Grey Relation Analysis of Science & Technology Input and Economic Growth

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Abstract. As industry upgrading progresses, science and technology plays more roles in economy development. This paper studied the current situation of the R&D input and personnel engaged in S&T activities, and analyzed their relation with economic growth from the perspective of grey relation theories on the basis of the GDP data of Henan province. The method used in the article is grey relative relation analysis. Results indicate that: (1) Both R&D input and personnel engaged in S&T activities have positive correlation with economic growth. (2) As a share of GDP, the R&D input in Henan Province is lower than that of developed areas in China. Based on the results, a series of policy suggestions are given in order to boost the economic development.

Keywords: economic growth, grey relation, science & technology input, personnel, GDP.

1. Introduction

To a large extent, China's economic growth is driven and accelerated by investment in science and technology. In western developed countries, economic growth mainly relies on the improvement of labor productivity driven by scientific and technological progress. In the current global situation of shortage of resources, environmental degradation, sustainable development of the economy heavily relies on scientific and technological progress. Human can solve the resources shortage problems and improve the ecological environment needs by means of more advanced science and technology. Due to the fact that science and technology progress requires a lot of capital input, investment in science and technology has become one of the important indicators measuring the scientific and technological capabilities in a country and area. Increasing investment in science and technology is a strategic measure to improve the progress of science and technology level and enhance the comprehensive national strength. R&D activities is the core content of science and technology activities, and the investment on it is an important part of the whole society science and technology input, which plays a guiding role for the development of the whole society. The investment of science and technology personnel in science and technology fields plays an active role for the economy's long-term sustainable development.

Quantitative analysis of investment in science and technology for economic growth is of great significance. Analysis on the interaction of science and technology activity and economic growth can be quantized by the method of econometric analysis model which has requirements for the data sample size and sample distribution demand. Grey relation analysis [1-6] method has no specific requirement for sample amount and regularity and involves a small amount of calculation. Therefore, the grey relation analysis method has been widely used in studying the relationship between different factors in economics [7-8]. In this article, we use the method of grey relative relation degree in grey system theory to analyze the relationship between science and technology input and economic growth from two aspects of science and technology input, namely, science and technology investment and personnel. We used the statistical data from 2006 to 2012 in Henan province, in which economic growth is mainly based on gross domestic product (GDP) data.

2. Investment in science and technology

We choose a list of factors as effective data to measure the relation between investment in science and technology and economic development. They are GDP data, nominal growth date of GDP, R&D input, nominal growth rate of R&D input, share of R&D input as GDP, and personnel engaged in S&T activities (by population size). Take data from 2006 and 2012 in Henan Province as example, and we can get the data table as following.

Table 1 R&D Input and GDP data of Henan province from 2006 to 2012

Year	GDP (a hundred million yuan)	Nominal growth rate (%)	R&D input (ten thousand yuan)	Nominal growth rate (%)	Share of R&D Input as GDP (%)	Personnel Engaged in S&T Activities (person)
2006	12362.79	--	798414	--	0.65	177226
2007	15012.46	21.43	1011302	26.66	0.67	192173
2008	18018.53	20.02	1240890	22.70	0.69	209793
2009	19480.46	8.11	1747599	40.83	0.90	226500
2010	23092.36	18.54	2113773	20.95	0.92	262112
2011	26931.03	16.62	2644922	25.13	0.98	292902
2012	29599.31	9.91	3107803	17.50	1.05	305990

The following can be seen from table 1: firstly, in the period 2006-2012, there is a rising tendency for overall R&D input in Henan province, in 2009 the growth reaches the peak point and the nominal growth rate per year is as high as 40.83%. Secondly, the nominal growth rate of R&D input is significantly higher than the nominal growth of GDP at the same period in Henan province, which shows a good momentum for development, because R&D activities are the core part of science and technology activities. In accordance with international practice, the growth rate of R&D input should be higher than the growth rate of GDP. Only in this way can a national or regional development of science and technology power and strength be maintained in a long run and strengthened constantly. Thirdly, despite the fact that the proportion of R&D input in GDP in Henan province shows an increasing trend year by year, the share of R&D input in GDP in Henan province is still too small, and below the national average in China. For example, R&D input is 7.98414 billion Yuan in Henan province in 2006, which takes proportion of 0.65% in GDP. In contrast, the national R&D input is 300.31 billion Yuan taking share of GDP as 1.42% at the same time. Another example is that R&D input in Henan province in 2012 is RMB 31.07803 billion Yuan, accounting for 1.05% in GDP, while at the same time the national R&D input is 1.02984 trillion Yuan, as a share of GDP is 1.98%. Compared with developed areas, the gap is even bigger. For instance, R&D input in Jiangsu province in 2006 accounts for as high as 1.6% in GDP, and R&D input in Jiangsu province in 2012 rises up to RMB 128.802 billion Yuan, as a share of GDP 2.3%. R&D input in Shanghai in 2006 is 25.884 billion Yuan, as a share of GDP 2.45%. Furthermore, R&D input in Shanghai in 2012 increases to 67.929 billion Yuan, as a share of GDP is 3.37%. R&D input as a share of GDP from 2006 to 2012 in different regions is shown in table 2.

Table 2 R&D input as a share of GDP in different regions (%)

Year / District	Henan	Jiangsu	Shanghai	Beijing
2006	0.65	1.6	2.45	5.33
2007	0.67	1.68	2.46	5.35
2008	0.69	1.93	2.58	5.58
2009	0.90	2.08	2.81	5.50
2010	0.92	2.1	2.81	5.82
2011	0.98	2.2	3.11	5.76
2012	1.05	2.3	3.37	5.95

3. Personnel engaged in S&T activities

There is growth trends for the number of personnel engaged in S&T activities. In 2006, the number is 177,226, while in 2012 the number rises up to 305,990 and the average annual growth is 9.52%. Personnel engaged in S&T activities is the most active element for the development of science and technology, and it has high mobility. This reflects that the allocation of talent is gradually towards marketization in our country. The situation of talent development in Henan province performs well on the whole. However, due to the mobility of talent, the positive effects from other talent magnet provinces and areas such as Shanghai, Guangdong, Beijing and other provinces and cities cannot be ignored. Under the influence of marketization for talent allocation, governments and enterprises should make full use of the mobility of science and technology personnel, and formulate effective policies and measures in order to retain talent and promote scientific and technological progress and economic growth. Personnel engaged in S&T activities from 2015 to 2013 can be seen in figure 1.

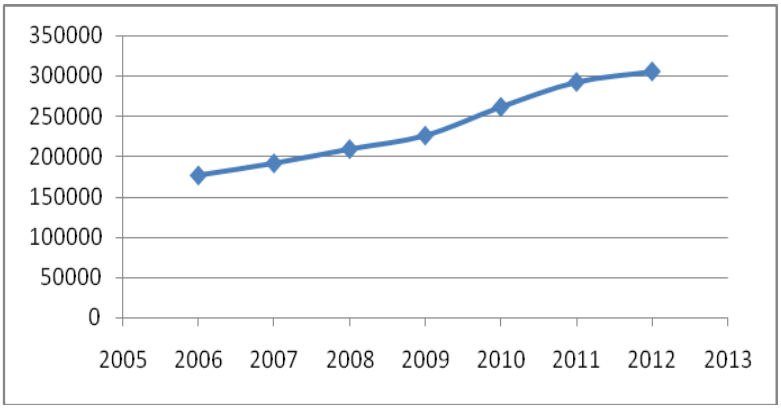

Fig. 1 Personnel engaged in S&T activities of Henan province from 2006 to 2012(person)

4. Grey relative relation analysis of science and technology input and economic growth

Grey relation analysis is one of the main content of the grey system analysis which is used to analyze the characteristic sequences and the related sequences so as to determine the main and secondary factors influencing the development of the system.

Step 1. We can get the following sequences according to the data from table 1.

X_0 = (12362.79, 15012.46, 18018.53, 19480.46, 23092.36, 26931.03, and 29599.31). (1)

X_1 = (798414, 1011302, 1240890, 1747599, 2113773, 2644922, and 3107803). (2)

X_2 = (177226, 192173, 209793, 226500, 262112, 292902, and 305990). (3)

Step 2. Initial images of the original sequences are as follows.

$X_0' = X_0 / X_0(1)$ = (1, 1.21, 1.46, 1.58, 1.87, 2.18, and 2.39). (4)

$X_1' = X_1 / X_1(1)$ = (1.00, 1.27, 1.55, 2.19, 2.65, 3.31, and 3.89). (5)

$X_2' = X_2 / X_2(1)$ =1.00, 1.08, 1.18, 1.28, 1.48, 1.65, 1.73). (6)

Step 3. Starting point zero images are as following.

$X_0'^0 = X_0'^0 - X_0'^0(1)$ = (0.00, 0.21, 0.46, 0.58, 0.87, 1.18, and 1.39). (7)

$X_1'^0 = X_1'^0 - X_1'^0(1)$ = (0.00, 0.27, 0.55, 1.19, 1.65, 2.31, and 2.89). (8)

$X_2'^0 = X_2'^0 - X_2'^0(1)$ = (0.00, 0.08, 0.18, 0.28, 0.48, 0.65, and 0.73). (9)

Step 4. $|s_0'|$, $|s_1'|$, $|s_2'|$, $|s_1' - s_0'|$, and $|s_2' - s_0'|$ can be gotten as follows.

$$|s_0'| = |\sum_{k=2}^{7} x_0'(k) + \frac{1}{2} x_0'(7)| = 3.995. \quad (10)$$

$$|s_1'| = |\sum_{k=2}^{7} x_1'(k) + \frac{1}{2} x_1'(7)| = 7.415. \quad (11)$$

$$|s_2'|=|\sum_{k=2}^{7}x_2'(k)+\frac{1}{2}x_2'(7)|=2.035; \quad (12)$$

$$|s_1'-s_0'|=|\sum_{k=2}^{7}x_1'(k)-x_0'(k)+\frac{1}{2}(x_1'(k)-x_0'(7))|=3.42. \quad (13)$$

$$|s_2'-s_0'|=|\sum_{k=2}^{7}x_2'(k)-x_0'(k)+\frac{1}{2}(x_2'(k)-x_0'(7))|=1.96. \quad (14)$$

Step 5. Relative relation degree can be calculated as follows.

$$r_{01}=\frac{1+|s_0'|+|s_1'|}{1+|s_0'|+|s_1'|+|s_1'-s_0'|}=0.7837. \quad (15)$$

$$r_{02}=\frac{1+|s_0'|+|s_2'|}{1+|s_0'|+|s_2'|+|s_2'-s_0'|}=0.7829. \quad (16)$$

The relative development speed of GDP, R&D Input and personnel engaged in S&T activities can be seen in figure 2.

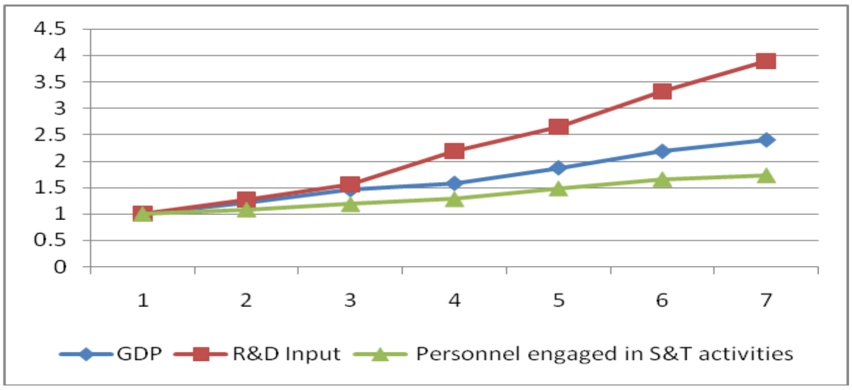

Fig. 2 The relative development speed of GDP, R&D Input and Engaged Personnel

5. Conclusion

At present, China is going throng the important period of economy transformation and upgrading. The role of science and technology in economic growth is increasingly obvious. Therefore, quantitative analysis of government investment in science and technology has very important significance for the economic growth. Through the grey relative relation analysis on the R&D input, personnel engaged in S&T activities, and gross domestic product (GDP) data, we can draw the following conclusions: (1) the science and technology input is closely related to the economic growth, and investment in science and technology plays an important role in economic growth. (2) The influence of number of personnel engaged in S&T activities on economic growth is also very important.

Therefore, in the process of economic development, the relevant government departments should attach importance to investment in science and technology, and increase investment in science and technology activities. On the other hand, in order to reduce the number of personnel involving in the activities of science and technology, a more reasonable allocation of human resources is need. Then the economy can keep stable and sustainable growth.

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