

TIME-DELAYED ANALYSIS OF UNIVERSITY R&D FUNDS DERIVING REGIONAL ECONOMIC GROWTH IN SICHUAN PROVINCE OF CHINA

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ABSTRACT

In view of the facts, there is little research about R&D expenditure of higher education on regional economic growth difference and the time lag. So the paper uses the time shift theory to build the model. It is a time lag analysis model based on grey relative correlation degree. Secondly, the paper studies R&D expenditure of higher education on economic growth influence and the time lag. Thirdly, the R&D expenditure structure for regional economic growth difference is further discussed. Lastly, the paper puts forward reasonable suggestions to R&D expenditure structure of higher education.

Keywords: *University R&D; expenditure structure; grey relation; time-delayed; economic growth.*

1. INTRODUCTION

In order to increase the amount of knowledge and apply knowledge to create new applications, which is called that Scientific research and experimental development, namely R&D. It include basic research, applied research and experimental development of three kinds of activities. in the field of science and technology. In the new economic growth theory, technology progress is endogenous source of long-term economic growth, the growth of technical knowledge is the source of [2] a separate research and development department, then they are based on the R&D of the endogenous growth model. R&D activity is a national important means to realize the sustainable development of independent innovation and economic; Yet college as the field of gathering information, talents and other resources, which is an important subject of R&D activities and the core of a national independent innovation system.

Griliches found college R&D to the geography spillover benefits of regional innovation ability by knowledge production function in 1979 [3]; Feldman said that knowledge spillover of regional college promotes the development of regional economy in 1999 [4]. However, foreign scholars studied interactive relationship on college R&D and economic growth, which is based on knowledge production function, regional economic output(GDP) or innovations as the dependent variable. The established regression model is analyzed after considering the R&D of time lag effect and spatial factors, but the amount of papers had different conclusions.

The researches started late about the interaction relationship between R&D and economic growth in china university. Sun wen xiang used principal component analysis to calculate the university R&D strength in different area, which was analyzed with regional GDP by regression analysis. So he found that R&D has significant promoting effect on regional economic growth [5,6]. Xu ai ping apply the panel data model for researching in the Beijing, Tianjing and Shanghai from year 1990 to year 2009. She found that R&D has a positive impact on urban economic growth in the three cities university[7]. Sun lun xuan used the provincial panel data from year 1999 to year 2011 in China, to research the diversity influence based on the different types of R&D expenditures to economic growth [8]. According to the existing researches, they established mathematical model of technological input variables and economic growth related variables to research their relationship, which used economic data model and a series of data in the assumed conditions; furthermore, in order to find their mechanism and regularity on interdependence and interaction, they applied time series of variables to establish the empirical model [9]. However, the actual situation is not easy to meet the assumptions, because the assumption of economic mathematical model has the certain requirement; Besides, traditional statistical methods made request for data, so that the results may not very accurate. Therefore, this paper establishes time-lag analysis model based on grey relational analysis, which study the university R&D expenditure on economic growth effect, time-lag and structure of R&D expenditure on difference effect of regional economic growth.

2. PRESENT SITUATION ANALYSIS OF R&D FUND INVESTMENT IN SICHUAN PROVINCE UNIVERSITY

In a country, R&D expenditure and its share of GDP are not only an important indicator to measure technological activities scale and technological investment level, but also reflect an important content of independent innovation

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capability and innovative type nation building process[1]. Therefore, in Si chuan province university, R&D expenditure and its share of GDP reflects the scale of activities, the level of investment and innovation capability of Si chuan technological. In recent years, total GDP has been steadily grow in Si chuan province, and the total amount of R&D investment has also shown a trend of continuous growth (Figure 1). Average growth rate of R&D expenditure investment of Si chuan university is 22.52%, which is significantly higher than the regional GDP growth in the same period, and it also showed a rising trend to account for regional GDP, then make sure power and strength of regional technological development have a longer-term keep and continuously strengthen. (data come from SiChuan Statistical Yearbook, The compilation of statistics of science and technology in university)

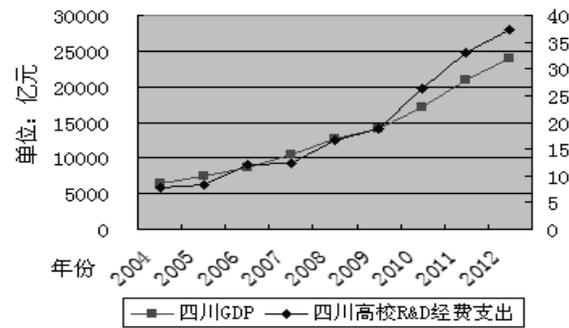


Figure 1 The development trend of R&D investment and regional GDP in Si chuan province university

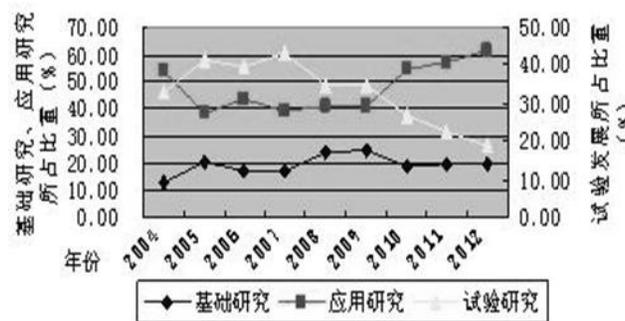


Figure 2 Structure of R&D funding investment in Si chuan province university

According to figure 2, it show that R&D expenditure is trend to applied research. Meanwhile, in expenditure structure, expenditure of applied research is better than the basic research and experimental development in the scale of investment or the growth rate of strength. In addition to basic research investment is continuous increase, trial development expenditure is continuous decrease, which is stay in step with the overall structure of R&D investment in China university. From the existing researches, the industry argues that the R&D investment can promote regional economical development, so is it reasonable for R&D expenditure structure in Si chuan province? How do it promote regional economic to effect growth in a long period of time? How do the funding of basic research, applied research and trial research contribute to the regional economic growth? Whether it exist difference? Then it must to further explore and study.

3. THE INDEX SELECTION AND RESEARCH METHODS

It is important to select the appropriate variables in the empirical study. The relationship between university R&D and regional economic growth is studied, which the variables of university R&D investment have so many. For example: university R&D funding, university R&D expenditure, R&D the number of activity and so on. The main variable of regional economic growth has regional gross domestic product and the industrial output value, these variables are time series, and their relevance research is suit for grey correlation measure. Therefore, The paper take university R&D expenditure as the index of expenditure, and take the regional GDP as the index of economic growth, then analyze their grey correlation. In order to discuss the difference effect of university R&D expenditure structure on the perspective of economic growth, the paper will discuss the time lag correlation, which is based on regional GDP and fund expenditure, which is basic research, applied research and trial development.

The existing researches have confirmed that the R&D investment promote the time-lag of economic growth, then the relation discussion of university R&D and regional economic growth must join time lag. Moreover, the existing time lag research apply distribute lag model, vector auto regressive and impulse response function, time difference correlation coefficient and so on, this kind of time series measurement method require a sample size of 30 or more [10]. In view of this kind of research data is small, the paper will use the idea of time translation to construct the time lag analysis model based on grey relative correlation degree.

$X = \{x(1), x(2), \dots, x(n)\}$, $Y = \{y(1), y(2), \dots, y(n)\}$ are called the system behavior sequence. The paper uses time shift method to establish the time delay analysis model, which is selected X as the system behavior characteristic sequence, then Y is also selected as system behavior sequence to compare. Time translation of the Y sequence, the moving step is marked as l , and every step to move a year. Because the grey correlation analysis require the time series of same length to analyze correlation, and the minimum amount of data is three, then the lagging behind step length meet $l \leq n - 3$. Therefore the time lag series is assumed to follow the function:

$$\begin{aligned} X^l &= \{x(1), x(2), \dots, x(n-l)\}, \quad l = 0, 1, 2, \dots, n-3. \\ Y^l &= \{y(l+1), y(l+2), \dots, y(n)\}, \quad l = 0, 1, 2, \dots, n-3. \end{aligned} \quad (1)$$

On this basis, the corresponding delay sequence is initialized processing, namely:

$$\begin{aligned} x^l(i) &= x(i) / x(1) \quad i = 1, 2, \dots, n-l, \\ y^l(i) &= y(i) / y(1) \quad i = l+1, l+2, \dots, n. \end{aligned} \quad (2)$$

The calculation formula of grey relative degree of X and Y is assumed to follow the function:

$$\begin{aligned} r_{XY}^l &= \frac{1 + |S_X| + |S_Y|}{1 + |S_X| + |S_Y| + |S_Y - S_X|}, \quad l = 0, 1, 2, \dots, n-3. \quad \text{Where,} \\ |S_X| &= \left| \sum_{k=1}^{n-l} x^l(k) + \frac{1}{2} x^l(n-l) \right|, \\ |S_Y| &= \left| \sum_{k=l+1}^n y^l(k) + \frac{1}{2} y^l(n) \right|, \\ |S_Y - S_X| &= \left| \sum_{k=l+1}^n y^l(k) - \sum_{k=1}^{n-l} x^l(k) + \frac{1}{2} [y^l(n) - x^l(n-l)] \right| \end{aligned} \quad (3)$$

Assume,

$$r_{XY}^l = \max_{l=0}^{n-3} r_{XY}^l \quad (4)$$

When $l^* = 0$, X and Y are called the synchronization index; When $l^* > 0$, Y is called the lag index of X , where l^* is called the lag step.

4. R&D EXPENDITURE DRIVE DELAY ANALYSIS OF REGIONAL ECONOMIC GROWTH IN SICHUAN UNIVERSITY

In order to analyze the effect of university R&D expenditure on regional growth, the difference effect of basic research, applied research and trial development to economic growth. The paper takes GDP as the basic index of lag analyze in Sichuan province from year 2004 to year 2012, respectively to university R&D expenditure, basic research, applied research and trial development expenditure as contrast analysis index, calculate grey relative correlation degree of distinct lag steps, the lag steps of maximum grey correlation degree as time difference of the derived regional GDP growth. (each index and data are shown in Table 1).

Table 1. GDP and University R&D in Sichuan province from year 2004 to year 2012

Index	2004	2005	2006	2007	2008	2009	2010	2011	2012
Regional GDP (X)	6379.63	7385.10	8690.24	10562.39	12601.23	14151.28	17185.48	21026.68	23872.80
University R&D expenditure (Y)	7.77999	8.44114	12.03276	12.28783	16.69878	18.65861	26.34499	33.10105	37.24274
Fundamental research (Y1)	1.01756	1.71901	2.03717	2.10168	4.00118	4.54571	4.88269	6.47959	7.39037
Application research (Y2)	4.21617	3.23394	5.19703	4.8422	6.89993	7.60034	14.37927	19.05721	22.76644
Development test (Y3)	2.54626	3.48819	4.79856	5.34395	5.79767	6.51256	7.08303	7.56425	7.08593

Regional GDP series

$$X = \{i = 1, 2, \dots, 9 | x(i)\} = \{6379.63, 7385.10, 8690.24, 1056.39, 12601.23, 14151.28, 17185.48, 21026.68, 23872.80\}$$

is called the system characteristic sequence,
University R%D expenditure sequence

$$Y = \{i = 1, 2, \dots, 9 | y(i)\} \\ = \{7.77999, 8.4114, 12.03276, 12.28783, 16.69878, 18.65861, 26.34499, 33.10105, 37.24274\}$$

is called the sequence of related factors.
Assume,

l is the lag steps of university R&D expenditure to regional GDP, so $l \leq n-3=6$. The time lag series is $X^l = \{x(1), x(2), \dots, x(9-l)\}$, $Y^l = \{y(l+1), y(l+2), \dots, y(9)\}$ and $l = 0, 1, 2, \dots, 6$. On this basis, the corresponding sequence is dealt with initialization, namely $x^l(i) = x(i) / x(1) \ i = 1, 2, \dots, 9-l$, $y^l(i) = y(i) / y(1) \ i = l+1, l+2, \dots, 9$.

When $l=0$,

$$X^0 = \{x(1), x(2), \dots, x(9)\} = \{6379.63, 7385.10, 8690.24, 1056.39, 12601.23, 14151.28, 17185.48, 21026.68, 23872.80\}$$

$$Y^0 = \{y(1), y(2), \dots, y(9)\} = \{7.77999, 8.4114, 12.03276, 12.28783, 16.69878, 18.65861, 26.34499, 33.10105, 37.24274\}$$

After initialization processing,

$$x^{0'}(i) = \{x(i) / x(1) | i = 1, 2, \dots, 9\} = \left\{ \frac{6379.63}{6379.63}, \frac{7385.10}{6379.63}, \frac{8690.24}{6379.63}, \frac{1056.39}{6379.63}, \frac{12601.23}{6379.63}, \frac{14151.28}{6379.63}, \frac{17185.48}{6379.63}, \frac{21026.68}{6379.63}, \frac{23872.80}{6379.63} \right\} = \{1, 1.157606, 1.362186, 1.655643, 1.975229, 2.218198, 2.693805, 3.295909, 3.742035\}$$

$$y^{0'}(i) = \{y(i) / y(1) | i = 1, 2, \dots, 9\} = \{1, 1.084981, 1.546629, 1.579415, 2.146376, 2.398282, 3.386250, 4.254639, 4.786991\}$$

according to the formula (2),

the relative degree of grey incidence X and Y

$$r_{XY}^0 = \frac{1 + |S_X| + |S_Y|}{1 + |S_X| + |S_Y| + |S_Y - S_X|} = \frac{1 + 24.57706 + 20.97163}{1 + 24.57706 + 20.97163 + 3.605429} = 0.9281$$

Similarly, according to the formula (3)

$$r_{XY}^1 = 0.9433, r_{XY}^2 = 0.9666, r_{XY}^3 = 0.9819, r_{XY}^4 = 0.9757, r_{XY}^5 = 0.9829, r_{XY}^6 = 0.9900$$

Lag step $l^* = 6$. Therefore, the university R&D expenditure, basic research, applied research and trial development is respectively calculated with grey correlation degree of regional GDP, which is used to the time lag analysis model based on grey relative correlation degree. (The calculation results are shown in Table 2).

Table 2. *L take different values of university R&D spending relative to GDP gray relational tables*

Value of l	0	1	2	3	4	5	6
Universtiy R&D expenditure(Y)	0.9281	0.9433	0.9666	0.9819	0.9757	0.9829	0.9900
Fundamental research(Y1)	0.7846	0.7958	0.8131	0.8086	0.8230	0.9060	0.8882
Application research (Y2)	0.9451	0.9856	0.9613	0.9071	0.9180	0.8880	0.9281
Development test(Y3)	0.9967	0.9690	0.9512	0.9257	0.9137	0.9259	0.9219

From Table 2, university R&D investment funds is relatively stable to promote economic growth, which is consistent with existing researches. But for the university R&D funds $\max_{l=0}^6 r_{XY}^l = r_{XY}^6 = 0.990$, lag step is $l^* = 6$. With the increase of time, sample sizes are magnified, the calculation results of the lag step may be more than 6. So what is the fast and efficient way to promote local economic growth? To basic research funding, the maximal correlation degree is 0.882 and the lag step is 5 years, which is mean that basic research is more effective to regional economic. But the result is suit to the basic characteristics of basic research. Because from the basic research to the publish of research achievement and the spread of knowledge, which need time to accumulate; Furthermore, if basic research achievement change to the direct motivation of promoting the economic development, there also need applied research and technological innovation. In addition, to applied research funding, the maximal correlation degree is 0.986, lag step is 1 year; To trial development funding, the maximal degree is 0.9967, lag step is 0, namely the input of trial development is synchronized with regional economic growth. It can be seen that the fund investment of applied research and trial development in the short term to generate economic benefits.

5. CONCLUSION AND SUGGESTION

The university R&D expenditure is remarkable to regional economic growth, but the influence of three kinds of R&D expenditure is very difficult to regional economic growth. Test results show that college test and development R&D funds into the fastest, the application of R&D funds to the second, the effect of basic R&D funding is the slowest. This difference is mainly due to their different effects on the mechanism of economic growth.

Trial development research is obtained from basic research, applied research and practical experiment. In order to product new materials, products and installation, the established new technology, system and service, which is the systematic work by change with produced and established affairs [11], which is a direct process to promote the economic growth and take the scientific research results into the ability of technology and products, and thus directly produce economic benefits. Application research is to determine the application of basic research result, or it is new method or new approach to achieve predetermined goals [11], which is the bridge between basic research and trial development. Although the effect of economic growth is less than trial development research, the result of economic stimulus is rapidly and significantly. Therefore, college should make full use of its scientific research and talent advantage, which make the scientific to application research, technology development and industrialization forward appropriately, there will be promising basic research results into applied results, which is great significant to college research development and economic development.

When university R&D spending on certain cases, the shift among the three kinds. In the transformation of industries and emerging strategic development, it will focus science and technology into the application of productivity and the link of trial development in university investment, which neglect of basic research investment. Firstly, basic research is the source of new knowledge and the guider of new inventions. Secondly, it is the core foundation of technological progress. Thirdly, it is the prerequisite for other research activities. Basic research funding is insufficient, so it will restrict the long-term sustainable development of science and technology. With the passage of time, although basic research investment is not synchronized with economic output, the role of the trend will be more strengthening. Therefore, colleges should be rational allocation of R&D funds, which ensure that the basic research is the core status of the chain in the "Science-Technology-Productivity".

It can be further attention to the rationality of education investment structure, finding the back reason of imbalance of university R&D investment structure, exploring the effectively for allocation of resource under the constraints of limited expenditure, obtaining maximum effectiveness and benefits, providing a more valuable comments and

suggestions for higher education development and local economic growth.

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