The GDP output of Liaoning Province will be less than 2 times the original GDP, but Zhejiang Province will reach more than four times of the original. This indicated that the innovation structure of Zhejiang Province had a greater ability to enhance GDP than that of Liaoning Province.

The innovation activities in Liaoning Province and Zhejiang Province in 2013 brought a new GDP output for the system, and the innovation seemed valid. Regarding the relative effectiveness of the innovation, the GDP of the Liaoning Province was 63.4% better in 2012 than in 2001, higher than the 28.14% in Zhejiang Province. The contribution of innovative behavior of Liaoning Province to GDP in 2013 was larger than that of Zhejiang Province.

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