The Impact of Different Type of R&D Activities on Productivity Growth: An Empirical Analysis Based on Chinese Provincial Panel Data, 2000-2011

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Abstract--**This paper estimates the total factor productivity (TFP) of each province and analyzes the impact of different type of R&D activities on TFP based on Chinese provincial panel data over the periods of 2000-2011. We divide R&D inputs into basic research, applied research and development according to the type of activities. The results show that the impact of basic research and applied research on TFP is less than development. This paper also finds that the impact is diverse in different regions. In the eastern region, the impact of basic research and applied research on TFP is greater than development. While in central and western regions, the development on TFP growth is more significant. Human capitals and FDI have a positive effect on TFP, while the ownership structure has a negative effect.**

I. INTRODUCTION

R&D is an important way to promote technological progress and total factor productivity (TFP) growth and also an important indictor to measure the innovation capability. With the rapid growth of economy in China, governments and enterprises paid great attention on innovation. The R&D expenditures increased continuously and maintain sustained growth in recent years. In 2010, China's total R&D expenditures reached 706.26 billion, which were less than the United States, ranking second in the world. The R&D intensity (the ratio of R&D expenditures to GDP) also increases steadily. In 2012, China's R&D intensity was 1.98%, which was higher than the level of some developed countries. However, some research indicated that China's TFP growth was slowing down in recent years, and the growth rate of TFP declined [5]. Wang et al., (2006) also found that TFP had been decreasing science 1995 in China [17]. The reasons of decreasing trend of TFP growth called for further research. Why the growth of R&D funding has no substantial impact on TFP?

R&D activities can be divided into basic research, applied research, and experimental development. There are some distinct differences among various types of R&D activities. Basic research, applied research are sources of technological progress without any commercial purposes. Experimental developments are the invention of new materials, new products, or optimization of products and services, which directly contributes to the growth of productivity. Though R&D expenditures continued to increase in China, the basic research intensity (the ratio of basic research expenditures to GDP) was significantly lower than developed countries, and even lower than some developing countries. The basic research intensity in 2012 was 0.096%, while the average level in developed countries was 0.46%. Moreover, the proportion of basic research, applied research to total R&D expenditures has appeared descending: the proportion of basic research, applied research decreased from 5.96% and 20.37 % in 2004 to 4.8% and 11.3% in 2012. Experimental development expenditures accounted for the vast proportion.

R&D is the key driving force for TFP. But there are significant differences about the influencing mechanisms to TFP among various types of R&D activities. Basic research and applied research are usually done by universities and research institutes. The research periods are very long. They will have an obvious effect on productivity if the research achievements were transformed into practical technologies successfully. Experimental developments are usually done by enterprises with relatively shorter cycles, and they will have a significant promotion on the development of a single firm or an industry, but with limited influences on a region's long-term productivity.

China's TFP growth is slowing down. Whether it is caused by the decline of the ratio of basic research and applied research? What is the difference about the impact of different types of R&D activities on TFP? Whether China must attach great importance to basic research at the present stage? What is the reasonable proportion of R&D inputs which matched with its own technological capabilities for different regions? These are important issues worthy arguing about for enhancing the indigenous innovation capabilities. More efforts should be made to improve technological progress continuously. Using Chinese provincial panel data from 2000 to 2011, this paper calculates the TFP of China's 30 provinces with the method of Solow residuals (Tibet is omitted because of the vacancy of some data) . Then this paper explores the effects of different types of R&D activities on TFP growth.

The remainder of this paper is organized as follows. The following section presents literature review. The third section introduces the theoretical model and analysis method. The fourth section introduces data and variables. It is then followed by the empirical analyses and results section. The last section is discussion and conclusion.

II. LITERATURE REVIEW

Recently, using TFP growth as a reflection of technological progress has been widely concerned by academic research [6]. The results show that since the reform and opening up, China's TFP growth maintain a rapid growth in a period. However, after 1990s, the TFP growth is slowing down [17], or even became a negative growth [5]. Yet a Chinese scholar, Yi et al., [22] provided four facts that there existed increasing efficiency in China economic growth. Further, for the particularity of emerging economies, Yi et al.,

[22] pointed out that the analytical framework of TFP was different from that of developed countries.

The purpose of R&D activities is to promote technological progress and advance innovation. Currently, many studies demonstrated that R&D was the main driving force of technological progress and TFP growth. Klette & Griliches [7] verified the relationship between firm's R&D inputs and productivity based on the theory of endogenous growth. They considered that R&D inputs can promote production efficiency. Guellec & Potterie [4] found that the R&D of industrial sector, public sector and foreign companies jointly promote a country's economic growth using panel data of 16 OECD countries from 1980 to 1998. Wu [18] investigated the relationship between R&D and productivity by using the data on the four digital manufacturing industries in China. He found that R&D had significant positive effects on productivity using data of China's manufacturing industry [18].

Currently there are many empirical studies about what are the determinants of TFP and the relationship of R&D activities and TFP changes. However, for the impact of different types of R&D activities on TFP still do not get enough attention. Mansfield [13] found that basic research had a greater impact than applied research on TFP using micro data. Basic research plays an important role in improving the original innovation capabilities, and therefore promotes economic growth and social development eventually. Xiao [20] raised and demonstrated three hypotheses about the proportion of basic research investment to R&D investment based on international experiences, especially the related data of USA in the past 50 years. Combining with practice of China, Xiao [20] also forecasted the proportion of basic research investment to R&D funding of China in the years of 2002~ 2020.

In addition to R&D activities, other factors also have impacts on technological progress and TFP growth. Romer [14] and Mankiw [12] considered the stock of human capital as a major factor in improving TFP growth. They considered that TFP growth depended primarily on the level of human capitals of the country. Lai et al., [10] discussed the inner mechanism of the impacts on economic growth of human capital, domestic R&D and the spillover effects of foreign R&D in an open economy. Foreign direct investment (FDI) was important to facilitate economic development and technological progress [1] [9] [16]. Relevant research results also showed that TFP of an open economy was affected by FDI.

The research about the impact of different types of R&D activities on TFP is still a vacancy. Does inadequate basic research become the main reason of TFP growth declination in China? What's more, the calculation of TFP in extant research is not satisfactory. TFP growth is negative in most of fast developing economies, which doesn't in accordance with the facts of obvious technological progress in those areas. Therefore, the method of TFP calculation should be improved. Yi et al., [22] pointed that the emerging economy differs from the developed economy in TFP calculation. This paper calculates TFP of 30 provinces in China using empirical data in periods of 2000-2011.We divide R&D investments into basic research, applied research and experimental development to explore the differences of the impact of various types of R&D activities on TFP.

III. THEORETICAL MODEL AND ANALYSIS METHOD

A. Theoretical model

Based on the expansion of the Cobb - Douglas production function, the R&D production function in this paper is set on the following form:

$$Q_{it} = A_{it} F(K_{it}, L_{it}) \tag{1}$$

Where t denotes time, i denotes province, Q_{it} is GDP, K_{it} is input of capital and L_{it} input of labor, A_{it} means TFP. A_{it} is affected by R&D inputs, and some other factors. Due to the significant differences about the impact of various types of R&D activities on TFP, this paper divides R&D inputs into basic research, applied research and experimental development, and calculates R&D capital stocks correspondingly. Therefore, equation (1) is converted to:

$$A_{it} = Q_{it} / F(K_{it}, L_{it}) = BR_{it}^{\alpha_1} AR_{it}^{\alpha_2} D_{it}^{\alpha_3} \Pi X_{ijt}^{\alpha_j} \tag{2}$$

Where BR_{it}, AR_{it}, D_{it} denote the R&D capital stocks of basic research, applied research and experimental development respectively. $\alpha_1, \alpha_2, \alpha_3$ denote the output elasticity of basic research, applied research and experimental development. Take logarithm on both sides of (2) , so that:

$$\ln(TFP) = \alpha_1 \ln(BR_{it}) + \alpha_2 \ln(AR_{it}) + \alpha_3 \ln(D_{it}) + \sum_j \alpha_j \ln(X_{ijt}) \tag{3}$$

Referring to literatures, other factors influencing total factor productivity (TFP) include:

(1) Human capital (H) . Borensztein et al. [1] proved that human capitals play an important role in improving absorption capacity. Lai et al., [10] used the indictor average years of education to measure the level of human capital. Xia [19] used the proportion of scientific and technical personnel to employees to measure the level of human capital. Many research verified that human capital are important factors for efficiency improvement and economic growth [10] [17] [19].

(2) Foreign Direct Investment (FDI) . Economic growth or total factor productivity (TFP) are also affected by foreign direct investments. Some scholars found that FDI was important to facilitate economic development and technological progress [1] [8] [9] [16].

(3) Ownership structure (G) . Jefferson et al., [6] found a significant negative correlation between the proportion of state-owned assets and productivity using the data of 22,000 Chinese large and medium industrial enterprises from 1994 to 1999. Wang et al., [17] found that the proportion of state-owned assets was harmful to productivity and it would increase production uncertainty.

Therefore, human capitals, foreign direct investments and ownership structure are included in the analytical model. Besides, this paper takes into account some unobservable factors. These factors are the regional effects which don't change with time, period effects which don't vary with regional variations, as well as random effects. So the theoretical model is:

$$\ln(TFP) = u_i + \lambda_t + \alpha_1 \ln(BR_{it}) + \alpha_2 \ln(AR_{it}) + \alpha_3 \ln(D_{it}) + \alpha_4 \ln(H_{it}) + \alpha_5 \ln(FDI_{it}) + \alpha_6 \ln(G_{it}) + \varepsilon_{it} \tag{4}$$

Where $\alpha_i (i = 1, \cdots, 6)$ denotes elasticity of the corresponding variable on TFP, and u_i, λ_t denote regional effects and time effects, ε_{it} denotes the random effects. Also, because of the similarity of basic research and applied research, this paper merges two types in order to avoid the multicollinearity. Thus we get model (5) :

$$\ln(TFP) = u_i + \lambda_t + \alpha_1 \ln(BR_{it} + AR_{it}) + \alpha_2 \ln(D_{it}) + \alpha_3 \ln(H_{it}) + \alpha_4 \ln(FDI_{it}) + \alpha_5 \ln(G_{it}) + \varepsilon_{it} \tag{5}$$

B. TFP calculation method

Currently, there are a variety of methods to calculate TFP. What is widely used is Solow residual method [21] [11] and non-parametric statistical analysis [25]. This paper uses Solow residual method to calculate TFP.

To use Solow residual method, it is necessary to calculate the elasticity of labor and capital on output at first. This paper uses average output elasticity of labor (0.6054) as that of each province, and the calculated result is similar to Young [23] and Ye [21].

IV. DATA AND VARIABLES

A. Data

The data used in this paper all come from "Chinese Science and Technology Statistical Yearbook", "Chinese Statistical Yearbook". And in order to maintain the consistency of the data, this paper selects the provincial panel data from 2000 to 2011.

B. Variables

(1) Total factor productivity (TFP) . In this paper, to calculate total factor productivity (TFP) , we use GDP (Q_{it}) as the output variable, and number of employees (L_{it}) and fixed capital stock (K_{it}) are used as input variables. To acquire real GDP, this paper deflates the nominal GDP by the price deflators, of which the base period is 2000.

This paper estimates the fixed capital stock using Cuneo & Mairesse's classical estimation method, that is the perpetual inventory method [2]. The estimation formula is:

$$K_{it} = I_{it} / P_t + (1 - \delta_t) K_{i,t-1} \tag{7}$$

Where K_{it} denotes actual fixed capital stock, P_t denotes the price index of investment in fixed assets, I_{it} denotes gross capital formation. To avoid double-counting the R&D capital, this paper will deduct the R&D capital from I_{it}. δ_t is the depreciation rate of fixed capital. This paper takes the depreciation rate of 9.6% and uses fixed capital stock of 2000 as the data of base year according to Chinese provincial capital stock calculated by Zhang et al. [24].

(2) R&D capital stock. Due to the availability of data, the paper selects R&D expenditures to represent R&D inputs. And we divided R&D expenditures into basic research, applied research and experimental development.

Similarly, this paper calculates R&D capital stock with Cuneo & Mairesse's perpetual inventory method [2]. The estimation formula is:

$$RD_{it} = E_{it} + (1-\delta) RD_{i(t-1)} \tag{8}$$

Where RD_{it} denotes the R&D capital stock, E_{it} denotes discounted R&D expenditures. R&D capital stock of the base year (2000) is calculated in accordance with the formula $RD_{i0} = E_{i0} / (g + \delta)$, g is the average annual growth rate of R&D expenditures within the period of 2000-2011. δ is the depreciation rate of R&D capital. This paper selects the depreciation rate of 15% with the reference to Griliches & Lichtenberg [3]. R&D expenditures are deflated by R&D price index to eliminate the impact of the price. Referring to Zhu & Xu [26], this paper takes the weight with the consumer price index and the price index of investment in fixed assets as 0.55 and 0.45 respectively to calculate R&D price index.

(3) Foreign Direct Investment (FDI) . For the data of foreign direct investments, this paper converts values in U.S. dollars to RMB based on exchange rate of current period. And then this paper discounts the amount of FDI by the consumer price index using the year of 2000 as the base period to eliminate the impact of price.

(4) Other variables. This paper uses the proportion of R&D personnel to total employees to measure the level of human capitals of each province. And this paper uses the proportion of state-owned enterprises output values to total output values of industrial enterprises to measure the ownership structure. Specially note that due to incomplete data in Tibet, the analysis will not take Tibet into consideration, and the research objects consist of 30 provinces in mainland.

C. The calculation results of TFP in China and each province from 2000 to 2011

This paper calculates TFP value of each province and national level using Solow residual method from 2000 to 2001. And then we calculate the average TFP and average growth rate. Results are shown in Table 1.

TABLE 1 TFP AND AVERAGE GROWTH RATE OF EACH PROVINCE IN CHINA FROM 2000 TO 2011

Province	TFP AVERAGE	TFP average growth rate	Province	TFP AVERAGE	TFP average growth rate
Beijing	2.36	4.12%	Chongqing	1.06	6.54%
Tianjin	2.63	7.05%	Sichuan	1.03	6.18%
Hebei	1.40	6.09%	Guizhou	0.69	6.76%
Shanxi	1.37	6.35%	Yunnan	1.04	4.23%
Inner Mongolia	1.71	7.95%	Shanxi	1.15	9.19%
Liaoning	1.79	4.14%	Gansu	0.95	4.69%
Jilin	1.53	4.69%	Qinghai	1.05	7.70%
Heilongjiang	1.55	4.46%	Ningxia	1.05	7.40%
Shanghai	3.03	4.46%	Xinjiang	1.39	5.37%
Jiangsu	1.88	5.67%	2000	1.07	-
Zhejiang	1.74	4.36%	2001	1.10	3.11%
Anhui	1.01	6.24%	2002	1.15	4.39%
Fujian	1.63	3.95%	2003	1.22	6.22%
Jiangxi	1.15	5.80%	2004	1.31	7.02%
Shandong	1.62	5.91%	2005	1.39	6.55%
Henan	1.09	5.82%	2006	1.48	6.24%
Hubei	1.36	4.95%	2007	1.56	5.41%
Hunan	1.17	6.19%	2008	1.67	7.30%
Guangdong	2.07	4.31%	2009	1.70	1.56%
Guangxi	1.01	5.30%	2010	1.83	7.74%
Hainan	1.21	5.18%	2011	1.93	5.61%
			Total average	1.45	5.56%

Table 1 shows the average level of TFP and average growth rate of each province from 2000 to 2011. In view of the variation tendency of TFP, China's TFP increase significantly from 1.07 in 2000 to 1.93 in 2011 with an average growth rate of 5.56% per year. However, the growth rate in 2009 decreased to 1.56%, the reason for which is governments' large investments on fixed assets to make response to the financial crisis.

For the provinces, there are significant regional differences about the average TFP and average growth rate of TFP. The average value of TFP in eastern coastal regions is higher (1.94) ; while the average growth rate of TFP is lower (5.02%) . On the contrary, the average value of TFP in inland areas is lower (1.18) , while the average growth rate of TFP is higher (6.09%) .

V. EMPIRICAL ANALYSES

A. Panel data stationary test (unit root test)

In order to avoid spurious regression and to ensure the validity of the estimation results, we should perform panel data stationary test first. That is unit root test. The methods for panel data unit root test are: LLC test, Breitung test, Hadri test, Im-Pesaran-Skin test, Fisher-ADF test and Fisher-PP test. The first three are the unit root test in the case of a same root, while the last three are performed in the case of a different root. Results of panel data unit root test are shown in Table 2.

TABLE 2 RESULTS OF PANEL DATA UNIT ROOT TEST

	IPS	*ADF-Fisher*	conclusion
$\ln(TFP)$	8.38 (1.00)	18.9 (1.00)	non-stationary
$\Delta\ln(TFP)$	-10.64 (0.00) ***	207.40 (0.00) ***	stationary
$\ln(AR)$	0.94 (0.78)	73.93 (0.12)	non-stationary
$\Delta\ln(AR)$	-4.06 (0.00) ***	107.03 (0.00) ***	stationary
$\ln(BR)$	2.58 (1.00)	55.23 (0.65)	non-stationary
$\Delta\ln(BR)$	-5.83 (0.00) ***	134.26 (0.00) ***	stationary
$\ln(D)$	5.79 (1.00)	33.10 (1.00)	non-stationary
$\Delta\ln(D)$	- 4.47 (0.00) ***	113.40 (0.00) ***	stationary
$\ln(H)$	7.13 (1.00)	14.47 (1.00)	non-stationary
$\Delta\ln(H)$	-12.52 (0.00) ***	242.93 (0.00) ***	stationary
$\ln(FDI)$	-0.66 (0.26)	72.69 (0.13)	non-stationary
$\Delta\ln(FDI)$	-8.44 (0.00) ***	177.25 (0.00) ***	stationary
$\ln(G)$	4.65 (1.00)	45.11 (0.92)	non-stationary
$\Delta\ln(G)$	-6.20 (0.00) ***	140.96 (0.00) ***	stationary

Note: Δ represents a first-order difference of variable;
***, ** and * denote that the value of the test statistic is significant at the 1%, 5% and 10% significance level respectively, values in brackets are the probabilities accomplishing with the corresponding test statistics

Table 2 shows that probabilities of all IPS test statistic and ADF-Fisher test statistic are larger than 0.1, and the null hypothesis that a unit root exists can't be rejected, which indicates that the original sequence is non-stationary. However, after performing the first-order difference to original sequence, null hypothesis that a unit root exists can be rejected because the probabilities of IPS test statistic and ADF-Fisher test statistics are less than 0.05, which indicates that the first-order difference sequence of all variables are stationary at the 0.05 level of significance. The results in Table 2 show that the original data are I (1) sequence, they are integrated of order, which meet the requirements of cointegration test on variable stationary.

B. Cointegration test of panel data

Since ln (TFP) , ln (AR) , ln (BR) , ln (D) , ln (H) , ln (FDI) , ln (G) are all first-order single integrated variables, so the panel data can be performed cointegration test. Firstly, we establish the regression model of panel data, and then perform unit root test for the residuals of the regression equation of each section.

Estimation results of fixed effects model with variable coefficients of the panel data are as follows:

$$\ln(TFP) = \underset{}{-0.4998} + \underset{(1.77)}{0.0154\ln(BR)} + \underset{(9.74)}{0.1215\ln(AR)} + \underset{(8.93)}{0.1006\ln(D)} + \underset{(3.12)}{0.0433\ln(H)} + \underset{(6.76)}{0.0369\ln(FDI)} - \underset{(-1.86)}{0.0148\ln(G)} + \hat{\mu}$$

R^2=0.99 DW=1.5678

The determinant coefficient R^2 is 0.99, which indicates the goodness of fit of the model is quite well; the DW statistic is 1.5678, it is close to 2, indicating that there is no first-order autocorrelation.

If these variables are cointegrated, the regression residuals of the model should be stationary. The results of unit root test on regression residuals are shown in Table 3.

Table 3 shows that statistics of LLC, ADF-Fisher,PP-Fisher test are all significant at the 0.1 level. The null hypothesis that "residual of the regression equation of each section has a unit root" can be rejected at the 0.1 level of significance. Therefore, these residual sequences are stationary, it indicates that there are cointegrations between ln (TFP) and ln (AR), ln (BR), ln (D), ln (H) , ln (FDI), ln (G) .

C. Parameter estimation

As we know, panel data has fixed effects and random effects in sections and time. For the length of time we selected was 11 years, which is significantly less than the number of provinces, we consider the individual effects. This paper presents the likelihood ratio test and Hausman test to determine which model is suitable, the mixed model, the fixed effects model or random effects model. Likelihood ratio test can detect the model for the mixed model or individual fixed effects. Hausman test can detect whether the model is random effects model or the fixed effects model.

TABLE 3 RESULTS OF COINTEGRATION TEST

variable	*LLC*	*ADF-Fisher*	*PP-Fisher*	conclusion
$\hat{\mu}$	-2.5250 (0.0058) ***	75.1764 (0.0896) *	80.4145 (0.0404) **	stationary

Note: ***, ** and * denote that the value of the test statistic is significant at the 1%, 5% and 10% significance level respectively, in brackets are the probabilities accomplishing with the corresponding test statistics.

TABLE 4 REGRESSION RESULTS OF 30 PROVINCES IN CHINA

variable	Model 1	Model 2
C	-0.4998 (-5.63) ***	-0.6548 (-7.35) ***
$\ln(BR)$	0.0154 (1.77) *	
$\ln(AR)$	0.1215 (9.74) ***	
$\ln(BR+AR)$		0.1279 (12.12) ***
$\ln(D)$	0.1006 (8.93) ***	0.1153 (11.12) ***
$\ln(H)$	0.0433 (3.12) **	0.0294 (2.19) **
$\ln(FDI)$	0.0369 (6.76) ***	0.0397 (7.17) ***
$\ln(G)$	-0.0148 (-1.86) *	-0.0106 (-0.60)
R^2	0.99	0.99
F	1032.61***	1047.75***
LR	214.5***	213.83***
Hausman	119.18***	129.29***

Note: ***, ** and * denote that the value of T statistic is significant at the 1%, 5% and 10% significance level, in brackets are the probabilities accomplishing with the T test statistics.

1) Analysis in national level

In the following regression analysis, model 1 in Table 4 is the basic model. In model 2 we merge capital stocks of basic research and applied research as an independent variable to partially eliminate the multicollinearity problem. The regression results are shown in Table 4.

By Table 4, LR statistic of model 1 and model 2 both reject the null hypothesis of mixed model, Hausman statistic also reject the null hypothesis of individual random effects. So the model is determined as individual fixed effects model.

By Table 4, model 1 shows that basic research, applied research and experimental developments all have a positive and significant effect on TFP, but the elasticity of basic research on TFP (0.0154) was significantly less than that of applied research (0.1215) and experimental development (0.1006) . The results are in contrast with Mansfield's view [13]. In examining the status of basic research and applied research in China, it is found that since the reform and opening up, less major basic research achievements came into being. Moreover the transformation efficiency of scientific and technological achievements into real productive forces is not so good. Therefore the impact of basic research on TFP is less than the applied research and experimental developments.

Further, in model 1, the elasticity of human capitals on TFP is 0.0433, indicating that human capitals play a significant role in promoting TFP. Foreign direct investments also have significantly impact on TFP, and the elasticity is 0.0369. Ownership structure has a negative effect on TFP with the elasticity -0.0148, which is significant at 0.1 significance level. The result indicates that inefficient state-owned assets will hinder the growth of TFP.

In the estimation results of model 2, the basic and applied research elasticity on TFP is 0.1279, slightly higher than the experimental development elasticity (0.1153) . While human capitals play a significant role in promoting TFP with the elasticity of 0.0294. Foreign direct investments have a positive effect on TFP, and the elasticity is 0.0397. Ownership structure has a negative effect on TFP with an elasticity of -0.0106, but not statistically significant.

2) Analysis in the regional level

As the eastern coastal and inland areas are at different stages of economic development, and there are significant difference in economic growth mode and type of R&D activities at different stages of economic development. Therefore, this paper divides 30 provinces into eastern coastal and inland areas, and then investigates how these variables affect TFP respectively. The regression results are shown in Table 5.

By Table 5, LR statistic of eastern coastal and inland regions both reject the null hypothesis of mixed model, Hausman statistic also reject the null hypothesis of individual random effects. So the model is determined as individual fixed effects model.

By Table 5, for eastern coastal areas, the elasticity of basic research and applied research on TFP is 0.1566, significantly larger than the elasticity of experimental development on TFP (0.0688). This indicates that with the economic and technological development in eastern coastal areas, basic research and applied research play a more important role in technological processes, which is consistent with the results of literatures [13]. Therefore, this indicates that to some extent, the way of technological progress in eastern coast has been different from that in inland.

Human capitals and foreign direct investments play a significant role in promoting TFP and the elasticity on TFP are 0.0274 and 0.0393 respectively. However, ownership structure has a negative impact on TFP, but the effect is not statistically significant.

For inland areas, the elasticity of basic and applied research on TFP is 0.1002 which is significantly less than that of experimental development (0.1681) , indicating that the TFP growth in inland areas mainly depends on development currently. Meanwhile it also illustrates that the ways of economic development in central and western regions are different from that in the eastern coastal areas.

TABLE 5 REGRESSION RESULT OF EASTERN COASTAL AND INLAND AREAS

variable	Eastern coastal	inland
C	-0.4841 (-3.35) **	-0.6220 (-4.43) ***
$\ln(BR+AR)$	0.1566 (9.95) ***	0.1002 (7.47) ***
$\ln(D)$	0.0688 (5.37) ***	0.1681 (11.13) ***
$\ln(H)$	0.0274 (1.97) *	0.0654 (3.07) **
$\ln(FDI)$	0.0393 (3.08) **	0.0190 (2.71) *
$\ln(G)$	-0.0029 (-0.12)	-0.0243 (-1.89) **
R^2	0.99	0.98
F	605.01***	518.36***
LR	175.94***	210.62***
Hausman	28.80***	94.86***

Note: ***, ** and * denote that the value of T statistic is significant at the 1%, 5% and 10% significance level, in brackets are the probabilities accomplishing with the T test statistics.

Further, both human capital and FDI play a significant role in promoting TFP, and the elasticity on TFP are 0.0654 and 0.0190 respectively. Elasticity of human capital on TFP in inland areas is greater than that in eastern coastal areas, which indicates that currently, compared with eastern coastal areas, there's a greater demand for human capitals in inland areas, and rich human capitals play an important role in promoting technological progress in inland areas. Similarly, the ownership structure inhibits TFP significantly.

VI. CONCLUSIONS

This paper uses the method of revenues share to calculate the output elasticity of labor α and capital β .Then this paper calculates TFP in each province in China from 2000 to 2011. This paper empirically analyzes the impact of different types of R&D activities on TFP based on Chinese provincial panel data from 2000 to 2011. The results show that:

(1) The impact of basic research and applied research on TFP is less than that of experimental development in China at the present stage

There lacks major innovations in basic research and applied research in China at the present stage. Moreover the efficiency of transformation of scientific and technological achievements into productivity is relatively low. Therefore basic research and applied research have less impact on TFP. In recent years, though China's R&D inputs increase at an annual rate of 20%, investments in basic research and applied research are still relatively inadequate. In order to keep up with the rapid pace of technology change and adapt to the global competitive environment, it is important for China to intensify basic research and applied research.

(2) Basic research, applied research and experimental development have different impact on TFP in different periods of economic development

The results of sub-region analysis show that basic research and applied research in eastern region contribute significantly to TFP growth and the impact of the research are greater than that of experimental development. While in inland areas the experimental developments have greater impact than basic and applied research on TFP. This result shows that there are significant differences in technological progress in those regions where economic and technological development are at different stages. The proportion of investments in basic and applied research should be accordance with the stage of economic development.

At the present stage, encouraging technological innovation especially original innovation is the main way for eastern coastal areas to make technological progress. With the characteristics of high risks, long-term periods, and considerable complexity for basic research, this needs a great deal more attention. Meanwhile, inland areas should pay more attention to the transformation of scientific research, and then increase investment efforts in experimental development to promote TFP growth and technological progress.

(3) Human capitals play an important role in technological progress and TFP growth

Investments in human capitals can not only improve the quality of workers, it also enhances a nation or region's absorptive capacity of foreign advanced technology, thereby promote economic growth. Therefore, at the present stage China should increase investments in human capital, especially in education in central and west regions.

(4) Foreign direct investments have a significant role in promoting TFP

As a developing country, China is facing a shortage of economic resources, especially lack of R&D resources. Therefore, it is still important for China to attract FDI and increase absorptive capacity to make full use of spillover effects and foreign advanced technology. Combining with increasing domestic R&D inputs and indigenous innovation capabilities, FDI and domestic investments boost economic development and technological progress mutually.

(5) The proportion of state-owned economy has a negative effect on TFP growth

This inhibition is largely due to the low efficiency of state-owned economy which led regional total factor productivity to a low level. Therefore the reform of state-owned economy and increasing the proportion of non-state-owned economy will play an important role in China's economic and social development.

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