THE IMPACT OF UNIVERSITY RESEARCH AND DEVELOPMENT ON LOCAL INCOME GROWTH

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ABSTRACT

Research and Development (R&D) is the backbone of innovation. With the increasing R&D investment, Chinese universities are playing an more important role of social innovation. In 2016, 256 universities R&D has exceeded 10 million RMB. Increasing R&D input makes positive impact on local economic development, upgrades employment structures and improves human capital. However, the regional distribution of educational resources is uneven in China, which could exacerbate regional disparities and social inequity. Thus, this study examines the hypothesis that more R&D investment in universities can promote the local wage growth by using the four databases. This paper mainly finds two conclusions: (1) more R&D input of universities and colleges is related with increasing wage of the primary sector, secondary sector and tertiary sector, and (2) compared with other regions, universities R&D input is associated with larger increases in wage of the three sectors in the East China.

The research and writing of this thesis is
dedicated to everyone who helped along the way,
especially during Covid-19 outbreak.

Many thanks,
Yi Zong

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1. INTRODUCTION

Research and Development (R&D) are the backbone of innovation. China's R&D spending accounted for the GDP is increasing rapidly from 0.72 percent to 2.07 between 1991 and 2015. And China is moving forward to the goal of 13th 5-year plan (2015-2020), achieving 2.5 percent by 2020 (China Power Team, 2019). The OECD depicts four main users of R&D funding: government, business, higher education institutions and private non-profits (China Power Team, 2019).

Universities play an important role of social innovation. Chinese universities are becoming more important as R&D investment is increasing. In 2016, 256 universities' R&D has exceeded 10 million RMB (Department of Science and Technology of Ministry of Education PRC., 2018).

In addition, researchers found that there is a significant disparity in research funding among various institutions of higher education in China. There are 39 universities of the "985" project which contains top 50 universities in mainland China, accounting for 5 percent of total Chinese universities. But 985 project universities accounts for about two-third of R&D fund (Tian & Xu, 2015) of total R&D fund for universities. In addition, there is an existing uneven distribution of higher educational resources of universities in China. About 61 percent of "985" universities with large amount of R&D fund, are located in the east coast region. In contrast, the number of high-quality universities is less in the west and central China.

There is a burgeoning interest in understanding and modeling the effects of higher education institutions on regional and national economic conditions from both research and policy areas (Drucker & Goldstein, 2007). Very few studies have focused on the relationship between Chinese universities R&D and regional inequality. The existing research found that "*university activities, particularly knowledge-based activities such as teaching and basic research, have been found to have substantial positive effects on a variety of measures of regional economic progress*" (Drucker & Goldstein, 2007, p.20).

Based on the research, this study examines the hypothesis that more R&D investment in universities can promote the local economic growth and improve human capital, leading to local wage growth, which would escalate disparities among different regions, and proposes the available ways to reduce the gap in education and economic growth among different regions in China.

Data on wage and R&D are for 31 provinces in China between 2006 and 2016. The dependent variable is the average wage of urban staff and workers from three sectors. The article focuses on the wages of workers from specific industries including scientific research and technical services, education, agriculture, manufacturing and construction. The independent variables is university's R&D research fund input per year. The control variables include GDP, per capita, the number of undergraduate students, employment in urban areas. The article uses China Statistical Book from National Bureau of Statistics, the Compilation of Scientific and Technological Statistics of Higher Education Institutions from Ministry of Education of the People Republic of China, China Statistical Yearbook on Science and Technology 2007-2017 and China Labor Statistical Yearbook 2007-2017, as four databases.

The regression results show that more R&D input of universities and colleges is related with increasing wage of the primary sector, secondary sector and tertiary sector.

And the imbalance of regional R&D allocation could make the regional disparity worse off.

Based on these findings, this paper suggests the central government to include more universities of the inland provinces into the national education development project and cooperate with local governments to establish qualified universities by giving financial support. Also, local governments should attract more R&D resources with more economic incentives and policies.

CHAPTER 2. BACKGROUND

China has experienced a rapid improvement in innovation capabilities, reducing the gap with leading OECD countries. Chinese global innovation index has risen steadily, becoming the highest among developing countries (World Bank Group & Development Research Center of the State Council, 2019). China is one of the global leaders in many technological areas such as e-commerce, artificial intelligence, fintech, high-speed trains, renewable energy, and electric cars. Chinese economic development benefits from innovation. Take digital technologies as an example. Among the 252 non-listed start-ups with a valuation of 1 billion dollars and above, also called unicorns, 98 are from China (World Bank Group & Development Research Center of the State Council, 2019). Between 2004 and 2018, the annual amount of e-commerce trade in China grew 30 times. (World Bank Group & Development Research Center of the State Council, 2019), achieving RMB 31.6 trillion. Thus, according to the 13th Five-Year Plan, the Chinese government is engaging in enhancing the domestic force of innovation, technology, science and R&D, with the purpose of accelerating the transformation of traditional industries and upgrading emerging economies.

R&D is the backbone of innovation. China's R&D spending accounted for the GDP is increasing rapidly from 0.72 percent to 2.07 between 1991 and 2015. And China is moving forward to the goal of 13th 5-year plan (2015-2020), achieving 2.5 percent by 2020 (China Power Team, 2019). In 2018, Chinese R&D spending is the second largest in the world, accounting for about 20 percent. (World Bank Group & Development Research Center of the State Council, 2019). Although 76 percent of R&D spending is from industries and facilitating commercial applications, Chinese universities are playing important roles of innovations by improving human capital and producing high-quality researches, which is the foundation of China's growing innovation capabilities. There are 7 million graduate university students, 1.5 million of them majoring in science and engineering, and 30,000 PhDs from technical disciplines working in technological companies (World Bank Group & Development Research Center of the State Council, 2019). China owns the second largest number of publications and quality of academic papers, as measured by the number of citations, just behind the United States (World Bank Group & Development Research Center of the State Council, 2019).

However, the regional distribution of educational resources is uneven in China. The qualities of Chinese higher education sectors are highly different. The implementation of projects 985 and 211 (Appendix 1), launched by central government in the mid-1990s, are important ways to strengthen global competitiveness of first-class higher education institutions with higher qualities in China (Michael & Gu, 2016). According to the report from Ministry of Education of PRC released in 2017, the input of R&D funding from 211 projects and provincial ministry of higher education, totally 110 institutions, accounts for about 70.5 percent of total R&D input. Universities with larger amount R&D input are associated with more research activities and better research capabilities, which are able to attract more students and companies including start-up to come (Lundberg, 2017). But about 61 percent of “985” universities with large amount of R&D fund, are located in the east coast region. In the contrast, the number of high-quality universities are less in the west and central China compared to coastal provinces.

Currently, the authorities are aware of the uneven distribution of educational resources among provinces and have launched several policies to reduce the gap in higher education between east and west China. For example, the Ministry of Education of PRC has released the document to opposite that higher education institutions in the East China attract high level talents from the institutions in the West China by high salaries and other preferential policies. But higher institutions in the West China are still facing serious competitions and brain drain.

CHAPTER 3. LITERATURE REVIEW

In light of the importance of the subject among academics, there is a burgeoning interest in understanding and modeling the effects of higher education institutions on regional and national economic situations from both research and policy areas (Drucker & Goldstein, 2007).

Many researches explore how universities contribute to the functioning of regional economies (Drucker & Goldstein, 2007) and distinguish the different ways in which universities lead to a regional economic development. Researchers provided systematic frameworks to explain the mechanism of R&D and regional growth such as the tripod approach of knowledge creation, commercialization and retention of knowledge (Koo & Kim, 2009). Based on the framework, the universities are the main producers of knowledge and technology by conducting basic research and providing with large amount of expertise so universities are able to improve the abilities of regions to produce knowledge and take advantage of innovations, contributing to the regional growth. Previous research of Goldstein, Maier, and Luger make a conclusion on eight various functions or outputs that potentially lead to economic development, including "*creation of knowledge, human-capital creation, transfer of existing know-how, technological innovation, capital investment, regional leadership, knowledge infrastructure production, influence on regional milieu*" (Drucker & Goldstein, 2007, p.22). Those eight factors are not mutually exclusive and their impacts may overlap by different university activities.

According to the eight outputs identified by the scholars, many researches specify some of those functions in detail with both empirical evidence and theoretical underpinnings support. Knowledge can make direct and indirect influence on productivity gains in private enterprises and other regional innovative capacities, leading to a long-term economic growth (Drucker & Goldstein, 2007). In addition, technology transfer and technological innovation and capital investment are also used to improve productivity and products with the application of knowledge. And economists also research on different methods of measuring economic impacts with the use of knowledge-production functions. Griliches (1979) measured the creation of knowledge by using expenditures on R&D and included it as an input to analyze the output at the firm and other industry-sector level. The optimized general Griliches model involves a measure of innovation as the dependent variable and industry and University R&D as independent variables (Jaffe, 1989).

According to regional leadership and regional milieu, research focus on influence of universities on communities and surrounding areas "*by they intellectual, social, cultural, or recreational, by attracting a concentration of highly educated and creative professionals and establishing a particular locational dynamic*" (Luger and Goldstein, 1997, p. 104-34). Researchers explore the way of R&D spillover by examining the geography of innovation and production. Knowledge externality is a key of the geographically cluster of innovative activities (Audretsch & Feldman, 1996).

Some research discusses mechanisms on how R&D makes impact on innovation, how makes R&D profitable and how R&D promotes economic growth under the framework on the university-industry relationship. Some research found that the impact of university-industry collaboration on innovation efficiency is not always significant due to enterprises' innovation ability (Hou et al., 2019). But some researchers found that the relationship between corporations and Chinese universities is important to make R&D profitable. Such cooperation is able to supply channels for technology spillover by academic exchange, human capital flow, demonstration and imitation, informal exchange, causing profits of R&D (Cui et al., 2010). Besides cooperation with industries, Chinese universities are also able to launch start-ups owned by themselves with the use of strong resources including R&D (Eunet al., 2006).

Human capital is necessary for establishing new knowledge which drive economic growth. Students and scholars with intellectual and technical skills create new knowledge which also occurs through academic conferences and other activities. In addition, the

Swedish case provides another explanation on local growth related with human capital, which is that R&D in specific research activities and mature universities may have positive impact on average income growth by increasing human capital (Lundberg, 2017). The assumption is also supported by American labor data, which shows that more four-year colleges and universities per capita could enhance the mobility in human capital (Hammond & Thompson, 2010). In addition, based on Chinese employee-employer database, some researchers examined the relationship between R&D intensity and wages that "a *one standard deviation increase in R&D intensity is associated with an increase in the hourly wage rate between 3.4% and 6.9%*" (Mishra & Smyth, 2014, p.136). The results show that the wage elasticity for R&D intensity is higher in lager companies and for workers with better education and technical skills .

There exists a lack of empirical research on how R&D investments impact wage dynamics in China. Existing research focuses on the impacts of R&D input and R&D spillovers on changing employment structure (Zou et al., 2015), and increasing human capital premium (Huan & Zhang, 2012). There are some articles that showcase how Chinese higher education uses R&D investment to improve innovative abilities, upgrade industrial structure, and promote the interaction with regional economy (Zheng, 2011). When exploring the relationship between universities R & D expenditure and wage, the research focuses on the allocation of research funding and salary system in universities (Huang & Li, 2013). Exiting researches explore to establish an effective distribution system to make scientific researchers benefit from the increasing R&D expenditure on projects (Wang, 2007).

Thus, the article can enrich empirical research on exploring the relationship between university's R&D and regional income growth.

CHAPTER 4. HYPOTHESIS AND CONCEPTUAL MODEL

The article will examine how provincial R&D input makes impact on regional wage in three sectors.

R&D investment could optimize the industrial structure, contributing to employment structure upgrading (Zou et al., 2015). R&D can promote technological progress, resulting in the product innovation and process innovation (Ebersberger & Pyka, 2002). R&D investment in products and emerging technologies can promote the boom in mass entrepreneurship and innovation. As a result, new consumer demands and the specification of labor expand the production scale and promote more new enterprises. However, technological advancement may lead to the reduction in demand for labor with capital and automation (Schumpeter, 2013). For example, agricultural mechanization would reduce employment in the primary sector (Zou et al., 2015) because R&D investment may focus more on improving the production technology instead of the product technology which is relevantly difficult to make innovation on product upgrading. According to the secondary sector including manufacturing industries, R&D investment can promote both product and production progress. Although automation would replace low-skilled and cheap labor, the relative demand for skilled labor with higher wage will be significantly increasing as R&D spillover effects influence the domestic manufacturing, especially technology-intensive manufacturing sectors (Yu, 2010). For the tertiary sector which mainly provides services, depends on production and product innovation. R&D investment can generate more employment chances with increasing demands promoted by better services and products. (Li & Bi, 2004). Empirical research shows that for every 1 percent increase in R&D stock, the proportion of employment in the primary industry will decrease by 7.726 percent, the proportion of employment in the secondary industry will increase by 5.636 percent, and the proportion of employment in the tertiary industry will increase by 1.845 percent (Zou et al., 2015).

Based on the data from National Bureau of Statistics of China in 2018, the average annual income in the primary sector is 36,466 RMB, the average annual income in the manufacturing industry is 72,088 RMB, and the average annual income in the tertiary sector is 80,551 RMB. Therefore, the first hypothesis is concluded as follows:

Hypothesis 1: *with more R&D investment, the increasing employment and GDP in the the secondary and the tertiary sector is related with lager increase in wage of these two sectors than the increase in the primary sector.*

Larger R&D funding and personnel input in the university can improve educational qualities. Investments on human capital have positive impact on labor productivity and output (Koenig et al., 2017), which is able to improve the average wage rate. Additional research found that human capital endowments is positively associated with average income growth (Lundberg, 2017). And such positive effect is stronger for poorer households and beneficial for promoting greater equity (Abrigo et al., 2018). In addition, increasing in R&D expenditures could raise wages of researchers who share part of R&D subsidies. Expenditures on research personnel account for about 17 percent of R&D fund output (Department of Science and Technology of Ministry of Education PRC., 2018). Thus, the second hypothesis is concluded as:

Hypothesis 2: *Universities with a larger R&D funding could improve the human capital by cultivating better educated graduates with technical skills, positively associated with the local average income growth.*

Research shows that R&D outcomes are able to benefit for the local companies in labor productivity improvement and productive efficiency, and thus increase the local income (Zheng, 2011). Based on European regional growth, cross-regional knowledge spillovers with the R&D efforts of the public sector is associated with 1.8 percent increase in regional labor productivity growth (Kose, 2002). In addition to the public sector, the cooperation between researchers and private-sector partners contribute more to the spillovers of high-quality research across the regions through the university-industry relationship (Eun et al., 2006). For example, based on the survey, 10.04 percent (867 firms) of all the firms registered in Zhongguancun district in Beijing are firms run by universities and public research institutes (Eun et al., 2006). Since the market-oriented reform, Chinese universities and other research institutions would have strong propensity to pursue economic gains and strong internal resources including R&D to launch start-ups or involve in industrial firms (Eun et al., 2006). Thus, R&D outcomes can be transferred into economic benefits for individual researchers. So, the third hypothesis is concluded as:

Hypothesis 3: *R&D input from universities and research institutions are associated with higher average income of workers from the scientific industry, by transferring research outcomes into economic benefits, increasing the returns to researchers' wages.*

Universities with more R&D can increase their rank and reputation. Research quality is one of the three most important dimensions of university rankings (Shin &

Toutkoushian, 2011), which is measured by the number of quality research and publications cited and the amount of external research grants that the institution secured (Johnes, 1988). Universities with good reputation can attract more immigrants, more companies including start-ups, and more investments into the regions, resulting in income growth with the development of local economy. The research found that, with the research output, knowledge production and human capital, the location of universities could play an important role of shaping regional growth(Lundberg, 2017).

However, because the high-rank universities mainly concentrated in the coastal provinces, they can get more R&D funding and personnel input than inland provinces. According to the report from Ministry of Education of PRC released in 2017, the input of R&D funding from 211 projects and provincial ministry of higher education, totally 110 institutions, accounts for about 70.5 percent of total R&D input. Universities with larger amount R&D input is associated with more research activities and better research capabilities. The imbalance education resources among different provinces will exacerbate the income inequality. Thus, the final hypothesis is concluded as:

Hypothesis 4: *In the East China, more R&D of universities is associated with larger income growth, compared with the increasing wage in the other parts of China.*

CHAPTER 5. EMPIRICAL RESULTS

Owing to the research design for the hypothesis and the characteristics of my panel database, this article estimates a fixed effect model for the wage of three sectors in each Chinese province. The equation is given as following:

$$log(Wage_{it}) = \beta_0 + \beta_1 log(RD_{it}) + \beta_2 log(GDP_{it}) + \beta_3 log(GDP\ per\ capita_{it}) + \beta_4 log(Enroll_{it})$$

$$+ \beta_5 log(Population_{it}) + \beta_6 log(Grad_{it}) + \beta_7 log(Employ_{it}) + \beta_8 log(Female_{it}) + year_t + a_i + u_i$$

Where a_i is the unobserved characteristics for each province that does not change over time (province fixed effect), and u_i is the error term. Variable GDP_{it} considers the gross domestic production of the primary, secondary and tertiary sectors of each province in a given year, representing the economic condition of the region. Variable $GDP\ per\ capita_{it}$ captures the living condition of households in the provinces. Variables $Enroll_{it}$ and $Grad_{it}$ capture the education conditions of each province in each year. Variable $Population_{it}$ is the year end population of each region in a given year. Variables $Female_{it}$ and $Employ_{it}$ capture the employment condition of a province in a given year.

Because there is no data about average wage of each sector but just the data of average wage of each industry in three sectors, the article makes calculations with the equation as below:

$$Wage_i = \sum (W_a * P_a) / \sum P_i$$

W_a: average wage of each industry in each sector

P_a: the number of people work in each industry

P_i: the number of people work in each sector

The total wage of each industry is equal to the average of the industry times total population working in that industry. The total wage of each sector is the sum of the total wage of each industry in that sector. The average wage of each sector is equal to the total wage of each sector divided by the total population working in that sector.

Variable RD_{it} represents the R&D input of universities including basic research, applied research and experiment research, research institutions and industrial enterprises of each province in a given year. In addition, the article calculates the R&D capital stocks with PIM method, concerning R&D depreciation rate and R&D growth rate. The PIM is employed widely for calculating R&D capital stocks (Coe & Helpman, 1995; Frantzen, 1998). The construction of the R&D capital stock is based on PIM using the equation as below:

$$Kt = \lambda_0 I_t + \lambda_1 I_{t-1} + \ldots + \lambda_T I_{t-T} \quad with\ 0<\lambda<=1\ (1)$$

Where λ is the share of knowledge of the corresponding vintage used in production at time t, and T indicates the age of the oldest surviving vintage of R&D investments I (Bitzer & Stephan, 2007). Because the share of obsolete knowledge in past vintages of R&D cannot be observed directly, the article assumes about the depreciation of knowledge (Bitzer & Stephan, 2007). A geometric depreciation of knowledge is: $\lambda_0 = 1$, $\lambda_1 = (1-\delta)$, $\lambda_2 = (1-\delta)^2$,...., $\lambda_T = (1-\delta)^T$, so the equation (1) can be simplified to:

$$Kt = I_t + (1-\delta)K_{t-1},\ \delta = \frac{\lambda t-1-\lambda t}{\lambda t-1} \quad (2)$$

where δ is the depreciation rate assumed to be constant over time. Usually a value between 5% and 15% is taken for (Bitzer & Stephan, 2007), so the article makes a mean and δ is assumed to be 10%. The initial R&D capital stock can be calculated by the equation as following,

$$R_{i,0} = A_{i,1} / (g_{i,A} + \delta_i) \quad (3)$$

$R_{i,0}$ is the initial R&D capital stock of province i, $A_{i,1}$ is the initial R&D input of province i, $g_{i,A}$ is the annual growth rate of R&D input of province i between 2006 and 2007, δ_i is the depreciation of R&D capital of province i.

$$g_{i,A} = [(R_{07} - R_{06})/R_{06}]*100\% \quad (4)$$

The eventual equation of R&D capital stocks is

$$R_{t,i} = R_{i,0} + (1-\delta)R_{t-1,i} \quad (5)$$

According to the equation (5), R&D capital stock is equal to the initial R&D capital stock, which is the R&D capital stock in 2006 calculated by equation (4), plus the R&D capital stock of previous year times 0.9 (δ = 10% in paper).

5.1 Descriptive Statistics

This paper uses data from China Labor Statistical Yearbook 2007-2017, China Statistical Book from National Bureau of Statistics and Compilation of scientific and technological statistics of higher education institutions 2007-2017 (高等学校科技统计资料汇编 2007-2017), China Statistical Yearbook on Science and Technology

2007-2017 and China Statistical Yearbook 2007-2017. These data are provincial-level in 31 provinces of Mainland China from 2006 to 2016.

Table C summarizes the available data for the dependent variables. This paper includes average wage of three sectors to explore how R&D input makes impact on wage differently in different sectors. The primary sector includes agriculture, forestry, animal husbandry and fishery. The secondary sector includes mining, manufacturing, construction and production and supply of electricity, heat, gas and water. 14 industries are included in the tertiary sector like wholesale and retail trades, transport, hotels and catering services, information transmission, financial inter- mediation, real estate, education and so on. According to the total population of urban workers, only 2.6 percent of the total population working in the primary sector. 50.3 percent and 47.1 percent working in the secondary and tertiary sector. Workers in the tertiary sector have the highest average wage, approximately 1.8 times more than the wages of workers in the primary sector. But the average wage of the primary sector has risen by 13.4 percent per year between 2006 and 2016, which is more rapidly than wage of the secondary sector (12.0%) and the tertiary sector (12.8%).

Table D summarizes the available data for the independent variables. It shows that average R&D input and R&D capital stocks from universities is larger than research institutions and approximately three times less than the input of industrial enterprises. According to the R&D fund of universities, applied research enjoys the largest average fund and experiment research received the least research fund each year. There is an approximately 296 percent growth rate of university R&D input from 2006 to 2016, compared with 233 percent growth rate of industrial enterprise and 147 percent growth rate of research institutions. The average university R&D input in the East China is nearly more than double than it in the West and Central China, which shows the regional disparity in R&D resources.

This paper selects several variables to control the impact of the regional economic conditions, regional education, population and gender on the dependent variable. Provincial gross domestic production (GDP) is correlated with the wage.The economic growth may make a fundamental change in China's wage and employment structures by increasing the base wage, rising returns to human capital and promoting a higher state-sector wage premium (Ge & Yang, 2014). Based on the Table E, average GDP of the secondary sector is 7777.47 hundred million yuan, nearly equal to the GDP of the tertiary which is 7028.94 hundred million yuan. Two sectors' GDP are 4 times more than the GDP of the primary sector. GDP per capita in the East China is double more than the one in the West and Central China. Another two variables are related with the education level. Wages depend on productive workers whose productivity depends on human and physical capital used in the production process (Shambaugh et al., 2017). Education is correlate with human capital. The average growth rate of graduation and school enrollment per year from 2006 to 2016 is about 4.5 percent and 6.6 percent separately. The number of school enrollment of high-education and graduation in the East China is double larger than the number in the West China.

In summary, the large standard deviations show that there are huge disparities across provinces in R&D input, average wage of three sectors, economic and education conditions between 2006 and 2016. The following analysis uses relevant data drawn from various sources. The sample size is 341, data from 31 provinces within 10 years. Specific data sources and descriptive statistics can be found in the Appendix (see, Table B, Table C, Table D and Table E).

5.2 Preliminary Findings

The regression results of the baseline model (see, Table 1) shows that the increasing universities R&D is positively associated with the wage of three sectors, which partly support the first hypothesis. The coefficients on universities' R&D input in the three models where controlling other variables' influence are all positively and statistically significant at the 5% significance level (See, Table 1). The baseline model indicates that 1 percent increase in universities' R&D input is associated with 20.8 percent increase in the wage of the tertiary sector and 15.8 percent increase in the wage of the primary sector. However, the magnitude of changes in the wage of the secondary sector is much smaller. The baseline model supports the third hypothesis that R&D input from universities and research institutions are associated with higher average income of workers from the scientific industry. Universities' R&D input is positively and significantly associated with the wage of scientific research and technical services ($p<0.05$). 1 percent increase in R&D of universities is associated with 18.6 percent increase in the wage of scientific research.

As for the control variables, GDP of the secondary sector is negatively significantly associated with the wage of three sectors ($p<0.05$). The result indicates that economic growth in the secondary sector is not related with the wage growth because the rising labor cost and material price could cause the loss of Chinese industrial competitiveness (Xu & Hu, 2014). In addition, the development of industries like manufacturing and infrastructure could attract more labor immigrants from rural places, solving a labor shortage and rising wages. GDP per capita are positive significant associated with the wage of the secondary sector and tertiary sector but is negative significant associated with the wage of the primary sector, which indicates that the wage growth in the primary sector can't keep pace with per capita GDP growth in the primary sector.

Due to more education resources concentrating in the East China, it is assumed that the relationship between university R&D investment and the wage of different sectors would be different across different Chinese regions. Therefore, Table 2 is developed to examine the effects of R&D investment on the wage change in different Chinese regions. This paper divided the 31 provinces of Mainland China into four categories according to the economic development, based on the classification of the National Bureau of Statistics of China, which are East China, Central China, West China, Northeast China. When the difference across regions is considered, as shown in Table 2, universities' R&D input is all positive significant associated with the wage of all three sectors in the East China. 1 percent increase in universities R&D is associated with 53.54 percent increase in the wage of the primary sector, 18.19 percent increase in the wage of the secondary sector and 42.11 percent increase in the wage of the tertiary sector. However, the coefficient on universities R&D is not statistically significant for the wage of three sectors in Central China. For West China, the coefficient on universities R&D is positively and significantly for the wage of the primary sectors and tertiary sector, but one percent increase in R&D is associated with 16.11 percent increase in the wage of the primary sectors and 11.87 percent increase in the wage of the tertiary sector. The effect of universities R&D on the wage of these two sectors in the West China are smaller than it in the East China. The result shows the disparity across different regions in the wage of three sectors.

Table 3 shows the regression results when disaggregating R&D into three sub-categories including basic research, applied research and experiment research. Basic research and applied research is positively associated with the wage of the three sectors ($p<0.05$). The coefficient on experiment research fund is only positively significant for the wage of the tertiary sector.

5.3 Robustness Tests

This paper performs two robustness checks by using three types of model specifications including ECM model and GMM model. In Table 5, we find that lagged universities R&D input is significantly positively related to wage differences of the primary and secondary sector. For example, based on Model 4, universities are associated with an increase in wage of the secondary sector by 9.3 percent ($p<0.05$).

GMM model is applied if some of the endogenous variables are latent (Wilde, 2008). To mitigate such concerns, we use GMM model. In the Table 6, we found the similar result compared to the baseline model, indicating that the baseline model is sufficiently robust.

CHAPTER 6. CONCLUSION AND PUBLIC IMPLICATIONS

R&D is important for the economic growth and increasing productivity driven by innovation. This paper finds that more R&D input of universities and colleges is related with the increasing wage of the primary sector, secondary sector and tertiary sector. More investment in basic research and applied research fund could make positive impact on wage growth in three sectors. Based on the analysis of the extension model when considering about geographic factors, we find that, compared with other regions, universities R&D input is associated with more increases in wage of the three sectors in the East China. So, the difference of R&D regional allocation could make the regional disparity worse off.

6.1 Policy Implications

It is clear that more universities in the 985 Project concentrate in the Chinese coastal provinces than inland part, which causes the regional disparity in education resources. So it is necessary to adjust the 985 Project to pay more attention on the education development in the inland provinces. For example, Chinese government proposed a new project called *Double First-Class Initiative* in 2018, which aims to develop a number of Chinese universities and disciplines into the leading position among world-class and make China an international higher education power. In this initiative, the government has noticed the lack of higher education resources in the West and Central China so the

Ministry of Education plans to establish a cooperation with local governments in those regions to help build up at least one qualified provincial university, with more financial and human capital support.

In addition, the local government could attract R&D teams and R&D institutions with several economic incentives and policy tools including tax, subsidies, discount of purchasing property and easier residential permit. There are many Chinese local governments have proposed different policies to attract scientific talents. For example, Dalian, located in Northeast China, attracts high-level talents by allowing them to purchase real estate with relevant cheaper prices. And Tangshan, a city of Hebei Province, attracts talents with PhD degree by giving 100,000 RMB (about $15,000) financial support for purchasing estate property.

6.2 Potential Limitation

In spite of the robustness checks, this research has several limitations. First, the sample size is not big enough especially when analyzing the data divided into four geographic categories. The sample from the Northeast China is only 66, which would cause errors for the estimation. Furthermore, the data for the dependent variable only covers the urban population but ignoring the rural population. The research does not estimate the impact of R&D on urban and rural disparity. Future research might address these short-comings using more fine-grained data.

There are still limited researches to explore the relationship between university R&D input and local wage growth. This paper finds that university R&D input is positively associated with average wage of three sectors and the result shows the significantly regional disparities. Thus, it is important for policy makers to recognize the unbalanced allocation of education resources among different Chinese provinces and be aware of the regional economic disparities caused by such unbalanced educational resources.

Table 1. Basic Model

	Primary Sector		Secondary sector		Tertiary Sector		Science	
	1	2	1	2	1	2	1	2
Input of universities R&D(log)	.0017 (.0031)	.1574** (.0486)	-.0162** (.0042)	.0756** (.0193)	.0266** (.0021)	.2081** (.0384)	.0183** (.0032)	.1862** (.0353)
GDP of primary sector(log)		.0883 (.0489)		.0085 (.0180)		.0565 (.0322)		.0581 (.0328)
GDP of secondary sector(log)		-.6058** (.0638)		-.1147** (.0262)		-.3619** (.0359)		-.4786** (.0324)
GDP of tertiary sector(log)		-.1839* (.0818)		-.2129** (.0448)		.0792 (.0374)		.0542 (.0324)
GDP per capita (log)		-.1362* (.0606)		.1895** (.0412)		.1167** (.0189)		.3787** (.0786)
Enroll(log)		-.6259* (.2785)		-.4598** (.0706)		-.3237 (.1637)		-.3564* (.1464)
Graduate(log)		.4431 (.2224)		.3330** (.0577)		.1491 (.1333)		.2946 (.1392)
Population(log)		.1290* (.0481)		.0284** (.0141)		.1430** (.0114)		.1971** (.0174)
Female(log)		1.150** (.2687)		.1271 (.0653)		.1560 (.1209)		-.2094 (.1481)
Employ(log)		-.8156* (.2801)		.2036** (.1099)		-.0963 (.1051)		.2742 (.1417)
Control R&D		.2467** (.0504)		-.0207 (.0322)		.0166 (.0259)		-,0166 (.0278)
Constant	10.00** (.0403)	4.510* (1.86)	10.69 (.0548)	1.512** (.4602)	10.30** (.0269)	8.472** (.8089)	10.52** (.0418)	8.920** (.5510)
R square	.0986	.0485	.1134	.0908	.1617	.3660	.1503	.5739

* statistical significant at 5%level
** statistical significant at 1%level

Table 2. Extension Model: Variation in Geographic Regions

	East (N = 110)			West (N = 119)			Central (N = 66)			Northeast (N = 33)		
	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary
Input of universities R&D(log)	.5354** (.0635)	.1819** (.0206)	.4211** (.0392)	.1611** (.0510)	.0307 (.0241)	.1187** (.0313)	-.1581 (.1356)	.0492 (.0390)	.0365 (.0662)	-.2241 (.1856)	-.1828 (.1074)	-.3034* (.1087)
GDP of primary sector(log)	.2658** (.0369)	-.1543** (.0298)	.2181** (.0315)	-.1237 (.2428)	.0440 (.0573)	.1239 (.1118)	.0527 (.1687)	-.2528* (.0881)	.0429 (.1963)	-.0335 (.6855)	-.0276 (.2997)	1.365** (.3440)
GDP of secondary sector(log)	-1.737** (.1702)	-.7691** (.0781)	-.9218** (.0966)	-.7516** (.2164)	-.1993 (.1334)	-.6573** (.1903)	1.048 (.4778)	.0204 (.4306)	-.2257 (1.163)	.3775 (.5059)	-.3177 (.3424)	1.402** (.3009)
GDP of tertiary sector(log)	-.8524 (.4300)	-.7908** (.2017)	-.3474 (.2458)	-.4085 (.2792)	-.2381 (.0468)	-.1482 (.1398)	-.0488 (.4057)	.2687 (.3486)	.3547 (.8785)	-1.118 (.8000)	-.6312 (.5167)	.4685 (.5840)
GDP per capita (log)	1.926* (.6398)	1.727** (.3105)	1.349** (.3475)	.0802 (.2745)	.1379 (.0802)	.4666* (.1899)	-1.778* (.7260)	.4003 (.6676)	.4985 (1.987)	-.6652 (.9522)	.5430 (.6053)	-3.356** (.6447)
Enroll(log)	-.0590 (.7479)	.1207 (.2385)	-.0392 (.5295)	-.0959 (.2025)	-.2208 (.1039)	.0886 (.1661)	.2608 (.1267)	-.2648 (.1329)	-.6406** (.1447)	-2.235 (1.449)	-.1640 (.6579)	-.3342 (.5663)

Graduate (log)	.0124 (.5547)	.1049 (.1695)	-.2848 (.3853)	-.1707 (.1835)	-.1121 (.1100)	-.5188* (.1910)	.2508 (.1844)	.2448* (.1078)	.1523 (.3314)	-2.004** (.5419)	-1.091** (.2396)	-1.589** .3498)
Population (log)	2.078** (.5985)	1.617** (.2712)	1.179** (.3145)	.1580** (.0314)	-.0005 (.0145)	.0891* (.0301)	-1.210 (.7238)	.5330 (.6176)	.7232 (1.895)	3.982 (2.710)	2.060 (1.305)	-2.038 (1.435)
Female(log)	.3462 (.2553)	-.5128** (.0947)	.3705* (.1610)	.1270 (.5824)	.9382 (.2968)	.8455 (.5944)	.0803 (.6646)	-.5250 (3235)	-1.234 (.7049)	.0130 (1.360)	-.6945 (.6395)	-.4886 (.6519)
Employ (log)	-.5935* (.2511)	.6843** (.0919)	-.7407** (.1755)	.8118 (.5259)	-.4455 (.2509)	.0939 (.4858)	-.5841 (.4904)	.2179 (.3030)	.7984 (.5700)	2.387* (.8033)	1.929** (.3621)	2.603** (.4618)
Control R&D	.3087** (.0792)	-.2442** (.0540)	.1948** (.0470)	.2293* (.0746)	.1447 (.0507)	.0415 (.0536)	-.0491** (8.502)	-.1966** (.0543)	-.1821 (.1524)	-.2448 (.1512)	-.3357** (.0848)	-.3229** (.1008)
Constant	-17.46* (6.431)	-6.526 (3.485)	-7.309** (3.961)	8.097* (3.048)	4.739 (2.294)	1.294 (3.578)	29.13 (22.01)	9.593 (6.178)	17.96 (20.84)	31.50* (10.91)	12.73 (8.404)	53.93** (7.040)
R square	.7026	.5665	.8503	.0851	.0093	.0388	.4725	.8423	.7690	.0489	.0636	.0070

* statistical significant at 5% level

** statistical significant at 1% level

Table 3. Extension Model: Disaggregated Research and Development

	Wage of Primary sector(log)			Wage of Secondary Sector(log)			Wage of Tertiary Sector(log)		
	1	2	3	4	5	6	7	8	9
R&D basic research fund(log)	.1423** (.0343)			.0747** (.0188)			.1077** (.0278)		
R&D applied research fund(log)		.0688* (.0225)			.0331* (.0137)			.1010** (.0192)	
R&D experiment research fund(log)			-.0188 (.0135)			-.0060 (.0069)			.0450** (.0111)
GDP of primary sector(log)	.0715 (.0476)	.0599 (.0386)	.0404 (.0407)	.0021 (.0190)	-.0051 (.0130)	-.0263 (.0159)	.0131 (.0306)	.0227 (.0231)	-.0084 (.0236)
GDP of secondary sector(log)	-.6139** (.0703)	-.5809** (.0573)	-.5789** (.0660)	-.1199** (.0295)	-.1027** (.0234)	-.0912* (.0293)	-.3551** (.0416)	-.3285** (.0305)	-.3636** (.0343)
GDP of tertiary sector(log)	-.2411* (.0938)	-.1721* (.0697)	-.2352** (.0661)	-.2439** (.0515)	-.2072** (.0441)	-.1719* (.0571)	.0477** (.0337)	.0934* (.0320)	.1777** (.0341)
GDP per capita (log)	-.0778 (.0816)	-.1206 (.0631)	-.0631 (.0621)	.2186** (.0307)	.1970** (.0391)	.1970** (.0402)	.1807** (.0259)	.1346** (.0192)	.1127** (.0232)
Enroll(log)	-.6279* (.2655)	-.5285 (.2547)	-.4174 (.2384)	-.4662** (.0740)	-.4130** (.0664)	-.4270** (.0660)	-.2582 (.1427)	-.1980 (.1406)	-.2583 (.1603)
Graduate(log)	.4730 (.2137)	.4218 (.2165)	.3785 (.1972)	.3484** (.0623)	.3227** (.0554)	.3700** (.0578)	.1748 (.1259)	.1170 (.1228)	.1966 (.1490)
Population(log)	.1393* (.5900)	.1437 (.0456)	.1781** (.0310)	.0321* (.0106)	.0354* (.0153)	.0377** (.0098)	.1717** (.0136)	.1591** (.0169)	.1851** (.0182)

Female(log)	1.044** (.2951)	1.128** (.2686)	1.081** (.2625)	.0751 (.0528)	.1167 (.0591)	.0608 (.0553)	.0340 (.1295)	.1350 (.1113)	.0940 (.1088)
Employ(log)	-.6696 (.3222)	-.7914* (.2946)	-.6966* (.2899)	.2753* (.0904)	.2152 (.1049)	.2738* (.0919)	.0772 (.1350)	-.0770 (.1080)	.0085 (.2099)
Control R&D	.2599** (.0532)	.2349** (.0459)	.2635** (.0489)	-.0129 (.0338)	-.0266 (.0296)	-.0483 (.0319)	.0153 (.0270)	.0021 (.0207)	-.0347 (.0230)
Constant	4.632* (1.848)	4.546* (1.815)	3.890* (1.685)	9.041** (.3934)	9.002** (.3931)	9.449** (.4097)	8.662** (.7004)	8.499** (.7507)	-3.836* (1.658)
R square	.0169	.0844	.1032	.2145	.0234	.0234	.3678	.1635	.0996

*   statistical significant at 5% level
** statistical significant at 1% level

Table 4. Extension Model: Research and Development Capital Stock

	Wage of Primary sector(log)			Wage of Secondary Sector(log)			Wage of Tertiary Sector(log)		
	1	2	3	4	5	6	7	8	9
Input of universities R&D(log)	.1282* (.0475)			.0724** (.0178)			.1974** (.0159)		
Input of research institutions R&D(log)		.1090** (.0088)			.0313** (.0050)			.0289** (.0070)	
Input of industrial enterprises R&D(log)			.0362 (.0506)			-.0288 (.0339)			.0084 (.0285)
GDP of primary sector(log)	.0611 (.0689)	.0892 (.0559)	.0955 (.0667)	-.0163 (.0138)	.0095 (.0080)	.0109 (.0131)	.0052 (.0267)	.0021 (.0218)	.0339 (.0274)
GDP of secondary sector(log)	-.4035** (.0910)	-.2196* (.0811)	-.1537* (.0660)	-.2078** (.0356)	-.0822 (.0644)	-.1126* (.0480)	-.3953** (.0653)	-.4201** (.0708)	-.3341** (.0599)
GDP of tertiary sector(log)	.0317 (.1738)	.1526 (.1055)	.2569 (.1395)	-.3326** (.0417)	-.2208** (.0338)	-.2631** (.0411)	.0211 (.1080)	-.0109 (.0931)	.0764 (.1070)
GDP per capita (log)	-.4821 (.3280)	-.7344** (.1974)	-.8323** (.2582)	.4685** (.0737)	.2898** (.0661)	.3052** (.0714)	.3397 (.1708)	.3534* (.1586)	.1832 (.1661)
Enroll(log)	-.5508 (.2844)	-.4863 (.2616)	-.5660 (.2962)	-.4651 (.0572)	-.4091** (.0691)	-.4706** (.0632)	-.3071 (.1293)	-.2180 (.1370)	-.2898 (.1460)
Graduate(log)	.4691 (.2362)	.3543 (.2354)	.4377 (.2621)	.3445** (.0438)	.2874** (.0585)	.3139** (.0491)	.1822 (.1092)	.1167 (.1275)	.1415 (.1286)
Population(log)	-.2607 (.3431)	-.5260* (.2173)	-.6474* (.2848)	.3177** (.0801)	.1634 (0911)	.1709* (.0723)	.3636 (.1748)	.4413* (.1677)	.2638 (.5039)

Female(log)	1.175**	1.109**	1.071**	.0576	.0215	.0370	.0725	.0743	.0726
	(.3028)	(.2927)	(.2989)	(.0804)	(.0773)	(.0955)	(.1159)	(.1163)	(.1114)
Employ(log)	-.7901*	-.6867	-.6917	.2515	.2799*	.2439	-.0062	-.0210	-.0483
	(.3403)	(.3292)	(.3341)	(.1146)	(.0998)	(.1317)	(.1396)	(.1394)	(.1373)
Control R&D	.1586*	.1332	.2073**	-.0438	-.0782	.0689**	-.0702*	.0342	.1053**
	(.0648)	(.0787)	(.0317)	(.0304)	(.0363)	(.0093)	(.0233)	(.0353)	(.0116)
Constant	7.462	10.78**	11.87**	6.573**	9.086**	8.462**	6.578**	6.801**	8.502**
	(3.813)	(2.486)	(3.238)	(.7629)	(.9433)	(.7537)	(1.685)	(1.812)	(1.884)
R square	.1183	.0874	.0487	.0710	.1162	.0790	.2544	.0309	.0987

* statistical significant at 5% level
** statistical significant at 1% level

Table 5. Extension Model: An Error Correction Model (ECM)

	Wage of Primary sector(log)			Wage of Secondary Sector(log)			Wage of Tertiary Sector(log)		
	1	2	3	4	5	6	7	8	9
Input of universities R&D$_t$ (log)	-.2272** (.0271)			-.0557* (.0212)			-.0553 (.0142)		
Input of universities R&D$_{t-1}$ (log)	.3231** (.0673)			.0930** (.0257)			.2497 (.0383)		
Input of research institutions R&D$_t$ (log)		-.0408 (.0252)			.0100 (.0098)				
Input of research institutions R&D$_{t-1}$ (log)		.1238* (.0415)			-.0121 (.0222)				
Input of industrial enterprises R&D$_t$ (log)			-.1453** (.0357)			-.0060 (.0113)		-.0060 (.0113)	-.0166 (.0169)
Input of industrial enterprises R&D$_{t-1}$ (log)			.1381** (.0097)			-.0366 (.0227)		-.0366 (.0227)	.0453 (.0212)
GDP of primary sector(log)	-.0094 (.0367)	-.0838* (.0333)	-.1024* (.0335)	.0151 (.0112)	-.0005 (.0137)	-.0129 (.0094)	.0883 (.0277)	-.0129 (.0094)	.0094 (.0258)
GDP of secondary sector(log)	.1974** (.0587)	.2070** (.0474)	.2427** (.0625)	-.0232 (.0314)	.0129 (.0369)	-.0038 (.0301)	.0215 (.0678)	-.0038 (.0301)	.0999 (.0564)
GDP of tertiary sector(log)	.4657** (.1214)	.5334** (.1096)	.4871** (.1070)	.2379** (.0654)	.2488** (.0571)	.2667** (.0547)	.3205 (.1043)	.2667** (.0547)	.3758** (.0843)

GDP per capita (log)	-.5103* (.2271)	-.4916* (.1934)	-.3241 (.2074)	-.2280 (.1036)	-.2029* (.0870)	-.2079 (.0975)	-.1808 (.1535)	-.2079 (.0975)	-.1466 (.1323)
Enroll(log)	.2985 (.2565)	.4290 (.2310)	.4844 (.2441)	.0017 (.0791)	-.0091 (.0742)	.0008 (.0773)	.2916 (.1944)	.0008 (.0773)	.2736 (.1901)
Graduate(log)	-.2659 (.2747)	-.2722 (.2962)	-.2838 (.2700)	-.1310 (.0775)	-.1100 (.0778)	-.1135 (.0725)	-.4065 (.2037)	-.1135 (.0725)	-.2935 (.2098)
Population(log)	-.0792 (.0728)	-.0663 (.0576)	-.0874 (.0699)	.1100 (.0525)	.0786 (.0534)	.1027 (.0543)	.0668 (.0756)	.1027 (.0543)	.0302 (.0692)
Female(log)	-.9423* (.3702)	-1.232* (.4152)	-1.164** (.3634)	-.0861 (.1128)	-.1618 (.1507)	-.2090 (.1213)	-.5723 (.2267)	-.2090 (.1213)	-.8603** (.2356)
Employ(log)	.6620 (.3934)	.8989 (.4110)	1.004* (.4168)	-.0640 (.1138)	.0737 (.1319)	.0783 (.1100)	.1036 (.2101)	.0783 (.1100)	.4516 (.2203)
Control R&D	.0524 (.0595)	-.1983** (.0266)	-.1931 (.0392)	.0623 (.0212)	-.0657** (.0164)	-.0190 (.0190)	.1365 (.0270)	-.0190 (.0190)	-.0321 (.0155)
Constant	4.179 (3.395)	-3.877 (2.975)	-.1024 (.0335)	5.472** (1.693)	4.168* (1.809)	4.471* (1.526)	1.780 (2.490)	4.471* (1.526)	1.732 (2.670)
R square	.2496	.2632	.2579	.1433	.1313	.1324	.1910	.1324	.1505

* statistical significant at 5% level
** statistical significant at 1% level

Table 6. Extension Model: Gaussian Mixture Model (GMM)

	Wage of Primary sector(log)			Wage of Secondary Sector(log)			Wage of Tertiary Sector(log)		
	1	2	3	1	2	3	1	2	3
Input of universities R&D(log)	.1574** (.0456)			.0756** (.0181)			.2081** (.0360)		
Input of research institutions R&D(log)		.1006** (.0128)			.0238** (.0079)			.0123 (.0103)	
Input of industrial enterprises R&D(log)			.0883** (.0308)			-.0044 (.0300)			.0535* (.0252)
GDP of primary sector(log)	.0883 (.0458)	.0409 (.0343)	.0843* (.0419)	.0085 (.0169)	.0285** (.0082)	.0323* (.0161)	.0565 (.0302)	.0560** (.0200)	.0707* (.0291)
GDP of secondary sector(log)	-.6058** (.0598)	-.3715** (.0590)	-.4720** (.0680)	-.1147** (.0245)	-.0946** (.0202)	-.0712 (.0378)	-.3619** (.0336)	-.3393** (.0287)	-.3264** (.0400)
GDP of tertiary sector(log)	-.1839* (.0767)	-.0940 (.0564)	-.1227 (.0639)	-.2129** (.0420)	-.2189** (.0401)	-.2158** (.0399)	.0792* (.0350)	.0854** (.0344)	.0818** (.0300)
GDP per capita (log)	-.1362* (.0568)	-.1457 (.0837)	-.1448* (.0719)	.1895** (.0662)	.1573*** (.0304)	-.1532** (.0402)	.1167** (.0177)	.1104** (.0242)	.0812** (.0217)
Enroll(log)	-.6259* (.2610)	-.4953* (.2143)	.6407* (.2692)	-.4598** (.0662)	-.4811** (.0655)	-.4882** (.0698)	-.3237* (.1534)	-.3169* (.1403)	-.3489* (.1528)
Graduate(log)	.4431* (.2085)	.3204 (.2010)	.4338 (.2323)	.3330** (.0541)	.3087** (.0557)	.3093** (.0558)	.1491 (.1249)	.1350 (.1350)	.1555 (.1303)
Population(log)	.1290** (.0451)	.0647 (.0583)	.0877 (.0619)	.0284* (.0132)	0.172* (.0083)	.0166** (.0060)	.1430** (.0107)	.1358** (.0100)	.1542** (.0106)

Female(log)	1.150** (.2519)	.8636** (.2700)	.9818** (.2806)	.1271* (.0612)	.1454** (.0472)	.1167 (.0641)	.1560 (.1133)	.1359 (.1261)	.1549 (.1016)
Employ(log)	-.8156** (.2626)	-.4508 (.2984)	-.6300* (.2960)	.2036* (.1030)	.1635* (.0833)	.1776 (.1091)	-.0963 (.0985)	-.0735 (.1164)	-.1333 (.0917)
Control R&D	.2467** (.0472)	.0800 (.0371)	.2278** (.0284)	-.0207 (.0302)	.0661** (.0183)	.0862** (.0119)	.0166 (.0243)	.2003** (.0358)	.1431** (.0217)
Constant	-6.476** (1.684)	5.724** (1.503)	4.945* (1.864)	.8360** (.4094)	.8698** (.3638)	8.929** (.3332)	7.891** (.7826)	-8.134** (.7790)	8.541** (.9060)

* statistical significant at 5% level
** statistical significant at 1% level

APPENDIX

Table A1. Introduction of Project 211 and Project 985

Peking University	Renmin University	Tsinghua University
Beihang University	Nanjing University	Xi'an Jiao Tong University
Beijing Institute of Technology	Beijing Normal University	Central South University
Central University for Nationalities	Chongqing University	Dalian University of Technology
East China Normal University	Huazhong University of Science AND Technology	Hunan university
Jilin University	Ocean University of China	Tianjin University
Tongji University	University of Electronic Science and Technology of China	Wuhan University
Xiamen University	Shandong University	Sichuan University
South China University of Technology	Southeast University	Sun Yat-sen University
Shanghai Jiao Tong University	University of Science and Technology of China	Zhejiang University
China Agricultural University	Lanzhou University	Nankai University
National University of Defense Technology	Northeastern University	Northwest A&F university
Northwestern Polytechnical University	Fudan University	Harbin Institute of Technology

Project 211: The State Council, Department of Finance and the Ministry of Education of China co-issued the General Plan for Project 211 in 1995 to strengthen selected higher education institutions and key disciplines. The Project started with 99 institutions and currently includes 112 universities.

Project 985: The State Council, and the Ministry of Education of China launched project in 1998 with the aim of building world-class universities. There are totally 39 institutions receiving approximately $ US 40.4 billion from central government and $US 28.4 billion from local government. Institutions of Project 985 are also included in the Project 211. See the list of institutions as below,

Table A2. Description of Variables and Data Sources

Variables	Sources	Description	Unit
Input of universities R&D	The Compilation of Scientific and Technological Statistics of Higher Education Institutions 2007-2107	Total input of colleges and universities R&D fund by region	RMB 1000
Input of research institutions R&D	China Statistical Yearbook on Science and Technology 2007-2017	Intramural Expenditure on R&D of R&D Institutions by Region	RMB 10,000
Input of industrial enterprises R&D	China Statistical Yearbook on Science and Technology 2007-2017	Intramural Expenditure on R&D in Industrial Enterprises above Designated Size by Region(2016)	RMB 10,000
Input of universities R&D basic research fund(log)	The Compilation of Scientific and Technological Statistics of Higher Education Institutions 2007-2107	Input of colleges and universities R&D basic research fund by region	RMB 1000
Input of universities R&D applied research fund(log)	The Compilation of Scientific and Technological Statistics of Higher Education Institutions 2007-2107	Input of colleges and universities R&D applied research fund by region	RMB 1000
Input of universities R&D experiment research fund(log)	The Compilation of Scientific and Technological Statistics of Higher Education Institutions 2007-2107	Input of colleges and universities R&D experiment research fund by region	RMB 1000
GDP of primary sector	China Statistical Yearbook 2007-2017	Gross regional product of the primary sector by region	RMB 100 million
GDP of secondary sector	China Statistical Yearbook 2007-2017	Gross regional product of the secondary sector by region	RMB 100 million
GDP of the tertiary sector	China Statistical Yearbook 2007-2017	Gross regional product of the tertiary sector by region	RMB 100 million

GDP per capita	China Statistical Yearbook 2007-2017	Per Capita Gross Regional Product	Per unit/RMB
Enroll	China Statistical Yearbook 2007-2017	Number of regular students enrolled in normal, short-cycle and higher education on region	Per person
Graduate	China Statistical Yearbook 2007-2017	Number of regular students graduates in normal, short-cycle and higher education on region	Per person
Population	China Statistical Yearbook 2017	Population at Year-end by Region	10,000 persons
Female	China Labor Statistical Yearbook 2007-2017	Female employment in urban units by registration status and region	Per person
Employ	China Labor Statistical Yearbook 2007-2017	Employment in urban units by registration status and region	1000 persons
Wage of Science	China Labor Statistical Yearbook 2007-2017	urban units on-post staff and workers average wage of scientific research and technical services	Unit RMB

Table A3. Description of Dependent Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Wage of the primary sector	341	26152.12	13557.71	6615	73394
Wage of the primary sector(log)	341	10.04	.5296	8.80	11.20
Wage of the secondary sector	341	39161.75	15540.11	14353.49	97273.05
Wage of the secondary sector(log)	341	10.49	.4105	9.57	11.49
Wage of the tertiary sector	341	47452.95	21856.56	16408.74	134673
Wage of the tertiary sector(log)	341	10.67	.4504	9.71	11.81
Wage of Science	341	54216.9	27642.04	16117	161394
Wage of Science (log)	341	10.77	.5127	9.688	11.99
Population of the primary sector	341	96284	139185	2621	649065
Population of the secondary sector	341	1895407	2033677	15257	11817040
Population of the tertiary sector	341	1775307	1174785	111419	6570644

Table A4. Description of Independent Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Input of universities R&D	341	678331.8	576089	1672	3782861
Input of universities R&D(log)	341	12.97	1.19	7.42	15.15
Input of research institutions R&D	341	456194.3	935039.1	3177	7301166
Input of research institutions R&D(log)	341	11.98	1.49	8.06	15.80
Input of industrial enterprises R&D	339	2146252	2966478	1162.1	1.68e+07
Input of industrial enterprises R&D(log)	339	13.72	1.59	7.06	16.63
Input of universities R&D basic research fund	341	225599.7	240738.7	1109	1788620
Input of universities R&D basic research fund(log)	341	11.77	1.25	7.01	14.40
Input of universities R&D applied research fund	341	364087.1	295382.7	302	1858605
Input of universities R&D applied research fund(log)	341	12.33	1.26	5.71	14.44
Input of universities R&D experiment research fund	341	88644.98	91423.69	0	522568
Input of universities R&D experiment research fund(log)	336	10.70	1.58	3.00	13.17
Colleges and universities R&D capital stock	310	1280454	981291.3	4022.8	6345227

Colleges and universities R&D capital stock(log)	310	13.68	1.08	8.30	15.66
Research institutions R&D capital stock	310	866043.2	1731717	8778.4	1.36e+07
Research institutions R&D capital stock(log)	310	12.66	1.46	9.08	16.43
Industrial enterprises R&D capital stock	306	4060711	5288885	3978.8	2.91e+07
Industrial enterprises R&D capital stock(log)	306	14.43	1.49	8.29	17.19
Input of colleges and universities R&D in the East China	110	975356.9	755743.8	20799	3782861

Table A5. Description of Control Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Population	341	4436.62	3492.58	285	44602
Population(log)	341	8.10	.8639	5.65	10.71
Female	341	1751361	1304052	62495	8200978
Female(log)	341	14.06	.9040	11.04	15.92
GDP of primary sector	341	1473.45	1147.87	50.9	4979.08
GDP of primary sector(log)	341	6.830	1.15	3.93	8.51
GDP of secondary sector	341	7777.47	7136.48	80.1	35109.66
GDP of secondary sector(log)	341	8.48	1.14	4.38	10.47
GDP of tertiary sector	341	7028.94	6969.29	160.01	42050.88
GDP of tertiary sector(log)	341	8.38	1.09	5.08	10.65
GDP per capita	341	38106.11	22600.52	5787	118198
GDP per capita(log)	341	10.38	.5905	8.66	11.68
Enroll	341	734837.2	467508.1	23327	1995880
Enroll(log)	341	8.17	.8977	5.14	9.89
Graduate	341	186503.9	125266.1	3846	509142
Graduate(log)	341	11.79	1.01	8.25	13.14

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