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Research Article

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Study on relationship between investment in science and technology and economics growth for petrochemical enterprise based grey relational degree analysis

Yi Si fei

Sichuan Finance and Economics Vocational College, China

ABSTRACT

The investment in science and technology can affect the economics growth of the petrochemical enterprises, and researches on it are very important, therefore the grey relational degree analysis is applied in analyzing it. Firstly, Situation of investment in science and technology from 2004 to 2013 of the petrochemical enterprises is summarized. Secondly, the basic theory of grey relational analysis is studied. Thirdly, the analysis steps of the grey relational analysis for analyzing the investment in science and technology and economics growth of the petrochemical enterprises for the petrochemical enterprises are designed. Finally, the calculation is carried out for analyzing this relationship; results show that there has a positive correlation between the investments in scientific and technical personnel with economics growth of the petrochemical enterprises.

Keywords: investment in science and technology; economics growth; grey relational degree

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INTRODUCTION

Science and technology investment and economic growth are two aspects interacting each other in economical system. Science and technology are the primary productive forces, the investing growth of science and technology funds, whereas the economics is a material basis of increasing investment in science and technology. The economic growths can strength the ability of increasing the science and technology investment. Science and technology investment concludes human resources, material resources and financial resources, will finally appear as investment of human resources and financial resources. Since reform and opening up, Chinese overall national strength has been developed by leaps and bounds, but the differences in economics between China and developed countries are still great, therefore there are differences in the contribution of investment in science and technology on economic growth [1,2].

The petrochemical enterprises of the petrochemical enterprises has played an important role on promoting the development of society and improving the competitive strength [3,4]. The investment in science and technology can achieve the economics growth. The petrochemical enterprises are the pillar of Chinese economy, which has every important status in the process of economic development. The petrochemical enterprises belong to the capital and technology intensive industry, scientific and technological progress is a fundamental shift of their development. The investment in science and technology is the basic condition, which can improve the economies of petrochemical enterprises.

The econometrics can be applied in analyzing the relationship between the investment in science and technology and economic growth, but the sample size must be large enough and conform to specific distribution. And the quantifiable and qualitative results may be not consistent. Therefore it is necessary to find out an effective method. The grey relational analysis has not requirement for sample size and sample distribution, and the amount of calculation is little. It can be applied in analyzing the relationship between science and technology investment and economic growth [3] .

The grey theory was put forward by Professor Deng, the calculation of grey relational degree is carried out based on grey theory. The similar degree of geometric shapes of sequence curves is used to judge the whether relations is close. The closer the curves are, the bigger the relational degree of corresponding sequences is. The grey relational analysis can overcome the disadvantages of econometrics.

EXPERIMENTAL SECTION

(1) Situation of investment in science and technology from 2004 to 2013 for petrochemical enterprises
The data of investment in R&D and economic output from 2004 to 2013 for petrochemical enterprises is shown in table 1.

Table 1 data of investment in science and technology and ECONOMICS OUTPUT in China

Year	Investment in R&D (billion yuan)	economic output (billion yuan)
2004	88828	17615.93
2005	76281	31396.48
2006	89076	38638.60
2007	113905	46302.81
2008	132557	56798.40
2009	154854	53306.87
2010	175428	88836.65
2011	192631	108585.43
2012	214725	133140.56
2013	232762	142534.17

(a) Situation of investment in science and technology
As seen from table 1, the investment in science and technology has been increasing from 2004 to 2013, and the support of science and technology budget is strong. But the growth rate is very unstable, and fluctuations are quite big. The investment in science and technology grew by a large margin in 2008; therefore there is not a obvious increasing rule for it.

(b) Situation of R&D and economic output
From 2004 to 2013, the increasing rate of the investment in R&D is higher than that of economic output, which suits for the developing rules of economics. R&D activities are the core of technological activities, according to the international practice, if the increasing rate of investment in the R&D activities is higher than that of economic output, the technological prowess of a country can be strengthened continuously.

(c) Situation of ratio of R&D to economic output
The ratio of R&D to economic output can reflect the investment intensity in science and technology of a country. Generally, this ratio of developed country is higher than 3%, and this ratio of moderately developed countries changes from 2.0% to 3.0%. From 2004 to 2013, the financial strength of R&D activity investment of the petrochemical enterprises increase continuously. The financial strength of R&D activity investment has reached to 2.09%, but there is big difference comparing with developed countries. The investment in science and technology of the petrochemical enterprises is no easy task.

The investing situation of scientific and technological personnel for the petrochemical enterprises plays an important role in promoting the science and technology, because the scientific and technological personnel are the user of R&D investment. The situation of scientific and technological personnel for the petrochemical enterprises from 1999 to 2013 is shown in figure 1.

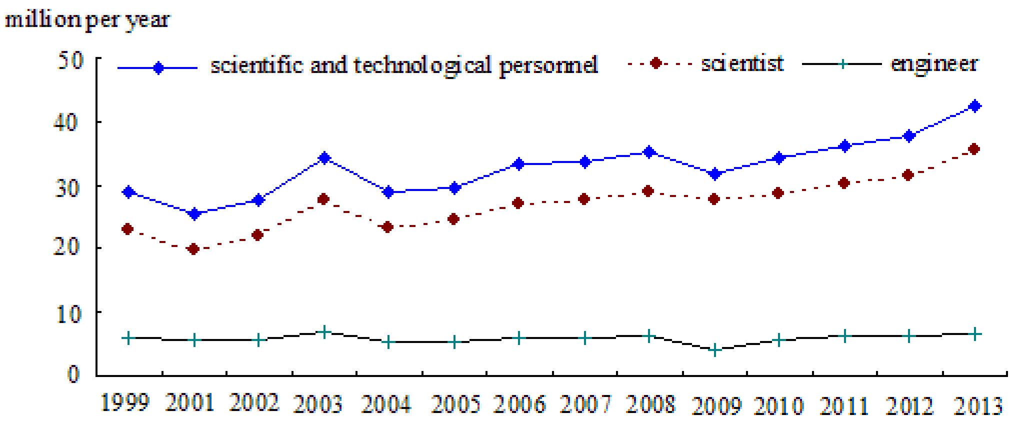

Figure 1 the changing rules of number of scientific and technological personnel the petrochemical enterprises from 1999 to 2013

As seen from figure 1, in recent years, the scientific and technological personnel the petrochemical enterprises have been growing stably. Not only the total number of scientific and technological personnel, but also the total number of scientists and engineers has increased quickly. The investment in scientific and technological personnel the petrochemical enterprises is very big in recent years, and the quality of scientific and technological personnel has also been concerned in China, the

(2) Basic theory of grey relational analysis
The linear data pre-processing method can be expressed as follows [5]:

$$x_i^* = \frac{x_i(k)}{x_{0j}(k)}, \quad i = 1,2,\cdots,m; \; k = 1,2,\cdots,n; \; j = 1,2 \tag{1}$$

where x_i^* denotes the normalized series, $x_i(k)$ denotes the original series, $x_{0j}(k)$ denotes the reference series.

The grey relational coefficient can be computed based on formula (1). The grey relational coefficient of unknown x_i for x_{0j} can be expressed as follows:

$$\gamma(x_{0j}(k), x_i(k)) = \frac{\Delta_{\min} + \eta\Delta_{\max}}{\Delta_{0i}(k) + \eta\Delta_{\max}}, \quad 0 < \gamma(x_{0j}(k), x_i(k)) \le 1 \tag{2}$$

where η denotes the distinguishing factor, which can show the relational degree between $x_{0j}(k)$ and $x_i(k)$, $\eta = 0.5$ in this research; $\Delta_{0i}(k)$ denotes the deviation series of the reference series, the test series.

$$\Delta_{0i}(k) = |x_{0j}(k) - x_i(k)| \tag{3}$$

$$\Delta_{\min} = \min_i \min_k |x_{0j}(k) - x_i(k)| \tag{4}$$

$$\Delta_{\max} = \max_i \max_k |x_{0j}(k) - x_i(k)| \tag{5}$$

The grey relational grade can be expressed as follows [6]:

$$\gamma(x_{0j}, x_i) = \sum_{k=1}^{n} \omega_k \gamma(x_{0j}(k), x_i(k)) \tag{6}$$

where ω_k denotes the weight value, which can be obtained based on the following steps:

Step 1: confirm the mother and sub indexes, the most important index in the plan evaluated is used as mother index, and the vector of index value corresponding to the mother index is defined by:

$$Y_0 = (x_{10}, x_{20}, \cdots, x_{n0})^T \tag{7}$$

where Y_0 denotes the mother series.

The other factors can be used as sub indexes, the vector of index value corresponding to sub indexes can be defined by [7]:

$$Y_j = (x_{1j}, x_{2j}, \cdots, x_{nj})^T \tag{8}$$

where Y_j denotes sub series.

Step 2: the original process is carried out for Y_0 and Y_j, which is expressed as follows [8]:

$$x'_{i0} = \frac{x_{i0}}{x_{10}} \tag{9}$$

$$x'_{ij} = \frac{x_{ij}}{x_{1j}} \tag{10}$$

Then $Y'_0 = (x'_{10}, x'_{20}, \cdots, x'_{n0})^T$, $Y'_j = (x'_{1j}, x'_{2j}, \cdots, x'_{nj})^T$, and the original index matrix can be obtained, $B = (Y'_0, Y'_j)$.

Step 3: The relational coefficient between Y_0 and Y_j can be calculated based on the following expression [9]:

$$y_{ij} = \frac{\min_{1\le j\le m}\min_{1\le i\le n} | x'_{i0} - x'_{ij} | + \mu \max_{1\le j\le m}\max_{1\le i\le n} | x'_{i0} - x'_{ij} |}{| x'_{i0} - x'_{ij} | + \mu \max_{1\le j\le m}\max_{1\le i\le n} | x'_{i0} - x'_{ij} |} \tag{11}$$

And the relational matrix can be obtained, which is expressed as follows:

$$Y = \{y_{ij}\}_{n\times m} \tag{12}$$

Step 4: Calculate the mean value of column for the relational matrix, which is expressed as follows [10]:

$$y_i = \frac{1}{n}\sum_{i=1}^{n} y_{ij}\ ,\quad j = 1,2,\cdots,m \tag{13}$$

Formula (7) shows that relational degree between j th index and mother index. When j th index is closer to the mother index, the effect of it on the plan evaluated is bigger, then this index will occupy bigger space in whole index space V .

Step 5: the normalization is used to deal with y'_j, and the weighting value can be obtained by the following expression:

$$\omega_k = \frac{y_k}{\sum_{k=1}^{m} y_k},\quad k = 1,2,\cdots,m \tag{14}$$

Then the grey relational degree can be acquired, which can show the relational degree between the reference series and testing series.

(3) Analysis steps of the grey relational analysis for analyzing the investment in science and technology and economics output of the petrochemical enterprises

The grey system can be established using variables of investment in science and technology and economics growth, which is defined by $\{X_i, X_j, \cdots\}$, i, j denote different variables, where X_i denotes the value of variable i from 2004 to 2013, which is expressed as follows:

$$X_i = [x_i(1), x_i(2), , x_i(10)] \quad (15)$$

The computing flow is shown as follows:
Step 1: Process the original like value. Because X_i sequence can reflect the value with different magnitude, in order to eliminate the effects of dimensions, and the original like value is carried out for X_i, the following expression is obtained:

$$X_i^{'} = \frac{X_i}{x_i(1)} = [x_i^{'}(1), x_i^{'}(2), , x_i^{'}(10)] \quad (16)$$

Step 2: Process the parameters. The difference sequences of $X_i^{'}$ to $X_j^{'}$ can be expressed as follows:

$$\Delta_{i,j} = [\Delta_{i,j}(1), \Delta_{i,j}(2), \cdots, \Delta_{i,j}(10)] \quad (17)$$

where $\Delta_{i,j}(\cdot) = | x_i^{'}(\cdot) - x_j^{'}(\cdot) |$, the collection of difference sequences is defined by $\{\Delta_{i,j}\}$.
The environmental parameter is expressed as follows:

$$\Delta(\max) = \max_i \max_j \{\max \Delta_{i,j}(\cdot)\} \quad (18)$$

$$\Delta(\min) = \min_i \min_j \{\min \Delta_{i,j}(\cdot)\} \quad (19)$$

The identification coefficients is defined by ε, $\varepsilon = 0.5$ in this research.

Step 3: Calculate the relational degree. The grey relational coefficient can be expressed as follows:

$$\gamma_{i,j}(\cdot) = \frac{\Delta(\min) + \varepsilon\Delta(\max)}{\Delta_{i,j}(\cdot) + \varepsilon\Delta(\max)} \quad (20)$$

Then the grey relational degree is calculated by the following expression:

$$\gamma_{i,j} = \frac{1}{10}\sum_{\cdot=1}^{10} r_{i,j}(\cdot) \quad (21)$$

RESULTS AND DISCUSSION

(1) Construct the mother sequence and subsequence
According to the grey relational analysis, investment in science and technology of the petrochemical enterprises and relating economical indexes, the grey relational model is established based on the corresponding data, which be used to analyze the relationship between investment in science and technology and economics growth.

The economics output of the petrochemical enterprises is defined by X_0, the investment of R&D activities is defined by X_1, the investment of scientific and technical personnel is defined by X_2. X_0 is used as mother sequence, X_1 and X_2 are subsequences, and the corresponding expressions are listed as follows:

$$X_0 = [15878.3,183084,209407,246619,300670,333244,397983,471564,519322,568845]$$
$$X_1 = [1966,2450,3003,4834,4420,5802,6980,8687,10298,11906]$$
$$X_2 = [30.2,32.9,34.3,36.8,37.3,39.5,41.2,43.1,44.3,45.6,47.8]$$

Then the original like value procession is carried out for every sequence, the corresponding results are shown as follows:

$$X_0^{'} = [1.0, 1.14, 1.31, 1.54, 1.88, 2.08, 2.49, 2.95, 3.25, 3.56]$$
$$X_1^{'} = [1.0, 1.25, 1.53, 2.46, 2.25, 2.95, 3.55, 4.42, 5.24, 6.06]$$
$$X_2^{'} = [1.0, 1.09, 1.14, 1.22, 1.24, 1.31, 1.36, 1.47, 1.51, 1.58]$$

The difference sequences of $X_0^{'}$ to $X_1^{'}$ is listed as follows:

$$\Delta_{0,1} = [\Delta_{0,1}(1), \Delta_{0,1}(2), \cdots, \Delta_{0,1}(10)] = [0, 0.10, 0.22, 0.92, 0.37, 0.87, 1.06, 1.47, 1.99, 2.50]$$

The difference sequences of $X_0^{'}$ to $X_2^{'}$ are listed as follows:

$$\Delta_{0,2} = [\Delta_{0,2}(1), \Delta_{0,2}(2), \cdots, \Delta_{0,2}(10)] = [0, 0.06, 0.17, 0.32, 0.65, 0.78, 1.13, 1.48, 1.74, 1.98]$$

According to the formulas (20) and (21), the relative relational degrees $\gamma_{0,1}$ and $\gamma_{0,2}$ can be calculated, which are listed as follows:

$$\gamma_{0,1} = 0.754, \gamma_{0,2} = 0.976$$

The relative relational degree between investment in science and technology and economics output is equal to 0.754, and the relative relational degree between scientific and technical personnel and economics output is equal to 0.967. These calculating results show that investment in science and technology has strong relational relationship with as well as the number of scientific and technical personnel. Because $\gamma_{0,1} < r_{0,2}$, the investment in scientific and technical personnel is even more important to economics output of a country than the investment in science and technology. There have a positive correlation between the investments in scientific and technical personnel with economics growth for the petrochemical enterprises.

CONCLUSION

The grey relational analysis is applied in analyzing the relationships between the investment in science and technology and economics growth for the petrochemical enterprises. The corresponding analysis model is established. And the calculation is carried out based on data of R&D investment, economics output and scientific personnel of the petrochemical enterprises. The investment in science and technology has an obvious relational relationship with economics according to the analysis results. The petrochemical enterprises should improve the investment in R&D, which can improve the capability of independent innovation of enterprise. The human resource in scientific activities for the petrochemical enterprises should be arranged perfectly, then the investment in scientific personnel can be improved, which can offer basis for promoting the economics of the petrochemical enterprises.

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