Design Engineering

ISSN: 0011-9342
Issue: 1 | Pages: 601 - 612

An Analysis of the Correlation between the Investment of Scientific Research Funds and the Progress of Regional Science and Technology

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Abstract:

The progress of regional science and technology is a decisive factor in promoting regional economic and social development, which contributes to regional economic growth. As an essential part of the science and technology innovation system, universities in ethnic regions play a vital role in promoting regional scientific and technological progress. Based on the panel data in Guangxi province from 2000 to 2016, this paper studies the impact of investment in scientific research in universities in ethnic region on the progress of regional science and technology in Guangxi, compare with the data of scientific research inputs that are not from scientific research institutions during the same period. The research finds that universities in ethnic areas invest less in scientific research, but their contribution rate to regional technological progress is higher than that of non university scientific research institutions in the same period; The results of the measurement model shows that every 1% increase in investment in scientific research in universities can promote the scientific and technological progress in Guangxi by 0.324%, so there is a strong positive correlation between the economic investment of universities in ethnic areas and regional scientific and technological progress.

Keywords: *Universities in ethnic areas, Scientific research funding, Regional scientific and technological progress, Relevance.*

I. INTRODUCTION

China's ethnic areas are basically distributed in remote areas, with undeveloped regional economy, backward science and technology resources. There are few universities in ethnic areas and the weak higher education seriously restricts the development of science and technology in ethnic areas. The investment in science and technology is seriously inadequate, which accounts for less than 0.1% of the whole province, far lagging behind developed regions and developed countries and far lower than the stipulated 3-5% proportion in China[1]. To verify that ethnic governments' scientific research investment in universities has relation to regional scientific and technological progress and regional economic development, this study takes data of Guangxi Zhuang Autonomous Region from 2000 to 2016 as an example, employs Cobb-Douglas production function measurement model to empirically analyze the correlation between scientific research investment in Guangxi universities and regional science and technology progress as well as economic growth, with a view to giving suggestions on the adjustment of structure and proportion of scientific and technological expenditure in ethnic areas, thereby further improving the efficiency of scientific research investment in ethnic areas, enabling more scientific and reasonable resource allocation, promoting scientific and technological progress, accelerating economic growth and stabilizing social development in ethnic areas.

II. LITERATURE REVIEW

Judging from the existing literature in China, most empirical research on university scientific research and regional development is dedicated to analyzing the contribution rate of university scientific research to the economy, including research from both national perspective and provincial perspective, and some research directly links inputs and outputs of universities. For example, Lu Genshu's research on quality indicators and expenditure data of university scientific research in China in 2001 also found the correlation between the two [2]. Li Shuohao and GengLele conducted an empirical study on the contribution rate of higher education to economic growth since the enrollment expansion in Chinese universities, and calculated that the contribution rate of higher education to the average annual economic growth rate was 2.77% since the enrollment expansion [3]. Han Xuefeng, Jin Li conducted an empirical analysis on scientific and technological progress rate and contribution rate of scientific and technological progress in universities and colleges in Liaoning Province [4]. Dai Wanliang and Feng Zhiyu evaluated scientific research efficiency of 31 provincial universities and analyzed the factors affecting scientific research efficiency, finding that there is no regional characteristic in the distribution of scientific research efficiency in universities [5]. Chen Yan calculated the contribution rate of higher education to economic development in six provinces of central China [6]. Cui Yuping calculated the contribution of China's higher education to the economic growth rate from 1982 to 1990, and compared the calculation results with the data of six western countries [7]. Liu Tianzuo, Xu Hang conducted empirical research on the input-output performance of university scientific research in different regions of China from 2009 to 2016, and then found the main factors affecting the input-output performance of scientific research in regional universities [8].Based on natural science research expenditure of Chinese universities from 1997 to 2015, Su Hui, Sun Yi conducted empirical research on the relationship between scientific research investment and scientific research progress in China's colleges and universities, and proved that the source of university research expenditure in China was

ISSN: 0011-9342
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dominated by government-supported vertical scientific research expenditure[9].Many scholars have conducted similar researches, mainly focusing on the contribution rate of college education and scientific research, and the above research samples were mainly collected from the national, central and eastern provinces. There are very few studies on the western ethnic areas. From the perspective of scientific research investment in universities in ethnic areas, this paper calculates the correlation between the increase or decrease of investment and regional scientific and technological progress.

III. METHOD

3.1 Construction of Guangxi Capital Stock and Total Factor Productivity Measurement Model

The measurement model adopted herein is mainly based on the Cobb-Douglas production function, which is used to measure Guangxi's total factor productivity, also known as technological progress rate. Cobb-Douglas production function is

$$Y_t = \alpha k^{\beta 1} L^{\beta 2} \mu (1)$$

Where, Y is the output growth rate, smaller tis the time,ais the scientific and technological progress rate,K is the capital stock,Lis the number of employees,β1 is the capital output elasticity coefficient,β2is the labor output elasticity coefficient,μis the random interference influence,μ≤1.Here, the estimation of capital stock K determines the calculation of total factor productivity. This papertakes Gordon Smith's perpetual inventory method to calculate the capital stock. The formula used is as follows:

$$K_t = K_{t-1}(1 - \delta) + I_t (2)$$

In the formula,K_t is the capital stock in year t,K_{t-1}) is the capital stock in t-1,$I_t$is the investment in year t, which is expressed in fixed capital formation,δis the capital depreciation rate. Some documents set China's capital depreciation rate at around 10%. It is difficult to calculate the capital depreciation rate of various provinces (cities) in China based on available data. Liu unifies the depreciation rate of all provinces (cities) in China as 10.96%. In this paperwith reference to this data for calculation, the capital stock K in 2000 is the sum of depreciation rate of total capital formation in 2001 and the average growth rate of fixed investment formation in 1953-1957 (which can be derived from the investment formula and the PIM equation set, the capital stock calculation formula: nominal fixed capital formation/deflator (actual fixed capital stock) + (1-0.1096) * capital stock of previous period). Through this calculation formula, the capital stock of Guangxi from 2000 to 2016 is:

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TABLE I. Guangxi capital stock in 2000-2016

Time	Total fixed capital formation (100 million yuan)	Actual fixed asset formation (year 2000=1)	Fixed asset investment price index (previous year=100)	Fixed asset investment price index (year 2000=1)	(K)Capital stock (K)
2000	670.65	670.65	101.4	1	2117.26
2001	735.56	721.137254902	102	1.02	2606.34
2002	842.72	823.72490372	100.3	1.02306	3144.41
2003	990.71	951.25655815	101.8	1.04147508	3751.13
2004	1296.55	1190.169186532	104.6	1.089382934	4530.07
2005	1749.87	1584.117032	101.4	1.104634295	5572.29
2006	2141.72	1915.859503	101.2	1.117889906	6931.38
2007	2791.97	2441.383915	102.3	1.143601374	8648.75
2008	3762.7	3049.323356	107.9	1.233945883	10588.32
2009	5533.23	4580.363212	97.9	1.208033019	14012.14
2010	7785.5	6257.062302	103	1.24427401	18736.45
2011	9745.72	7375.192889	106.2	1.321418998	24060.24
2012	10547.35	7934.230818	100.6	1.329347512	29360.54
2013	9725.64	7308.791709	100.1	1.33067686	33457.90
2014	10463.07	7739.142052	101.6	1.35196769	37539.20
2015	11264.7	8433.277146	98.8	1.335744077	41869.83
2016	12363.9	9302.702787	99.5	1.329065357	46410.07

Data source: Guangxi Statistical Yearbook, China Statistical Yearbook [10]

In addition to using the data of capital stock, it is necessary to estimate parameter β1 (capital output elasticity coefficient) and β2 (labor output elasticity coefficient) before determination of the contribution rate of technological progress, capital growth, and labor growth to output growth based on Cobb-Douglas production function, so that through the Cobb-Douglas production function, we can calculate the scientific and technological progress rate a in a certain period t. The calculation formula is:

$$a = \frac{Y_t}{k^{\beta 1} L^{\beta 2} \mu} (3)$$

To better calculate the rate of scientific and technological progress, it is assumed thatβ1+β2=1, that is, the return to scale remains constant (indicating that production efficiency will not increase with the expansion of production scale, only improvement in the technical level will increase economic efficiency). Taking the natural logarithm on both sides of formula (1), we can get:

$$\ln Y = \ln a + \beta_1 \ln K_t + \beta_2 \ln L_t + \mu_t (4)$$

According to the above assumptionβ1+β2=1, perform data regression on formula (4) to obtain the values of β1 (capital output elasticity coefficient) and β2 (labor output elasticity coefficient), and substitute this value into formula (3) to calculate the scientific and technological progress rate of a certain area over the years. By standardization, there is:

$$\beta_1^* = \frac{\beta_1}{(\beta_1+\beta_2)}, \beta_2^* = \frac{\beta_2}{(\beta_1+\beta_2)} \quad (5)$$

Then the total factor productivity is:

$$TFP_t = \frac{Y_t}{\left(K_t^{\beta_1^*}+L_t^{\beta_2^*}\right)} \quad (6)$$

This paperselects the time span of2000-2016 to calculate Guangxi's total factor productivity data. The data is mainly derived from the "Guangxi Statistical Yearbook" and "China Statistical Yearbook", the output is expressed in GDP, and deflation is performed according to the GDP index with 2000 as the base year. According to formula (2), the capital stock of Guangxi is calculated, and according to formula (4), β1 (capital output elasticity coefficient) = 0.402595, β2 (labor output elasticity coefficient) = 1.989952. Substitute this result into formula (5), then β_1^* =0.832,β_2^* =0.168. Substitute it into formula (6), then the total factor productivity of Guangxi from 2000 to 2016 is obtained, as shown in TABLE II:

TABLEII. Guangxi's total factor productivity

Year	Y (GDP/100 million yuan)	K (capital stock)	L (number of employees/ten thousand people)	TFP
2000	2080	2117	2566	1.000
2001	2253	2606	2578	1.043
2002	2491	3144	2589	1.115
2003	2746	3751	2601	1.189
2004	3069	4530	2649	1.269
2005	3476	5572	2703	1.367
2006	3949	6931	2760	1.472
2007	4553	8649	2769	1.633
2008	5140	10588	2799	1.768
2009	5860	14012	2849	1.897
2010	6698	18736	2903	2.035
2011	7522	24060	2936	2.174
2012	8372	29361	2983	2.311
2013	9226	33458	3029	2.461
2014	10010	37539	3073	2.590
2015	10821	41870	3120	2.716
2016	11611	46410	3166	2.830

Data source: Guangxi Statistical Yearbook [10]

To more clearly see the changes in Guangxi's capital stock and total factor productivity from 2000 to 2016, we can look at the following chart:

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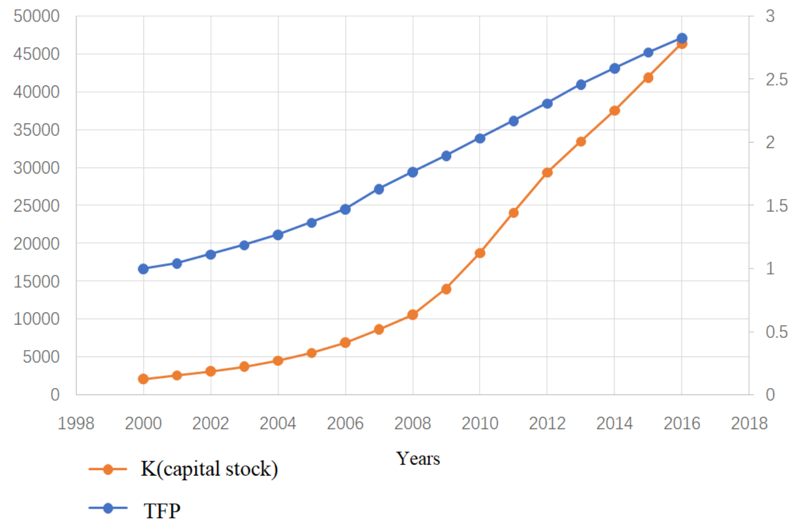

Fig 1: Guangxi's capital stock and total factor productivity from 2000 to 2016

As shown in Fig 1, it can be clearly seen that since 2000, Guangxi's capital stock surges up from 2000 to 2001, and it has maintained gradual growth since 2001, increasing from 21.11726 million yuan in 2000 to 464.1007 million in 2016, an increase of 21 times. Guangxi's capital stock has experienced such substantial growth in the past two decades, reflecting that Guangxi's economic development has also risen synchronously. The other line reflects that Guangxi's total factor productivity has also increased year by year, increasing from about 1 in 2000 to 2.83 in 2016, an increase of nearly 2 times. The increase is especially high since 2008-2009, reflecting that the technological progress after 2008 has played a gradual and increasing role in promoting the economic growth of Guangxi, which is also positively related to the continuously improved economic development strategy of the Guangxi government in the past decade.

3.2 The Construction of the Contribution Measurement Model for Scientific Research Investment in Universities

Han Xuefeng and Jin Li et al.learned from the model by which Dominique and Bruno estimates the contribution of government science and technology investment to technological progress from the perspective of science and technology investment, and improved this model. Theenterprise scientific research investment and government science and technology investment in the original model are adjusted in terms of data selection, which are replaced by high-tech science and technology expenditures, enterprise science and technology expenditures, science and technology expenditures of scientific research institutes and foreign technology spillovers [3]. This model features strong maneuverability and effectiveness, so this study intends to adopt this model. Where, science and technology expenditures of scientific research institutes is converted into science and technology expenditures ofresearch and development institutions based on the actual science and technology statistics of Guangxi, while foreign technology spillover is converted to other data, and the modified model is:

$$TFP_t = U_t^{\gamma 1} \cdot C_t^{\gamma 2} \cdot I_t^{\gamma 3} \cdot O_t^{\gamma 4} \cdot \mu^{\gamma 5} \quad (7)$$

Where, trepresents the year, TFP represents the total factor productivity (the results have been previously measured), U represents the amount of science and technology expenditures of universities, C represents the amount of science and technology expenditures of enterprises, I represents the amount of science and technology expenditures of research and development institutions, O represents other, μ represents the random interference term. Where, $\gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5$ are the elastic coefficients of universities, enterprises, research and development institutions, and others, respectively. After taking natural logarithms on both sides of formula (7), the formula is modified to:

$$\ln TFP_t = \gamma_1 \ln U_t + \gamma_2 \ln C_t + \gamma_3 \ln I_t + \gamma_4 \ln O_t + \gamma_5 \quad (8)$$

IV. RESULTS

4.1 Selection and Analysis of Basic Data of Scientific Research Expenditures in Universities

Because the 2005 and 2006 data have different sample names in Guangxi science and technology statistics, it is uncertain whether they are the same kind of data, and some samples lack specific data before 2006, so this study selects 2006-2016 Guangxi scientific research expenditure data as basic research data for preliminary analysis.The data is shown in TABLE III below:

TABLE III. Guangxi scientific research expenditure data (2006-2016) Unit: ten thousand yuan

Year	Research and Experimental Development Expenditure	Growth Rate (%)	Higher Education Expenditure	Growth Rate (%)	Large and Medium-sized Industrial Enterprises'Expenditure	Growth Rate (%)	Research and Development Institution Expenditure	Growth Rate (%)	Other	Growth Rate (%)
2006	185597		30948		110313		18029		26307	
2007	223036	20.17	38866	25.58	132264	19.90	26130	44.93	25776	-2.02
2008	334780	50.10	44372	14.17	196086	48.25	32545	24.55	61777	139.67
2009	472028	40.1	54773	23.44	265124	35.21	53183	63.41	98948	60.17
2010	628696	33.19	67052	22.42	358915	35.38	74629	40.32	128099	29.46
2011	810204	28.87	67328	0.41	497161	38.52	99413	33.21	146302	14.21
2012	961967	18.73	74919	11.27	608965	22.49	138724	39.54	139359	-4.75
2013	1076789	11.93	82815	10.54	716419	17.65	129585	-6.59	147970	6.18
2014	1118685	3.89	92788	12.04	747274	4.31	127985	-1.23	150638	1.80
2015	1059124	-5.32	112496	21.24	666124	-10.86	130616	2.06	149888	-0.50
2016	1177487	11.18	136599	21.43	708120	6.3	132405	1.37	200363	33.68
Average annual growth rate		**21.28**		**16.25**		**21.71**		**24.16**		**27.79**
Growth Multiple	**5.34 times**		**3.41 times**		**5.41 times**		**6.34 times**		**6.62 times**	

Data source: Guangxi science and technology statistics

ISSN: 0011-9342
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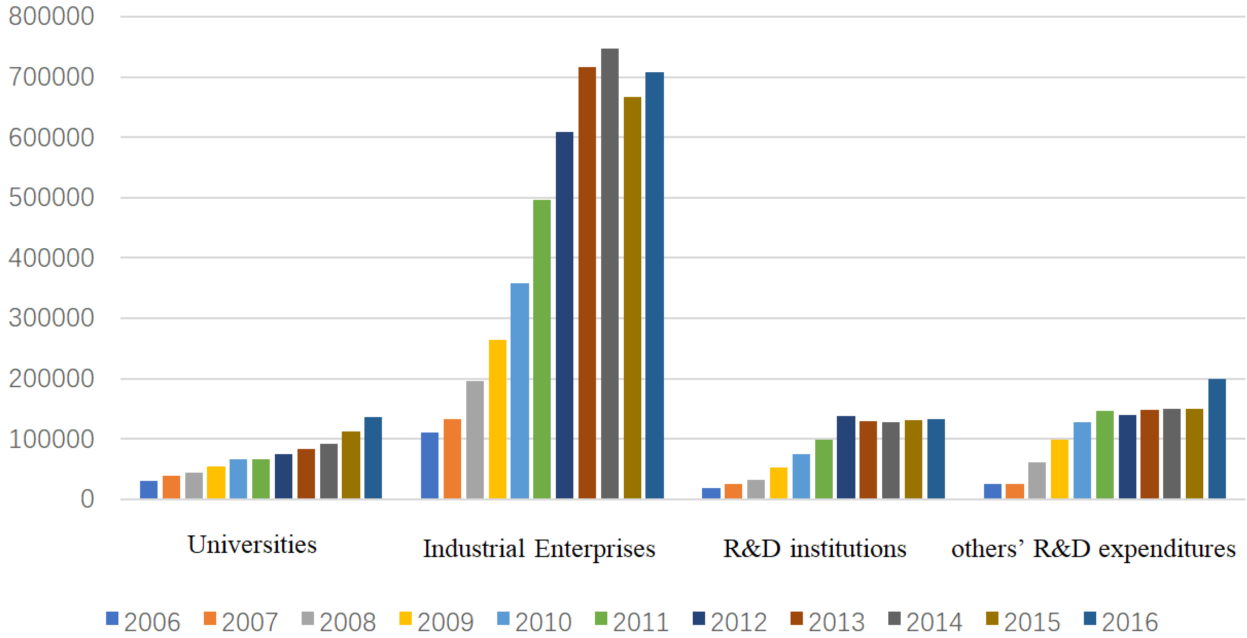

Fig 2: Data of scientific research expenditure in Guangxi (2006-2016)

It can be clearly seen from TABLE III and Figure 2 that in the past decade, the scientific research expenditure in Guangxi universities generally shows an upward trend, increasing from 309.48 million yuan in 2006 to 1365.99 million yuan in 2016, an increase of 3.41 times, with an average annual growth rate of 16.25%. However, the expenditure during the years fluctuates greatly. In comparison with other sectors, from 2006 to 2016, colleges, large and medium-sized industrial enterprises, scientific research institutions, and others' R&D expenditures increase by 3.41 times, 5.41 times, 6.34 times, and 6.62 times, respectively. Scientific research expenditure in Guangxi universities has the smallest increase, with an average annual growth rate of 16.25%, 21.71%, 24.16%, and 247.79%, respectively, and the growth rate is also the lowest, as in the same period, Guangxi's science and technology expenditure increases by 5.34 times, with an average annual growth rate of 21.28%. Scientific research expenditure in Guangxi universities has significantly lower growth rate than overall science and technology expenditure of Guangxi, and its growth rate is even slower compared to non-university research and development expenditure. It can be seen that the proportion of scientific research expenditure of Guangxi universities changes from 16.67% in 2006 to 11.6% in 2016, which does not rise but fall. From the above basic data, non-university research and development expenditure has higher average annual growth rate than university research and development expenditure. Take large and medium-sized industrial enterprises as example. Its overall science and technology expenditure is 4.2 times that of universities in 2016, accounting for 60% of total expenditures. Compared with it, proportion of research and development expenditure in Guangxi universities is quite small.

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4.2 Calculation and Analysis of the Correlation between Scientific Research Investment and Total Factor Productivity in Universities

This study selects the data required by formula (8) from the basic data in the above several tables, substitutes it into formula (8) for regression analysis and calculation:

$$\ln TFP_t = 0.324353 \ln U_t + 0.225462 \ln C_t - 0.068141 \ln I_t - 0.056997 \ln O_t - 4.326103$$

$$\gamma_1 = 0.324353 \gamma_2 = 0.225462 \quad \gamma_3 = -0.068141 \quad \gamma_4 = -0.056997$$

The above results indicate that the amount of scientific research expenditure in Guangxi universities exerts the largest impact on total factor productivity.γ_1 is about 0.324, that is, if the university scientific research investment is increased by 1%, the total factor productivity of Guangxi will be increased by 0.324%. The next comes large and medium-sized industrial enterprises. Every 1% increase in its research and development expenditure can increase total factor productivity by 0.225%, while other scientific research institutions bring unobvious scientific research contributions.

V. CONCLUSION

5.1 There is aCorrelation between University Scientific Research Investment and Science and Technology Progress in Ethnic Areas

From the above chart and formula calculation data, since 2000-2016, the efficiency of university scientific research expenditures in Guangxi (that is, the contribution of every 1 yuan of university scientific research expenditure to the scientific and technological progress rate) is about 0.324%, which is larger than large and medium-sized industrial enterprises' expenditure efficiency of 0.225%, which is about 1.5 times higher. Therefore, it can be considered that the increased university scientific research investment plays a certain role in promoting regional scientific and technological progress and regional economic development, demonstrating efficiency higher than other scientific research institutions. Judging from the data of GDP per capita from 2000 to 2016, it has been growing rapidly, while Guangxi's investment in scientific research keeps fluctuating. Moreover, although the allocation efficiency of scientific research resources in Guangxi colleges and universities has improved with investment growing year by year, the growth rate is not high, which is obviously lower than the total growth rate of Guangxi scientific research investment. In comparison, Guangxi university scientific research output has obviously higher growth rate than scientific research investment. In terms of overall scientific research investment in Guangxi, compared with the whole country, the 2016 survey of research and experimental development (R&D) expenditure in various regions of the country reveals that the national research and experimental development (R&D) investment intensity was 2.13% in 2017 [11]; while Guangxi investment intensity is lower than the national average level and scientific research investment intensity in other ethnic areas is also lower than the national average, for instance: 1.19% in Gansu, 1.13% in Ningxia, 0.82% in Inner Mongolia, 0.68% in Qinghai, 0.52% in Xinjiang, 0.25 in Tibet %[11]. Data from other provinces reveal that regions with more developed regional economies that Guangxi have higher scientific research investment intensity, and regions with less developed regional economies than Guangxi have

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lower scientific research investment intensity, showing certain correlation between the two, while university scientific research investment plays a certain role therein.

5.2 Build Diversified and Multi-Channel Scientific Research Investment and financing System

At present, the sources of scientific research expenditure for colleges and universities in Guangxi mainly rely on government scientific research expenditure and some cooperation projects with enterprises. You You, Wu Hongbin, Min Weifang et al. have analyzed the data of 20 world-class universities in the United States and showed that the level and structure of university expenditure are positively correlated with scientific research performance of universities, and for universities with higher expenditure, more investment is needed to improve their relative research performance. The most important matter is the government direct appropriation among all expenditure sources (instead of government research grants through projects and contracts), because it is less restricted in use and plays a unique role in promoting research output in universities[12]. This study suggests that the government should continue to increase university expenditure in ethnic areas and universities must have the right to use resources autonomously and effectively.

However, because the economic development of ethnic areas relatively lags behind in the country, there is relatively low scientific research investment, and the national mid- and long-term scientific and technological development planning outline (2000-2020) clearly proposes to support and encourage enterprises to become the pillar of technological innovation. As a result, from national to local governments, the scientific research investment is more inclined to industrial enterprises above the designated size (as can be seen from TABLE III). Therefore, if colleges and universities in ethnic areas want to receive government support and increase scientific research investment, they cannot entirely rely on government scientific research investment. Instead, they should develop more ways to invest in scientific research and establish diversified investment channels. The government may propose some economic means linking the development of enterprises with the investment of scientific research activities in universities, formulate institutional mechanisms and measures to guarantee the development of scientific research, and encourage enterprises to invest in scientific research activities in universities. Secondly, the government can formulate corresponding policies to promote and strengthen cooperation between universities and enterprises. For instance, universities and enterprises may jointly establish scientific and technological innovation organizations. In addition, some investment institutions in social organizations such as scientific research venture capital can also be introduced. Colleges and universities have successful experience in scientific research venture capital abroad. Local universities in China can learn from these experiences to develop their own investment channels. The "catalysis" effect of venture capital in transformation of scientific research results has been confirmed by the rapid development of high technology represented by information technology and biotechnology. As W.F. Miller, the director of the International Institute of Stanford University in the United States, said: Due to the participation of venture capital, the cycle for transforming scientific results into commodities has been shortened from the original 20 years to less than 10 years [14].

It is necessary to develop and improve science and technology finance, build a diversified and multi-channel scientific research investment and financing system of government, enterprises, and society, and gradually form government-oriented and market-led science and technology resource pattern in the investment and allocation of university expenditure resources. By further improving and rationally allocating the scientific research expenditure input mechanism in a scientific way to accelerate and guarantee the steady growth of science and technology expenditure of universities, the ability of university research to serve local development will usher in better, higher and faster improvement with the development of the regional economy.

ACKNOWLEDGEMENTS

The authors are grateful for the support by the National Social Science Fund Project onWestern Pedagogy: Basic Experiences and Promotion Strategies of Project System-based Support to the Development of Chinese Higher Education (XIA190300); Scientific Research Project of the Education Department of the Guangxi Zhuang Autonomous Region: Research on the Scientific Research Contribution Rate of Local Universities (201010LX265)

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