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10 April 2013

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Abstract

This paper examines effects of the formation of physical and human capital on the growth of labour productivity, Total Factor Productivity (TFP) and wages in China, incorporating the market reform factors such as ownership shifts, population policy, openness and fiscal expenditures on education. We find that Chinese economic miracle is mainly pushed by the (physical) capital service rather than formation of human capital. The physical capital inputs contribute even more after 1994 as the returns to education decrease with the education expansion and increasing tuition fees. The traditional four economic regions of China show different growth patterns. The capital inputs mostly help the labour productivity growth in the West region and the wages growth in the Interior region, while human capital formation contributes to the TFP in all four regions. Moreover, provinces within each region present strong evidence of convergence of economic growth. The convergence is most prominent in the provinces within the Northeast and Coastal regions for labour productivity and TFP growth, suggesting fast technology spill-over within these regions.

Keywords: labour productivity, convergence, regional inequality

JEL Classification Codes: D24, D63, J24, O47

1. Introduction

This paper focuses on the regional disparities and convergence of economic growth with regions in China. China is one country with the worst regional economic disparities in the world (Yang, 2002; Kanbur and Zhang, 2005; Fleisher et al., 2010). We categorize the 28 administrative divisions (excluding Tibet) of China into four regions: the northeast region (including Heilongjiang, Jilin, Liaoning), the Coastal (including Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, and Guangdong-Hainan), the Interior (Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan) and west (Guangxi, Sichuan-Chongqing, Guizhou, Yunnan, Inner Mongolia, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang).[1] Table 1 presents the changes of labour productivity, Total Factor Productivity (TFP) and wages among these four regions from 1978 to 2009.

In 1978, the real GDP per worker of the Northeast was double that of the Coastal and the Interior. Then, the Coastal caught up with the Northeast with annual growth rate at 8.6 percent during 1978-1995. All regions developed very quickly at 9.3 percent to 10 percent per year in 1995-2009. However, in 2009, the real labour productivity in the richer Northeast and Coastal regions (about 50,000 RMB) were still more than twice the poorer Interior and West regions (below 26,000 RMB) due to their low initial levels. A body of research has shown that TFP growth has played an important role in post-reform growth in China (Chow, 1993; Borensztein and Ostry, 1996; Young, 2003; Wang and Yao, 2003; Islam et al., 2006; Fleisher et al., 2010). Table 1 shows that the Northeast had the higher level of TFP index (73) in 1978, nearly 17 percent higher than the Coastal, and 54 percent higher than the Interior and West. The annual growth rate of the TFP index was the highest in the Interior at annual rate of 4.4 percent from 1978 to 1995 and 3.9 percent from 1995 to 2009. Therefore, the TFP index of the Interior (173) exceeds the industrial Northeast region in 2009.

In terms of wages, we find the same "gradualism, stagnation and sharp jumps" process of China's economy as described in Fleisher et al. (2010). The gradualism of reform brings the slow pace of China's transformation which distinguishes it from most other transition economies, especially those in Central and Eastern Europe and the Former Soviet Union (Fleisher et al., 2005). In the 1980s, the regional wages were similar to each other due to a rigid labour market, until Deng Xiaoping's "South Trip" in 1992 which speeds the pace of transition to a market based economy and changes the wage structure in China.[2] From 1978 to 1995, the annual growth rates of wages in the Coastal (7.4 percent) were much higher than the other three regions, especially the Northeast (4.9 percent) which was suffering the huge laid-off from State Owned Enterprises (SOEs). During 1995-2009, wages increased rapidly with growing labour productivity in all regions at about 10-11 percent per year. With lower initial levels, average wages of the Coastal were about 10 percent higher than those of the Northeast in 2009, 22.6 percent higher than the Interior and 28.3 percent higher than the West. Therefore, if the increasing regional disparities in China were not corrected in time, the uneven growth in productivity and wages would not only threaten the ultimate

1 The division of the four regions is based on research regarding the major economic and geographical clusters in economic growth and development in China. See geographic graph of regions in Appendix Figure A1.

2 In the spring of 1992, Deng Xiaoping visited the east region of China (Guangdong and Shanghai). His main idea was "To Get Rich Is Glorious". Hence, we follow the same line of Fleisher *et al.* (2010) to account for the structural break of Chinese market reforms around 1994 in the specification of our empirical models.

success of China's economic reform, but also bring about serious social and political unrest (Chen and Feng, 2000). Understanding the drivers of the increasing economic gap between the rich and poor regions and whether and how the poor regions are catching up with rich regions has become an urgent task for Chinese economists.

(Table 1 around here)

Figure 1 also presents a preliminary statistical examination of regional disparities and convergence of labour productivity, TFP and wages. Here regional disparities are measured as the coefficients of variation (CV) of labour productivity (left axis), TFP and wages (right axis) among the four regions. Regional disparities have been decreasing for all three productivity proxies before 1986 which showed a common trend of convergence for all regions. After that, the coefficients of variation for labour productivity become quite stable, while the wages are dramatically diverging in the 1990s and then converging in the 2000s. In contrast to the diverging wages in the 1990s, TFP index keeps on converging among regions and becomes quite stable in the 2000s. Thus, these three productivity proxies show different convergence patterns in the more dynamic economy after 1986.

(Figure 1 around here)

The different patterns of regional disparities of labour productivity, TFP and wages demand more comprehensive economic growth models which can take account of determining factors of economic growth such as demographic, social-economic and institutional changes. China need learn lessons from the economic growth path of developed economies. In a cross-country setting, numerous theoretical and empirical studies find that economic growth is determined by factors such as physical and human capital, privatization, international openness and public policy (Barro and Lee, 1993; 2001; Chen and Feng, 1996; van Ark et al., 2008). However, effects of these determinants on Chinese economic growth, especially their impacts on different productivity proxies have not been thoroughly analysed. Thus, this paper aims to investigate determining factors in production processes, labour productivity, TFP and wages in China. We study the beta-convergence processes in China to check whether the lagging regions would grow faster than the rich regions and eventually catch up with them. We focus on the role of human capital in economic growth and address the associations between human capital formation and ownership reform, One-Child Policy, openness and fiscal expenditures. The rest of this paper is organized as follows. The next section is the literature review; in section 3 we lay out our baseline empirical specifications for drivers of regional disparity and beta-convergence; Section 4 is for data description; Section 5 reports empirical results; Section 6 concludes.

2. Literature Review

2.1 Regional convergence

The hypothesis of economic convergence is a primary and particularly active area of research in empirical growth economics. The growth-convergence equation originates from the neoclassical growth model (Solow, 1956) and has been developed by long series of growth empirics such as Barro and Sala-i-Martin (1992). In more recent literature, Byrne and Vecchi (2010) examine convergence in a panel of industries between the United States, the United Kingdom and France, providing evidence of

conditional convergence. When the partial correlation between economic growth and its initial level is negative, there is beta-convergence (Islam, 2003).

Researchers generally deal with convergence in terms of GDP per capita across Chinese provinces. Jian *et al.* (1996) is a pioneering study proceeding from the neoclassical convergence and use the beta-convergence to analyze GDP per capita of 28 Chinese provinces for the period 1978-1992. They use agriculture share and costal location as conditional variables and report that convergence before 1985 and divergence afterwards, which is consistent with what we find in Figure 3.1. They argue that convergence is a result of provinces in the Coastal (rural area) growing faster as a result of policy advantage.

Raiser (1998) relies on light industry and investment rates as controlling variables and finds "weakening" convergence since 1985, which could be the result of either shifts in the steady state of some provinces in the Coastal or reduction in capital mobility. Chen and Fleisher (1996) find conditional convergence of production across provinces on physical investment share, employment growth, human capital investment, foreign direct investment (FDI) and coastal location from 1978 to 1993. Villaverde *et al.* (2010) find a strong convergence process for the periods 1978-1990 and 2004-2007 but divergence for the period 1990-2004. They argue that provincial inequality in China mainly lies within rather between regions, particularly for provinces in the Coastal.

Labour productivity convergence however can be the joint outcome of the twin processes of capital deepening and technological catch-up, known as issue of TFP convergence. Jorgenson and Nishimizu (1978) initiates the international comparison of relative TFP levels in the United States and Japan during the period 1952-1974. Dollar and Wolff (1994) examine TFP level convergence using time-series growth accounting method, while Dowrick and Nguyen (1989) use a cross-section regression to interpret the coefficients of the initial income variables of the equation as indicative of TFP-convergence.

Unfortunately, there is little literature about Chinese regional TFP convergence. As one of rare cases, Wu (2000) find that China's regional TFP converges to the same level from 1982 to 1995 using coefficient of variation, but he does not relate his study to convergence theory. In this paper, we use the following conditional variables to analyze the drivers of regional disparities and beta-convergence of labour productivity, TFP and wages in China.

2.2 Human capital

It is widely hypothesized that human capital has an important role in production through the direct generation of worker skills and also facilitate technology spillovers (O'Mahony and Vecchi, 2009; Fleisher et al., 2010). Human capital plays a critical role in the endogenous growth models, which hold that knowledge-driven growth can lead to a constant or even increasing rate of return. Romer (1986; 1990) argues that human capital is the major input to research and development that innovates technologies. Levine and Renelt (1992) and Young (1992) also find that countries with larger initial human capital stock are more likely to have new products and grow faster than other countries. Empirical evidence has revealed a positive relationship between human capital and growth. Fleisher *et al*. (2010) find that human capital positively affects labour productivity, TFP growth and wage growth in China.

This paper focuses on the effect of human capital on labour productivity, TFP and wages in China. Dearden *et al*. (2006), O'Mahony and Peng (2008) and Carmichael *et al*. (2009) compare the effect of education and training on productivity

and wages for European countries in an attempt to pick up external benefits of human capital. However, China does not have the labour force survey dataset for the whole country, so we apply the labour composition index into an economic growth model and address the associations between human capital formation and ownership reform, One-Child Policy, openness and fiscal expenditures.

2.3 Physical capital

Mankiw *et al*. (1992) show that an augmented Solow model including physical capital as well as human capital accumulation can describe the cross-country data. Bai *et al.* (2006) estimate average rates of returns on physical capital for Chinese industrial enterprises as 6.1 percent in 1998 and 12.2 percent in 2003. Ding and Knight (2011) verifies that China's exceptional growth performance is most fundamentally a reflection of the high investment rates of physical and human capital that characterised the economy.

2.4 Ownership reform

Knight and Song (2001) point out that there are two obvious explanations for the rise in regional disparity in China: economic growth and policies of economic reforms. The Chinese economy has experienced dramatic institutional reforms in last thirty years (Chen and Feng, 2000). Although urban economic reforms began in the period of 1983-85, the Chinese economy was still largely a command and market coordinated economy with rigid wage system over the entire period of our study. [3] The State-Owned Enterprises (SOEs) account for more than half of gross industrial outputs (Fleisher et al., 2010).

After 1992, Chinese reforms aimed to transform the rigid central-planned economy into a flexible market-oriented economy. Chen and Feng (2000) suggest that a larger share of production by non-state-owned enterprises (including collective and private units) results in higher economic growth in the Coastal region of China.[4] Consequently, curtailing the widening Coastal-Inner regional gaps can be effectively achieved by promoting collective-owned or private enterprises.

Fleisher *et al*. (2010) measure the degree of market reform in the local economy using the proportion of urban labour employed in private firms. We categorize staff and workers into three kinds of enterprises: SOEs, collective-owned units and private units, and assess the effect of privatization on labour productivity, TFP and wages. Under the rigid wage system until the early 1990s, the superior labour compensation in joint ventures and foreign firms attracted many talented workers to transfer from SOEs into the private sector which was well known as "jumping into the sea". It brought about a much more efficient allocation of human capital in the production processes.

However, the wages in the public sector began to increase sharply in the late 1990s and reached 16,227 Yuan in 2003 which finally surpassed the private sector wages and attracted Chinese professionals back to the public sector known as "coming back to shore" (Yang et al., 2010). These new changes could be from the

[3] Using data for advanced European countries such as Germany and Italy, Peng and Siebert (2007; 2008) find that the wage rigidity harms the economy of lagging regions by delaying their recovery from disadvantageous shocks. Kang and Peng (2012) analyze the CHNS data and also find similar wage rigidity for lagging private sector in China.

[4] "Private units" include cooperative enterprises, Joint enterprises, Limited liability enterprises, share-holding enterprises, private enterprises, self-employed individual, Funds from Hong Kong, Macro and Taiwan, Foreign funded enterprises.

capital deepening processes through the global value chain which make the economic scale more important than before and also improve human capital formation. Therefore, the ownership structure is a very important institutional factor in our study.

2.5 Openness

Levine and Renelt (1992) systematically study numerous economic factors that may account for long-run aggregate economic growth. They argue that government policies reducing protectionism and liberalising trade are major inputs for growth. Chen and Feng (2000) also argue that international trade is encouraged by geographical and political factors such as proximity to major ports, decisions to create special economic zones and free trade areas, local institutional characteristics such as laws and regulations, contract enforcement, local expenditures on infrastructure, and by labour market conditions. Trade also has facilitated the transformation of the state-owned and the collective sectors, and potentially bring in new production and managerial technologies with their attendant spill-overs (Liu, 2008; O'Mahony et al., 2008). Thus, we also account for the regional disparity with trade by measuring an openness variable as the share of international trade (export and import) to GDP, and assess its effect on regional productivity and wages.

2.6 One-Child Policy

Birth rate is regarded as an important variable representing human capital formation in the productivity model, but no conclusion that birth rate has positive or negative effect on productivity in the theoretical or empirical literatures. On the one hand, there is "population pessimism" which claims population growth will bring negative effect on economic growth. Malthus (1798 [1986]) claimed that large population will decrease the productivity because of diminishing marginal productivity. For a natural resource (land, water, etc.) augmented economy, such as rural economy, as population grows the per capita share of natural resource decreases. Hence, the marginal product of labour goes down.

On the other hand, there is "population optimism" which claims population growth will bring positive effect on economic growth. The neo-Boserupian school of thought (Boserup, 1981) mentions that population may have a scale effect that is beneficial to economic growth. Becker, Glaeser and Murphy (1999) argue that in modern urban economies with small agricultural and natural-resource sectors, the increased density that comes with higher population and greater urbanization promotes specialization and investment in human capital and more rapid accumulation of new knowledge, which would raise per capita incomes.

Thus, Becker, Glaeser and Murphy (1999) combine both negative effect (diminishing marginal productivity) and the positive effect (human capital accumulation, spill-over effect, etc.) and conclude that "the net relation between greater population and labour productivity depends on whether the inducements to human capital and expansion of knowledge are stronger than diminishing returns to natural resources. China started the "One-Child Policy" in 1979 which only be applied to the Han Chinese[5] and by way of affirmative policies, all ethnic minorities in China are allowed to have two or more children until the end of the 1980s (Qian, 1997). In this paper, I will study the net effect of birth rate on labour productivity, Total factor productivity and average wages in the transition of rural economy to

[5] Han Chinese is an ethnic group native to China and constitutes about 92 percent of the population of the People's Republic of China.

urban economy by urbanization reform.

2.7 Regional growth policies

The cross-country growth literature addresses the political roles that the central government can play in improving the lagging regions' economic growth. Since the widening productivity and wage gap between the Coastal and the other regions can lead to political unrest and polarization, the Chinese central government has emphasized the importance of the inner areas' growth and development.

Ma (1995), Ma and Norregaard (1998) and Chen and Feng (2000) argue that the central government policies should not be biased in favour of the Coastal. The central government led by Premier Zhu Rongji launched the "Western Development Strategy" in 1999 to boost the lagging Interior and West regions. The main components of the strategies include the development of infrastructure, enticement of foreign investment, increased efforts on ecological protection (such as reforestation), as well as human capital formation such as promotion of education and retention of talent flowing to richer provinces. As of 2006, a total of 1 trillion Yuan has been spent on building infrastructure in western China (Goodman, 2004).

Moreover, the Northeast was one of the earlier regions to industrialize in China, focusing mainly on equipment manufacturing including the steel, automobile, shipbuilding, aircraft manufacturing, and petroleum refining industries. Recent years, however, have seen the stagnation of the Northeast's heavy-industry-based economy, as economy continues to liberalize and privatize. Hence, the central government led by Premier Wen JiaBao has initialized the "Revitalize the Northeast" campaign in 2003. These policy factors should be considered in an economic growth model for China by the sensitivity test of different development patterns of the four regions.

2.8 Fiscal expenditures on human capital

Not only individuals but also government benefit from increasing wages. Heckman (2005) notes that China's government investment in human capital beyond the junior high school level (the compulsory 9-year education) has been very small and dispersed, in contrast to nations at similar levels of socio-economic development. Chinese government has increased education expenditures sharply aiming for 4 percent of GDP before 2010. In 2007, however, the government expenditures on education are still only 2.43 percent of GDP and have been below 3 percent in most years since 1992, which are much lower than the average of 5.1 percent in developed countries (Fleisher et al., 2010). Hence, we investigate the effect of provincial "fiscal expenditures on human capital (culture, education, scientific and health)" on labour productivity, TFP and wages.

2.9 Structural breaks in 1994

The year 1994 marks the fiscal decentralization processes beginning from withdrawal of government subsidies for loss-incurring SOEs, and the hardening of SOEs' budget constraints become much more earnest in 1997 (Appleton et al., 2002).[6] The shift toward fiscal federalism is also through separating central and local government

[6] The decentralization of fiscal revenue raising and spending decisions can improve the efficiency of the public sector, cut the budget deficit and promote economic growth because local governments are better positioned than the central government to locate and monitor the fiscal expenditure more efficiently, which reinforced imposition of hard budget constraints on SOEs (Qian and Weingast, 1997; Ma and Norregaard, 1998; Oates, 1972). It is also confirmed by numerous studies on intergovernmental fiscal relations in China (Agarwala, 1992).

taxation and relaxing ties between provincial and sub-provincial treasuries and the centre, reinforced imposition of hard budget constraints on SOEs (Su and Zhao, 2004). Therefore, We will follow the suggestion of Fleisher *et al.* (2010) to use the year 1994 as a structural break for the economic transition process in China.

3. Empirical specifications

3.1 Baseline empirical Specifications

First, we estimate a regional aggregate production function, in which inputs include physical and human capital. We measure human capital as the composition-adjusted labour inputs (= Number of employed persons * LCI[7]). The standard regional fixed effects (FE) specification is as follows:

$$\ln Y_{pt} = \alpha_0 + \alpha_1 \ln K_{pt} + \alpha_2 \ln(L_{pt} * LCI_{pt}) + \sum_{r=1}^{4} \varphi_r R_r + \sum_{t=1}^{32} \lambda_t T_t + \varepsilon_{pt} \qquad (1)$$

where Y_{pt} is the real GDP for province p (=1 ,…, 28) in year t (=1978, …, 2009); K_{pt} is real capital inputs; L_{pt} is the number of employed persons; LCI_{pt} is the labour composition index calculated with the micro CHNS dataset; R_r and T_t are region (=1,…,4) and time dummies; and ε_{it} is a random error term. We apply two sensitivity tests for the 1994 structural break, and the disparity in different development patterns in the four regions: 1) Adding variables interacted with the structural break year dummy S_{pt} (0 = before 1994, 1 = 1994 and thereafter); 2) Adding variables interacted with the regional dummies rd to capture the different growth paths of regions. The *rd1 – rd3* dummies are for the Northeast, Coastal and Interior regions, leaving the West as the baseline region. Hence, the coefficients of interactions are the incremental effect of specific period/region on the baseline period/region.

Second, the fixed effect (FE) models are applied to examine the impact of LCI and institutional variables on labour productivity, TFP and wages. We present the basic FE specification as follows:

$$\begin{aligned} \ln LP_{pt} &= \beta_0 + \beta_1 \ln KL_{pt} + \beta_2 LCI_{pt} + \delta_1 O1_{pt} + \delta_2 O3_{pt} + \beta_3 BR_{pt} \\ &+ \beta_4 \ln OP_{pt} + \beta_5 Fis_{pt} + \sum_{r=1}^{4} \chi_r R_r + \sum_{t=1}^{30} \lambda_t T_t + \varepsilon_{pt} \end{aligned} \qquad (2.1)$$

$$\begin{aligned} \ln TFP_{pt} &= \beta_0 + \beta_2 LCI_{pt} + \delta_1 O1_{pt} + \delta_2 O3_{pt} + \beta_3 BR_{pt} + \beta_4 \ln OP_{pt} \\ &+ \beta_5 Fis_{pt} + \sum_{r=1}^{4} \chi_r R_r + \sum_{t=1}^{30} \lambda_t T_t + \varepsilon_{pt} \end{aligned} \qquad (2.2)$$

$$\begin{aligned} \ln AW_{pt} &= \beta_0 + \beta_1 \ln KL_{pt} + \beta_2 LCI_{pt} + \delta_1 O1_{pt} + \delta_2 O3_{pt} + \beta_3 BR_{pt} \\ &+ \beta_4 \ln OP_{pt} + \beta_5 Fis_{pt} + \sum_{r=1}^{4} \chi_r R_r + \sum_{t=1}^{30} \lambda_t T_t + \varepsilon_{pt} \end{aligned} \qquad (2.3)$$

where LP_{pt} is the GDP per worker for province p in year t; KL_{pt} is real capital stock per worker; TFP_{pt} is the total factor productivity index; AW_{pt} is the real annual earnings per worker; $O1_{pt}$ and $O3_{pt}$ represent the ratios of staff and workers worked in the public sector and private enterprises respectively; BR_{pt} is the birth rate of

[7] The Labour composition index for 1989 – 2009 used in this paper is calculated from Kang et al. (2012).

population to measure the human capital formation from One-Child Policy on productivity; OP_{pt} is the share of trade (export and import) of GDP to capture the effect of openness and potential skilled-biased technology spill-overs; Fis_{pt} is the share of fiscal expenditures on human capital; R_r and T_t are region and time dummies; and ε_{pt} is a random error term.

Following the same vein of the sensitivity tests in the production function in equation (2.1), we also apply sensitivity tests for structural break (year 1994) in labour productivity as follows (the regressions in TFP and wage functions are similar):

$$\begin{aligned}\ln LP_{pt} &= \beta_0 + \beta_1 \ln KL_{pt} + \beta_2 LCI_{pt} + \delta_1 O1_{pt} + \delta_2 O3_{pt} + \beta_3 BR_{pt} + \beta_4 \ln OP_{pt} \\ &+ \beta_5 Fis_{pt} + \beta_6 \ln KL_{pt} * S_{pt} + \beta_7 LCI_{pt} * S_{pt} + +\delta_3 O1_{pt} * S_{pt} + \delta_4 O3_{pt} * S_{pt} \\ &+ \beta_8 BR_{pt} * S_{pt} + \beta_9 \ln OP_{pt} * S_{pt} + \beta_{10} Fis_{pt} * S_{pt} + \sum_{r=1}^{4} \chi_r R_r + \sum_{t=1}^{30} \lambda_t T_t + \varepsilon_{pt}\end{aligned} \tag{3}$$

And the sensitivity tests for regional disparities in labour productivity are just replacing the structural break dummy with the regional dummies *rd1-rd3* for the Northeast, Coastal and Interior regions.

3.2 Empirical specifications for beta-convergence

Following Sala-i-Martin (1996), we postulate that beta-convergence holds for provinces p in a region. Log form labour productivity in the province p can be approximated by

$$\ln LP_{pt} = \alpha + (1-\beta) \ln LP_{p,t-1} + \mu_{pt} \tag{4}$$

where $0<\beta<1$ and $\mu_{pt} \sim (0, \sigma_\mu^2)$, and is independent over province p and year t. Manipulating the equation (4) yields,

$$\ln(\frac{LP_{pt}}{LP_{p,t-1}}) = \alpha - \beta \ln LP_{p,t-1} + \mu_{pt} \tag{5}$$

Thus, $\beta>0$ implies a negative correlation between growth and initial level of labour productivity.

$$\beta = -(1-e^{-\lambda T}) \tag{6}$$

λ is the measure of speed at which a region proceeds towards its own steady state level, Hence, λ from cross-section data is often interpreted as the speed at which poorer regions are closing their productivity gap with richer countries.

The beta-convergence regression of provincial labour productivity for region r (=1, … ,4) are as follows:

$$\ln(\frac{LP_{pt}}{LP_{p,t-1}}) = \alpha + \beta \ln LP_{p,t-1} + \delta_1 \ln KL_{pt} + \delta_2 LCI_{pt} + \delta_3 O1_{pt} + \delta_4 O3_{pt} + \delta_5 BR_{pt} + \delta_6 OP_{pt} + \delta_7 Fis_{pt} + \delta_8 S_{pt} \quad (7.1)$$

where $LP_{p,t-1}$ is the lagged labour productivity for province p. The beta-convergence regression of provincial TFP and wages for region r are similarly as follows:

$$\ln(\frac{TFP_{pt}}{TFP_{p,t-1}}) = \alpha + \beta \ln TFP_{p,t-1} + \delta_1 LCI_{pt} + \delta_2 O1_{pt} + \delta_3 O3_{pt} + \delta_4 BR_{pt} + \delta_5 OP_{pt} + \delta_6 Fis_{pt} + \delta_7 S_{pt} \quad (7.2)$$

$$\ln(\frac{AW_{pt}}{AW_{p,t-1}}) = \alpha + \beta \ln AW_{p,t-1} + \delta_1 \ln KL_{pt} + \delta_2 LCI_{pt} + \delta_3 O1_{pt} + \delta_4 O3_{pt} + \delta_5 BR_{pt} + \delta_6 OP_{pt} + \delta_7 Fis_{pt} + \delta_8 S_{pt} \quad (7.3)$$

4. Data Description

Table 2 describes the variables used in this paper. In 1978, the real GDP in the Northeast (51.2 billion RMB) is higher than that of the Coastal (48 billion RMB) and Interior (39.1 billion RMB), and above twice that of the West (22.5 billion RMB). Hence, the industrial Northeast was the growth engine and the richest region. From 1978 to 1994, the GDP in the Coastal increases about 6 fold, compared with about 4 fold in the other three regions so that the Coastal took the No.1 position of the Northeast gradually. From 1994 to 2009, all regions increase 5 fold, suggesting a convergence trend among regions. Hence, over the last 32 years, the Coastal has the highest annual growth rate of GDP at 11.9 percent, while the Northeast grows slower than the Coastal at 8.7 percent per year.

The capital inputs have the similar pattern to GDP. The Northeast had the highest capital inputs (65 billion RMB) in 1978. Then, the capital inputs in the Coastal increased rapidly so that they were 50 percent higher than the Northeast in 2009. The annual growth rate is the highest in the Coastal (14.2 percent) and lowest in the Northeast (10.9 percent). TFP index has been increasing in all four regions, but the growth is most prominent in the Interior. TFP index in the Interior (50) was the lowest among the four regions in 1978 which increased to 94 in 1994, and finally achieved the second highest level (173) among four regions in 2009. As average wage rates are concerned, the Coastal has the lowest wages (1,766 Yuan, about 211 US$ in 1995) among the four regions in 1978. However, its growth rate was the fastest at 8.6 percent per year and increased 16 fold from 1978 to 2009. Hence, the average wages of the Coastal (27,697 Yuan, about 4,054 US$) became the highest among the four regions in 2009. The labour composition index is normally higher in the Interior than in the other three regions, which may be because the Interior is closer to the municipal cities with rich education resources, such as Beijing and Shanghai (see more details in Appendix Table A1).

We also compare several relevant factors that may affect growth, such as ownership (the share of persons employed in SOEs or private enterprises), birth rate, openness and fiscal expenditures on human capital. First of all, the share of private enterprise has been increasing over time, and now is higher than SOEs in the Coastal

(88 percent). In 1978, all four regions had a share of SOEs more than 70 percent (86 percent in the West). Thereafter, the SOEs share of staff employed persons has declined to the range of 16-24 percent in the three inner regions and even lower in the Coastal (only 11 percent) in 2009.

The birth rate keeps on decreasing for all regions resulting from the One-Child Policy, and in 2009, the Northeast had the lowest birth rate (7.07‰) while the West had the highest rate (12.75‰). The provinces in the Coastal tend to be more engaged in international trade because of their geographic, historical and institutional advantages, while inner provinces tend to be less open to international trade. The openness ratio (5 percent) in the Coastal was much higher than the second most open region - the Northeast (2 percent) in 1978. From 1994, the openness ratios were quite stable in the four regions: the Coastal (9 percent), the Northeast (3 percent) and the other two lagging regions (1 percent). As noted above, the openness of these provinces in the Coastal is likely to be an important factor conducive to higher growth.

Finally, the proportion of fiscal expenditures on human capital in the Interior was the highest among the four regions in 1978 (18 percent), as the other regions are nearly the same (16 percent). Human capital expenditures have been increasing very fast in both absolute and relative sense over the period 1978-1994. The West region even achieved a peak proportion as 59 percent in 1994 because the central government transfer huge investment on human capital to the Xinjiang province of the West region. After 1994, this expenditures share slowly has been decreasing in all regions, possibly due to the dramatic process of fiscal decentralization in 1994, possible due to the substitution effect of infrastructural investment of local government (Fleisher et al., 2010; Zhang and Zou, 1998).

(Table 2 around here)

5. Empirical results

5.1 Results of baseline regressions

This section reports statistical results estimating cross-region productivity and wages from 1978 to 2009 in China. Table 3 presents the estimation results from the simple production function using equation (1). The estimated output elasticises of capital services, adjusted labour inputs are positive and significant, which is consistent with the literature. For the overall regression (1), the contribution of adjusted labour inputs is slightly higher than capital services.

For the sensitivity test on structural break in 1994, regression (2) shows that significantly positive incremental effect in physical capital (14.7 percent) and significantly negative incremental effect in adjusted labour inputs (-12.9 percent), confirming the structural break in China's economy in 1994. Regression (3) shows the sensitivity tests on regional heterogeneity that the adjusted labour inputs mainly benefits output in the West (1.14) and the Interior (0.785), while the capital inputs are more important in the Northeast (0.81) and the Coastal (0.69) than others.

(Table 3 around here)

Table 4 displays estimation results of the baseline specification for effect of human capital on labour productivity, TFP and wages. We find that capital deepening

improves labour productivity and wages. The labour composition index improves all three productivity proxies and benefits workers' earnings (3.6 percent) more than TFP (3 percent) and labour productivity (1.1 percent).

Other variables include the market reform factors such as ownership, birth rate, openness and fiscal expenditures on human capital. Compared to collective-owned enterprises, the private firms have much higher productivity and wages; while the public sector has lower productivity but similar wages. The birth rate is negatively associated with the three productivity proxies, which is consistent with Li and Zhang (2007). Openness can increase TFP (45 percent) and the labour productivity (29 percent), but not for wages. Fiscal expenditures on human capital have no significant effect on the labour productivity and TFP, but decrease wage (-12.4 percent).

We conclude that capital deepening as well as human capital formation, privatization and openness significantly improve economic growth, while higher birth rate and the relatively inefficient public sectors harm productivity growth. Fiscal expenditures on human capital have no significant positive effect on economic growth, and are even harmful for wages, verifying Zhang and Zou (1998)'s argument that central government spending (such as in highways, railways, power stations, telecommunications and energy) benefits economic growth, while a high degree of provincial government spending is associated with lower provincial economic growth.

(Table 4 around here)

As the dramatic fiscal reform happens during in 1994, we argue that the structural break may produce biases in our estimation. Hence, we next have the sensitivity tests on disparities in the two time periods (1978-1993 and 1994-2009) and four regions using the equation (3). The results are reported in Table 5 and 6. In Table 5, economic growth mainly benefits from the capital services (48 percent) and openness (33 percent) before 1994, but mainly from the birth rate (1.642), the capital inputs (60.5 percent) and the fiscal expenditures on human capital (12.8 percent) after 1994. The public sector harms labour productivity overall for the whole time period, but it improves TFP and wages after 1994. These results confirm our postulation on structural break in 1994. Especially for fiscal expenditures on human capital, the positive effect on productivity is found after 1994, as well as positive effect on wages before 1994.

Openness has significantly positive effect on labour productivity and TFP. The LCI accelerate both TFP and wage growth from 1978 to 2009. Among other variables, the privatization is the most important institutional change for the three productivity proxies after 1994.

Since the One-Child Policy was implemented after late 1970s, people who born under this policy have not join the labour market before 1994, supporting the negative effect of birth rate on labour productivity due to the dominant diminishing marginal productivity. However, after 1994, the birth rate has positive effect on labour productivity due to the human capital accumulation in the One-Child family, the development of urban area and the gradual process of urbanization. For the whole time period 1978-2009, the birth rate has negative effect on TFP mainly due to the still low technology level across the population. The effects of birth rate on labour productivity and average wages are inconsistent, maybe because Chinese labour market is still rigid in the transition process. Overall, this table shows that the post-1994 period is different from the pre-1994, supporting that year 1994 is a structural break year for Chinese productivity analysis.

(Table 5 around here)

Table 6 shows the different growth patterns for the four regions. Capital accumulation benefits the labour productivity and TFP growth in all four regions, especially in the Northeast and Interior. The labour composition index is more important in the Coastal, mainly possibly due to 56 percent of top universities in China are located in this region (see Appendix Table A1). The public sector only improves labour productivity and TFP in the Northeast and Coastal, and wages in the Interior. The Northeast and Coastal also benefit from more private firms. The birth rate has no effect on labour productivity, but harms the TFP in all the four regions which is consistent with quality and quantity argument of human capital formation. Openness has huge positive effect on all three productivity proxies, except in the Northeast for the labour productivity, and in the Coastal for wages. The fiscal expenditures on human capital are also significantly positive in the Coastal for wages, suggesting a new growth pattern in this advanced region.

(Table 6 around here)

5.2 Results of beta-convergence regressions

Table 7 presents estimation results for conditional beta-divergence. The dependent variables are growth rates of labour productivity, TFP or average wages. We control relevant condition variables such as capital deepening, LCI, ownership, birth rate, openness, fiscal expenditures on human capital and structural break in year 1994 as above. The conditional beta-convergence is present if the coefficient on lagged dependent variable is significantly less than 0.

The main difference between the OLS and GLS specifications appears on the coefficients of the controlled variables. For example, regarding to the labour productivity regressions, GLS method finds upwards bias of OLS estimators on capital deepening and ownership variables, and GLS method verify the significant positive effect of LCI on labour productivity in the Interior region which is consistent with our discuss about LCI indices.

The convergence speeds are similar in the two specifications, and both methods confirm that only provincial within the Northeast region do not show evidence of convergence for average wages. The provinces within the richest Northeast and Costal regions have the highest speed (above 2) converging to their steady states of labour productivity and TFP growth, while the provinces within the poorest West region have the lowest convergence speed (1.89). For the convergence trends of average wages, the provinces within the Coastal regions still have highest speed (2.03) while the provinces within the West region has the lowest speed (1.99). From the convergence analyse, we can see that the poorest West region not only suffer from the severe regional inequality, but also suffer from the relative slower convergence speed across provinces within this region.

(Table 7 around here)

6. Conclusions

China's spectacular economic growth is from unequal economic performance of provinces and regions. This paper examines effects of the formation of physical and human capital on labour productivity, Total factor productivity (TFP) and wages

incorporating the market reform factors such as ownership shift, population policy, openness and fiscal expenditures on education. We find that, in a simple production function, the human capital (measured as composition-adjusted labour inputs) is more important than physical capital for GDP. And, the returns to adjusted labour inputs in the West which has the poorest education resources are the highest among the four regions, while the returns to capital inputs are the highest in the traditional industrial Northeast region.

In more accurate specifications for labour productivity, TFP and wages, Chinese economic miracle mainly pushed by the (physical) capital service per capita rather than labour composition index, possibly due to that the effect of human capital has been reflected into market reform variables such as privatization, One-Child Policy, openness, and fiscal expenditures on human capital. The share of persons employed in the private sector and openness (competing with the foreign companies to the globalization processes) are very important for labour productivity and TFP growth, which allow a more efficient allocation of human capital based on market demand rather than central planning. The higher birth rate is harmful for human capital formation within the families and negative for productivity. The average wage rate is harmed by the fiscal expenditures on human capital, possible due to the substitution effect of infrastructural investment of local government (Zhang and Zou, 1998).

The structural break between the pre-1994 and post-1994 periods illustrates significant difference on economic growth patterns, indicating that the more radical market reforms after 1994 improve productivity and wages. The capital inputs contribute more after 1994, while the returns to Labour composition index (LCI) decrease with the education expansion and increasing tuition fees since the late 1990s (Wang et al., 2010).

The four regions also show different patterns in economic growth paths. The capital inputs mostly help the labour productivity growth in the West as well as the wages growth in the Interior. LCI contributes to the TFP in all four regions. The privatization processes improve labour productivity and TFP in the Northeast and Coastal, as well as wage growth in all four regions except the West. The collective ownership seems a better choice than the pure private or public organisation for the West because its economy is still based on agriculture. Openness is good for three productivity proxies in all four regions, except labour productivity in the Northeast and wages in the Coastal. It is consistent with two phenomenal economic issues in China: the declining production power of the Northeast under the international and internal competition and the great migration of unskilled workers from the rural areas around the country to the coastal region after 1994.

Moreover, provinces within each region present strong evidence of beta-convergence for all three productivity proxies. The highest convergence speed is found in the provinces in the Northeast and Coastal regions for labour productivity and TFP growth, suggesting fast technology spill-over within these regions. The provinces in the Coastal, as the most advanced region in China have the highest convergence speed for average wages, while the provinces in the Northeast region do not show convergence in both Ordinary Least Square (OLS) and Generalized Least Square (GLS) regressions.

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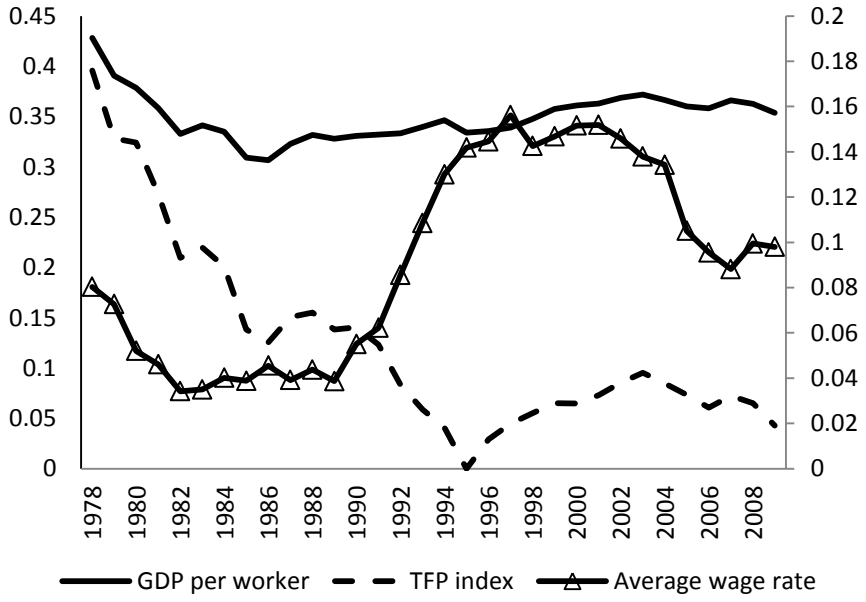
Figure 1: Coefficients of variation, 1978-2009



Data sources: (Hsueh and Li, 1999); various years China Statistical Yearbook (NBS, 1999); National Bureau of Statistics (1999).

Table 1 Changes of labour productivity, TFP and wages, 1978- 2009

	Northeast	Coastal	Interior	West
Real labour productivity				
1978 value	5288	2964	2115	1993
1995 value	12263	12766	6637	5905
2009 value	49728	48818	25657	21644
1978-1995 (growth rate)	0.049	0.086	0.067	0.064
1995-2009 (growth rate)	0.100	0.096	0.097	0.093
Total factor productivity index (1995=100)				
1978 value	73	63	47	50
1995 value	100	100	100	100
2009 value	170	166	173	165
1978-1995 (growth rate)	0.018	0.028	0.044	0.040
1995-2009 (growth rate)	0.038	0.036	0.039	0.036
Real average annual wages				
1978 value	2162	1773	1812	1999
1995 value	4541	6266	4555	4801
2009 value	22431	24662	20116	19222
1978-1995 (growth rate)	0.044	0.074	0.054	0.052
1995-2009 (growth rate)	0.114	0.098	0.106	0.099

Data sources: (Hsueh and Li, 1999)); various years China Statistical Yearbook; National Bureau of Statistics (1999).

Table 2: Data description of economic growth in China

Region	GDP	Capital input	Labour input	TFP index	Average wage	Labour composition index	Public sector	Private Firms	Birth rate (‰)	Openness	Fiscal expenditures on human capital
						1978					
Northeast	512	650	969	70	2148	101.64	0.78	0	16.93	0.02	0.16
Coastal	480	377	1620	71	1766	101.37	0.74	0	17.63	0.05	0.16
Interior	391	509	1848	50	1786	102.50	0.81	0	20.19	0.01	0.18
West	225	308	1127	54	2147	100.92	0.86	0	22.75	0.01	0.15
						1994					
Northeast	1825	3030	1592	96	4128	101.39	0.47	0.37	11.46	0.03	0.27
Coastal	2866	4353	2445	96	5646	101.66	0.35	0.54	12.66	0.08	0.3
Interior	1751	2324	2929	94	4059	103.23	0.36	0.55	16.83	0.01	0.31
West	953	1329	1793	94	4521	101.24	0.53	0.37	20.04	0.02	0.59
						2009					
Northeast	8391	21113	1687	178	21919	103.90	0.24	0.75	7.07	0.03	0.24
Coastal	15538	35817	3183	167	27697	104.36	0.11	0.88	10.38	0.09	0.29
Interior	8729	21366	3402	173	19799	108.82	0.16	0.82	11.97	0.01	0.27
West	4474	12707	2067	170	18632	104.10	0.22	0.77	12.75	0.01	0.25

Data sources: (Hsueh and Li, 1999); various years China Statistical Yearbook; National Bureau of Statistics (1999).

Notes:

1. “GDP”: 100 million Yuan. “Capital input”: 100 million Yuan. “Labour input”: Number of employed persons, 10,000 persons. “TFP index”, “Labour composition index”: 1995=100. Average wage: annual wage rate (Yuan per worker).
2. The value of the labour composition index in 1978 is assumed to equal those in 1989, since the LCI is calculated by the Chinese Household Nutrition Survey (CHNS) (1989-2009).

Table 3: Production function and sensitivity tests, fixed effect model using equation (1)

	Reg (1)	Reg (2)		Reg (3)			
Dep. Variable: Ln (GDP)	Overall effect	Before 1994	After 1994 (Incremental)	Northeast (Incremental)	Coastal (Incremental)	Interior (Incremental)	West
Ln (Capital)	0.681***	0.510***	0.147***	0.213***	0.091***	0.080***	0.599***
	0.007	*0.011*	*0.01*	*0.029*	*0.02*	*0.026*	*0.018*
Ln (adjusted labour input)	0.696***	0.998***	-0.129***	-0.905***	-0.563***	-0.355**	1.140***
	0.044	*0.043*	*0.01*	*0.175*	*0.126*	*0.148*	*0.111*
R-squared	0.986	0.991		0.987			
N	832	832		832			

Notes: Standard errors are in italics. The stars *, ** and *** indicate the significance level at the 10%, 5% and 1%, respectively for two-tail test.

Significant coefficients table:

	Reg (1)	Reg (2)		Reg (3)			
Dep. Variable: Ln (GDP)	Overall effect	Before 1994	After 1994	Northeast	Coastal	Interior	West
Ln (Capital)	0.681	0.51	0.657	0.812	0.69	0.679	0.599
Ln (Adjusted labour input)	0.696	0.998	0.869	0.235	0.577	0.785	1.14

Table 4: Baseline model, fixed effect models using equation (2.1), (2.2) and (2.3), 1978-2009

Dependent variable	Ln (Labour productivity)	Ln (TFP index)	Ln (Average wage)
Ln (Capital per worker)	0.564***		0.568***
	0.01		*0.01*
Labour composition index	0.011***	0.030***	0.036***
	0.00	*0.00*	*0.00*
Public sector (%)	-0.343***	-0.498***	0.19
	0.12	*0.15*	*0.17*
Private sector (%)	0.296***	0.515***	0.547***
	0.10	*0.11*	*0.14*
Birth rate	-3.505***	-5.585***	-0.87
	1.04	*1.28*	*1.49*
Openness	0.290**	0.446***	-0.17
	0.14	*0.16*	*0.19*
Fiscal expenditures on human capital	-0.05	-0.03	-0.124***
	0.03	*0.04*	*0.05*
R-squared	0.99	0.89	0.97
N	832	832	832

Notes: Standard errors are in italics. The stars *, ** and *** indicate the significance level at the 10%, 5% and 1%, respectively for two-tail test.

Significant coefficients table

Dependent variable	Ln (Labour productivity)	Ln (TFP index)	Ln (Average wage)
Ln (Capital per worker)	0.56		0.57
Labour composition index	0.01	0.03	0.04
Public sector (%)	-0.34	-0.50	-
Private sector (%)	0.30	0.52	0.55
birth rate	-3.51	-5.59	-
Openness	0.29	0.45	-
Fiscal expenditures on human capital	-	-	-0.12

Table 5: Sensitivity tests for structural break (Y1994), fixed effect models using equation (3), 1978-2009

Dependent variable	Log (Labour productivity)		Log (TFP index)		Log (Average wage)	
	Before 1994	After 1994 (Incre.)	Before 1994	After 1994 (Incre.)	Before 1994	After 1994 (Incre.)
Ln (Capital per worker)	0.483***	0.122***			0.383***	0.223***
	0.01	*0.01*			*0.01*	*0.01*
Labour composition index	0.01	0.00	0.034***	-0.012***	0.033***	-0.016***
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Public sector (%)	-0.595***	-0.06	-0.554***	1.145***	-0.20	1.911***
	0.12	*0.28*	*0.15*	*0.33*	*0.14*	*0.32*
Private sector (%)	0.13	0.17	0.309**	1.375***	0.404***	1.847***
	0.10	*0.22*	*0.12*	*0.25*	*0.12*	*0.26*
birth rate	-4.763***	6.405***	-6.906***	6.067***	2.275*	-4.666**
	1.11	*1.90*	*1.42*	*2.20*	*1.31*	*2.23*
Openness	0.327**	-0.298**	0.549***	-0.421***	-0.11	-0.524***
	0.14	*0.14*	*0.18*	*0.16*	*0.16*	*0.16*
Fiscal expenditures on human capital	-0.07	0.128**	-0.135**	0.196***	0.155***	-0.182***
	0.05	*0.05*	*0.06*	*0.07*	*0.05*	*0.06*
R-squared	0.99		0.90		0.98	
N	832		832		832	

Notes: Standard errors are in italics. The stars *, ** and *** indicate the significance level at the 10%, 5% and 1%, respectively for two-tail test.

Significant coefficients table

Dependent variable	Log (GDP per worker)		Log (TFP index)		Log (Average wage)	
	Before 1994	After 1994	Before 1994	After 1994	Before 1994	After 1994
Ln (Capital per worker)	0.48	0.61			0.38	0.61
Labour composition index	0.01	0.01	0.03	0.02	0.03	0.02
Public sector (%)	-0.60	-0.60	-0.55	0.59	-	1.91
Private sector (%)	-	-	0.31	1.68	0.40	2.25
birth rate	-4.76	1.64	-6.91	-0.84	2.28	-2.39
Openness	0.33	0.03	0.55	0.13	-	-0.52
Fiscal expenditures on human capital	-	0.13	-0.14	0.06	0.16	-0.03

Table 6: Sensitivity tests for 4 regions, fixed effect models, 1978-2009

Dependent variable	**Ln (Labour productivity)**			
	Northeast (Incre.)	Coastal (Incre.)	Interior (Incre.)	West
Ln (Capital per worker)	0.028	-0.053*	0.029	0.568***
	0.048	*0.028*	*0.032*	*0.025*
Labour composition index	0.017	0.035***	0.003	0.008
	0.017	*0.011*	*0.01*	*0.009*
Public sector (%)	2.336***	1.954***	0.319	-2.350***
	0.647	*0.346*	*0.452*	*0.314*
Private sector (%)	1.985***	1.748***	0.365	-1.395***
	0.419	*0.278*	*0.353*	*0.253*
birth rate	-0.55	-3.891	2.779	-2.924
	3.525	*2.537*	*3.237*	*2.199*
Openness	-4.895***	-4.430***	-2.856	4.583***
	1.314	*1.219*	*1.956*	*1.211*
Fiscal expenditures on human capital	-0.275	-0.173	0.069	0.017
	0.309	*0.121*	*0.196*	*0.031*
R-squared	0.989			
N	832			
Dependent variable	**Ln (TFP index)**			
	Northeast (Incre.)	Coastal (Incre.)	Interior (Incre.)	West
Labour composition index	-0.002	-0.002	-0.014	0.037***
	0.02	*0.012*	*0.011*	*0.01*
Public sector (%)	1.618**	2.581***	-0.26	-2.459***
	0.811	*0.456*	*0.597*	*0.415*
Private sector (%)	1.544***	1.943***	0.04	-1.071***
	0.551	*0.357*	*0.462*	*0.33*
birth rate	5.23	-2.324	6.579	-6.969**
	4.488	*3.317*	*4.25*	*2.871*
Openness	-3.654**	-4.485***	-0.502	4.912***
	1.699	*1.57*	*2.469*	*1.56*
Fiscal expenditures on human capital	-0.773*	-0.553***	-0.42	0.044
	0.407	*0.153*	*0.257*	*0.04*
R-squared	0.904			
N	832			
Dependent variable	**Ln (Average wage)**			
	Northeast (Incre.)	Coastal (Incre.)	Interior (Incre.)	West
Ln (Capital per worker)	-0.022	-0.039	0.118**	0.538***
	0.072	*0.043*	*0.049*	*0.038*
Labour composition index	0.034	0.037**	-0.02	0.047***
	0.026	*0.016*	*0.015*	*0.014*
Public sector (%)	0.946	0.772	2.162***	-1.395***
	0.969	*0.519*	*0.678*	*0.471*
Private sector (%)	1.415**	0.924**	1.559***	-0.812**
	0.628	*0.417*	*0.529*	*0.379*
birth rate	7.386	4.967	4.267	-5.336
	5.281	*3.801*	*4.849*	*3.295*
Openness	-3.238	-3.515*	-0.399	3.356*

	1.969	*1.826*	*2.931*	*1.815*
Fiscal expenditures on human capital	-0.781*	0.404**	-0.193	-0.077*
	0.463	*0.181*	*0.293*	*0.046*
R-squared		0.974		
N		832		

Notes: Standard errors are in italics. The stars *, ** and *** indicate the significance level at the 10%, 5% and 1%, respectively for two-tail test.

Significant coefficients table:

	Northeast	Coastal	Interior	West
Dependent variable	**Ln (Labour productivity)**			
Ln (Capital per worker)	0.568	0.515	0.568	0.57
Labour composition index	-	0.035	-	-
Public sector (%)	-0.014	-0.396	-2.35	-2.35
Private sector (%)	0.59	0.353	-1.395	-1.40
birth rate	-	-	-	-
Openness	-0.312	0.153	4.583	4.58
Fiscal expenditures on human capital	-	-	-	-
Dependent variable	**Ln (TFP index)**			
Labour composition index	0.037	0.037	0.037	0.04
Public sector (%)	-0.841	0.122	-2.459	-2.46
Private sector (%)	0.473	0.872	-1.071	-1.07
birth rate	-6.969	-6.969	-6.969	-6.97
Openness	1.258	0.427	4.912	4.91
Fiscal expenditures on human capital	-0.773	-0.553	-	-
Dependent variable	**Ln(Average wage)**			
Ln (Capital per worker)	0.538	0.499	0.656	0.54
Labour composition index	0.047	0.084	0.047	0.05
Public sector (%)	-1.395	-1.395	0.767	-1.40
Private sector (%)	0.603	0.112	0.747	-0.81
birth rate	7.386	-	-	-
Openness	3.356	-0.159	3.356	3.36
Fiscal expenditures on human capital	-0.858	0.327	-0.077	-0.077

Table 7: Regressions to test for beta-convergence in China using equations (7.1), (7.2) and (7.3), 1978-2009

Dependent: LP growth	OLS regression				GLS regression			
	Northeast	Coastal	Interior	West	Northeast	Coastal	Interior	West
Lagged labour productivity	-0.269***	-0.151***	-0.152***	-0.033*	-0.233***	-0.134***	-0.122***	-0.034**
	0.068	0.024	0.036	0.017	0.057	0.023	0.03	0.015
Capital deepening	0.168***	0.105***	0.081***	0.027**	0.154***	0.091***	0.058***	0.030***
	0.042	0.017	0.022	0.011	0.037	0.017	0.017	0.01
Labour composition index	0.007**	0	0.002	0	0.006**	-0.002	0.002**	0
	0.003	0.002	0.001	0.002	0.002	0.002	0.001	0.002
Public sector	-0.092	-0.218***	-0.109	-0.300***	0.024	-0.236***	-0.088	-0.244***
	0.214	0.074	0.148	0.096	0.203	0.067	0.116	0.092
Private enterprises	0.187	-0.130**	0.102	-0.181**	0.237	-0.140**	0.118	-0.162**
	0.16	0.066	0.12	0.078	0.15	0.058	0.094	0.077
Birth rate	-2.497**	-3.980***	1.021	-1.068	-2.450**	-3.760***	1.426*	-1.548**
	1.123	0.859	1.096	0.7	1.01	0.845	0.851	0.658
Openness	-0.386***	0.120**	2.090***	0.556	-0.355***	0.143**	1.255**	0.725**
	0.121	0.055	0.688	0.398	0.122	0.057	0.555	0.331
Fiscal expenditures on human capital	0.230**	0.001	0.178*	0.014	0.295***	0.004	0.122	0.011*
	0.109	0.081	0.102	0.009	0.1	0.079	0.081	0.006
Year1994 dummy	-0.026	-0.005	-0.009	-0.01	-0.033*	-0.001	-0.012	-0.008
	0.02	0.015	0.022	0.014	0.018	0.014	0.016	0.012
R-squared	0.53	0.178	0.278	0.236				
N	93	279	186	248	93	279	186	310
Wald chi2 (Prob>chi2)					132.4	68.9	104.9	72.3
Beta	-0.27	-0.15	-0.15	-0.03	-0.23	-0.13	-0.12	-0.03
Lambda	2.07	2.04	2.04	1.89	2.06	2.04	2.03	1.91

Dependent: TFP growth	**OLS regression**				**GLS regression**			
	Northeast	Coastal	Interior	West	Northeast	Coastal	Interior	West
Lagged TFP	-0.116***	-0.119***	-0.121***	-0.055***	-0.124***	-0.112***	-0.114***	-0.048***
	0.038	0.014	0.023	0.015	0.037	0.011	0.021	0.013
Labour composition index	-0.001	0.001	0.001	-0.001	-0.001	0	0	-0.001
	0.001	0.002	0.001	0.002	0.001	0.002	0.001	0.001
Public sector	0.159	0.047	0.045	-0.092	0.176	0.021	-0.025	-0.091
	0.188	0.049	0.114	0.07	0.176	0.051	0.106	0.068
Private enterprises	0.22	0.160***	0.200**	-0.012	0.254*	0.133***	0.152*	-0.042
	0.152	0.043	0.09	0.056	0.143	0.043	0.084	0.056
Birth rate	-2.028**	-2.538***	0.867	-1.02	-1.449*	-2.204***	1.237	-1.392**
	0.956	0.603	0.903	0.619	0.841	0.571	0.788	0.575
Openness	-0.154	0.081**	0.76	0.357	-0.124	0.078**	0.103	0.587**
	0.108	0.037	0.558	0.319	0.108	0.036	0.477	0.242
Fiscal expenditures on human capital	0.188**	-0.026	0.098	0.013*	0.185**	-0.009	0.056	0.009**
	0.092	0.058	0.087	0.008	0.088	0.056	0.074	0.004
Year1994 dummy	0.011	-0.016	-0.009	-0.009	0.006	-0.01	-0.01	0.001
	0.018	0.011	0.018	0.012	0.017	0.01	0.014	0.01
R-squared	0.25	0.303	0.177	0.037				
N	93	279	186	248	93	279	186	310
Wald chi2 (Prob>chi2)					42.5	175.4	54.4	25.9
Beta	-0.12	-0.12	-0.12	-0.06	-0.12	-0.11	-0.11	-0.05
Lambda	2.03	2.03	2.03	1.99	2.03	2.03	2.03	1.98

Dependent: Average wages growth	**OLS regression**				**GLS regression**			
	Northeast	Coastal	Interior	West	Northeast	Coastal	Interior	West
Lagged average wages	-0.039	-0.121***	-0.057**	-0.058***	-0.05	-0.118***	-0.055**	-0.056***
	0.04	0.02	0.025	0.02	0.036	0.02	0.024	0.019
Capital deepening	-0.033	0.053***	0.019	0.004	-0.014	0.053***	0.016	0.002
	0.033	0.011	0.017	0.01	0.028	0.011	0.015	0.009
Labour composition index	0.006**	0	0.002	-0.001	0.004*	0	0.002	-0.002
	0.003	0.002	0.002	0.003	0.002	0.002	0.002	0.002
Public sector	-0.43	-0.115	-0.243	-0.097	-0.356	-0.135*	-0.244	-0.079
	0.328	0.086	0.175	0.134	0.293	0.081	0.165	0.126
Private enterprises	0.014	0.025	-0.023	0.019	0.009	0.011	-0.033	0.048
	0.245	0.076	0.15	0.116	0.217	0.071	0.139	0.113
Birth rate	-1.501	-3.071***	0.521	-2.480**	-2.453*	-2.964***	0.9	-1.626
	1.478	0.984	1.44	1.158	1.336	0.931	1.221	1.133
Openness	-0.257	0.118*	1.421*	1.029	-0.302*	0.107	1.263*	0.8
	0.169	0.066	0.855	0.624	0.164	0.072	0.761	0.572
Fiscal expenditures on human capital	0.095	0.079	-0.142	0.007	0.062	0.121	-0.16	0.007
	0.137	0.094	0.128	0.016	0.115	0.089	0.117	0.015
Year1994 dummy	0.006	0.021	-0.007	0.048**	0.012	0.02	-0.005	0.047**
	0.03	0.018	0.029	0.023	0.028	0.017	0.026	0.021
R-squared	0.464	0.216	0.226	0.208				
N	93	279	186	248	93	279	186	310
Wald chi2 (Prob>chi2)					98.4	94.8	69.1	70.3
Beta	no convergence	-0.12	-0.06	-0.06	no convergence	-0.12	-0.06	-0.06
Lambda		2.03	1.99	1.99		2.03	1.99	1.99

Notes: Standard errors are in italics. The stars *, ** and *** indicate the significance level at the 10%, 5% and 1%, respectively for two-tail test.

Appendices

Figure A1: Geographic graph of four regions in this thesis

(1)Northeast region: Heilongjiang, Jilin, Liaoning;

(2)Coastal region: Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, and Guangdong-Hainan;

(3) Interior region: Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan;

(4)West region: Guangxi, Sichuan-Chongqing, Guizhou, Yunnan, Inner Mongolia, Shaanxi, Gansu, Qinghai, Ningxia and Xinjiang.

Note: We do not study Tibet due to data limitation.

Table A1: The location of the project 211 universities

Coastal region											
Province	Whole	Beijing	Tianjin	Hebei	Shanghai	Jiangsu	Zhejiang	Fujian	Shandong	Guangdong*	
Number	63	26	4	1	10	11	1	2	3	5	
Percentage	56%	23%	3%	1%	9%	10%	1%	2%	3%	4%	
Northeast region											
Province	Whole	Liaoning	Jilin	Heilongjiang							
Number	12	4	3	5							
Percentage	10%	3%	3%	4%							
Middle region											
Province	Whole	Shanxi	Anhui	Jiangxi	Henan	Hubei	Hunan				
Number	16	1	3	1	1	7	3				
Percentage	15%	1%	3%	1%	1%	6%	3%				
West region											
Province	Whole	Inner Mongolia	Guangxi	Sichuan*	Guizhou	Yunnan	Shaanxi	Gansu	Qinghai	Ningxia	Xinjiang
Number	24	1	1	7	1	1	8	1	1	1	2
Percentage	22%	1%	1%	6%	1%	1%	7%	1%	1%	1%	2%

Note: Project 211 is a project of National Key Universities and colleges initiated in 1995 by the Ministry of Education of the People's Republic of China, with the intent of raising the research standards of high-level universities and cultivating strategies for socio-economic development.