

Convergence in China? An Empirical Study: 1985-2005

Wu Di
(4620547)

Major Paper presented to the
Department of Economics of the University of Ottawa
In partial fulfillment of the requirement of the M.A. Degree

Supervisor: Kathleen M. Day

ECO 7997

Dec. 12, 2007

Ottawa, Ontario

Acknowledgements

The author is grateful to Professor Kathleen Day for her supervision and her insightful and helpful ideas and comments.

The author also thanks to Professor Gilles Grenier for his helpful comments.

Abstract

This paper tests for the existence of both absolute and conditional convergence using panel data, with seven-year intervals, from 1985 to 2005 for 27 provinces in China. The paper adopts Barro and Sala-i-Martin's classical approach to test for absolute convergence in China and follows Mankiw et al.'s (1992) method to test for conditional convergence. This updated study confirms the prediction about divergence of some previous studies, when all regions in China are assumed to have the same steady state. It also provides strong evidence of conditional convergence in China.

I. Introduction

According to recent news stories the Chinese Government spent 2.7 billion RMB¹ to build the National Great Theatre in the capital of China, which occupies 12 hectares of land. In addition, 5 billion RMB will be invested in Beijing for a new CCTV Tower, which will have a construction area of 550 thousand square meters. At the same time, in Gansu, 30 primary students are crowded in a “classroom” that is less than 50 square meters, which has no windows, no desks, and no chairs, but has lots of holes in the ceiling and walls. The “classroom” is made from mud and wood. The estimated cost is no more than 2000 RMB.²

What a difference! Almost thirty years (1978-2007) of continuous high-speed economic growth have created a myth of development in China. However, what does the myth actually bring to this country and its people? Thirty years of reform contributes a 9.5% average annual GDP growth rate and a great increase in GDP per capita from 381 RMB in 1978 to 14040 RMB in 2005.³ Thirty years of open door policy, plus four years of membership in the World Trade Organization (WTO) have made “Made in China” labels stretch into every corner of the world and provided a profit to China in the form of a US\$837.44 billion positive trade balance in 2005. In June 2007, China’s foreign exchange reserves sharply rose to US\$1332.6 billion, which makes

¹ RMB is Chinese currency. It is also called the Yuan. One Canadian Dollar is approximately equal to 7.5 Yuan.

² The news and numbers are from <http://pop.6park.com/life2/messages/gvk82607.html> (09/11/2007)

³ The data on the GDP growth rate and GDP per capita are from China Statistic Bureau (2006) China Statistic Year Book.

China the largest foreign exchange reserves holder, bypassing Japan, at the beginning of 2007.⁴ While this is amazing, it does not add up.

During the same thirty years, the Gini coefficient, which began at 0.18 in 1978, flew up to 0.561 in 2005 and broke the 0.6 boundary in 2007, implying an extremely unequal income distribution.⁵ In the year 2005, the richest province, Shanghai, reached a GDP per capita of 51474 RMB, which is more than ten times that of the poorest province, Guizhou, at 5052 RMB. In addition, after thirty years of development in Beijing, Japanese rice can be sold out at almost 40 RMB per pound;⁶ moreover, American meat products are also highly priced at 50 RMB per pound.⁷ Meanwhile, in Anhui, many parents go out to large cities to work and struggle to make five RMB a day for meals, leaving their child alone at home. While some children luckily have grandparents at home to watch them, others do not.

From all the above, it is not hard to see that, after the thirty years of effort, China is still trying desperately to make a larger and larger economic cake, but somehow, the country forgets to divide the cake into more equal pieces. This income inequality poses a serious problem for welfare economists interested in the relationship between economic efficiency and income distribution in China.

⁴ China's foreign exchange reserves data are from <http://finance.sina.com.cn/g/20070711/18593775713.shtml> (07/11/2007)

⁵ The Gini coefficient is a measure of inequality of income distribution or inequality of the wealth distribution. When the Gini coefficient is under 0.2, it implies an equal income distribution. When the Gini coefficient is between 0.2 and 0.4, it means a relatively equal income distribution. When the Gini coefficient is between 0.4 and 0.6, it indicates an inequality of the income distribution. When the Gini coefficient is above 0.6, it implies an ultimate inequality of the income distribution. The data for the Gini coefficient is from <http://finance.sina.com.cn/g/20050622/18181713560.shtml> (08/24/2007)

⁶ The price of the Japanese rice comes from <http://www.ynet.com/shanghai/view.jsp?oid=23316913> (08/28/2007)

⁷ The price of the American meat products is from <http://www.6park.com/news/messages/64840.html> (09/04/2007)

Economic efficiency is largely positively related to economic growth and deals with increasing the size of the cake; income distribution, on other hand, deals with dividing the cake. An economy has to find a good balance between these two aspects. Otherwise, it will either end up with slow economic development but an equally all-poor income distribution or generate high-speed development also with a high risk of social instability. As a result, the extreme inequality of the income distribution has become one of the most serious problems that the Chinese government has to face. While this paper does not deal with the welfare economics problem posed by the personal income distribution, it does investigate regional productivity dispersions to see if there is any economic convergence. In other words, this paper will examine some issues relating to inequality of income or productivity at the provincial level.

According to neoclassical economic theory, the Solow-Swan model of Solow (1956) and Swan (1956) implies that the per capita growth rate has a negative relationship with the initial level of output per capita. This means that poor economies will experience a higher growth rate and tend to catch up to the leading economies. Thus, there is a force leading towards convergence of outputs or income in per capita levels to a steady state among the economies. The poor will not always be poor and the leaders cannot always lead.

After the development of the neoclassical growth model, many empirical studies and extensions of the model have been carried out. Studies have shown that a trend toward convergence among economies exists and is

particularly strong and obvious if the economies are similar in terms of preferences and technology. For example, this trend exists among the states of the U.S.A (Barro and Sala-i-Martin, 1992) and the provinces of Canada (Coulombe and Lee, 1995), and the countries of the OECD (Mankiw, Romer and Weil, 1992). Thus, the question is whether there is also evidence of convergence among Chinese provinces, even though the above discussion suggests that there are huge divergences between them, or is China an exception to convergence theory? If there is convergence, is it possible for us to predict the steady state and calculate the speed of convergence?

With all these questions in mind and the neoclassical growth model at hand, we will use panel data for the 27 provincial economies (excluding Tibet, Hainan, Qinghai and Chongqing) from 1985 to 2005 to examine whether there is evidence of convergence in China or not.⁸ The paper is structured as follows. The next section will look at some previous studies on convergence, especially the studies on China. After that, an estimating equation based on the neoclassical model will be constructed to test the convergence thesis of this paper. The following section provides some explanation of the data and notation, and examines the relevance of the model to China. Section IV will present the interpretations of the estimation results from the panel data. The last section will provide some concluding thoughts.

⁸ The reason for the exclusion of the four provinces is explained in the data section.

II. Literature Review

The theory of economic growth can be traced very far back in time to Adam Smith (1776), David Ricardo (1817), and much later, to Frank Ramsey (1928). These economists all provided some basic concepts and models to economic growth theory. After them, a very important contribution came from the Solow-Swan growth model in 1956. In this model, Solow (1956) and Swan (1956) hypothesized a neoclassical form of production function, using the assumptions of constant returns to scale, diminishing returns to inputs, positive and smooth elasticity of substitution between the inputs, and last but not least, a constant saving rate. The Solow-Swan model implied a simple general equilibrium of the economy and a prediction of “conditional convergence.” The model demonstrated that an economy with a lower initial level of real GDP per capita, relative to its steady state position, tends to grow faster than a richer one. Subsequently, Cass (1965) and Koopmans (1965) adopted the analysis of consumer optimization in the Ramsey model and developed an endogenous growth model. The determination of long-run growth within the model led to the name “endogenous growth model”. By contrast, the exogenous growth model, like the Solow-Swan model, leaves the determination of some key variables, such as technological progress, outside the model. Still, the endogenous growth model also predicts a “conditional convergence”.

What is conditional convergence? Are there also some other kinds of convergence? Barro (1989) advanced the idea that holding the initial human

capital level constant reveals the negative relationship between the starting level of income and the growth rate. A few years later, more explicit definitions of convergence were formulated in Barro and Sala-i-Martin (1992) and Mankiw, Romer and Weil (1992). So far, three types of convergence have been defined: conditional convergence, absolute convergence, and σ -convergence. The definitions are given respectively as follows.⁹

Conditional convergence (also referred to as conditional β -convergence), in contrast to absolute convergence, occurs when “countries that are poorer after controlling for the determinants of income on the balanced growth path grow faster” (Romer, 2006, p. 162). For example, in the Solow-Swan model, convergence is conditional on the savings rate, the growth rate of population, the level of technology, the depreciation rate of capital, and some other additional determinants that vary across economies. In conditional convergence, every economy has its own steady state and the growth rate depends on the distance between the starting level of per capita GDP and the country’s steady state level. On the other hand, absolute convergence (also referred to as absolute β -convergence or unconditional convergence), as defined by Sala-i-Martin (1996a, p. 1020), occurs “if poor economies tend to grow faster than rich ones.” In absolute convergence, all economies are converging to the same steady state and the only difference among the economies is the initial GDP or income per capita. The hypothesis of absolute

⁹ The definitions were developed by consulting various authors’ ideas on the same subject.

β -convergence assumes that the poorest economy, in the sense of per capita GDP or income, will experience a faster growth rate along the transition path during its catching-up period.

There is also another concept of convergence, called σ -convergence. Sala-i-Martin (1996a, p. 1020) defines it as follows: “a group of economies are converging in the sense of σ if the dispersion of their real per capita GDP levels tends to decrease over time”. According to Sala-i-Martin (1996a, p. 1022), “ σ -convergence relates to whether or not the cross-country distribution of world income shrinks over time. β -convergence, on the other hand, relates to the mobility of different individual economies within the given distribution of world income.”

Even though the Ramsey model, the Solow-Swan growth model, and the endogenous growth model had existed for many years, it was not until the beginning of the 1990s that further empirical studies of convergence were carried out, due to the lack of data. Barro and Sala-i-Martin (1992) empirically tested the 48 U.S. states' data on personal income since 1840 and gross state product (GSP) since 1963. They used cross section data and based their work on the regression equation below:

$$\frac{1}{T} \cdot \log\left(\frac{y_{i,t_0+T}}{y_{i,t_0}}\right) = B - \left(\frac{1 - e^{-\beta T}}{T}\right) \cdot \log(y_{i,t_0}) + u_{i,t_0,t_0+T}$$

where y is the personal income or GSP per capita, T is the length of the period, t_0 is the starting time, u_{i,t_0,t_0+T} is an error term, and the constant term is $B = x + [(1 - e^{-\beta T}) / T] \cdot [\log(\hat{y}^*) + x t_0]$. The constant term shifts with the trend of

technology x and a change in the starting time t_0 . They concluded that there was clear evidence of convergence among U.S. states, whether or not any other variables besides the starting level of per capita income or GSP were held constant. The speed of convergence, β , appeared to be roughly the same under both conditional and absolute convergence - approximately 2 percent a year. However, they obtained a very high value for the capital share coefficient α , which is calculated from $\beta = (1 - \alpha)(n + g + \delta)$ around 0.8 in their model.¹⁰ This high value of α does not make sense in real life because in practice the capital share in production cannot reach that high level.

Almost simultaneously, this problem was solved by Mankiw, Romer and Weil (1992), by addition of human capital into the Solow-Swan model:

$$Y_t = K_t^\alpha H_t^\gamma (A_t L_t)^{1-\alpha-\gamma},$$

where Y is output, K means physical capital, H denotes human capital and L is labor. Adding human capital into the textbook Solow-Swan model was clearly an improvement and solved the problem of the high value of the capital share. According to the regression results of Mankiw, Romer and Weil the shares of physical and human capital both became around one-third, which is more realistic. In addition, Mankiw, Romer and Weil also tested for convergence based on the following equation:

$$\log(y(t)) - \log(y(0)) = (1 - e^{-\lambda t}) \frac{\alpha}{1 - \alpha - \gamma} \log(s_k) + (1 - e^{-\lambda t}) \frac{\gamma}{1 - \alpha - \gamma} \log(s_h) - (1 - e^{-\lambda t}) \frac{\alpha + \gamma}{1 - \alpha - \gamma} \log(n + g + \delta) - (1 - e^{-\lambda t}) \log(y(0))$$

¹⁰ In the β equation, n is the population growth rate, g is the technology growth rate and δ is the capital depreciation rate.

In the equation, y stands for the output per capita, s_k is the rate of investment in physical capital; s_h is the rate of investment in human capital; and n , g and δ denote the population growth rate, the technology growth rate and the depreciation rate of capital respectively. They used cross-section data on non-oil producing countries (98 observations), intermediate countries (75 observations) and OECD countries (22 observations), and the estimated speed of conditional convergence is respectively 1.37%, 1.82% and 2.03%.¹¹

More and more empirical studies on the subject were carried out after this point. Xavier Sala-i-Martin (1996a) examined a sample of 110 countries over the thirty-year period from 1960 to 1990. Using an estimating equation similar to the equation in Barro and Sala-i-Martin (1992), he concluded that there was no evidence of absolute convergence at all. During the thirty-year period, poor countries did not show any signs of catching up to rich countries. The results also indicated that, in terms of σ -convergence, the world income disparities not only failed to narrow, but also had a tendency to increase over time. However, controlling for primary and secondary school enrolments, the saving rate and some political variables, there was conditional convergence in the set of 110 countries, and the speed of convergence was approximately two percent per year. Note that the two percent per year convergence speed does not imply that poor countries are growing faster than rich countries or that the income gap between poor economies and rich ones has shrunk. The former

¹¹ Intermediate countries are that non-oil producing countries excluding the ones whose real income figures are based on extremely little primary data or whose population in 1960 was less than one million,

would be absolute β -convergence and the latter would be σ -convergence. Instead, the conditional convergence speed just means each economy is approaching its own steady state at a speed of two percent per year.

In a similar study, Barro and Sala-i-Martin (1995, chapter 12) estimated the Barro-type equation using data for 119 countries between 1965 and 1985. This time they controlled for educational attainment, life expectancy, the interaction between GDP and human capital, public spending on education, the investment ratio, government consumption, the black-market premium on the foreign exchange rate, political instability and the terms of trade. Conditional convergence was confirmed. They also applied the same equation and a similar estimation method both to the data of 47 Japanese Prefectures from 1930 to 1990 and to the data of 90 European regions in eight European countries between 1950 and 1990 to test for convergence of income per capita. They used both cross section and panel methods with or without region dummies and structural variables. They concluded that the patterns of convergence in Japan and Europe were similar. These two regions presented evidence of both absolute convergence and conditional convergence. The speed of convergence was higher when the equation was estimated using panel data than when using cross section data. For Japan, the speeds of convergence were 1.25% (unconditional) and 3.12% (conditional); for Europe, the speeds of convergence were 1.9% (unconditional) and 1.8% (conditional).

For Canada, using six different measures of per capita income and

output from 1961 to 1991, Coulombe and Lee (1995) followed Barro and Sala-i-Martin's model and provided evidence of convergence. They found that the convergence pattern in Canada was similar to the patterns in the U.S, Japan, and Europe observed in Barro and Sala-i-Martin (1995). In an extension, Lee (1996) used the augmented version of the neoclassical model (Mankiw, Romer and Weil, 1992) and created a sample of panel data by dividing provincial data from 1960 to 1992 into three sub-periods. Each sub-period contains eight years. He concluded that the trend towards convergence became more pronounced when differences in industrial structure, physical and human capital investments were considered.

In a further study of income disparities, Coulombe and Day (1999) investigated relative regional income disparities in Canada, using as a reference group the northern U.S. states. They concluded that relative regional income disparities were decreasing, which reduces the need for government policies intended to decrease regional income differences. Moreover, their analysis suggested that, if the Canadian economy was close to the long-run equilibrium or steady state, policies promoting the accumulation of human and physical capital, which would have been appropriate during the transition path to the steady state, were becoming less effective. They would have little influence on regional income differentials once the steady state had been reached.

To compare with the U.S, Coulombe (1997) estimated the speed of β -

convergence of production per worker for ten provinces from 1967 to 1993 based on the following equation:

$$M_t = x + (1 - e^{-\beta})[\hat{y}_t^* + x(t-1)] + e^{-\beta} M_{t-1} + \sum_{i=1}^{10} u_{it} ,$$

where M denoted the average production per worker, \hat{y}_t^* is the production per worker at the steady state, and x is for the growth rate of productivity. His estimated speed of convergence was generally more rapid than that obtained by Barro and Sala-i-Martin for regional data. He also pointed out two statistical facts for Canada compared with the U.S.A.: one was that the Canadian provinces achieved a lower steady state than that of the bordering U.S. states, and took much longer to get there. The other one was that, even though the Canadian economy was close to its long-run equilibrium, the production per capita differentials among Canadian provinces were still twice as high as those observed in the U.S. states.

How about China? As the largest developing country, China, with thirty years of continuous rapid growth, has certainly captured the attention of many macroeconomic theorists and econometricians. Tsui (1991), working with data from 1952 to 1985, stated that the income gap among provinces had not declined. However, Denny (1992) argued that economic disparities had narrowed during the period of economic reform. He used per capita net material product (NMP) rather than real GDP per capita to measure growth, and his data only covered the ten years from 1978 to 1988.¹² Subsequently,

¹² NMP is calculated as the nominal gross value of output minus nominal material consumption. Before

Chen and Fleisher (1996) reported evidence of the conditional convergence of per capita production across 25 provinces in China after economic reform using both cross-section and panel approaches. Their study followed the method of Mankiw, Romer and Weil (1992) and controlled for employment, physical capital, and human capital. It also included dummy variables for the coastal zone. They also pointed out that the differentials in production per capita between the coastal and interior provinces were widening, but the gaps within the groups of coastal and interior provinces were decreasing. Their findings were confirmed by Choi (1996), who examined cross-sectional data between 1984 and 1991 using similar methods.

Next, a more important paper was published by Jian, Sachs and Warner (1996). They divided the period from 1952 to 1993 into three sub-periods. They examined the tendency toward convergence of GDP per capita and observed that different sub-periods displayed different phenomena. During the central planning period (1952-1965), there was no evidence of convergence at all. After that was the Cultural Revolution (1965-1978). During the Cultural Revolution, regional income disparities not only failed to decrease, but rather increased. Since 1978, the starting year of China's economic reform, there has been strong evidence of convergence, but the analysis indicated that since 1990 the coastal provinces apparently grew much faster than the interior provinces with the consequence of divergence in regional income.

1978, China still followed the Soviet Union's statistical methods. In 1985, China began to use GDP as the national output indicator.

Gundlach (1998) re-examined the period after the reform by applying the neoclassical growth model. His conclusion was similar to that of Jian et al. (1996). He confirmed convergence of regional output per capita across 29 provinces since 1979, and predicted a trend towards divergence after 1989, but he argued that this trend was due to fiscal decentralization. In the same year, Raiser (1998) used Mankiw, Romer and Weil's (1992) equation, with annual data on per capita income from 1978 to 1992, and controlled for enrollment rates in school and industry structure. He also pointed out that the speed of convergence had slowed down after 1985, because of the much faster growth rate in the coastal area as compared to the interior area. Li, Liu and Rebelo (1998) utilized both cross-sectional and panel data over the reform period 1978-1995 and concluded that the growth rate of GDP per capita was negatively related to population growth, and positively related to openness to foreign countries and investment in physical and human capital. They even found evidence for both conditional and unconditional convergence after reform.

The study of convergence in China has continued into the 21st century. Zhang, Liu and Yao (2000) employed a time series analysis approach to investigate the provincial income per capita convergence problem. The existence of stochastic convergence is related to the unit root hypothesis. If shocks to relative regional income per capita are temporary, then relative incomes will not have a unit root. If regional income has a unit root, there must

be divergence, since it would mean that the region's income was diverging from the national income. They divided China into three regions: eastern regions, central regions, and western regions. They used income per capita data from 1952 to 1997 and carried out an ADF test based on the following equation:

$$\Delta RI_t = \alpha + \beta t + \rho RI_{t-1} + \sum_{i=1}^k \theta_i \Delta RI_{t-i} + \varepsilon_t$$

where RI_t was the log of regional income per capita relative to the national average at time t , ΔRI_t was the first difference of RI_t , k was the lag order of ΔRI_t , and ε_t was a serially uncorrelated error term with zero mean and a finite variance. The analysis showed that conditional convergence exists in China, especially in the eastern and western areas. These areas have both moved toward their own specific steady state over the past forty years.

Another important contribution was made by Yao and Weeks (2000). In their paper, they followed Barro and Sala-i-Martin's (1996) approach with panel data from 1953 to 1997 over 28 provinces in China. They used 5-year intervals, used the investment ratio as the steady state control variable, and found evidence of conditional convergence over the past 40 years. Yao and Weeks estimated the speed of conditional convergence before 1978 to be 0.414 percent per year, and 2.23 percent one year after 1978. They concluded that there was no absolute convergence in China, either before or after the reform. However, one problem with the study is that the coefficient of the control variable is not statistically significant all the time.

Following the classical approach of Barro and Sala-i-Martin, Yang and Yang (2005) found evidence of conditional convergence using panel data from 1978 to 2003 for 30 provinces. They also divided the 30 provinces into three areas within which there was some degree of homogeneity, with respect to initial income level and growth performance pattern. They concluded that across 30 provinces, there was no evidence of absolute convergence or σ -convergence. Yet, there was evidence of conditional convergence.

After all of the above previous studies on China's economic convergence, obviously there are still some unresolved questions. For example, is there at all absolute convergence among all of the provinces in China? Numerous studies agreed that there was strong evidence of conditional convergence after 1978. However, even in this agreement, some researchers demonstrated the existence of conditional convergence with data that examined the provinces from the whole country, while others concluded that conditional convergence only existed regionally, when the provinces were divided into three regions. At the start of the 1990s, many researchers predicted that conditional convergence would slow down after 1990, and some even forecasted that divergence might arise in the 1990s. Due to the lack of data, they cannot provide any detailed and explicit explanations for their prediction. Therefore, this paper will try to clarify whether absolute convergence exists or not. In addition, the paper will test for evidence of conditional convergence in three regional areas as well as in the country as a whole. As data after 1990 are now

available, the paper will attempt to verify previous researchers' predictions about the slowing-down of convergence, or even divergence, in the 1990s.

III. Model

III. 1 Absolute β -convergence

This paper follows Barro and Sala-i-Martin's approach to test for absolute convergence in China. As mentioned before, in empirical studies absolute β -convergence occurs only if the evidence shows "a negative relation between the growth rate of income per capita and the initial level of income" (Sala-i-Martin 1996b, p. 346). To be consistent with the notation in Sala-i-Martin (1996a), let $\gamma_{i,t,t+T}$ be the annual growth rate of GDP per capita for economy i between time t and $t+T$. By definition, $\gamma_{i,t,t+T} \equiv \log(y_{i,t+T} / y_{i,t}) / T$. Thus, absolute β -convergence will exist if one finds a positive value for the coefficient b in the equation:

$$\gamma_{i,t,t+T} = a - b \log(y_{i,t}) + \varepsilon_{i,t} \quad , \quad (1)$$

where a is a constant, b is the estimated coefficient, and $\varepsilon_{i,t}$ is a random error that reflects random shocks to GDP per capita. According to Sala-i-Martin (1996a), the speed of convergence β can be calculated using the formula $b = 1 - e^{-\beta T}$, where T is the length of time between two observations. β , as the name says, measures the average speed at which poor economies catch up to rich ones. β has to be positive for absolute β -convergence.

Substituting the expression for $\gamma_{i,t,t+T}$ into equation (1) yields the

regression equation used in this paper to test for absolute β -convergence in China:

$$\frac{1}{T} \log(y_{i,t+T} / y_{i,t}) = a - b \log(y_{i,t}) + \varepsilon_{i,t} . \quad (2)$$

To reiterate, in absolute β -convergence, the growth rate of GDP per capita is inversely related to the initial level of GDP per capita and all the economies are converging to the same steady state.

III. 2 σ -convergence

By definition, σ -convergence is a downward trend in the dispersion of GDP per capita over time. That is, if

$$\sigma_{t+T} < \sigma_t , \quad (3)$$

where σ_t is the standard deviation of $\log(y_{i,t})$ across all the provinces at time t , then there is evidence of σ -convergence. Recall that the existence of β -convergence, whether absolute or conditional, is just a necessary condition for σ -convergence, not a sufficient condition.

III. 3 Conditional β -convergence

In the conditional β -convergence part, this paper will follow the approach of Mankiw, Romer and Weil (1992), with some extensions. This paper continues with their equation, as follows in regression form:

$$\frac{1}{T} \ln(y_{i,t_0+T} / y_{i,t_0}) = \eta_0 + \eta_1 \ln y_{i,t_0} + \eta_2 \ln(g_{i,t} + n_{i,t} + \delta_{i,t}) + \eta_3 \ln s_{k,i,t} + \eta_4 \ln s_{h,i,t} . \quad (4)$$

Here, y_{i,t_0} denotes the initial GDP per capita in each time interval, and T

stands for the length of the time interval. $g_{i,t}$, $n_{i,t}$, and $\delta_{i,t}$ are respectively the growth rate of technology, the growth rate of population and the depreciation rate of capital in each province i at time t . $s_{k,i,t}$ is the physical capital investment rate in each province i at time t , and similarly $s_{h,i,t}$ is each province's human capital investment rate at time t .

In equation (4), η_1 and η_2 are expected to be negative while η_3 and η_4 are expected to be positive. A negative value of η_1 means a negative relation between the growth rate of GDP per capita and the initial level of GDP per capita, which exactly agrees with the definition of convergence. Under the assumption of a constant growth rate of technology and constant depreciation rate of capital in each province over time, a negative η_2 implies that the higher the growth rate of population, the lower the GDP per capita growth rate. Positive values for η_3 and η_4 make sense because these imply that the higher the rate of investment in capital, the higher the GDP per capita growth rate. Note that if $g_{i,t}$, $n_{i,t}$, $\delta_{i,t}$, $s_{k,i,t}$, and $s_{h,i,t}$ are identical across all the provinces, then the equation will imply the existence of absolute convergence rather than conditional convergence.

In addition, this paper intends to add more control variables, such as industry structure shares, Foreign Direct Investment (FDI), and degree of openness, as an extension of Mankiw, Romer and Wail's model. Thus, a more comprehensive regression equation for testing for conditional convergence is:

$$\frac{1}{T} \ln(y_{i,t_0+T} / y_{i,t_0}) = \eta_0 + \eta_1 \ln y_{i,t_0} + \eta_2 \ln(g_{i,t} + n_{i,t} + \delta_{i,t}) + \eta_3 \ln s_{k_{i,t}} + \eta_4 \ln s_{h_{i,t}} + \sum_{j=5}^8 \eta_j \ln x_{i,j,t} + \eta_9 \ln FDI_{i,t} + \eta_{10} \ln Open_{i,t} + \varepsilon_{i,t} \quad (5)$$

The variable $x_{i,j,t}$ represents the output shares of the primary, manufacturing, transportation, and commerce sectors in each provincial economy. The output shares of the construction sector, the finance and insurance sector, the real estate sector and other sectors are excluded from the equation. $x_{i,j,t}$ is measured as the fraction of output in each sector over GDP. The variable FDI denotes the value of the ratio of Foreign Direct Investment to GDP in each province, and the variable $Open$ is a measure of the openness of the provinces to foreign countries. The degree of openness is calculated as the sum of exports and imports over GDP

The reason for including $x_{i,j,t}$ is to see the contribution of each industry sector to the growth rate of GDP per capita, and their effect on the change in the growth rate of GDP per capita. The industry sector variables were added by Lee (1996) in his study of Canadian convergence. Therefore, this paper adapts the approach of Lee (1996) to the case of China. η_5 , which is the coefficient of the primary sector, is expected to be negative. In China, although industrialization and urbanization have proceeded for many years, the proportion of peasantry to total population is still as high as 70%.¹³ However, only 23% of land in China is cultivable.¹⁴ That means that too many people now are farming on such limited land. So there is no doubt that the primary

¹³ This data is from <http://www.bomi.gov.cn/Article/ShowArticle.asp?ArticleID=2132> (03/02/2007)

¹⁴ This data is from China Statistics Bureau. (2006) *China Statistic Year Book - 2006*

sector is a low productivity sector. Shifts of persons out of agriculture and into higher-productivity jobs in industry and services will definitely improve the growth rate of GDP per capita. Therefore, it is reasonable to expect a negative value for η_5 . In contrast, the coefficients of the shares of manufacturing, transportation, and commerce are expected to be positive.

Since China joined the World Trade Organization (WTO), trade and FDI have played a more and more important role in the growth of GDP. In 2005, trade contributed 36% of GDP and the fixed asset investment (including FDI) rate became 44%.¹⁵ Thus, including the variables *FDI* and *Open* is reasonable and they are already in previous studies, such as Li, Liu and Rebelo (1998). The coefficients *FDI* and *Open* are expected to be positive. The more FDI that goes into the provincial economy, the higher the growth rate of GDP per capita will be. Similarly, the higher is the degree of openness, the higher the growth rate of GDP per capita will be.

So far, the equations to estimate absolute, sigma, and conditional convergence have been constructed. In the following section, the paper is going to present the data source and discuss some data problem.

IV. Data

IV. 1 Data sources

Firstly, it is important to mention China's statistical system reform. Before

¹⁵ The data are from <http://finance.sina.com.cn/economist/jingjixueren/20050622/07581710155.shtml> (06/22/2005)

1978, the year of implementing economic reform and an open-door policy, China used the MPS (System of Material Product) to meet the requirements of a central planning economy. The MPS mainly calculated National Income as an output indicator, but did not take income from services into account. After 1978, China's statistical system began the transition to the western SNA (System of National Accounts). The SNA uses GDP (Gross Domestic Product) as an output indicator. In 1985, China began to estimate its GDP.

Thus, in this paper, the panel data with time-series and cross-sectional observations covers 21 years, from 1985 to 2005, and 27 provincial economies in China. The raw data for GPP (Gross Provincial Product), provincial population, provincial investment in fixed assets, provincial working population and graduates of higher education, and provincial output from each industry sector are from the *China Statistic Year Book* (1985-2006).¹⁶ The raw data of provincial FDI and the sum of exports and imports are from the China Economic Information Network¹⁷.

The provincial data excludes Hainan Province, which is a newly established small province (created in 1988), as well as Qinghai and Tibet, due to a lack of data. Since Hainan, Qinghai, and Tibet are all small economies, the exclusion of these three provinces should not have a significant impact on China's economy. Thus, an analysis based on the other 27 provinces is still able to provide sufficient results on China's entire economy. The paper also

¹⁶ Higher education is education from college, university, and graduate school.

¹⁷ The website is <http://db.cei.gov.cn/> (10/14/2005)

merges Chongqing municipality into Sichuan Province because Chongqing used to be a part of Sichuan before 1997.

In addition, after examining the economy of China as a whole, this paper will divide the 27 provinces into three regions according to geography and homogeneity in degree of openness in 2004.¹⁸ These three regions are called the Coastal region, the Middle region, and the Western region. This regional breakdown is the same as that in the previous studies. The Coastal region contains Beijing, Tianjin, Liaoning, Shandong, Jiangsu, Zhejiang, Fujian, Guangdong, and Shanghai. The Middle region includes Heilongjiang, Jilin, Hebei, Henan, Jiangxi, Anhui, Hubei, Hunan, and Sichuan. The remaining provinces Inner Mongolia, Ningxia, Gansu, Shanxi, Shaanxi, Xinjiang, Guizhou, Yunnan, and Guangxi belong to the Western region. Each region contains nine provinces.

IV. 2 Variable Definitions

Real GPP per capita is calculated as nominal GPP per capita over the national CPI (Consumer Price Index) based on 1985 ($CPI_{1985}=100$). It is assumed that $g + \delta$ is equal to 0.05. This assumption is widely used in previous studies, for example, in Hou (2002), Yang and Yang (2005), and Zhang, Liu and Yao (2000). Mankiw, Romer and Weil (1992, p. 8) noted that “reasonable changes in this assumption have little effect on the estimation”.

¹⁸ See Table 1 for the degree of openness.

The physical capital investment rate $s_{k,t}$ is measured as nominal investment in fixed assets divided by nominal GDP. The investment rate in human capital $s_{h,t}$ in this study is measured as the number of people who graduated from higher education and technical secondary school in year t divided by the working population in year t .¹⁹

The measure of human capital investment rate in this paper is clearly imperfect. It ignores primary education, high school education, and occupational training. Moreover, it measures a proportion of the flow, not the stock of the investment in human capital. Yet if it is proportional to the real ratio of human capital investment to GDP, it can be used to estimate the equation. This is explained in Mankiw, Romer and Weil (1992, p. 14), who argue that “the factor of proportionality will only affect the constant term”.

The definitions of the output shares of industry sectors x , FDI , and $Open$ are the same as stated in section III. However, the data for the variables FDI and $Open$ are only available between 1993 and 2004. Thus, to estimate conditional convergence in China, this study will carry out two regressions based on equation (5). One regression excludes the variables FDI and $Open$ and covers the 21 years from 1985 to 2005. The other one covers only the 12 years between 1993 and 2004, but includes the variables FDI and $Open$. Table 1 shows the degree of openness in each province in 2004.

¹⁹ This measure follows Zhang, Liu and Yao (2000).

V. Results

V.1 σ -convergence

As σ means the dispersion of real GDP per capita, the standard deviation (SD) of real GDP per capita is used as a measure of σ . In Figure 1, instead of decreasing, there is actually a slightly increasing trend in the standard deviation of real GDP per capita across 27 provinces in China from 1984 to 2005. However, if one divides the whole trend into three segments, one can see that before 1989, the SD of real GPP per capita tended to decrease; between 1990 and 2002, it increased; and after 2003, it decreased again.

The reasons for these two downturns in 1989 and 2003 can be explained as follows. In 1986, the leader of China, Deng Xiaopin, made the famous speech that allowed certain people and certain areas to get rich first; then after their lead, others could get rich together.²⁰ This speech broke Chairman Mao's rule of equality, even though it was of poverty. Consequently, the coastal area, which is the "certain area" referred to in Deng's speech, took off ahead and the national dispersion of real GPP per capita increased. In 2000, China's central government decided to enforce government investment in the western area, which includes 10 provinces, to help the western area catch up to the coastal area.²¹ This project is also called "Development of the West Regions." As a result, the growth of GPP in the western area increased sharply and the national dispersion of real GPP per capita decreased. It took time to bring the

²⁰ See <http://www.people.com.cn/GB/shizheng/252/8956/8965/20021029/853373.html> (10/29/2002)

²¹ See <http://finance.sina.com.cn/nz/westkf/> (04/12/2005)

government policies into reality; thus there were time delays for the break points, and they both happened two or three years after the date of pronouncement of the policies.

Figure 2 displays the standard deviation of real GPP per capita in the Coastal region from 1984 to 2005. In the Coastal region, there is a vivid trend of decreasing dispersion of real GPP per capita. This shows clear evidence of the existence of σ -convergence in the Coastal region. Taking Liaoning and Fujian as a specific example, Figure 3 shows their real GPP per capita. During the Central Planning period, Liaoning was the most important heavy industry base in China. The government invested billions and billions to develop Liaoning. Thus, at that time, GPP per capita in Liaoning was much higher than that in other provinces, except for Beijing and Shanghai. After the reform, the government reduced its investment in Liaoning gradually, and had an equal open door policy to all the coastal provinces. The other provinces, like Fujian, took the opportunity and thus caught up with Liaoning. Under the same policy, these two provinces have reduced the gap of GPP per capita and now grow at almost the same rate.

Figure 4 shows that in the Middle region, the SD of real GPP per capita appears to decrease, but only slightly. In Figure 5, the SD of the Western region continuously increases over time. Thus, there is no evidence of σ -convergence in either the Middle region or the Western region.²²

²² The reason will be explained in a later subsection.

From the analysis of Figures 1 to 5, it is clear that there is no σ -convergence in China as a whole as measured by the SD of real GPP per capita across 27 provinces. However, within each region the result turns to be different. In the Coastal region, there is strong evidence of σ -convergence. The decrease in dispersion of real GPP per capita is obvious. In the Middle region, the dispersion of real GPP per capita has become so stable that over 22 years it did not change much. There is only a small decrease. However, in the Western region, there is obvious evidence of an increase in the dispersion of real GPP per capita.

Figure 6 presents the SDs of the real GPP per capita of the Coastal, Middle, and Western regions in one figure. Even though the SD of real GPP per capita in the Coastal region is decreasing, it still displays the highest dispersion of real GPP per capita among the three regions. The dispersion of real GPP per capita in the Western region surpassed that in the Middle region in 1990 and it has continued increasing. The Middle region has had the lowest dispersion of real GPP per capita since 1990.

One reason for the Coastal region to have the highest dispersion of real GPP per capita is the higher mean income in this region. Figure 7 displays the coefficient of variation of real GPP per capita in each region. The coefficient of variation, a measure of relative dispersion, is equal to the SD over the mean of real GPP per capita. Figure 7 shows that before 1992, the Coastal region indeed had the highest relative dispersion of real GPP per capita, but as it kept

decreasing over time, by 2005, it was already nearly the same as that in the Western region. The distance between the two relative dispersion lines in the Coastal region and in the Western region is much smaller than the distance between the two dispersion lines in Figure 6. This is because the Coastal region has higher mean real GPP per capita than the Western region. In Figure 7, the relative dispersion of real GPP per capita in the Middle region displays a slight tendency to decrease.

Earlier, it was noted that β -convergence is a necessary condition for σ -convergence. That is, if σ -convergence occurs, then β -convergence must also occur. Therefore, is there any β -convergence in China or in each region? This examination of σ -convergence suggests that there should be β -convergence at least in the Coastal region. Is it true? This question is addressed in the next subsection.

V. 2 Absolute β -convergence

Before looking at the estimation results, it might be interesting to look at some figures, which illustrate the relationship between the average GPP per capita growth rate from 1985 to 2005 and the logarithm of GPP per capita in 1985. Figure 8 surprisingly exhibits an almost flat relationship, neither increasing nor decreasing, between the average GPP per capita growth rate and the logarithm of initial GPP per capita in 1985 for 27 provinces in China. It seems that there is no tendency for poor economies to grow faster. Thus, it

seems that there is no such thing as β -convergence in China after all.

Figure 9 shows the regional average real GPP per capita growth path of the three regions from 1984 to 2005. In the initial year, the Coastal region has higher real GPP per capita than the other two regions, but it also grows at a higher rate than the others do. There is no evidence of catch-up for the other two regions. The growth paths of the Middle and Western regions' economies are almost the same. They share similar levels of initial real GPP per capita and similar growth rates. After 2003, the graph shows that the Western region does attempt to catch up, but there is not sufficient data to support a conclusion that convergence has occurred.

Next, each region is analyzed separately. In the Coastal and Middle regions, shown in Figures 10 and 11, there are clearly downward-sloping lines, which indicate that lower initial GPP per capita generates a higher average GPP per capita growth rate. However, in the Middle region, the trend is not as noticeable; the line is just slightly decreasing. In the Western region, shown in Figure 12, the trend is very different. The upward-sloping line shows that the higher the initial GPP per capita, the higher the average GPP per capita growth rate. Instead of convergence, the Western region displays a trend towards divergence. This is consistent with the analysis of the dispersion of real GPP per capita in the Western region. The richer economies are just getting richer, which results in a larger and larger gap between them and the poorer economies.

The conclusions of the graphical analysis are interesting, but what do the estimation results say about β -convergence? All the estimations in this paper use panel-corrected standard errors to correct for the effect of cross-sectional heteroscedasticity and contemporaneous correlations. This method only changes the standard errors and t-statistics, not the coefficient of each variable. The method of Ordinary Least Squares (OLS) is used to estimate the equations.

Absolute β -convergence is tested using both annual panel data and seven-year interval panel data based on equation (2).²³ The top and the middle parts of Table 2 show the results from the annual data approach with and without an AR (1) correction added to the regression in order to account for the effects of short-term business cycles.²⁴ At the bottom part of Table 2, the results for panel data with seven-year intervals are presented.

According to the results of the annual data approach without an AR (1) correction, nationally, not only is there no evidence of absolute β -convergence, but there is in fact divergence among the Chinese provinces. The coefficient of $\log(y_{i,t})$ is positive, and significant at the 10% level. However, the adjusted R-squared is very low, which means that this equation does not do a good job of explaining the variation in the dependent variable. The results are similar for the Middle and Western regions. For the Coastal region, the coefficient of $\log(y_{i,t})$ is not significant even at the 10% level of significance.

²³ This paper also tested three-year and four-year intervals. The results with seven-year intervals are much better than the others.

²⁴ The AR (1) term is restricted to be the same for all provinces.

The results become somewhat better when an AR (1) term is added to the equation. The adjusted R-Squared becomes higher than before. The coefficients of $\log(y_{i,t})$ in the National, Middle and Western region columns are still positive and significant at the 10% and 1% critical level. Thus, there is no absolute β -convergence, either nationally or in the Middle and Western regions. In the Coastal region, the coefficient of $\log(y_{i,t})$ is still not statistically significant. It is hard to tell if there is convergence or divergence.

Using seven-year rather than one-year intervals, there is further evidence of divergence in the Middle and Western regions. In the Coastal region and nationally, the coefficient is still not significant.

From the above, one can conclude that there is evidence of divergence both nationally and regionally in the Middle and Western areas.²⁵ Thus, so far, with respect to absolute β -convergence, this paper has reached the same conclusion as Yao and Weeks (2000): in China, there is no evidence of absolute β -convergence. Moreover, it also partially confirms Jian, Sachs and Warner's (1996) prediction about divergence. Only in the Coastal region do the results suggest that neither convergence nor divergence exist, because of the insignificant coefficient of $\log(y_{i,t})$.

V.3 Conditional β -convergence

Conditional β -convergence is tested both using panel data with

²⁵ There is evidence of divergence nationally when the national equation is estimated using annual panel data.

seven-year intervals for the period from 1985 to 2005, and four-year intervals for the period from 1992 to 2004. The estimation is based on equation (5).²⁶

To test for multicollinearity, Table 3 displays the auxiliary R-squared values with and without *FDI* and *Open* using national data.²⁷ Without *FDI* and *Open*, $\ln(y_{i,t})$, *Ins* and *lnprimary* have high multicollinearity with other independent variables, as the auxiliary R-squared values are more than 0.8. This paper tried to delete the variable *lnprimary* from the estimation, but the results only change slightly. No new independent variables become significant after deleting *lnprimary*. Similar results were obtained when *FDI* and *Open* were deleted. This paper also tried to delete *lnprimary* and *lnOpen* both separately and together, but the results do not change much. Therefore, this paper just leaves these variables there, which is valid despite the multicollinearity.

Table 4 presents the results for conditional convergence without the variables *FDI* and *Open*, using seven-year intervals from 1985 to 2005. Nationally, the coefficient of $\ln(y_{i,t})$ is negative and significant at the 1% level, which implies the existence of conditional β -convergence across 27 provinces in China. The calculated speed of convergence is about 2.2%, which is slightly higher than the world general speed of 2% as in Barro and Sala-i-Martin (1992) and 1.37% as in Mankiw, Romer and Weil (1992). That is because they used a

²⁶ This paper also tried to use panel data with one-year intervals. The short-term business cycle effect has a significant impact on the results. Therefore, it is not used in this paper.

²⁷ Auxiliary R-squared values are a method of detecting of multicollinearity. It consists of regressing each explanatory variable in turn on the other explanatory variables, and examining the R-squared values obtained. If any of them exceed 0.8, it would be a clear indication of strong linear relationship between the explanatory variables.

single cross-section of data. Generally, panel data results tend to generate a slightly higher convergence speed than that from the single cross-section results. The half-life of convergence, the number of years it would take for half of the gap between the rich economies and the poor economies to be eliminated, is 31.53 years in China according to this result.

Moreover, the national results also imply that the coefficients of the population growth rate and the investment ratio of physical capital are not statistically significant. The coefficient of the investment ratio of human capital has the expected positive sign and is statistically significant at the 1% level. The sign of the coefficient of the log of the primary sector share is negative and significant at the 1% level as expected, and the coefficients of the logs of the shares of the manufacturing, commerce and transportation sectors have significant positive signs. These results imply that shifts of persons out of lower-productivity agriculture and into higher-productivity jobs in manufacturing, commerce and transportation will improve the growth of GPP per capita. The adjusted R-square is as good 0.787.

The results for the Coastal, Middle and Western regions are similar to those for China as a whole, except for the coefficients of the investment ratio of human capital and the output shares of manufacturing and commerce. From the results, one can see the Coastal region has the highest speed of convergence at 2.37%, and the Western region has the lowest speed of convergence at 1.9%. The F-statistics are all significant both nationally and

regionally.

When FDI and the degree of openness are added to the regression, the results, in Table 5, are not quite as expected. The results show that the coefficients of *FDI* and *Open* are not statistically significant, either nationally or regionally.²⁸ However, the results still provide evidence of the existence of conditional convergence. For example, nationally, the coefficient of $\log(y_{i,t})$ is negative and significant at the 1% level. The indicated speed of convergence is 3.52%, which is higher than when not taking *FDI* and *Open* into account. The half-life becomes shorter: 19.69 years. The Western region has the highest speed of convergence now, at 3.91%. The Middle region has the lowest at 3.62%.

The reason for the insignificance of *FDI* may be the distribution of FDI. In a relatively rich province, FDI is mainly focused on capital-intensive industry. It contains more technical and management factors and it generates more output. In a relatively poor province, FDI is mainly used in labour-intensive industries. It does not generate as big an increase in output.²⁹ Therefore, in the estimation, FDI does not have a significant impact on convergence.

The reason for the lack of significance of the coefficient of the degree of openness is the method of data collection. The data on the sum of imports and exports are collected based on the location of the company. However, many import and export companies do not just do local business. They may have

²⁸ The coefficient of FDI is not significant except for that in the Western region.

²⁹ For further discussion, see Yan Hou (2002).

business in other provinces rather than just where they are registered. Therefore, the data do not accurately reflect the degree of openness of China's provinces.

This paper also tried to figure out the reason for the changes in results after *FDI* and *Open* are added into the equation. The equations, without *FDI* and *Open*, were re-estimated using four-year intervals from 1986 to 2005 and from 1992 to 2004. Comparing these two sets of results (not shown here) with the results in Table 4 and Table 5, one can conclude that the changes are mainly because of the different time period. As the time period changes from 1985-2006 to 1992-2004, the speed of convergence gets higher and the significance of some coefficients changes as well.

VI. Conclusion

This paper adopts Barro and Sala-i-Martin's classical approach to test for absolute convergence in China, nationally and regionally. It concludes that there is no evidence of absolute convergence at all in China. However, in the Middle and Western regions and in China as a whole, there is strong evidence of divergence when all regions are assumed to have the same steady state. Thus, this updated study, using data from 1985 to 2005, confirms the prediction about divergence in China after 1990 made by previous studies, as mentioned in the literature review.

In addition, this paper follows Mankiw, Romer and Weil's (1992) method

to test for conditional convergence, nationally and regionally, in China. There is indeed evidence of conditional convergence in China nationally and in the Coastal and Western regions. The negative impact of the primary sector's output share on convergence, as shown in the estimation results, is also reasonable for China. As there is currently a large surplus of labour in agriculture, shifts of labour out of the agricultural sector into some more productive industry sector will improve the growth of China's economy.

This study actually prompts more questions than it answers. Further study is needed to examine the relationship between international openness and convergence. Due to the distribution of FDI and the data collection problem with respect to the sum of exports and imports in each province, this study does not provide a good explanation of how international openness affects convergence. As China became involved in the WTO in 2002 and as international trade plays a more important role in GDP growth, the effect of international openness on convergence will attract more and more attention from empirical studies in the future.

Finally, in the Western region, even though evidence showed the existence of conditional β -convergence, the Chinese government still needs to introduce some policies to reduce the income or GPP per capita gap between provinces within the region. This is because the dispersion of real GPP per capita is still going up as shown in the examinations of σ -convergence. In 2005, real GPP per capita in Xinjiang, which is the wealthiest province in the

Western region, was more than three times that in Guizhou, which is the poorest province in this region. The Chinese government needs to pay more attention to the GPP or income gap between the provinces within this region.

References

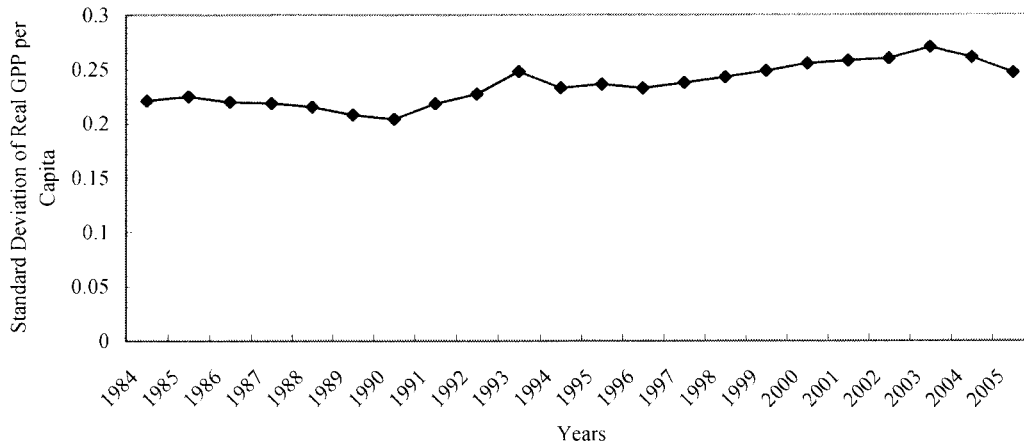
- Barro, Robert J. (1989) "A Cross-Country Study of Growth, Saving, and Government," *NBER Working Papers 2855*, National Bureau of Economic Research, Inc.
- Barro, R., and X. Sala-i-Martin (1992) "Convergence," *Journal of Political Economy*. 100: 223-251.
- Barro, R., and X. Sala-i-Martin (1995) *Economic Growth*, McGraw Hill, New York.
- Cass, David (1965) "Optimum Growth in an Aggregative Model of Capital Accumulation," *Review of Economic Studies*, 32 (July): 233-240.
- Chen, Jian and Belton M. Fleisher (1996) "Regional Income Inequality and Economic Growth in China," *Journal of Comparative Economics*, 22(2): 141-64
- Choi, H. (1996) "Inequality of income growth in China". *Asian Economics* 25, 80–91.
- Choi, Hak and Hongyi Liu (2000) "Economic Development and Growth Convergence in China," *The Journal of International Trade & Economic Development*, 9:1 37–54.
- Coulombe, Serge (1997) "Regional Disparities in Canada: Characterization, Trends and Lessons for Economic Policy," working paper No. C21-24/19, Industry Canada, Ottawa, Canada.
- Coulombe, S. and F. C. Lee (1995) "Convergence across Canadian Provinces, 1961 to 1991." *Canadian Journal of Economics*, 28: 886–98.
- Coulombe, Serge and Kathleen M. Day (1999) "Economic Growth and Regional Income Disparities in Canada and the Northern United States," *Canadian Public Policy / Analyse de Politiques*, Vol. 25, No. 2. (Jun. 1999): 155-178.
- Denny, D.L. (1992) "Provincial economic differences diminished in the decade of reform." In: *China's Economic Dilemmas in the 1990s: The Problems of Reforms, Modernization, and Interdependence – Studies on Contemporary China*, pp. 186–208, US Congress Joint Economic Committee, Armonk, NY and London: Sharpe.

- Gundlach, Erich (1998) "Regional Convergence of Output per Worker in China: A Neoclassical Interpretation," *Asian Economic Journal*, 11(4): 423-42.
- Jian, Tianlun, Jeffrey D. Sachs, and Andrew M. Warner (1996) "Trends in Regional Inequality in China," *China Economic Review*, 7(1): 1-21.
- Koopmans, Tjalling C. (1965) "On the Concept of Optimal Economic Growth," *The Econometric Approach to Development Planning*, Amsterdam, North Holland, 1965.
- Lee, Frank C. (1996) "Convergence in Canada?" *The Canadian Journal of Economics / Revue canadienne d'Economique*, Vol. 29, Special Issue: Part 1. (Apr. 1996): S331-S336.
- Li, Hong, Liu, Zinan and Ivonia Rebelo (1998) "Testing the Neoclassical Theory of Economic Growth: Evidence from Chinese Provinces," *Economics of Planning* 31: 117-132.
- Mankiw, N.G., D. Romer, and D.N. Weil (1992) "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics*, 107: 407-437.
- Raiser, Martin (1998) "Subsidising Inequality: Economic Reforms, Fiscal Transfers and Convergence across Chinese Provinces," *Journal of Development Studies*, 34(3): 1-26.
- Ramsey, Frank (1928) "A Mathematical Theory of Saving," *Economic Journal*, 38 (December): 543-559.
- Ricardo, David (1817) *On the Principles of Political Economy and Taxation*, Cambridge, Cambridge University Press, 1951.
- Romer, David (2006) *Advanced Macroeconomics*, Irwin: McGraw-Hill.
- Sala-i-Martin, X. (1996a) "The Classical Approach of Convergence Analysis," *Economic Journal* 106: 10 19-36.
- _____(1996b) "Regional Cohesion: Evidence and Theories of Regional Growth and Convergence," *European Economic Review* 40: 1325-52
- Smith, Adam (1776) *An Inquiry into the Nature and Causes of the Wealth of Nations*, New York, Random House, 1937.
- Solow, Robert M. (1956) "A contribution to the Aggregate Production Function," *Quarterly Journal of Economics*, 70, 1 (February): 65-94.

- State Statistical Bureau (SSB), *China's Statistical Yearbook*, various years.
- Swan, Trevor W. (1956) "Economics Growth and Capital Accumulation," *Economic Record*, 32 (November): 334-361.
- Tsui, Kai Yuen (1991) "China's regional inequality, 1952-1985," *Journal of Comparative Economics*, 15 (1): 1-21.
- Yan Hou (2002) "Regional Convergence in China." Major Paper, Department of Economics, University of Ottawa.
- Yang, Kelei and Yujing Yang (2005) "The Convergence Analysis of Chinese Regional Inequality." *Chinese Business Review*, Volume 4 (Sep. 2005) No.9.
- Yao, YD, and M. Weeks. (2000) "Provincial Income Convergence in China, 1953-1997: a panel data approach," Cambridge Working Paper in Economics No. 0010, Faculty of Economics, University of Cambridge, Cambridge, UK.
- Zhang, ZY, Liu, AY, and Yao SJ (2000) "Convergence of China's Regional Incomes: 1952-97," Economics Discussion Paper No.95, Middlesex University Business School, London, UK.

Figure 1

Dispersion of Real GPP per Capita Across Provinces in China

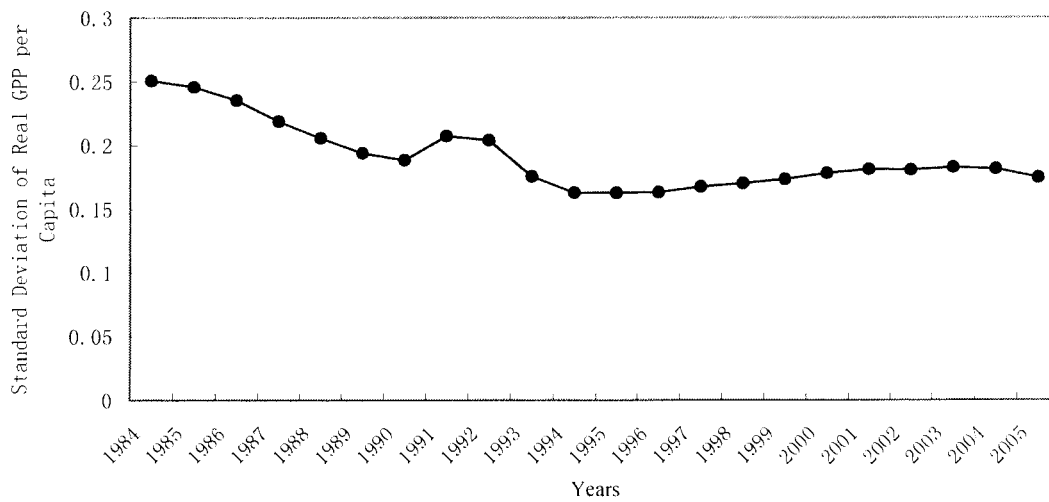


*

The data of real GPP per capita in each province is from China Statistic Year Book (1985-2006)

Figure 2

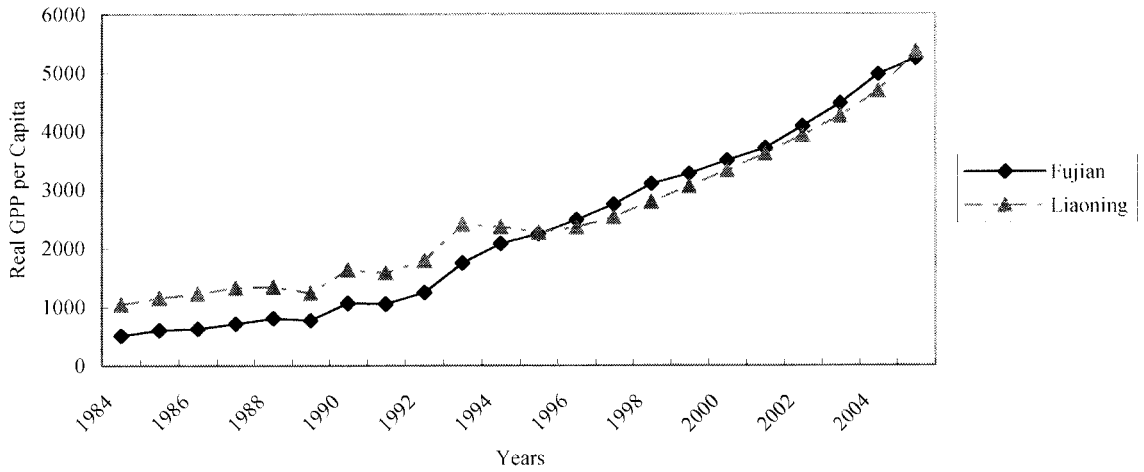
Dispersion of GPP per Capita Across Coastal Provinces



*The data of real GPP per capita in each province is from China Statistic Year Book (1985-2006)

Figure 3

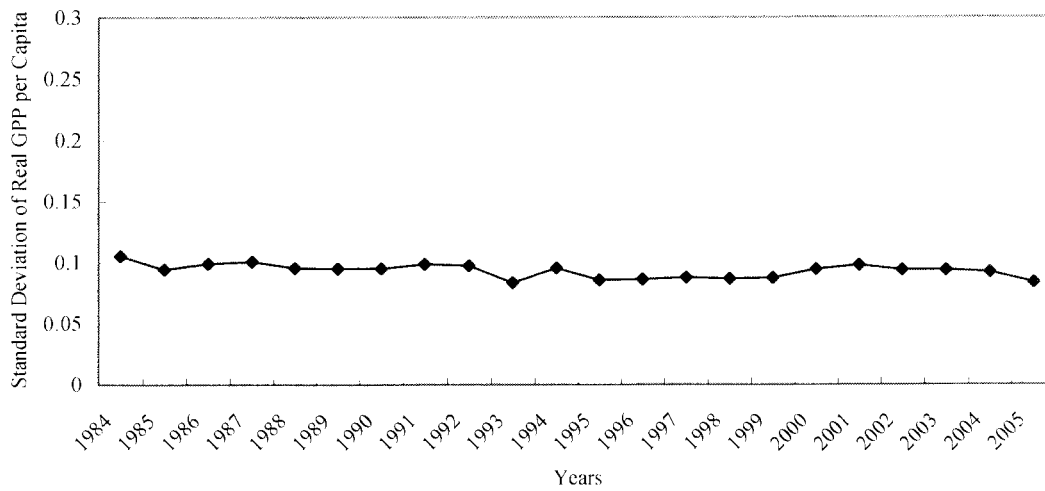
Real GPP per Capita in Liaoning and Fujian from 1984 to 2005



*The data of real GPP per capita in each province is from China Statistic Year Book (1985-2006)

Figure 4

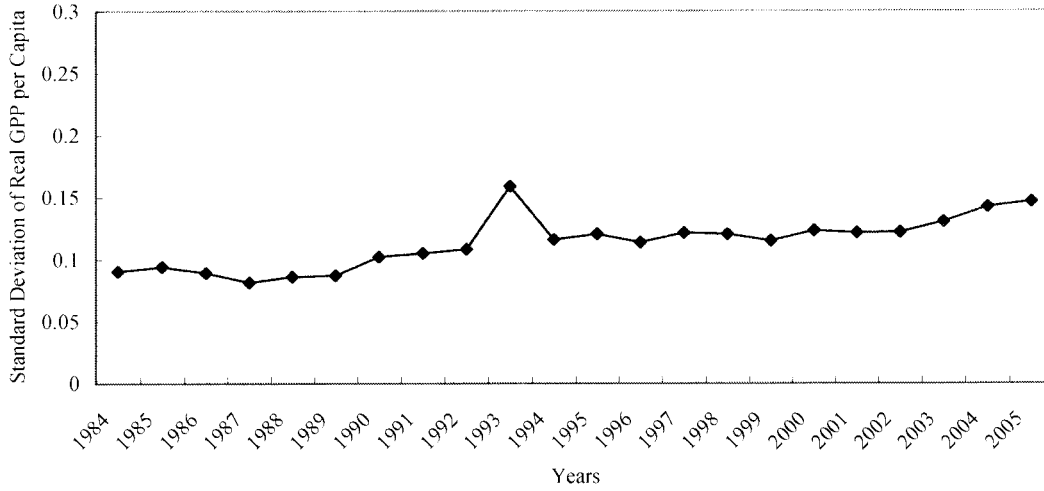
Dispersion of GPP per Capita Across Middle Provinces



*The data of real GPP per capita in each province is from China Statistic Year Book (1985-2006)

Figure 5

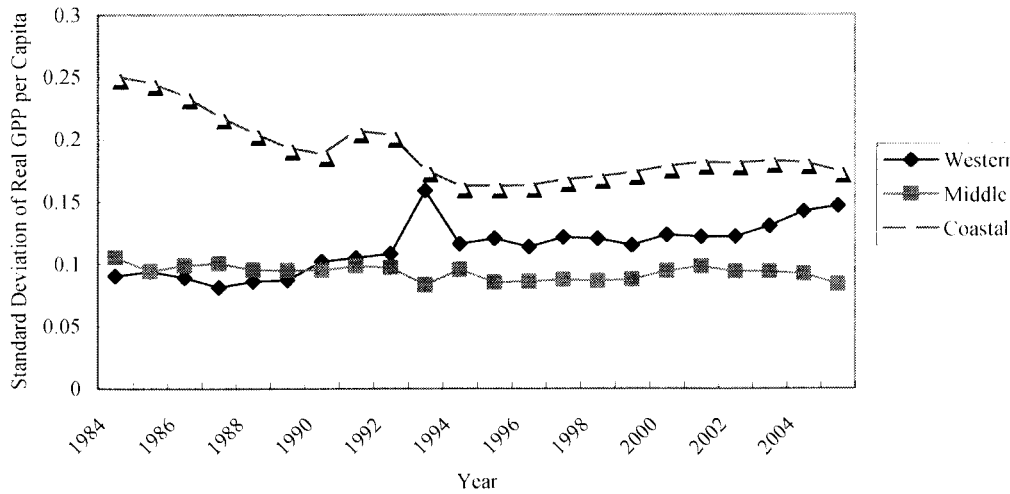
Dispersion of GPP per Capita Across Western Provinces



*The data of real GPP per capita in each province is from China Statistic Year Book (1985-2006)

Figure 6

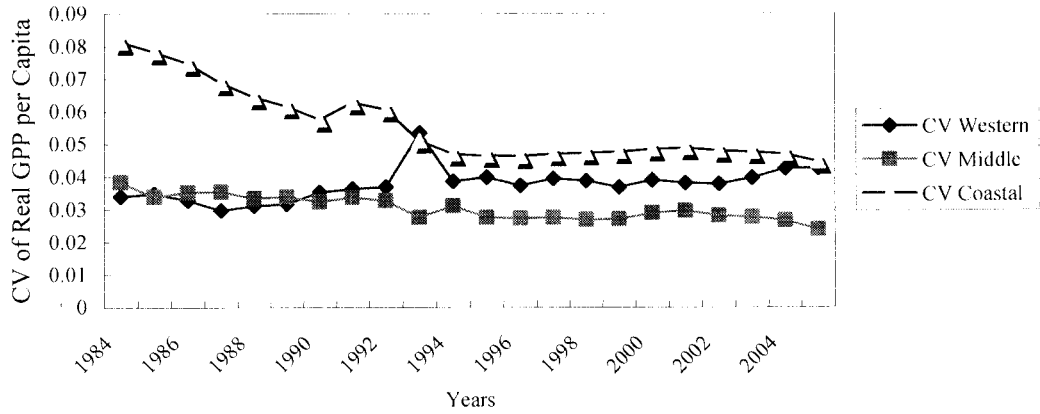
Dispersion of Real GPP per Capita Across Coastal, Middle and Western Provinces



*The data of real GPP per capita in each province is from China Statistic Year Book (1985-2006)

Figure 7

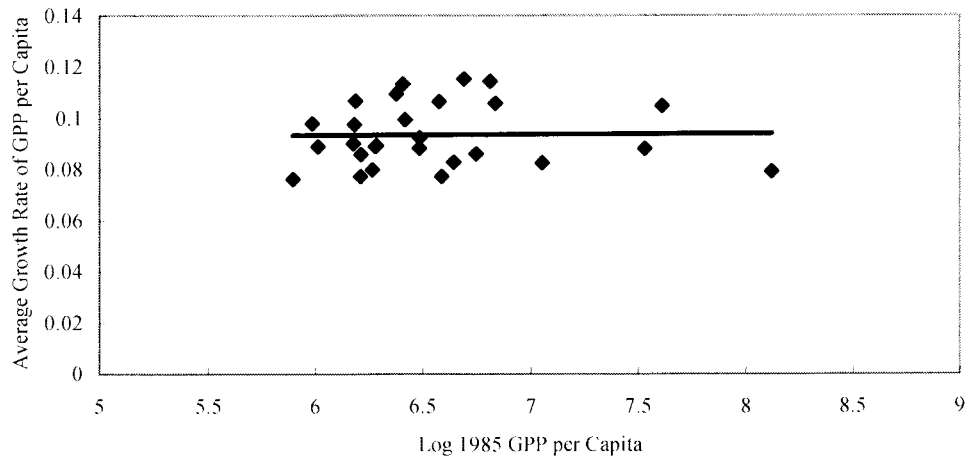
Coefficient of Variation of Real GPP per Capita Across Coastal, Middle and Western Provinces



The data of real GPP per capita in each province is from China Statistic Year Book (1985-2006)

Figure 8

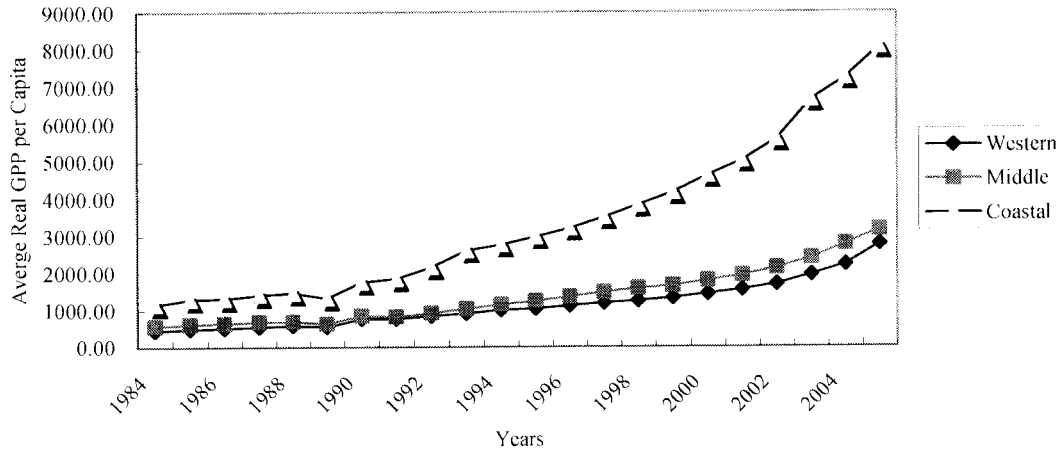
Average Growth Rate of GPP per Capita (1985-2005) vs. log 1985 GPP per Capita



*The data of real GPP per capita in each province is from China Statistic Year Book (1985-2006)

Figure 9

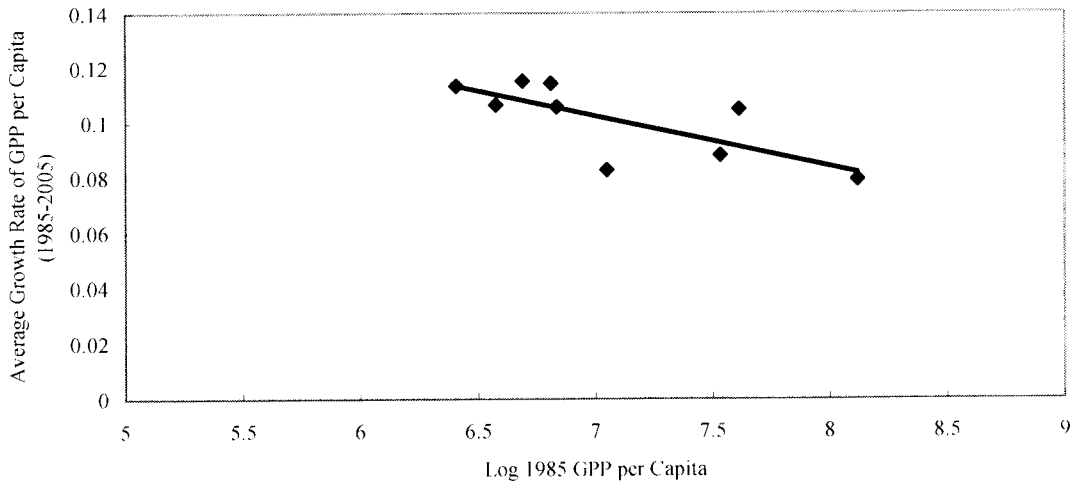
Average Real GPP per Capita From 1984 to 2005 in Three Regions



*The data of real GPP per capita in each province is from China Statistic Year Book (1985-2006)

Figure 10

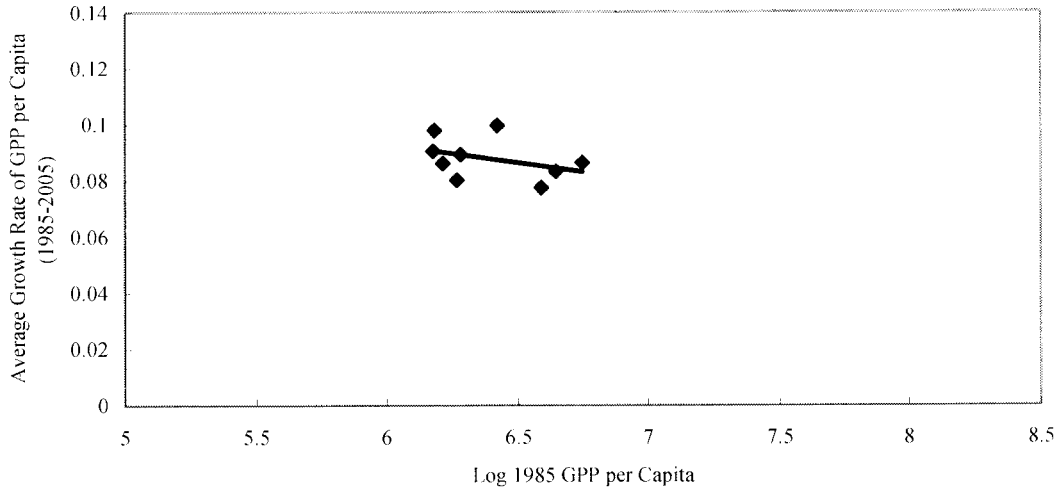
Average Growth Rate of GPP per Capita (1985-2005) vs. log 1985 GPP per Capita Across Coastal Provinces



*The data of real GPP per capita in each province is from China Statistic Year Book (1985-2006)

Figure 11

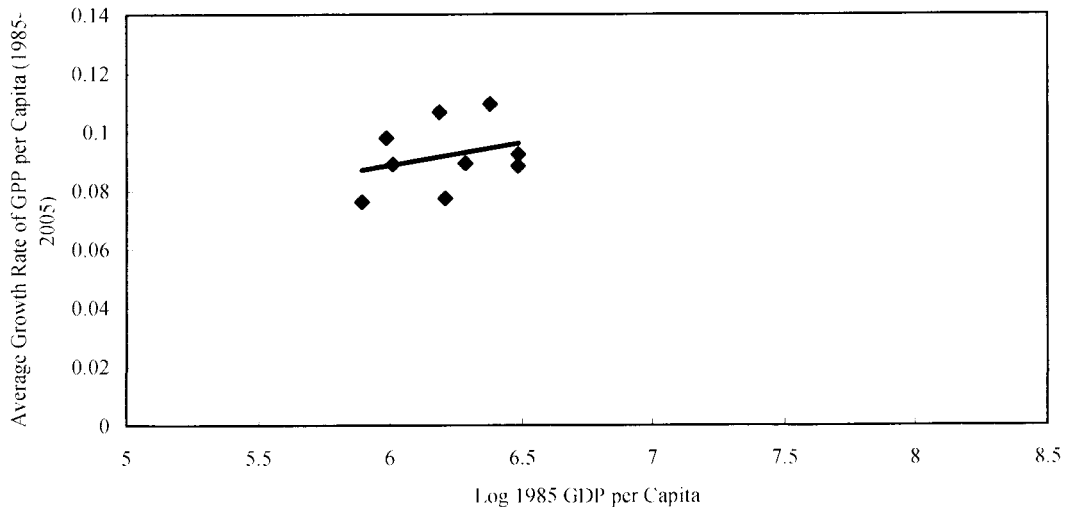
Average Growth Rate of GPP per Capita (1985-2005) vs. log 1985 GPP per Capita Across Middle Provinces



*The data of real GPP per capita in each province is from China Statistic Year Book (1985-2006)

Figure 12

Average Growth Rate of GPP per Capita (1985-2005) vs. log 1985 GDP per Capita Across Western Provinces



*The data of real GPP per capita in each province is from China Statistic Year Book (1985-2006)

Table 1**Degree of Openness in Each Province in 2004**

Coastal	Openness	Middle	Openness	Western	Openness
Beijing	1.827593	Heilongjiang	0.10597	Inner Mongolia	0.113608
Tianjin	1.186491	Jilin	0.189949	Ningxia	0.163262
Liaoning	0.915761	Hebei	0.127709	Gansu	0.093602
Shandong	0.324108	Henan	0.062163	Shanxi	0.146416
Jiangsu	0.918053	Jiangxi	0.083529	Shaanxi	0.104559
Zhejiang	0.627256	Anhui	0.124034	Xinjiang	0.179604
Fujian	0.649859	Hubei	0.088744	Guizhou	0.07872
Guangdong	1.842936	Hunan	0.080299	Yunnan	0.104664
Shanghai	1.777664	Sichuan	0.087283	Guangxi	0.106672

*The degree of Openness is calculated as the sum of export and import divided by GPP. The source of export and import data is from China Economic Information Network.

Table 2**Results for Absolute Convergence**

Annual Panel Data Without AR(1) Correction				
	National	Coastal	Middle	Western
Observations	567	189	189	189
log(y)	0.046588** (0.018959)	0.012059 (0.017877)	0.03738* (0.024099)	0.17301* (0.053656)
Adjusted R-Squared	0.036141	0.003608	0.058287	0.109742
Annual Panel Data With AR(1) Correction				
	National	Coastal	Middle	Western
Observations	540	180	180	180
log(y)	0.02713* (0.009184)	0.012446 (0.014641)	0.034314*** (0.016465)	0.069721* (0.022043)
AR(1)	-0.775652* (0.144665)	-0.246733 (0.138003)	-0.405879* (0.143387)	-0.951021* (0.177418)
Adjusted R-Squared	0.373293	0.064662	0.21572	0.492338
7-year Interval Panel Data				
	National	Coastal	Middle	Western
Observations	81	27	27	27
log(y)	0.014534 (0.007339)	0.006002 (0.010634)	0.030796*** (0.01292)	0.036776* (0.013585)
Adjusted R-Squared	0.140491	-0.014128	0.393973	0.332028

Note: * indicates that the null hypothesis can be rejected at the 1% significance level; ** indicates that the null hypothesis can be rejected at the 5% significance level; and *** indicates that the null hypothesis can be rejected at the 10% significance level. Underneath the coefficient of each variable, in parentheses, is the standard error.

Table 3**Auxiliary R-Squared with and without *FDI* and *Open***

National Data (1985-2005)		National Data (1992-2004)	
dependant variable	R-Squared	Dependant variable	R-Squared
<i>lny</i>	0.897734	<i>lny</i>	0.917987
<i>lnn</i>	0.12633	<i>lnn</i>	0.016649
<i>lns_k</i>	0.546026	<i>lns_k</i>	0.355802
<i>lns_h</i>	0.818776	<i>lns_h</i>	0.725401
<i>lnprimary</i>	0.811107	<i>lnprimary</i>	0.82455
<i>lnmanu</i>	0.227301	<i>lnmanu</i>	0.285119
<i>lntrans</i>	0.114377	<i>lntrans</i>	0.281271
<i>lncom</i>	0.246369	<i>lncom</i>	0.311661
		<i>lnFDI</i>	0.575759
		<i>lnOpen</i>	0.805067

S_h

Table 4**Results for Conditional Convergence without *FDI* and *Open***

Variables	National	Coastal	Middle	Western
<i>lny</i>	-0.14262* (0.030899)	-0.152703*** (0.048527)	-0.133989*** (0.050518)	-0.124234* (0.024498)
<i>lnn</i>	-0.00103 (0.003050)	-0.028421 (0.042656)	-0.007471*** (0.003207)	0.000158 (0.002156)
<i>lns_k</i>	-0.005136 (0.013478)	0.023509 (0.012166)	0.014288 (0.015823)	-0.011111 (0.028801)
<i>lns_h</i>	0.039341* (0.008726)	0.013879 (0.014578)	0.015697 (0.015664)	0.013051 (0.013746)
<i>lnprimary</i>	-0.05131* (0.008421)	-0.072566* (0.014474)	0.078866 (0.050822)	-0.077161* (0.023563)
<i>lnmanu</i>	0.037125** (0.017135)	0.067629 (0.047817)	0.106631* (0.025131)	0.0156 (0.045791)
<i>lntrans</i>	0.010156** (0.00447)	-0.013903 (0.023347)	-0.01252 (0.012635)	0.008522 (0.004062)
<i>lncom</i>	0.011921* (0.00162)	0.01632 (0.014055)	0.003719 (0.003228)	0.017 (0.014341)
No. of observations	81	27	27	27
Adjusted R-Squared	0.786977	0.700253	0.8649	0.739248
F-statistic	9.20961	4.474435	10.24725	5.095094
Convergence Speed	2.2%	2.37%	2.06%	1.9%
Half-life	31.53	29.28	33.73	36.58

Note: * indicates that the null hypothesis can be rejected at the 1% significance level; ** indicates that the null hypothesis can be rejected at the 5% significance level; and *** indicates that the null hypothesis can be rejected at the 10% significance level. Underneath the coefficient of each variable, in parentheses, is the standard error. *lnprimary* is the output share of primary sector, *lnmanu* is the output share of manufactory sector, *lntrans* is the output share of transportation, and *lncom* is the output share of commerce sector.

Table 5

Results for Conditional Convergence with *FDI* and *Open*

Variables	National	Coastal	Middle	Western
<i>lny</i>	-0.218455* (0.065637)	-0.233244* (0.019876)	-0.223692* (0.04307)	-0.239169* (0.057298)
<i>lnn</i>	-0.037948 (0.030131)	0.011598 (0.013395)	0.011095 (0.007478)	-0.020225 (0.009758)
<i>lns_k</i>	0.003068 (0.042882)	0.029786 (0.031016)	-0.01364 (0.013131)	0.726017* (0.108296)
<i>lns_h</i>	0.1754*** (0.075823)	0.011951 (0.014673)	0.025974 (0.016426)	0.589785* (0.074314)
<i>lnprimary</i>	0.129138 (0.117811)	-0.09893*** (0.035349)	0.054188** (0.017797)	-1.693396* (0.317997)
<i>lnmanu</i>	-0.26378 (0.313062)	-0.077659 (0.097562)	0.165332* (0.043829)	0.039458 (0.236687)
<i>lntrans</i>	-0.359265 (0.180389)	-0.089156 (0.058415)	0.032662 (0.015298)	-0.690328* (0.04978)
<i>lncom</i>	-0.127813 (0.122422)	0.063341 (0.051818)	0.007133 (0.020724)	-0.358336** (0.106132)
<i>lnFDI</i>	-0.014626 (0.016565)	0.00975 (0.011211)	0.005372 (0.003352)	-0.08434* (0.017356)
<i>lnOpen</i>	0.008734 (0.009335)	0.015168 (0.012349)	0.64128 (0.047889)	0.128979 (0.058689)
No. of observations	81	27	27	27
Adjusted R-Squared	0.313086	0.78343	0.762953	0.855335
F-statistic	1.959548	5.702667	35.76391	9.686284
Convergence Speed	3.52%	3.79%	3.62%	3.91%
Half-life	19.69	18.27	19.16	17.75

Note: * indicates that the null hypothesis can be rejected at the 1% significance level; ** indicates that the null hypothesis can be rejected at the 5% significance level; and *** indicates that the null hypothesis can be rejected at the 10% significance level. Underneath the coefficient of each variable, in parentheses, is the standard error.