Determinants of the Chinese TFP: National & Regional Level

By

Doowon Lee[1]
(School of Economics, Yonsei University, Seoul, Korea)

Abstract

The high growth rate of the Chinese economy is puzzling in many senses. One of the areas the Chinese economy differs from the other emerging economies is the rapid rise of the Chinese TFP (total factor productivity). This paper aims to estimate the TFP of the Chinese economy in the national and regional level, using the method introduced in the existing literature. This paper finds out that TFP of each region fluctuate over time, and there are substantial differences among TFPs of regions. In order to explain for these fluctuations and differences, this paper tries to find out determinant factors of regional TFP by using panel analysis. The explanatory variables used in this analysis are taken from the existing literatures. They are FDI inflow, export volume, educational level, and research capacity of each region. It is the author's hypothesis that there would be positive correlation between TFP of each region and these explanatory variables. As a result of the panel analysis, the author finds out that education level, number of scientific researchers, and FDI inflow ratio are the major determinant factors of regional TFP in China.

[1] Please forward your inquiry to Professor Doowon Lee, School of Economics, Yonsei University, Seoul, Korea. The address is 262 Seongsanno, Seodaemun-gu, Seoul, 120-749, Korea. The day time telephone number is 82-2-2123-2489, and the fax number is 82-2-313-2893. E-mail address is leedw104@yonsei.ac.kr .

I. Introduction

The sustainable long-run high growth of the Chinese economy is puzzling in many senses. With respect to capital accumulation both in physical and human capital, China has outperformed most of the other developing economies. What is more puzzling, however, is the rapid speed of technological progress. When technological progress is measured in terms of TFP (total factor productivity), China shows a clear distinction from the other emerging economies. Economic literatures on economic growth assume that a country's economic growth depends on three factors of production, which are labor, capital, and technology. Using growth accounting, we can see how much each of these three factors has contributed to GDP growth of a certain country. Generally speaking, emerging economies rely more on physical inputs such as labor and capital, while more advanced economies rely more on technological progress measured by TFP. Based on this observation, Krugman (1994) criticized that growth of East Asian NIEs (newly industrialized economies) relied too much on perspiration such as hard labor and massive accumulation of capital and too little on inspiration such as TFP growth.

However, unlike the criticism of Krugman (1994), China has relied not only on massive accumulation of labor and capital inputs but also on rapid rise of TFP. As it is analyzed by Young (1995), the so-called four tiger economies of Korea, Taiwan, Singapore, and Hong Kong relied more heavily on massive input of labor and capital than on TFP. From the period of 1966 to the early 1990s, the average growth rates of TFP for these economies were around 2% per year.[2] As the average GDP growth rates of these economies were around 9% during the observed time period, TFP growth can account for 20 to 25% of the GDP growth rates for these economies. On the other hand, many existing literatures show that the contribution of TFP growth to GDP growth in the Chinese economy is much larger than those of the four East Asian NIEs. For example, Ezaki and Sun (1999) estimated the Chinese TFP growth rate at around 3 to 4%, and concluded that TFP growth was accounting for approximately 40% of the Chinese GDP growth during 1981-1995 periods. A well documented summary of Crafts (1998) also illustrates this point. Using results of existing literatures, Crafts (1998) show that TFP growth used to contribute approximately 40 to 60% of GDP growth in OECD countries in the 1950s and 1960s when these economies were growing relatively fast. On the other hand, for most of the developing economies, TFP growth

[2] According to Young (1995), the average TFP growth rates for Hong Kong, Singapore, Korea, and Taiwan were 2.3%, 0.2%, 1.7%, and 2.1% respectively.

contributed approximately 20% of GDP growth from 1960 to 1994.[3] However, China was an exception in this study as well. Using the study of Collins and Bosworth (1996), Crafts shows that Chinese TFP growth during the period of 1984 to 1994 was 4.6%, which was accounting for approximately 43% of the Chinese GDP growth.

The aim of this paper is to calculate TFP growth rate of the Chinese economy in the national and regional level by relying on the method used by Ezaki and Sun (1999). Ezaki and Sun (1999) has estimated national and regional TFP of China from 1981 to 1995, and this paper aims to extend this estimation up to 2005 with more updated and improved data. Furthermore, this paper aims to find out the determinant factors of regional TFP of China using explanatory variables such as trade, FDI (foreign direct investment) inflow, and indices that represent human capital level of each region. By estimating the Chinese national and regional TFP, this paper can identify the distinctive pattern of the Chinese growth. Also, by finding out determinant factors of TFP in each region, this paper can provide policy implications for TFP improvements not only for China but also for the other emerging economies.

II. TFP Estimation Model, Data, and Results

II.1. Estimation Model

In estimating TFP growth, this paper follows the way used by Ezaki and Sun (1999). Following the general definition of growth accounting, growth in real GDP (GY) can be decomposed as equation (1).

(1) $GY = \omega\, GL + (1 - \omega)\, GK + GT$

Equation (1) is the growth accounting identity where G denotes growth rate and Y, L, K, T, ω denotes real GDP, labor, real capital stock, TFP, and labor income share respectively. In order to estimate equation (1), we need capital accumulation identity such as equation (2).

(2) $GK = I / K - \delta$

Where I denotes real investment and δ denotes depreciation rate.

[3] Refer to Table 5 of Crafts (1998).

Using equation (1) and (2), we can define the relationship between capital stock (K) and investment flow (I) like the following equation (3).

(3) $K = [\ (1 - \omega) / (\ GY - \omega\ GL - GT + (\ 1 - \omega)\ \delta)\ ] \cdot I$

Ezaki and Sun (1999) has calculated the level of real capital stock at the mid-point of the target period, which is mid-year of 1988 as the target period is 1981-1995. Using this data of real capital stock at the mid-year of 1988 as K(t), Ezaki and Sun has calculated real capital stock before and after 1988 using equation (4) and (5).

(4) $K(t+1) = (1 - \omega)\ K(t) + (\ I(t) + I(t+1)\ ) / 2)$
(5) $K(t-1) = [\ K(t) - (\ I(t) + I(t-1)\ ) / 2\ ] / (1 - \omega)$

This paper has basically followed the method used by Ezaki and Sun (1999) to extend the estimation of TFP growth rates up to 2007. Furthermore, this paper also improves the estimation by using more realistic data for ω. In the work of Ezaki and Sun (1999), they used the average ω value of 1993-1995, which is 0.515, as the proxy for the whole target period of 1981-1995. However, this paper has calculated ω for each year, and applied this value in estimating TFP growth rates from 1996 to 2007. This estimation model is used in calculating both national and regional TFP growth rates of China. The time period for the national TFP growth estimation is from 1981 to 2007. Due to the lack of data, however, the time period for the regional TFP growth is from 1989 to 2005.

II. 2. The Data

The growth rates of real GDP (GY) for the Chinese national and regional economies are obtained from the *China Statistical Yearbook* (various years). In order to estimate equations (4) and (5), we need to obtain real investment data (I(t)). Real investment data of each year is calculated by using nominal investment data (total investment in fixed assets in the whole country and in each region) and price indices (with the base year of 1995) of investment in fixed assets in the whole country and in each region. Also, ω for each year is calculated by dividing payment for labor over GDP. Finally, in order to calculate GL, this paper used number of employed persons at the year-end in the whole country and in each region. All of these data are obtained from the *China Statistical Yearbook* (various years). In calculating regional real capital stock, we found that Zhang, Wu, and Zhang (2007) has used the same method as described above. Therefore, this paper used the data estimated by Zhang, Wu, and Zhang (2007) for regional real capital stock.

II. 3. Estimation Results

First, this paper extended the national TFP growth rates estimation done by Ezaki and Sun (1999) with improved estimation of ω for the period of 1996 to 2007. The result of this estimation is summarized in Table 1.

Table 1. Estimation of National TFP Growth Rates (1981 – 2007)

Year	Growth Rates (%)					Real Capital Stocks (billion RMB)
	GDP	ω	Labor	Capital	TFP	
1981	5.2	0. 515	3.2	7.4	-0.1	2908.2
1982	9.3	0. 515	3.6	8.2	3.4	3146.2
1983	11.2	0. 515	2.5	9.6	5.3	3447
1984	15.3	0. 515	3.8	10.8	8.1	3819.6
1985	12.9	0. 515	3.5	12.8	4.9	4307.1
1986	8.9	0. 515	2.8	13.8	0.7	4900.8
1987	11.6	0. 515	2.9	13.8	3.4	5575.3
1988	11.3	0. 515	2.9	13.5	3.2	6326.5
1989	4.1	0. 515	1.8	10.5	-2	6989.8
1990	3.8	0. 515	2.6	7.4	-1.1	7504.3
1991	9.2	0. 515	2.9	7.1	4.3	8035.9
1992	14.2	0. 515	1.9	8.5	9.2	8717.5
1993	13.5	0. 515	1.3	10.7	7.6	9652.5
1994	12.7	0. 515	2.1	12.4	5.6	10846.1
1995	10.6	0. 515	1.5	12.6	3.7	12218
1996	9.6	0. 533	1.3	12.3	3.2	13721.9
1997	8.8	0. 528	1.3	11.7	2.6	15330.2
1998	7.8	0. 531	1.2	11.6	1.7	17103.6
1999	7.1	0. 524	1.1	11.3	1.2	19030.9
2000	8	0. 514	1	10.7	2.3	21066.7
2001	8.3	0. 515	1.3	10.7	2.4	23326.5
2002	9.1	0. 504	1	11.3	3.0	25961.1

2003	10	0. 496	0.9	12.7	3.1	29265.4
2004	10.1	0. 455	1	14.2	1.9	33426.0
2005	10.4	0. 414	0.8	15.6	1.0	38626.2
2006	11.6	0. 406	0.8	16.9	1.3	45140.7
2007	11.9	0. 397	0.8	17.6	0.9	53103.4
Average	9.87	0.50	1.92	11.69	2.99	

Note: The base year in estimating real capital stocks is 1995.

Using the results of Table 1, we can calculate the contribution of each production factor to GDP growth. The results are summarized in Table 2.

Table 2. Contribution of Each Production Factor to GDP Growth (1981 – 2007)

Year	GDP Growth Rates (%)	Contribution of Each Production Factor (%)		
		Labor	Capital	TFP
1981	5.2	31. 69	69. 02	−0. 71
1982	9.3	19. 94	42. 76	36. 56
1983	11.2	11. 50	41. 57	47. 32
1984	15.3	12. 79	34. 24	52. 94
1985	12.9	13. 97	48. 12	37. 98
1986	8.9	16. 20	75. 20	7. 87
1987	11.6	12. 88	57. 70	29. 31
1988	11.3	13. 22	57. 94	28. 32
1989	4.1	22. 61	124. 21	−48. 78
1990	3.8	35. 24	94. 45	−28. 95
Average (1981-1990)	9.36	19. 00	64. 52	16. 19
1991	9.2	16. 23	37. 43	46. 74
1992	14.2	6. 89	29. 03	64. 79
1993	13.5	4. 96	38. 44	56. 30
1994	12.7	8. 52	47. 35	44. 09
1995	10.6	7. 29	57. 65	34. 91
1996	9.6	7. 22	59. 88	32. 90
1997	8.8	7. 80	62. 86	29. 34
1998	7.8	8. 17	69. 56	22. 27

1999	7.1	8.12	75.55	16.34
2000	8	6.43	64.99	28.59
Average (1991-2000)	10.15	8.16	54.27	37.63
2001	8.3	8.07	62.68	29.25
2002	9.1	5.54	61.56	32.90
2003	10	4.46	64.15	31.39
2004	10.1	4.50	76.71	18.78
2005	10.4	3.18	87.66	9.16
2006	11.6	2.80	86.36	10.84
2007	11.9	2.67	89.38	7.95
Average (2001-2007)	10.2	4.46	75.50	20.04
Total Average (1981-2007)	9.87	11.22	63.57	25.13

From Table 2, we can find that contribution of TFP growth to GDP growth in China is truly remarkable compared to the other emerging economies throughout the whole period of 1981 to 2007. The findings of Table 2 coincide with existing literatures. For example, Ozyurt (2009) estimated that contribution of TFP growth to the Chinese GDP growth during the period of 1993 to 2005 would be 33%. According to Table 2, the equivalent figure would be 29.71%, which is close to Ozyurt (2009)'s estimate. However, we can also find that there was a substantial degree of fluctuation across the periods. Generally speaking, contribution of TFP growth to GDP growth in the 1990s was much higher than the 1980s and 2000s. However, we can regard 1989 and 1990 as exceptional years due to the drastic slowdown of the Chinese economic growth. When we leave 1989 and 1990 out of our observation, then, the average contribution of TFP during the 1980s would be 29.95, which is substantially higher than the original estimate. Therefore, we can say that contribution of TFP growth to the Chinese GDP growth fluctuated in the range of 30 to 40% during the 1980s and 1990s except for the so-called adjustment period of 1989 and 1990. However, there is a sign that contribution of TFP growth in the 2000s is decreasing. In particular, after 2005, contribution of TFP growth to GDP growth is only about 10%, which is much lower than the average of the entire period. On the other hand, contribution of capital stock to GDP growth dominates contributions of labor and TFP since 2005. Even though we have not accumulated enough time-series data to tell whether this is a temporary phenomena or a revision of long-term trend, it is surely worthwhile to watch whether this trend will continue in the near future.

Let us now apply the same method to calculate regional TFP growth rates from 1989 to 2005. As mentioned earlier, this paper used real capital stock data estimated by Zhang, Wu, and Zhang (2007) in calculating regional TFP growth rates. Table 3 summarizes the results of this estimation.[4]

Table 3. Estimation of Regional TFP Growth Rates (1989-2005)

Periods	BJ	TJ	HEB	SX	IMG	LN	JL	HLJ	SH	JS	ZJ
1989-1990	-6.36	-0.77	-0.55	1.92	0.91	-3.52	-4.30	0.79	-2.45	-3.89	-4.10
1991-1995	3.40	5.33	6.16	2.90	2.00	3.34	5.15	3.24	3.72	7.87	8.00
1996-2000	3.18	7.30	2.77	1.76	6.30	5.73	7.87	3.86	3.20	4.55	2.18
2001-2005	0.37	5.06	4.03	3.28	5.04	3.16	4.16	5.18	3.38	3.83	1.54
1989-2005 Average	1.30	5.11	3.75	2.56	4.03	3.18	4.55	3.71	2.74	4.32	2.96

Periods	AH	FJ	JX	SD	HEN	HUB	HUN	GD	GX	HAIN
1989-1990	-1.21	2.62	0.45	-0.84	-0.42	-0.91	1.15	1.62	2.75	1.49
1991-1995	9.02	10.87	7.84	6.83	7.40	5.92	6.82	7.39	9.49	8.13
1996-2000	4.98	3.47	5.90	2.56	2.75	5.38	5.86	2.71	2.89	4.70
2001-2005	4.23	2.57	2.34	2.72	4.61	1.21	3.72	3.68	4.00	4.87
1989-2005 Average	5.22	5.28	4.78	3.47	4.29	3.57	4.96	4.24	5.14	5.38

Periods	SC	GZ	YN	TB	SX	GS	QH	NX	XJ	Average across Regions
1989-1990	1.43	-0.23	3.18	5.91	-0.57	2.99	-1.02	2.77	1.86	0.02
1991-1995	6.98	5.48	1.53	6.93	6.37	5.11	3.92	3.30	3.51	5.80
1996-2000	6.87	3.39	1.47	6.92	5.20	3.66	2.96	3.83	3.47	4.26
2001-2005	3.83	2.20	2.26	0.40	4.41	1.30	3.26	2.38	2.83	3.19
1989-2005 Average	5.37	3.23	1.92	4.89	4.64	3.31	2.86	3.12	3.11	3.90

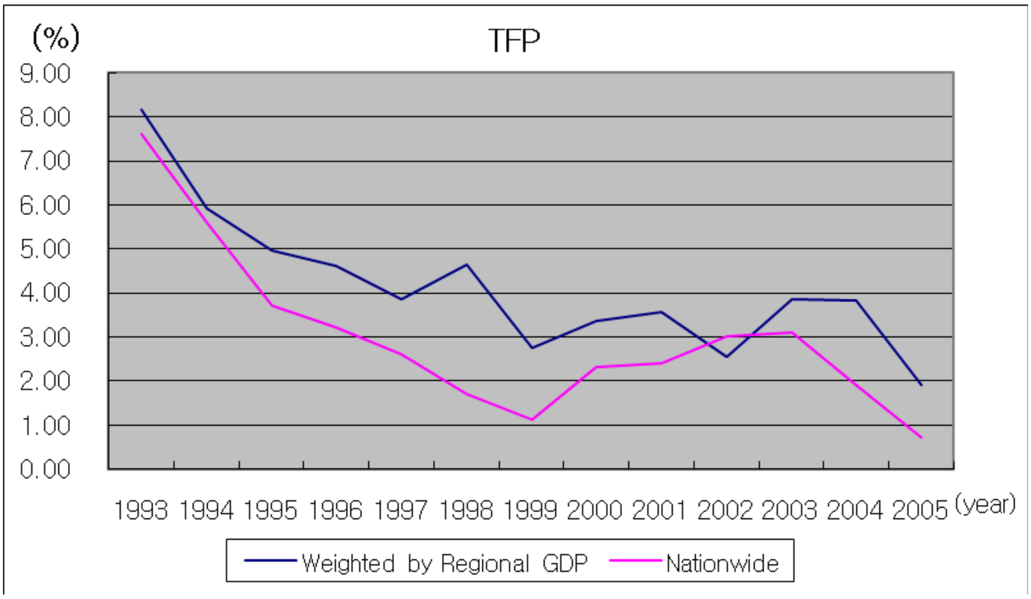
[4] As we do not have data for Chongqing province before 1996, we exclude Chongqing from our analysis.

Note: The name of each region has been abbreviated like the following; BJ (Beijing), TJ (Tianjin), HEB (Hebei), SX (Shanxi), IMG (Inner Mongolia), LN (Liaoning), JL (Jilin), HLJ (Heilongjiang), SH (Shanghai), JS (Jiangsu), ZJ (Zhejiang), AH (Anhui), FJ (Fujian), JX (Jiangxi), SD (Shandong), HEN (Henan), HUB (Hubei), HUN (Hunan), GD (Guangdong), GX (Guangxi), HAIN (Hainan), SC (Sichuan), GZ (Guizhou), YN (Yunnan), TB (Tibet), SX (Shaanxi), GS (Gansu), QH (Qinghai), NX (Ningxia), and XJ (Xinjiang).

In order to examine the relation between national TFP and regional TFP, the weighted average of regional TFP (weighted by regional GDP) is compared with national TFP. Figure 1 shows this comparison. As it is predicted, the two lines of TFP move together through the observed period of 1993 to 2005. Even though there exists a certain degree of discrepancy between the two TFPs, we can safely say that estimate of regional TFP coincide with national TFP estimate.

We can notice from Table 3 that Chinese regions have suffered from sluggish growth of TFP in the end of 1980s when the Chinese economy went through adjustment period. However, TFP growth rates in most of regions were peaked during the first half of the 1990s, and it gradually decreased afterward. This finding coincides with the finding we had with regard to the national TFP. Another thing we can notice is that there exists a great deal of differences among different regions with regard to their TFP growth rates. For example, regions such as Yunnan and Beijing had average TFP growth rates of 1.92 and 1.30 during the observed period, while regions such as Hainan and Sichuan had average TFP growth rates of 5.38 and 5.37 during the same period. Therefore, we can conclude that Chinese regional TFPs have not only fluctuated across time but also differ across regions. This fluctuation across time and difference across region need to be explained, and it is analyzed in the following chapter.

Figure 1. Comparison of Regional and National TFP



Now, let us calculate contribution of regional TFP growth to regional GDP growth. This result is summarized in Table 4. As many regions experienced negative growth of TFP during the period of 1989-1990, we left this period out in making Table 4.

Table 4. Contribution of TFP to Regional GDP Growth (1989-2005)

Periods	BJ	TJ	HEB	SX	IMG	LN	JL	HLJ	SH	JS	ZJ
1991-1995	29.92	35.55	42.02	19.06	19.38	27.59	42.07	39.57	27.45	38.03	43.01
1996-2000	31.44	66.55	24.42	13.03	63.41	67.40	81.20	43.73	30.07	40.63	20.25
2001-2005	1.55	36.39	36.22	25.40	33.60	29.86	40.96	49.03	27.84	30.59	11.92
1991-2005 Average	20.97	46.16	34.22	19.16	38.79	41.62	54.74	44.11	28.45	36.42	25.06

Periods	AH	FJ	JX	SD	HEN	HUB	HUN	GD	GX	HAIN
1991-1995	86.78	54.00	57.69	42.72	53.78	42.70	61.39	37.60	57.39	26.15
1996-2000	46.26	27.27	60.37	23.22	24.73	49.46	58.74	26.24	33.41	62.00
2001-2005	40.74	24.10	21.35	20.72	41.63	11.18	36.73	27.80	38.52	48.92
1991-2005 Average	57.93	35.12	46.47	28.89	40.05	34.45	52.29	30.54	43.10	45.69

Periods	SC	GZ	YN	TB	SX	GS	QH	NX	XJ	Average across Regions
1991-1995	60.95	61.84	11.02	34.65	62.90	51.02	48.29	36.21	28.80	42.65
1996-2000	71.43	38.89	16.39	63.62	56.42	38.48	33.20	41.62	42.47	43.21
2001-2005	34.57	20.65	24.89	2.39	38.82	12.39	27.16	21.82	27.85	28.19
1991-2005 Average	55.65	40.46	17.43	33.55	52.72	33.96	36.22	33.22	33.04	38.02

Table 4 shows similar results as Table 3. Not only we have fluctuation over time, but also we have differences across regions in terms of TFPs.

III. Determinants of Regional TFP

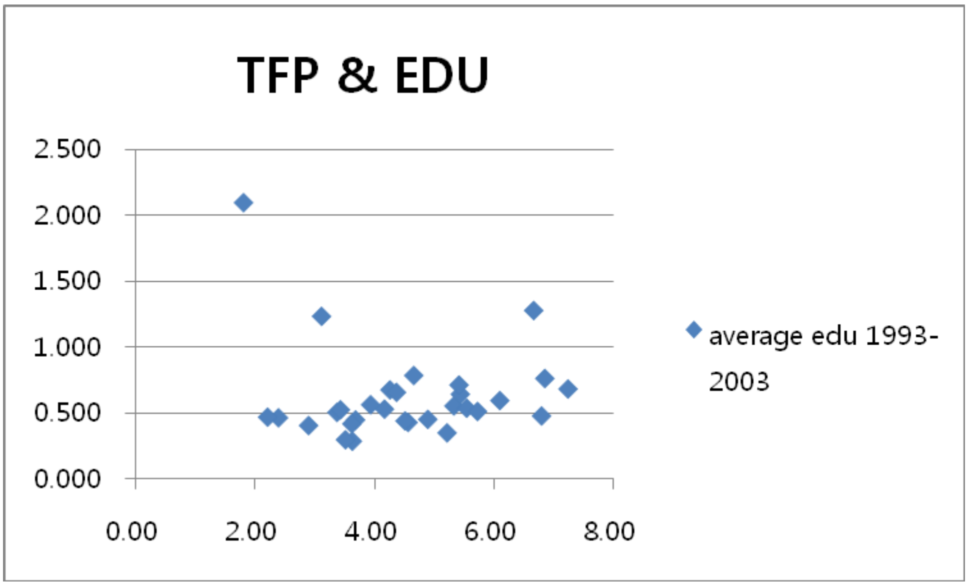
As it is found that there exist substantial differences in terms of TFP across regions, let us explore what factors are responsible for these differences. Existing literatures on finding out determinants of TFP growth usually dealt with cross-country differences in TFP. For example, Ha (2004, in Korean) calculated TFP growth rates of advanced countries and Korea from 1970 to 2000, and tried to find out determinants of TFP across countries using time-series analysis. As a result, he found out that R&D activities and technological gap between Korea and advanced countries are the major determinant factors for TFP. Also, Woo (2004) calculated TFP growth rates of 93 countries including OECD and developing economies from 1970 to 2000, and found that international trade, sound regulatory settings, and quality institutions are positively associated with TFP growth.

This paper uses TFP growth rates of each region (denoted as TFP) as dependent variable. For independent variables, variables that can represent technological capacity and international openness are used. These independent variables are most frequently used by existing literatures in explaining differences of TFP growth rates across countries. Even though Woo (2004) used regulatory settings and institutional quality as independent variables to explain TFP differences across countries, this paper does not include these variables as they are deemed to be identical across regions of China.

With regard to independent variables that represent technological capacity, we used three independent variables of college enrollment ratio (denoted as EDU, which is measured by the ratio of new student enrollment in higher education over number of graduates in senior secondary schools), number of staff and workers in scientific research and polytechnical services (denoted as RP). With regard to independent variables that represent international openness, use used two variables; ratio of FDI inflow into each region over the regional GDP (denoted as FDI/GDP), and ratio of export volume of each region over the regional GDP (denoted as EXP/GDP). All independent variables are found in the *China Statistical Yearbook*, and GDP is converted into dollar term using official exchange rates.

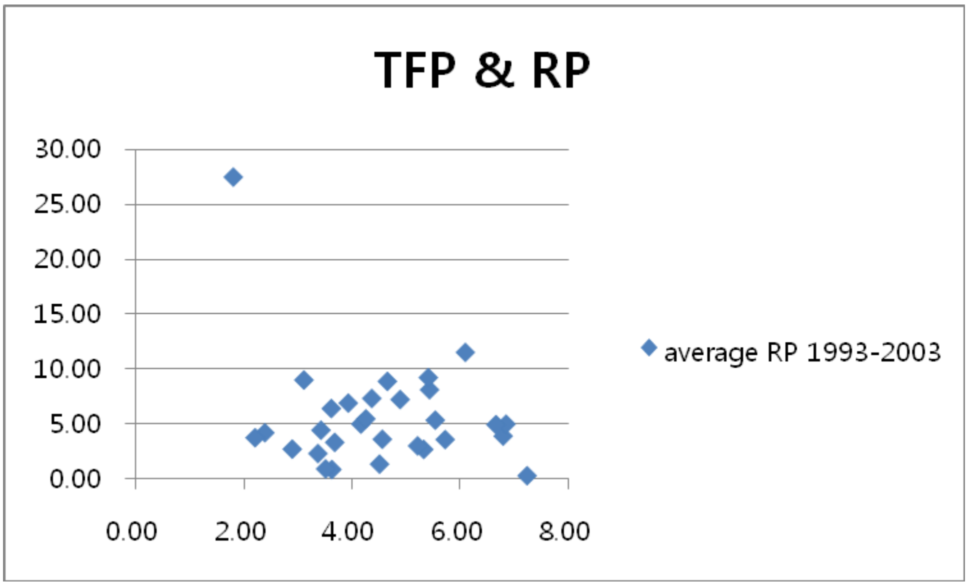
In estimating the determinants of TFP growth rates in each region, we have left Chongqing and Tibet regions out of our sample.[5] Therefore, the number of regions in our study would be 29 regions. Also, the sample period is from 1993 to 2003.[6] Let us first illustrate the relationship between dependent variable (TFP) and each independent variable in Figure 2.

Figure 2. Correlation between Dependent Variable and Independent Variables



[5] We could not find regional GDP for Chongqing region before 1996, and could find FDI data for Tibet region.

[6] We could not find trade data of each region before 1993, and FDI inflow data after 2003.


TFP & RP
30.00
25.00
20.00
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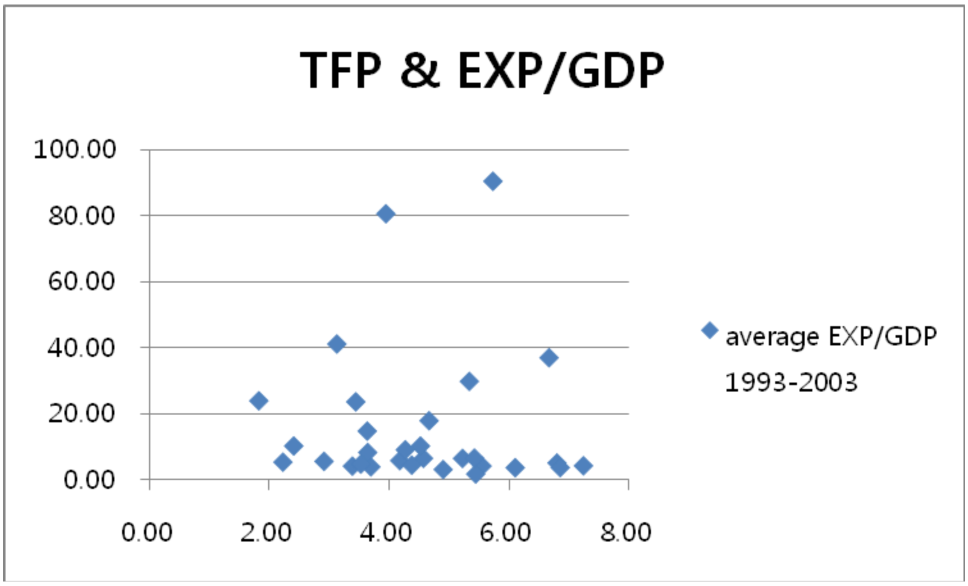
6.00
8.00
average RP 1993-2003


TFP & EXP/GDP
100.00
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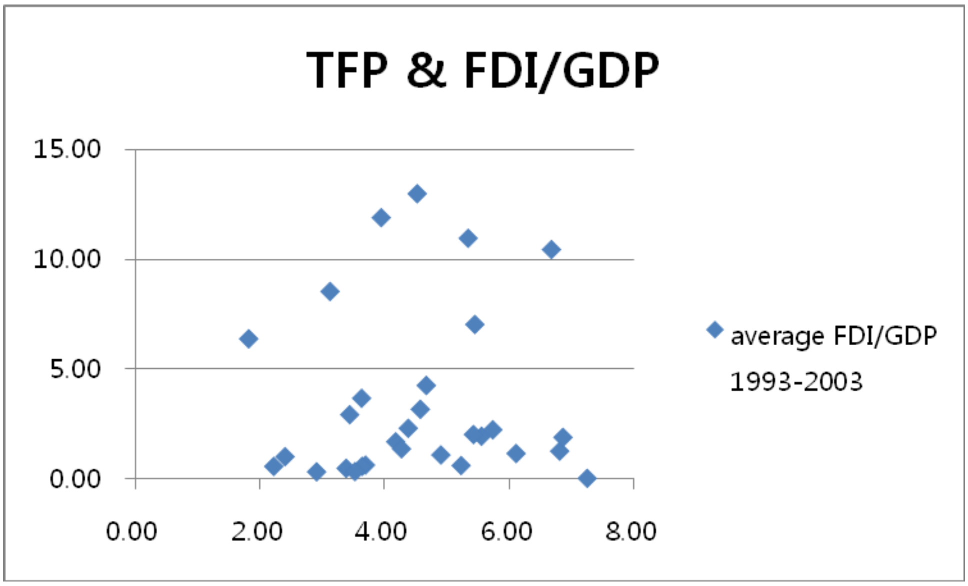
average EXP/GDP 1993-2003



Let us now examine the relation between dependent variable and independent variables using panel analysis. The result of this empirical analysis is summarized in Table 5.

Table 5. Result of Panel Analysis

Dependent Variable: TFP?

Method: Pooled Least Squares

Date: 06/17/09 Time: 10:11

Sample: 1993 2003

Included observations: 11

Cross-sections included: 29

Total pool (balanced) observations: 319

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EDU	2.130420	0.710078	3.000262	0.0029
RP	0.125372	0.063094	1.987084	0.0478
EXP_GDP	0.010827	0.010690	1.012809	0.3119
FDI_GDP	0.225711	0.055971	4.032645	0.0001

R-squared	-0.790781	Mean dependent var	4.420504
Adjusted R-squared	-0.807837	S.D. dependent var	2.886280
S.E. of regression	3.880771	Akaike info criterion	5.562405

Sum squared resid	4744.022	Schwarz criterion	5.609617
Log likelihood	-883.2036	Hannan-Quinn criter.	5.581260
Durbin-Watson stat	0.584321		

Table 5 shows that both technological capacity and international openness are significant determinant factors for TFP growth. In particular, education level, number of staff and workers in scientific research and polytechnical services, and the FDI inflow ratio show statistically significant positive impact on TFP growth. In particular, this empirical study shows that FDI inflow is more important than trade openness in determining the Chinese regional TFP growth level. This result coincides with findings of existing literatures on the technology spill-over effect of FDI in China. It also reflects the local concern of Chinese policy makers that Chinese firms' trading activities focus mainly on processing and assembling intermediate inputs that are imported by advanced countries and exporting final products. There is a concern inside China that this kind of trading pattern would not help a lot to improve technological level of Chinese firms, and the result of Table 5 coincides with this concern.

IV. Concluding Remarks

The high growth rate of the Chinese economy is puzzling in many senses. One of the areas the Chinese economy differs from the other emerging economies is the rapid rise of the Chinese TFP (total factor productivity). This paper aims to estimate the TFP of the Chinese economy in the national and regional level, using the method introduced in the existing literature. This paper finds out that TFP of each region fluctuate over time, and there are substantial differences among TFPs of regions. In order to explain for these fluctuations and differences, this paper tries to find out determinant factors of regional TFP by using panel analysis. The explanatory variables used in this analysis are taken from the existing literatures. They are FDI inflow, export volume, educational level, and research capacity of each region. It is the author's hypothesis that there would be positive correlation between TFP of each region and these explanatory variables. As a result of the panel analysis, the author finds out that education level, number of scientific researchers, and FDI inflow ratio are the major determinant factors of regional TFP in China.

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