The Long-term Trend of Productivity and the Determinants of Factor Inputs Since China's Economic Reform

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The Long-term Trend of Productivity and the Determinants of Factor Inputs Since China's Economic Reform[1)]

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Key words: China, economic development, productivity analysis, human capital

1. Introduction

Before the current world-wide economic recession, initiated by the financial crisis of the United States (US), the world economy observed a rapid expansion of globalization. Under the globalized economy, many developed and emerging countries enjoyed economic growth. China is no exception. China, however, is an exception with regards to having impressive economic growth, beginning before the current economic globalization that could be backdated to the economic reform in 1978. According to the World Bank (2009), China's per capita GDP was only US$165 (2000 constant price) in 1978, one of the poorer countries at that time, but it now has grown to US$1811 in 2007 with an average annual growth rate of about 8.7%. If we estimate China's income level at the purchasing power parity (PPP), its economic success has been even more impressive.[2)]

In the economic literature, the investigation of the sources of China's economic growth has been one of the popular issues associated with its increasing economic power in the world. We also investigate the sources of China's economic growth in this paper, though the objective of this paper is relatively modest. We highlight the long-term trend of productivity, and the determinants of factor inputs of labor and physical capital with the provincial data, which are not very much a point of focus in the existing literature. We moreover emphasize the role of human capital since the economic reform in 1978. There are controversies over the role of human capital as the sources of economic growth, since in some literature there is more emphasis on the roles of foreign

1) The earlier draft was presented at the Spring Conference of the Japan Association for Applied Economics which was held at Nagoya University, 13-14 June 2009, and the author thanks Cai Dapeng for his helpful comments at the Conference. Moreover, the author also thanks two referees for useful comments, and Devin Cowling for the English corrections.

2) For example, China's per capita GDP is US$5084 for the year of 2007 at the PPP price level (at the 2005 international dollar, World Bank, 2009).

direct investment (FDI) and international trade for China's economic growth. This paper can be seen as a complimentary analysis of the existing literature, with a new aspect which focuses on the long-term trend of productivity and the determinants of factor inputs. This paper is organized as follows. In Chapter 2, we briefly review the existing literature. We then investigate the long-term trend of productivity in Chapter 3. We furthermore attempt to analyze the determinants of factor inputs in Chapter 4, followed by concluding remarks in Chapter 5.

2 . Literature Review

Rapid growth of the Chinese economy has attracted vast economic literature. China's economic success, especially after the economic reform in 1978, has been highlighted by its impressive GDP growth. However, unlike the predecessors of rapid economic growth in East Asia, it is also unique that China has been scrutinized for the accuracy of its statistics by researchers. Many researchers agree to the fact of the rapid economic expansion, but they often disagree to the extent of the speed of China's economic growth. While China's rapid economic growth has been agreed upon, the accuracy of its growth statistics remains one of the consequent issues for investigation. Research such as in Tsui (2008), Young (2000) and Wu (2000) among others question the reliability of China's economic statistics. Wu (2000) indicates the dichotomy of China's growth statistics by the notion of the underestimated level GDP and the overestimated GDP growth rates. According to Wu (2000), China's level GDP has been underestimated due to the legacy of the old material product system (MPS), which underestimates the contribution of services, while the GDP growth rates tend to be overestimated due to China's reporting system in association with the government's heavy involvement, which might be explained by local officials exaggerating output performance.[3] These issues for China's statistics require careful implications from the statistical analyses in its economic growth. Our investigation of the long-term trend of productivity and factor inputs employs primarily the macroeconomic data, so our results need to be treated as suggestive in this regard.

We initially investigate the long-term trend of productivity in this analysis. One of the popular methods of examination is through the productivity analysis in growth accounting, which estimates the total factor productivity (TFP) as well as the contributions of labor and physical capital stock inputs. Many economic analyses of China's productivity often find constant improvement in TFP since the economic reform, though the emphasis has been somewhat different among reseachers. For example, Collins and Bosworth (1996) provide a relatively higher estimates,

3) Wu (2000), pp.475-476.

while Borensztein and Ostry (1996), and Young (2000) show more conservative estimates. Their different estimates also depend on which GDP statistics are used. The usage of official statistics or adjusted statistics, including other macroeconomic data, may affect the outcome. As the issues for the afore-mentioned official GDP statistics suggest, the TFP estimates appear to be higher when the official statistics are used while they tend to be lower when the official statistics are adjusted by reseachers for the lower growth rates. Additionally, the growth of physical capital factor inputs has often been highlighted as the engine of China's rapid economic growth by many researchers while that of labor factor inputs seems to be less important.[4)]

Next, one of our other research interests in this paper is the determinants of factor inputs in China's economic growth. Many researchers focus on the role of human capital as well as that of physical capital. Chi (2008), for example, empirically investigates the role of human capital in the provincial economic growth and finds it has an important role for physical capital formation. Education, more specifically, higher education, rather than primary and secondary education, is the important determinant of fixed assets investment in Chi (2008)'s analysis. Chi suggests the possibility of capital-skill complementarity in China, and further implies worsening regional inequality due to the rapid accumulation of physical capital investment associated with a higher level of human capital in the eastern area. Morevoer, Hossain (1997) and Heckman (2005) also analyze the role of human capital and education in China's economic growth. Hossain (1997), in particular, focuses on poverty reduction through the increase of productivity and efficiency of the labor forces while Heckman (2005) urges towards more investment in human capital which is relatively low compared to the high level of investment in physical capital. Heckman (2005) also suggests that the current level of investment in human capital is inequitably and inefficiently distributed across regions, and also between rural and urban areas which hence leads to inequality.[5)]

Besides human capital, various sources of economic growth are also investigated by researchers. Gao (2005), for example, suggests the role of provincial FDI in economic growth. In his empirical analysis, Gao (2005) conducts a balanced panel data analysis for 29 provinces for the years 1996-1999 and finds the importance of labor quality in attracting FDI, especially that from the United States and Japan. Chen and Feng (2000) provide more wide-ranged sources of China's economic growth from their cross-province regression analysis for 1978-1989. In their analysis, private and semi-private enterprises, higher education and international trade have a positive impact on growth while high fertility, high inflation, and the presence of state-owned enterprises

4) Please refer to Chi (2008) who provides a more detailed review for the recent literature on the sources of China's economic growth.
5) Heckman (2005), p.53.

(SOE) have a negative impact on growth across provinces.

In a nutshell, many researchers attempt to investigate the sources of China's rapid economic growth. The productivity analysis tends to highlight the consequent role of physical capital stock and investment associated with TFP growth. Moreover, human capital, FDI and international trade (*i.e.* trade openness) also tend to be the consequent sources of China's economic growth.

3. Productivity Analysis

In this Chapter, we first conduct the productivity analysis for China in growth accounting and focus on the factor inputs prior to our investigation for the determinants of factor inputs in Chapter 4.

3.1 TFP analysis: framework and data

Our productivity analysis employs the following framework of transcendental logarithmic production function based on Christensen, Cummings, and Jorgenson (1980), Jorgenson, Gollop, and Fraumeni (1987), and Young (1995). Our total factor productivity (TFP) is thus defined as the following popular equation.

$$TFP=(\ln Q(T)-\ln Q(T-1))-(v_K'(\ln K(T)-\ln K(T-1))-(v_L'(\ln L(T)-\ln L(T-1)))$$

where,

TFP: total factor productivity
Q: output
K: physical capital stock
L: labor
T: time
v_K': capital factor share
v_L': labor factor share

The necessary data is obtained from China, National Bureau of Statistics (2005, various issues). Since the official data for physical capital stock is not available, we construct the physical capital stock data from the gross fixed capital formation based on the perpetual inventory method with an annual depreciation rate of 5%. We ignore the constructed physical capital stock of the first 10 years since the rapid accumulation of this period may bias the TFP estimates. It should also be noted that the nominal prices are deflated by the retail prices since the relevant deflators are not available in China, National Bureau of Statistics (2005, various issues). Further, the factor

shares of physical capital stock and labor are conventionally set as 0.3 and 0.7 respectively, based on Gollin (2002). Gollin (2002) finds that the labor factor shares of many developing countries tend to be underestimated due to a large number of self-employed and small businesses, which are not adequately reflected in the relevant statistics. Upon his estimation, the labor factor shares both in the majority of developing and developed countries are in the range of 0.65 to 0.80 with an average of about 0.7. Since the relevant data for the estimates of China's provincial factor shares are not available at the time of writing this paper, we depend on Gollin (2002) and set a labor factor share of 0.7, and hence we set 0.3 for the physical capital factor share for all provinces in China.[6] It should be noted therefore that our TFP estimates for China should be considered to be crude, since we employ the conventional factor shares and the retail prices for the constant output and physical capital stock estimates.

3.2 The TFP estimates with the provincial data

Appendix 1 shows our TFP estimates for the whole nation and 31 individual provinces in China for the period of 1979-2005.[7] The sample period is further divided into three sub-periods, based for the most part on a ten year period: 1979-1988, 1989-1998, and 1999-2005. We report the average TFP, and factor contributions of physical capital stock and labor in Appendix 1, which provides three observations.

First, the provincial TFP estimates for the three sub-periods generally show an increasing trend over time, though their estimates vary. Second, the provincial factor contributions of physical capital stock also show an increasing trend over time. Third, conversely however, the provincial factor contributions of labor tend to show a decreasing trend. These three observations become much more clear when we combine these estimates with the income level data. Figure 1 exhibits our average estimates of provincial TFP, and factor contributions of physical capital stock and labor associated with the average provincial income for the sub-periods of 1979-1988, 1989-1998, and 1999-2005.

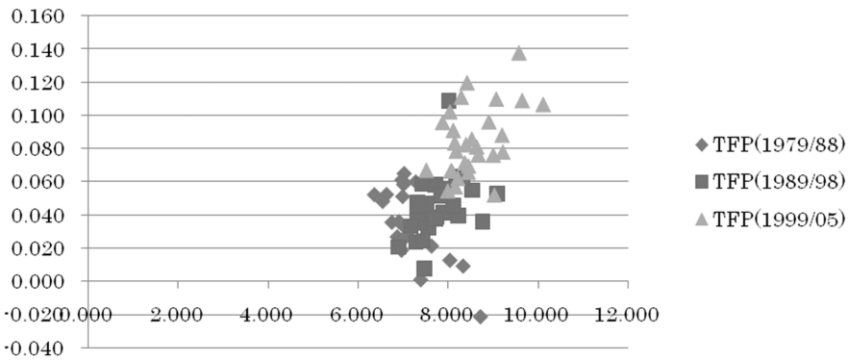
Appendix 1 moreover provides interesting insights when we observe the provincial average TFP with the two dimensions of TFP performance and region. Table 1 summarizes Appendix

6) Besides Gollin (2002), Collins and Bosworth (1996) presume the plausible range of the physical capital share from 0.3 to 0.4, and employ 0.35 as their physical capital share across the sample countries (Collins and Bosworth, 1996, p.155). Moreover, the exploitation of the uniform factor income shares for the cross-country comparison is occasionally seen in the existing literature such as in Collins and Bosworth (1996). It should be also noted that the provincial data also includes data for the cities of Beijing, Tianjin, Shanghai and Chongqing in this paper.

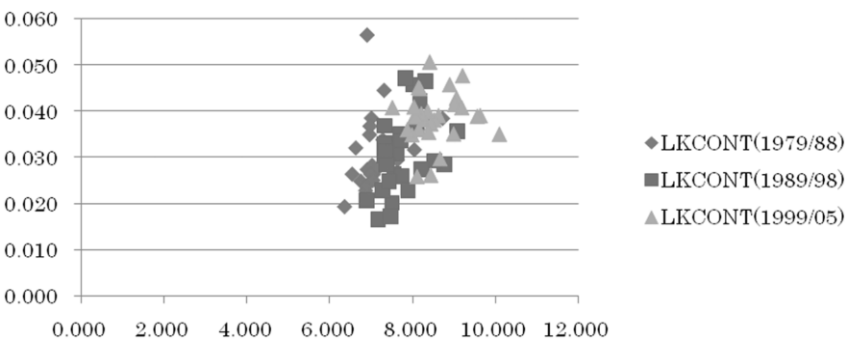
7) The relevant TFP estimates for Chongqing are not available due to a lack of data. Moreover, 1979 signifies 1978/79 as our relevant estimates are in growth. It should be also noted that the provincial employment data for the year of 2006 are not available at the time of writing this paper so that the sample period up to 2005 are mostly updated in the time series.

Figure 1: TFP, Factor Contributions and Income Level at the Provincial Level

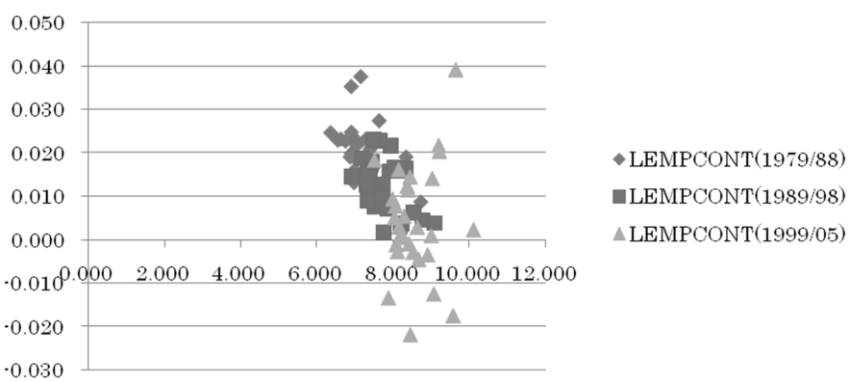
1-1. TFP and Income Level (Correlation: 0.566)



1-2. Physical Capital Factor Contribution and Income Level (Correlation: 0.465)



1-3. Labor Factor Contribution and Income Level (Correlation: -0.508)



Source: Author's estimates
Notes: TFP, LKCONT, LEMPCONT as the vertical axis, and LGRPH as the holizontal axis in the figures
LGRPH: per capita gross regional product (log, local currency, 1990 price)
LKCONT: physical capital factor contribution
LEMPCONT: labor factor contribution
Factor contribution: factor input growth × factor share

1 for the two dimensional classifications with the economic and social data of interest which are also used in the subsequent regression analysis.[8] First of all, the average TFP for the whole nation during the sample period is indicated as 0.051 with the factor shares of 0.3 for LK and 0.7 for LEMP in Appendix 1. When we consider the average TFP value of the whole nation as the yardstick, 14 provinces out of 31 show a higher TFP.[9] These higher TFP performers' average TFP is 0.058 which is in contrast to 0.041 for that of the lower TFP performers.[10] As well, we have two observations from Table 1. First, the higher TFP performers indicate higher growths in gross regional product (GRP), per capita GRP (GRPH), physical capital stock (K), FDI, and educational data of both regular secondary school student enrollment and higher education student enrollment (SEC and HIGH, respectively) on average than those of the lower TFP performers. Second, the higher TFP performers show slightly lower growth of employment (EMP) than that of the lower TFP performers while trade openness (OPEN) indicates similar average figures. In short, the higher TFP performers generally show better economic and social indicators than those of the lower TFP performers.

Furthermore, we classify 31 provinces into three regions: central, eastern and western regions.[11] Table 1 also exhibits each region's average TFP with economic and social indicators. We now compare this data with the average statistics across the provinces which are also shown in Table 1. The average TFP across the provinces is now indicated as 0.049 instead of 0.051 for the whole nation with a factor share of 0.3 for LK and 0.7 for LEMP.[12] There are two findings from Table 1. First, only the eastern region shows a higher TFP than the average TFP across the provinces with a higher growth of GRP, GRPH, and K. In addition, the other two regions show lower TFP, GRP, and K than the average provincial figures. Second, among the economic and social indicators of interest, OPEN, SEC and HIGH do not appear to provide clear indication of their trends upon the level of the average TFP. The possible exception might be FDI of the eastern region

8) It should be consequently noted the different sample period between Appendix 1 and Table 1 due to the data availability of economic and social data. The subsequent descriptive data analysis is based on Table 1 whose sample period is up to 2004.

9) 14 higher TFP performers include 8 eastern, 5 central, and 1 western provinces.

10) The lower TFP performers include the provinces which show the equivalent average TFP estimates of 0.051 with the whole nation in Appendix 1.

11) Our regional classification is as follows, based on Minami, Makino and Luo (2008, p.49): central region (10 provinces: Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan, Guangxi), eastern region (11 provinces and cities: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan), and western region (10 provinces and city: Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang). Moreover, it should be noted that Chongqing and Tibet are excluded from the estimates in Table 1 due to a lack of data.

12) It should be noted that TFP of the whole nation is estimated with the aggregate data on the nation basis so that it is different from the average provincial TFP. Moreover, the sample period is also slightly different between Table 1 and Appendix 1 as already noted.

Table 1: Summary of the Provincial Average TFP, and Economic and Social Data (1979–2004)

	TFP	GRP	GRPH	K	EMP	OPEN	FDI	SEC	HIGH
Higher TFP	0.058	0.108	0.094	0.120	0.019	0.075	0.292	0.010	0.104
Lower TFP	0.041	0.087	0.074	0.101	0.022	0.075	0.283	0.000	0.089
Center	0.048	0.094	0.084	0.107	0.020	0.083	0.275	0.006	0.102
East	0.054	0.105	0.091	0.124	0.020	0.072	0.323	0.000	0.096
West	0.045	0.090	0.074	0.097	0.022	0.069	0.253	0.011	0.090
AVG	0.049	0.097	0.084	0.110	0.021	0.075	0.287	0.005	0.096

Notes: all data is in growth (log) and averaged. Center (central region), East (eastern region), West (western region), TFP (total factor productivity), GRP (gross regional product), GRPH (per capita GRP), K (physical capital stock), EMP (employment), OPEN (trade openness), FDI (foreign direct investment), SEC (regular secondary school student enrollment), HIGH (higher education student enrollment), AVG (the simple average across the provinces). Please also see Appendices 1 and 2.

which indicates the highest figure among regions with the highest average TFP which may suggest the positive association between TFP and FDI among the data of interest. Since the descriptive data analysis from Appendix 1 and Table 1 does not offer much more information, we explore the impacts of economic and social indicators of interest on the determinants of factor inputs in the subsequent empirical analysis.

In summary, two dimensional descriptive analyses provide two interesting insights. First, the higher TFP performers demonstrate a higher GRP, GRPH, K, FDI, SEC and HIGH than those of the lower TFP performers. Second, our observations from the regional base show that only the eastern region indicates a higher TFP than the provincial average with a higher GRP, GRPH and K. It should be noted that 8 out of 11 eastern provinces are included in the 14 higher TFP performers. Therefore, these two observations can be seen as similar to some extent. Moreover, compared to the TFP performance base observations, the regional base analysis does not offer much clear information among the data of interest with the possible exception of FDI. Finally, we emphasize that our productivity analysis with the provincial data indicates the increasing trends of TFP and physical capital factor contribution, and the decreasing trend of labor factor contribution associated with the income level over time, whose factor determinants are to be examined in the subsequent analysis.

3.3 Discussion

As previously noted, our TFP estimates are very crude and suggestive since we employ the retail prices for the estimates of gross regional product (GRP) at the constant price since we are not able to obtain the relevant deflators. We also apply the conventional factor income shares

based on Gollin (2002) since the necessary data for these estimates are unavailable. Since the accuracy of the statistics seems to be the common issue for researchers in China's economic analysis, as was suggested by Wu (2000) with the notion of an underestimated level GDP and an overestimated GDP growth rate as previously noted, our crude TFP estimates need to be re-estimated and improved in the near future when the relevant data becomes available. We now must consider to what extent our crude current regional TFP estimates are useful in comparison with other literature. Table 2 compares the nation-wide TFP estimates of Collins and Bosworth (1996), and Young (2000) with our estimates. First, Collins and Bosworth (1996) reports a nation-wide average TFP of 4.6 for 1984-94 while we indicate a TFP estimate of 3.9 for the same period. As well, Young (2000) estimates 3.0 for the average TFP of the non-agricultural sector for 1978-98 with the official statistics (*i.e.* before his adjustment) while our nation-wide TFP is 4.0 for the same period. At first glance, our TFP estimates are between Collins and Bosworth (1996), and Young (2000). One of the possible explanations for these different TFP estimates is based on the employed deflators for output and physical capital stock estimates. In addition, the crude workforce or the quality adjusted workforce may also provide a different outcome. As noted, the retail prices are only available for our estimates of gross regional product (GRP) and physical capital stock at the constant prices, and we also use the crude employment data. Another possible explanation is the use of different factor income shares. Collins and Bosworth (1996) employs 0.35 for physical capital factor share and 0.65 for labor factor share, and Young (2000) uses 0.54 for physical capital factor share and 0.46 for labor factor share of the non-agriculture sector. Though we need to take this into account, we may conclude that these TFP estimates are relatively comparable and our TFP estimates are in line with the existing literature.

Table 2: Comparison of TFP Estimates

	Collins-Bosworth (1996)	Young (2000)	This paper
1984-94	4.6		3.9
1978-98		3.0 (official) 1.4 (adjusted)	4.0

Sources: Collins and Bosworth (1996), and Young (2000)
Notes: the following factor income shares are used for TFP estimates
Collins and Bosworth (1996): 0.35 for physical capital and 0.65 for labor factor share
Young (2000): 0.54 for physical capital and 0.46 for labor factor share, moreover the TFP estimates for the non-agricultural sector
This paper: 0.3 for physical capital and 0.7 for labor factor share (TFP is shown in percentage)

We now investigate to what extent the different factor income shares may affect our TFP estimates. We previously made use of the analysis of Gollin (2002) and set 0.7 for the labor factor

share and 0.3 for the physical capital factor share. Based on Young (2000) and Tsui (2008), we now set 0.6 for the labor factor share and 0.4 for the physical capital factor share in order to see its impact on the TFP estimates.[13] The newly estimated TFP are also reported in Appendix 1. The change of factor income shares by 0.1 leads to lower labor factor contributions with much larger capital factor contributions. We observe a decline in the nation-wide TFP of 0.007 on average for the entire sampling period. The nation-wide labor factor contribution decreased by 0.002 on average but the physical capital factor contribution increased by 0.010 during the same period. It thus leads to lower TFP estimates on average and signifies a capital driven economic growth since the economic reform in China.

Furthermore, the decreasing labor factor contributions for 1999-2005 in our estimates need to be treated with caution. As Young (2000) and Tsui (2008) indicate, lower labor factor contributions for this period are more likely to be influenced by the change of employment statistics which included workers on leave before 1998, but not afterwards. This may affect the upward bias of TFP estimates after 1998. Our crude TFP estimates appear to be in line with the other literature, though these estimates should be treated as suggestive.

Lastly, as we noted, we utilize the conventional factor income shares due to limitations in the relevant data. The possible and popular alternative method in estimating proxies of the factor income shares is the parameter estimates in the regressions, as being analyzed in Chow and Li (2002), Chow and Lin (2002), and Tsui (2008). Chow and Li (2002) and Chow and Lin (2002), for example, estimate the coefficients of physical capital and labor in the China's production function for the period of 1952-1998. Though our sample period in this analysis is only 1978-2005, being less than 30 observations in the time series, and quite limited in drawing useful outcomes, we preliminarily conduct the parameter estimates for physical capital stock and labor in the production function with brevity. Since our results may indicate a small sample bias due to the limited sample size, we conduct the regression analysis for only the whole nation as one example. We employ the same framework as Chow and Li (2002) as follows.

$$\ln Y = c + \alpha_1 \ln K + \alpha_2 \ln L + \alpha_3 t$$
$$\ln (Y/L) = c + \alpha_4 \ln (K/L) + \alpha_5 t$$

Y, K, L, and t indicate output, physical capital stock, employment and time trend, respectively.

13) Young (2000, Table 23) estimates 0.6 for the average labor factor share of the whole economy, and 0.46 for the non-agricultural sector for 1978-1995 from the national accounts statistics. Moreover, Tsui (2008) estimates 0.58 for the quality adjusted labor factor share and 0.52 for physical capital factor share with other variables in regressions for 1964-1999.

c is a constant. The time trend variable is the proxy of TFP. Before estimating the above regressions, we conduct the unit root test for each variable as the routine work for the time series data. Our unit root test of the ADF shows a possible I (1) process for lnL and I (2) for other variables. However, most macroeconomic data are generally a I (1) process and the test power of ADF is known to be low. Additionally, our sample size is limited so we conventionally presume our variables are all I (1) regardless of the test results. We then proceed to the cointegration analysis. Our cointegration analysis is based on the solved static long-run equation in the econometric analysis software of PcGive, and our results for the cointegration analysis are summarized in Table 3.[14)]

Table 3: Summary of the Cointegration Analysis (Sample Period: 1978-2005)

Dependent variable: lnY for Models 1 and 2, and ln(Y/L) for Models 3 and 4

	Model 1	Model 2	Model 3	Model 4
Constant	-3.774	-0.279	0.385	-0.128
	(7.274)	(0.229)	(0.757)	(0.196)
lnK	1.077	0.810		
	(0.557)	**(0.039)		
lnL	0.556	0.297		
	(0.557)	*(0.137)		
ln(K/L)			0.794	0.883
			**(0.131)	**(0.031)
t	-0.033		0.007	
	(0.068)		(0.010)	
Long-run σ	0.048	0.047	0.070	0.075
Wald test	2585.5	2765.8	941.7	830.8
Cointegration	No	Yes	No	No

Notes: the cointegration analysis is conducted with one lag of each variable.
**, * indicate the statistical significance at 1%, and 5% level, respectively.

Our analysis indicates a statistically significant cointegrating relationship at 5% level for Model 2 only, as other models appear to be insignificant. The estimated parameters for lnK and lnL in Model 2 are 0.810 and 0.297, respectively. If our parameter estimates are correct, these are equivalent to the factor income shares in growth accounting. However, our estimates appear to be unreasonable. The estimated parameter of 0.810 for lnK is simply too large, and that of 0.297 for lnL is too small. However, the unreasonable estimates from the regression analysis are not

14) The details of unit root test and cointegration analysis are submitted upon request.

unusual in existing literature. Chow and Lin (2002), for example, show in their analysis that one of their estimates indicates 0.774 for the parameter of lnK and 0.002 for lnL.[15] Moreover, our estimates for t, time trend, appear to be statistically insignificant, which signifies no TFP growth over time. In summary, our regression analysis provides unreasonable outcomes. As we noted before, our sample size is quite limited so our regression analysis may be biased.

Finally, we may conclude the current regression analysis of the parameter estimates for lnK and lnL are unreasonable and unreliable. We thus depend more upon our analysis in growth accounting, though it is also suggestive. When more observations in the time series become available, we will once again conduct the regression analysis.

4. Determinants of Factor Inputs: Panel Data Analysis

4.1 Framework

As shown in our TFP estimates, China's TFP indicates an increasing trend over time since its economic reform which is accordingly affected by both factor contributions of physical capital stock and labor. In order to investigate the determinants of factor inputs of labor and physical capital stock which affect TFP, we employ the following regression framework.

$$Y = c + \alpha_x X + \alpha_i I + \varepsilon$$

The dependent variable, Y, is either the data for the factor inputs of labor or that for physical capital stock. The explanatory variables of X signify the possible determinants of each factor input. We mainly concern the role of human capital for labor factor inputs while we also investigate the impacts of foreign direct investment (FDI) and trade openness, our proxies for globalization, on physical capital factor inputs. As well, the explanatory variables of I indicate other variables of interest. In our analysis, we also examine the impact of globalization on the labor factor inputs and the role of human capital on physical capital as suggested by the economic literature. Our proxies for human capital are regular secondary school student enrollment and higher education student enrollment. We additionally consider population and per capita gross regional product as proxies for regional demand. Consequently, the year dummy is also included in the regressions for the determinants of the labor factor inputs in order to examine the impact of the change of employment statistics which included workers on leave before 1998 but not afterwards, as suggested by Young (2000) and Tsui (2008). ε is an error term. The data is

15) See Chow and Lin (2002), p.527, for details.

obtained from China, National Bureau of Statistics (2005, various issues). It should be noted that Chongqing and Tibet are dropped from our sample due to very limited observations.

4.2 Results

Appendix 2 shows the results of our unbalanced panel data analysis. Here we only report the results of the fixed effect model since our tests for the random effect model exhibit similar results.[16] Appendix 2 provides eight observations.

First, the panel data analysis of the determinants of labor factor inputs does not always indicate a significant role of human capital. Only Models 1 and 2 show statistical significance, however it is not robust with other variables in Model 3. Second, population has a positive impact on the labor factor inputs in Models 5 and 6. Population is our proxy for regional demand, however it is also the source of labor supply. Thus, it should be regarded as a reasonable outcome. Third, trade openness, one of our proxies for globalization, has a positive impact on labor factor inputs while FDI appears to be statistically insignificant in our regressions. Since it is well known that China has benefitted from the expansion of exports, mostly labor intensive products, the positive association of trade openness with labor factor inputs appears to be reasonable. Fourth, our year dummy variable for the change of employment statistics appears to be significant with a negative sign, which suggests its importance.

Fifth, our panel data analysis for the determinants of physical capital factor inputs surprisingly does not suggest any globalization impacts, highlighted by the statistical insignificance of trade openness and FDI variables. Sixth, human capital has a positive impact on physical capital stock. The higher education student enrollment appears to be more consequent than the secondary school student enrollment for physical capital stock, both with its values and statistical significance. In addition, though FDI alone does not enter positively in the panel data regressions, its interaction term with the higher education student enrollment now becomes statistically significant at the 10% level in Models 12 and 13. It may signify that more FDI inflows can be expected in the regions with higher human capital which also contributes to physical capital stock formation. Seventh, we also find a positive impact of per capita gross regional product, our proxy for domestic demand, on physical capital stock. Finally, both lagged labor and lagged physical capital stock do not significantly enter into the panel data regression, which may suggest the exogenous status of one another.

To summarize, our panel data analysis highlights the consequent role of trade openness on the labor factor inputs and that of human capital, proxied by secondary school and higher education

16) The results for the random effect model are submitted upon request.

student enrollment, on physical capital stock. In particular, we can observe the positive impact of FDI on physical capital stock through the interaction term with higher education student enrollment, which appears to be in line with Chi (2008) and other literature. Moreover, our result demonstrates the larger role of human capital, especially in terms of higher education student enrollment, as having even more a catalytic role in attracting FDI. It can be regarded as one of the important contributions of this paper to the existing literature for China's economic growth.

5 . Concluding Remarks

In this paper, we investigate the long-term trend of productivity and the determinants of factor inputs in China, especially focusing upon both physical and human capital. We initially conduct the productivity analysis with the provincial data and find an increasing trend of TFP and physical capital factor contribution, and a decreasing trend of labor factor contribution associated with the income level over time. This demonstrates that China's rapid economic growth is associated with increasing TFP.

Furthermore, our panel data analysis for the determinants of factor inputs suggests the consequent role of human capital on physical capital stock. The higher human capital may induce more FDI inflows for physical capital formation. The implication from our analysis is rather simple and straightforward: China's further economic growth is based on TFP and physical capital stock associated with the expansion of human capital, which is in line with other literature. Our empirical analysis may suggest that the provincial differences in human capital affect the provincial capital formation, and hence provincial economic growth in China whose further examination is one of our tasks for future research. Moreover, further examination for the components of factor inputs and the determinants of TFP also remains for our future research topic.

Appendix 1: China's Provincial TFP

		Growth	(A) Factor Contribution		TFP	(B) Factor Contribution		TFP	TFP Difference
		LGRP	LK (0.3)	LEMP (0.7)		LK (0.4)	LEMP (0.6)		(A)−(B)
Whole Nation	1979-88	0.087	0.027	0.021	0.039	0.035	0.018	0.033	0.006
	1989-98	0.089	0.029	0.018	0.042	0.039	0.016	0.034	0.008
	1999-05	0.126	0.036	0.007	0.083	0.048	0.006	0.072	0.011
	1979-05	0.098	0.030	0.016	0.051	0.040	0.014	0.044	0.007
Beijing	1979-88	0.067	0.039	0.019	0.009	0.051	0.016	−0.001	0.010
	1989-98	0.069	0.029	0.004	0.036	0.038	0.004	0.027	0.009
	1999-05	0.187	0.039	0.039	0.109	0.052	0.034	0.102	0.007
	1979-05	0.099	0.035	0.019	0.045	0.047	0.016	0.036	0.009
Tianjin	1979-88	0.061	0.032	0.017	0.012	0.042	0.014	0.004	0.008
	1989-98	0.090	0.029	0.006	0.055	0.039	0.005	0.046	0.009
	1999-05	0.160	0.039	−0.017	0.138	0.052	−0.015	0.122	0.016
	1979-05	0.097	0.033	0.004	0.061	0.044	0.003	0.050	0.011
Hebei	1979-88	0.083	0.027	0.020	0.036	0.037	0.017	0.029	0.007
	1989-98	0.106	0.035	0.013	0.058	0.047	0.011	0.048	0.010
	1999-05	0.123	0.039	0.003	0.081	0.052	0.003	0.068	0.013
	1979-05	0.102	0.033	0.013	0.056	0.044	0.011	0.046	0.010
Shanxi	1979-88	0.077	0.026	0.018	0.032	0.035	0.016	0.026	0.006
	1989-98	0.074	0.020	0.007	0.047	0.027	0.006	0.041	0.006
	1999-05	0.155	0.038	0.005	0.111	0.051	0.005	0.099	0.012
	1979-05	0.096	0.027	0.011	0.058	0.036	0.009	0.050	0.008
Inner Mongolia (1981-)	1981-88	0.116	0.028	0.023	0.065	0.038	0.020	0.059	0.006
	1989-98	0.068	0.026	0.010	0.032	0.035	0.009	0.025	0.007
	1999-05	0.170	0.051	−0.001	0.120	0.068	−0.001	0.103	0.017
	1981-05	0.112	0.034	0.011	0.067	0.045	0.010	0.057	0.010
Liaoning	1979-88	0.078	0.029	0.028	0.021	0.039	0.024	0.015	0.006
	1989-98	0.071	0.027	0.004	0.039	0.037	0.003	0.031	0.008
	1999-05	0.112	0.035	0.001	0.076	0.047	0.001	0.064	0.012
	1979-05	0.084	0.030	0.012	0.042	0.040	0.010	0.034	0.008
Jilin	1979-88	0.092	0.028	0.038	0.026	0.037	0.032	0.023	0.003
	1989-98	0.066	0.026	0.002	0.039	0.035	0.001	0.030	0.009
	1999-05	0.121	0.038	−0.003	0.086	0.051	−0.002	0.073	0.013
	1979-05	0.090	0.030	0.014	0.046	0.040	0.012	0.038	0.008
Heilongjiang	1979-88	0.054	0.032	0.021	0.001	0.043	0.018	−0.007	0.008
	1989-98	0.080	0.023	0.016	0.041	0.031	0.013	0.036	0.005
	1999-05	0.101	0.030	−0.004	0.076	0.040	−0.004	0.065	0.011
	1979-05	0.076	0.028	0.012	0.035	0.038	0.011	0.028	0.007

Shanghai	1979-88	0.026	0.039	0.009	−0.022	0.051	0.008	−0.033	0.011
	1989-98	0.092	0.036	0.004	0.053	0.048	0.003	0.041	0.012
	1999-05	0.144	0.035	0.002	0.107	0.047	0.002	0.095	0.012
	1979-05	0.081	0.037	0.005	0.039	0.049	0.005	0.028	0.011
Jiangsu	1979-88	0.101	0.045	0.016	0.040	0.059	0.014	0.028	0.012
	1989-98	0.098	0.036	0.016	0.045	0.048	0.014	0.036	0.009
	1999-05	0.140	0.043	−0.012	0.110	0.057	−0.011	0.094	0.016
	1979-05	0.110	0.041	0.009	0.060	0.055	0.007	0.048	0.012
Zhejiang	1979-88	0.117	0.034	0.023	0.060	0.045	0.020	0.052	0.008
	1989-98	0.108	0.042	0.003	0.063	0.056	0.003	0.049	0.014
	1999-05	0.146	0.048	0.020	0.078	0.064	0.017	0.065	0.013
	1979-05	0.121	0.041	0.015	0.066	0.054	0.013	0.054	0.012
Anhui	1982-88	0.103	0.057	0.025	0.022	0.076	0.021	0.006	0.016
(1982-)	1989-98	0.085	0.033	0.017	0.035	0.044	0.014	0.026	0.009
	1999-05	0.096	0.036	0.003	0.057	0.048	0.003	0.045	0.012
	1982-05	0.093	0.041	0.015	0.037	0.054	0.013	0.026	0.011
Fujian	1979-88	0.076	0.035	0.023	0.018	0.047	0.020	0.010	0.008
	1989-98	0.171	0.046	0.017	0.109	0.061	0.014	0.096	0.013
	1999-05	0.108	0.042	0.014	0.052	0.055	0.012	0.040	0.012
	1979-05	0.120	0.041	0.018	0.061	0.054	0.016	0.050	0.011
Jiangxi	1979-88	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
(1989-)	1989-98	0.089	0.031	0.014	0.044	0.041	0.012	0.036	0.008
	1999-05	0.124	0.045	0.001	0.078	0.060	0.001	0.063	0.015
	1989-05	0.103	0.037	0.008	0.058	0.049	0.007	0.047	0.011
Shandong	1979-88	0.116	0.039	0.019	0.058	0.051	0.016	0.048	0.010
	1989-98	0.112	0.035	0.022	0.055	0.047	0.018	0.047	0.008
	1999-05	0.139	0.046	−0.003	0.096	0.061	−0.003	0.080	0.016
	1979-05	0.120	0.039	0.014	0.067	0.052	0.012	0.056	0.011
Henan	1979-88	0.107	0.032	0.023	0.052	0.043	0.020	0.045	0.007
	1989-98	0.107	0.031	0.017	0.059	0.041	0.015	0.051	0.008
	1999-05	0.124	0.040	0.012	0.071	0.053	0.011	0.060	0.011
	1979-05	0.111	0.034	0.018	0.059	0.045	0.016	0.051	0.008
Hubei	1979-88	0.093	0.026	0.016	0.051	0.035	0.014	0.044	0.007
	1989-98	0.092	0.031	0.023	0.038	0.041	0.019	0.031	0.007
	1999-05	0.085	0.037	−0.022	0.069	0.050	−0.019	0.054	0.015
	1979-05	0.091	0.031	0.009	0.051	0.041	0.007	0.042	0.009
Hunan	1979-88	0.069	0.023	0.019	0.027	0.030	0.016	0.022	0.005
	1989-98	0.085	0.028	0.013	0.043	0.038	0.011	0.036	0.007
	1999-05	0.103	0.040	0.002	0.062	0.053	0.001	0.049	0.013
	1979-05	0.083	0.029	0.012	0.042	0.039	0.011	0.034	0.008

Guangdong	1979-88	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
(1989-)	1989-98	0.125	0.046	0.016	0.063	0.062	0.014	0.049	0.014
	1999-05	0.151	0.041	0.022	0.088	0.055	0.019	0.078	0.010
	1989-05	0.136	0.044	0.019	0.073	0.059	0.016	0.061	0.012
Guangxi	1979-88	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
(1989-)	1989-98	0.099	0.037	0.015	0.047	0.049	0.013	0.037	0.010
	1999-05	0.113	0.039	0.008	0.066	0.052	0.007	0.055	0.011
	1989-05	0.105	0.038	0.012	0.055	0.050	0.010	0.044	0.011
Hainan	1979-88	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
(1990-)	1990-98	0.106	0.047	0.007	0.052	0.063	0.006	0.037	0.015
	1999-05	0.106	0.026	0.015	0.066	0.035	0.012	0.059	0.007
	1990-05	0.106	0.038	0.010	0.058	0.051	0.009	0.046	0.012
Chongqing	1979-88	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	1989-98	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	1999-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	1979-05	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Sichuan	1979-88	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
(1989-)	1989-98	0.083	0.033	0.009	0.041	0.044	0.008	0.031	0.010
	1999-05	0.104	0.039	−0.001	0.066	0.052	−0.001	0.053	0.013
	1989-05	0.092	0.035	0.005	0.051	0.047	0.004	0.040	0.011
Guizhou	1979-88	0.096	0.019	0.025	0.052	0.026	0.021	0.049	0.003
	1989-98	0.056	0.021	0.014	0.021	0.028	0.012	0.016	0.005
	1999-05	0.126	0.041	0.018	0.067	0.055	0.016	0.056	0.011
	1979-05	0.089	0.025	0.019	0.044	0.034	0.017	0.038	0.006
Yunnan	1979-88	0.097	0.026	0.023	0.048	0.035	0.020	0.042	0.006
	1989-98	0.091	0.031	0.014	0.045	0.042	0.012	0.037	0.008
	1999-05	0.099	0.035	0.009	0.054	0.047	0.008	0.044	0.010
	1979-05	0.095	0.031	0.016	0.049	0.041	0.014	0.041	0.008
Tibet	1979-88	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
(2003-)	1989-98	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	2003-05	0.143	0.089	0.018	0.036	0.119	0.015	0.009	0.027
	2003-05	0.143	0.089	0.018	0.036	0.119	0.015	0.009	0.027
Shaanxi	1979-88	0.083	0.025	0.023	0.035	0.033	0.020	0.030	0.005
	1989-98	0.059	0.023	0.013	0.024	0.031	0.011	0.018	0.006
	1999-05	0.149	0.041	0.005	0.102	0.055	0.004	0.089	0.013
	1979-05	0.091	0.028	0.014	0.048	0.038	0.012	0.041	0.007
Gansu	1983-88	0.083	0.024	0.035	0.023	0.032	0.030	0.020	0.003
(1983-)	1989-98	0.069	0.017	0.019	0.033	0.022	0.016	0.030	0.003
	1999-05	0.119	0.036	−0.013	0.096	0.048	−0.011	0.082	0.014
	1983-05	0.087	0.024	0.013	0.050	0.033	0.011	0.043	0.007

Qinghai	1979-88	0.073	0.025	0.022	0.026	0.033	0.019	0.021	0.005
	1989-98	0.048	0.017	0.023	0.008	0.023	0.020	0.005	0.003
	1999-05	0.128	0.040	−0.003	0.091	0.053	−0.002	0.077	0.014
	1979-05	0.078	0.026	0.016	0.036	0.035	0.014	0.030	0.006
Ningxia	1979-88	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
(1989-)	1989-98	0.067	0.025	0.018	0.024	0.033	0.015	0.018	0.006
	1999-05	0.145	0.045	0.016	0.083	0.060	0.014	0.071	0.012
	1989-05	0.099	0.033	0.017	0.048	0.044	0.015	0.040	0.008
Xinjiang	1979-88	0.111	0.037	0.013	0.061	0.049	0.011	0.050	0.011
	1989-98	0.081	0.034	0.010	0.037	0.045	0.008	0.028	0.009
	1999-05	0.129	0.036	0.012	0.082	0.047	0.010	0.072	0.010
	1979-05	0.105	0.035	0.011	0.058	0.047	0.010	0.048	0.010

Source: Author's estimates.
Notes:
LGRP: gross regional product (log)
LK: physical capital (log), factor share in ( )
LEMP: employment (log), factor share in ( )
TFP: total factor productivity

Appendix 2: Panel Data Analysis (Fixed Effect Model)

A2-1. Determinants of Factor Inputs: Employment

Dependent variable: GRLEMP

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	0.024	0.017	0.023	0.025	0.017	0.023
	***(0.001)	***(0.002)	***(0.005)	***(0.001)	***(0.002)	***(0.005)
GRLSEC	−0.055	−0.040	−0.040			
	***(0.016)	*(0.024)	(0.024)			
GRLHIGH				−0.009	−0.007	−0.002
				(0.011)	(0.016)	(0.016)
GRLPOP		0.128	0.120		0.168	0.163
		(0.088)	(0.089)		*(0.086)	*(0.086)
GRLGRPH		0.030	0.032		0.022	0.024
		(0.022)	(0.023)		(0.022)	(0.023)
GRLFDI		−0.001	−0.001		−0.0002	−0.0004
		(0.002)	(0.002)		(0.002)	(0.002)
GRLOPEN		0.015	0.015		0.016	0.015
		**(0.006)	**(0.006)		**(0.006)	**(0.006)
GRLKAPLAG			−0.049			−0.052
			(0.038)			(0.039)
Dum1998	−0.011	−0.010	−0.010	−0.013	−0.010	−0.010
	***(0.002)	***(0.003)	***(0.003)	***(0.003)	***(0.004)	***(0.004)
Obs	682	546	540	682	546	540

Group	29	29	29	29	29	29
Overall R^2	0.070	0.064	0.065	0.058	0.064	0.065
F test	26.38	6.23	5.54	20.56	5.75	5.13
Prob	0.000	0.000	0.000	0.000	0.000	0.000

A2-2. Determinants of Factor Inputs: Physical Capital

Dependent variable: GRLKAP

	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13
Constant	0.091	0.091	0.091	0.091	0.086	0.087	0.086
	***(0.002)	***(0.002)	***(0.002)	***(0.003)	***(0.002)	***(0.003)	***(0.003)
GRLFDI	−0.000	0.001	0.001	0.001	0.0004	−0.001	−0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
GRLOPEN	0.001	0.001	0.002	0.001	−0.004	−0.008	−0.009
	(0.006)	(0.006)	(0.007)	(0.007)	(0.006)	(0.008)	(0.008)
GRLPOP	−0.163	−0.095	−0.095	−0.099	−0.023	−0.031	−0.040
	*(0.088)	(0.093)	(0.093)	(0.094)	(0.087)	(0.087)	(0.087)
GRLGRPH	0.278	0.263	0.263	0.262	0.232	0.232	0.228
	***(0.022)	***(0.023)	***(0.023)	***(0.023)	***(0.022)	***(0.022)	***(0.022)
GRLSEC		0.054	0.054	0.057			
		**(0.025)	**(0.026)	**(0.026)			
GRLHIGH					0.078	0.070	0.076
					***(0.012)	***(0.013)	***(0.013)
GRFDI x GRLSEC			0.010	0.010			
			(0.027)	(0.027)			
GRLOPEN x GRLSEC			−0.045	−0.048			
			(0.127)	(0.129)			
GRFDI x GRLHIGH						0.025	0.024
						*(0.014)	*(0.014)
GRLOPEN x GRLHIGH						0.035	0.035
						(0.067)	(0.068)
GRLEMPLAG				−0.006			0.042
				(0.048)			(0.047)
Obs	546	546	546	540	546	546	540
Group	29	29	29	29	29	29	29
Overall R^2	0.276	0.283	0.284	0.284	0.313	0.318	0.322
F test	44.76	37.04	26.40	21.95	47.79	34.85	29.96
Prob	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes:
GRLEMP: employment growth (log, 10000 persons), GRLEMPLAG is a lagged GRLEMP (1 lag).
GRLKAP: capital stock growth (log, 100 million local currency, 1990 constant price), GRLKAPLAG is a lagged GRLKAP (1 lag).
GRLSEC: regular secondary school student enrollment growth (log, per 10000 persons)
GRLHIGH: higher education student enrollment growth (log, per 10000 persons)
GRLPOP: population growth (log, million)
GRLGRPH: growth of per capita gross regional product (log, local currency, 1990 constant price)

GRLFDI: foreign direct investment growth (log, 100 million local currency, 1990 constant price)
GRLOPEN: growth of trade openness ((export+import)/GRP)(log, percent)
Dum1998: year dummy (0 before 1998, and 1 since 1998)
Obs: number of observations
Group: number of provinces
Prob: probability (F test)
***, **, *: statistical significance at 1%, 5%, and 10% level, respectively

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