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# Regional Growth in China

A Study on Convergence across the Chinese Regions


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# Abstract

This study investigates whether the income is equalising across the Chinese regions. This is done by answering the research question *do the Chinese regions show any signs of convergence in gross regional product (GRP).* Regressions have been done using the OLS-method to find correlation between initial GRP and the growth rate in GRP. This has been done for four time periods: 1952-2007, 1952-78, 1978-99 and 1999-2007. Three geographic areas have been investigated: China, western China and eastern China. The time distinctions are based on political reforms and policies that have had different regional impact. The policies have benefitted different geographical areas, hence the geographic distinctions.

The results show weak signs of convergence. But the lack of convergence can be interpreted as China being a transitional economy. The calculations indicate that all the Chinese regions are moving towards a higher income level and that all regions are getting richer. Nonetheless, the eastern regions that have experienced preferential treatment have started growing at an earlier stage, and thus is growing faster than the western.

Keywords: China, growth, regional convergence, technology transfer, steady state

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# 1 Introduction

”If the rich become richer and the poor become poorer, there would occur polarization that is exactly what a socialist system should and can avoid”

- Deng Xiaoping 1992[1]

Since the late 1970’s, China’s economy has had an average GDP growth rate of 10 percent per year. Today, it is the third largest economy in the world, after USA and Japan, and the second largest trading nation, after Germany (Ljunggren, 2008:43). Few people doubt that China in a few decades will be the largest economy in the world – but possibly far from the most developed. The remarkable speed of growth has put China in a complex process of modernization in which the Chinese people experience increasing welfare (and urbanization) while they collaterally are struggling with great inequality. Today the richest region, Shanghai, is about 10 times richer than the poorest region, Guizhou. Generally, the eastern provinces are the more developed ones while the western provinces have not grown as quickly. Inequality, through a variety of political, social and economic reasons, impedes the prospect of future growth (Kanbur and Zhang, 2005). Measures have been taken to decrease the gap within the country and as the quote by the initiator of the reforms that lead to the growth seen today, Deng Xiaoping (the former premier of China), states: a socialist society should strive towards equality and increased standard of living for all. The ideological direction of Chinese politics in combination with the concentration of growth policies to certain areas causes a lot of curiosity, and questions arise: is China on the right path towards equalising income across the nation? Was equality greater during the command economy than during the present socialist market economy? What effects have the changes of political agendas had on growth? And where is the Chinese economy heading? These are just a few of the questions arising when considering the Chinese economy’s development, and these are the questions that have inspired this study and will be answered by the overall research question. Inequality in China will be analysed from a regional perspective from the 1950’s to the present to try to determine if there are any evidence of Deng Xiaoping’s vision to avoid the

[1] Holbig 2004: 337

rich from becoming richer while the poor become poorer, but instead make the whole Chinese economy blossom.

## 1.1 Purpose and Research Question

The purpose of this essay is to investigate the development of the Chinese regions income levels in relation to each other and to the political policies. This will be investigated from a growth perspective to see if the poorer regions tend to catch up with the richer ones. The overall research question is thus:

*Do the Chinese regions show any signs of convergence in Gross Regional Product?*

Answering this question will show how the patterns of inequality in China have changed over time and might give a hint on how future growth policies should be designed.

## 1.2 Research Description

The purpose of this essay is not to investigate the factors behind China's growth but to determine if there is any evidence of convergence between the Chinese regions. We will check for absolute convergence of the regions Gross Regional Products (GRP), conditional convergence of the GRP moving towards the regions steady state GRP level, and convergence among the regions steady state GRP level.

A time period of 55 years (1952-2007) will be looked at. In order to get more comprehensive results we have additionally decided to look at the growth rates during three shorter periods: 1952-78, 1978-99 and 1999-2007. These periods are based on major political reforms, as China has gone from a socialist command economy to a partially open economy to a socialist market economy. Based on previous studies (Kanbur and Zhang 2005), political decisions have played an important role for the Chinese economic growth, and especially the differences in regional growth due to different policies in the eastern and western parts, we have decided to analyse convergence across the whole nation, but also across the western respectively the eastern parts to find out if there is any difference in the result when the two areas are treated as separate economies. The different policies affecting growth will be further explained in chapter 3 where a brief historical background is given. The following part (1.2.1.) will give an introduction to the Chinese regions and which regions are included in this study.

### 1.2.1. The Chinese Regions

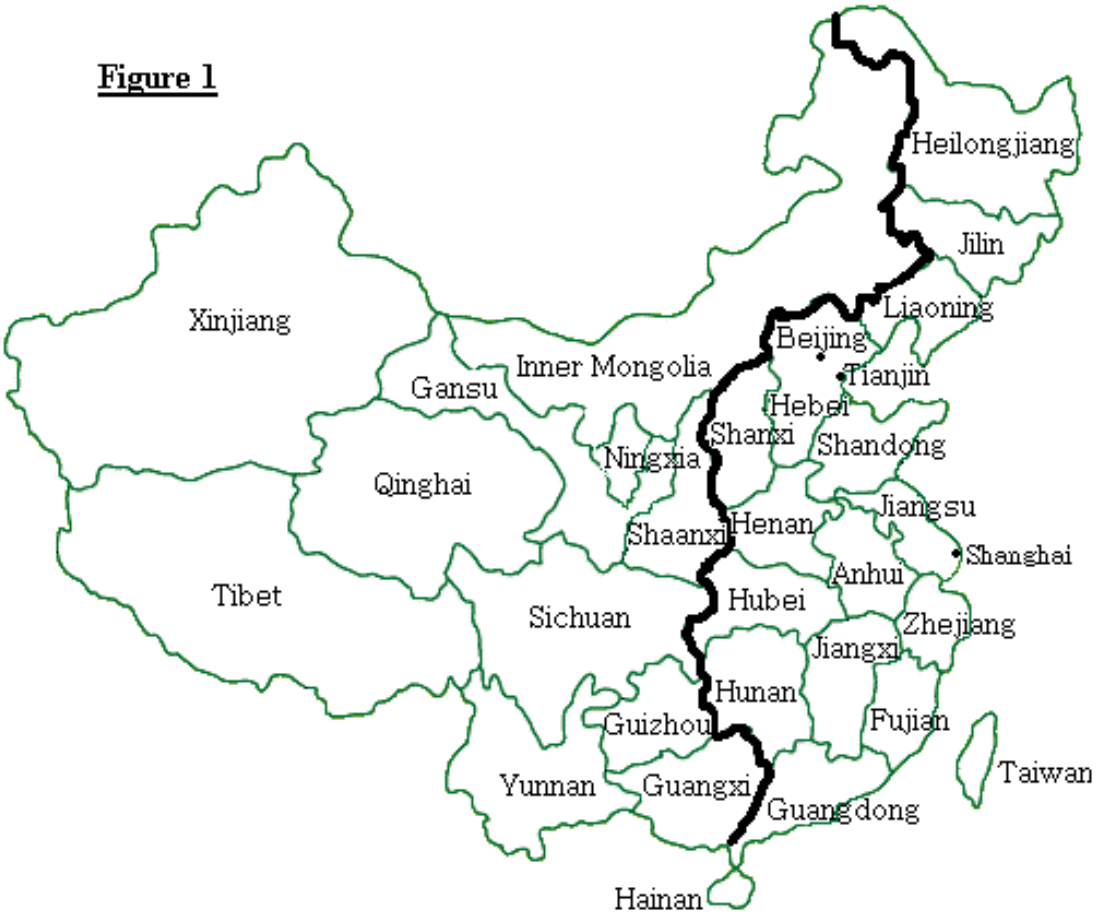
Today China consists of 22 provinces, 5 autonomous regions, 4 municipalities and 2 special administrative regions (Kjellgren 2000: 27). In this study the mainland provinces of China will be considered (except for Tibet that due to its unstable political situation does not have enough data to show reliable results). The provinces not considered, except for Tibet, are the two special administrative regions, Hong Kong and Macau, and the island of Taiwan. These exceptions have been made since their connections to mainland China have been somewhat unclear and changing during the time-span looked at, hence they are not of interest for this study where political decisions affecting growth will be studied.

Other exceptions are the two provinces of Chongqing and Hainan. Both of these regions have reached provincial status during the time period covered by this study; Chongqing became independent from Sichuan in 1997 and Hainan from Guangdong in 1988 (Naughton 2007: 22). There is not enough available data for these provinces previous to them reaching regional status to draw conclusions on the behaviour of these provinces as independent regions, thus Chongqing and Hainan have throughout the study been included in the provinces they originally belonged to.

As mentioned above, the Chinese regions are assumed to have been affected differently by the growth policies. By using the distinction made by the Chinese Government certain regions will be referred to as belonging to eastern respectively western China. This distinction was established in 1999 to determine which regions that had been neglected during the reform era and that were meant to benefit from the 1999 policy to increase western growth (Goodman 2004).

Figure 1 shows the Chinese regions and the border between the eastern and western provinces. To illustrate the differences in GRP-levels between eastern and western China diagrams 1.1, 1.2, 1.3 and 1.4 have been included for 1952, 1978, 1999 and 2007.

**Figure 1**


Heilongjiang
Jilin
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Hainan

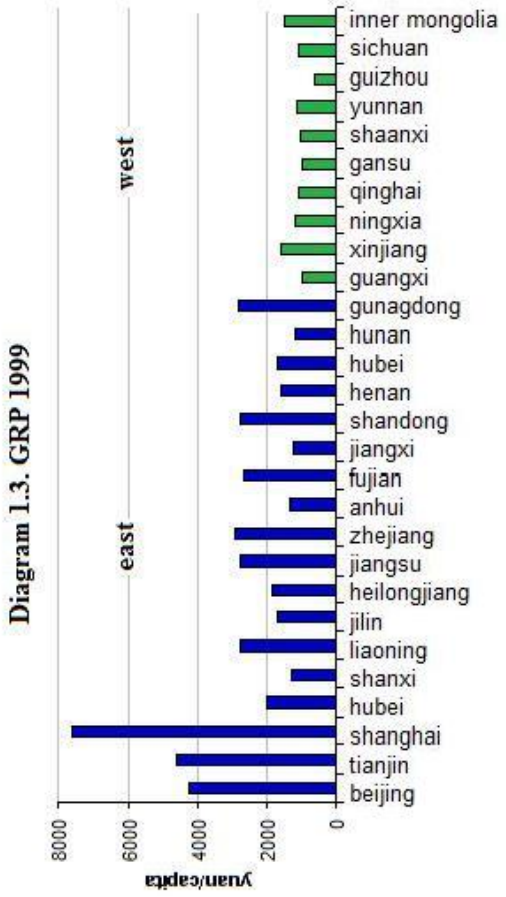
Diagram 1.3. GRP 1999
west
east
inner mongolia
sichuan
guizhou
yunnan
shaanxi
gansu
qinghai
ningxia
xinjiang
guangxi
gunagdong
hunan
hubei
henan
shandong
jiangxi
fujian
anhui
zhejiang
jiangsu
heilongjiang
jilin
liaoning
shanxi
hubei
shanghai
tianjin
beijing
8000
6000
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2000
0
yuan/capita

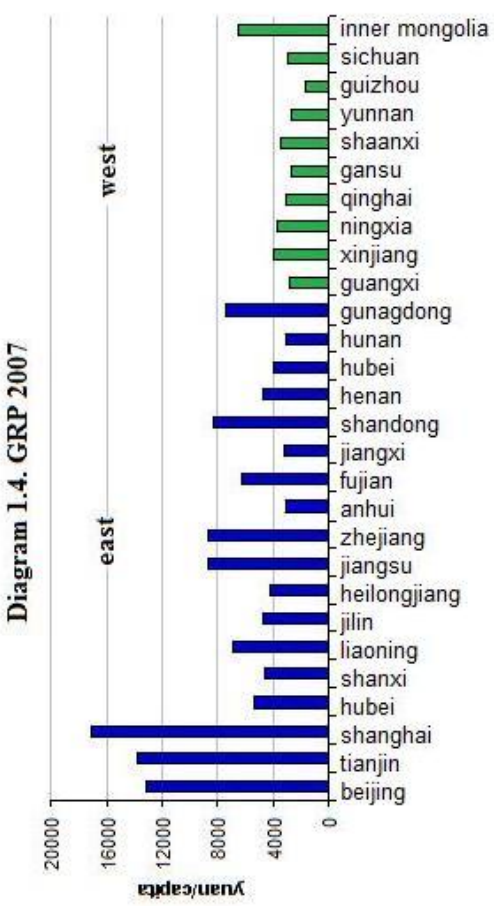
Diagram 1.4. GRP 2007
west
east
inner mongolia
sichuan
guizhou
yunnan
shaanxi
gansu
qinghai
ningxia
xinjiang
guangxi
gunagdong
hunan
hubei
henan
shandong
jiangxi
fujian
anhui
zhejiang
jiangsu
heilongjiang
jilin
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beijing
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yuan/capita

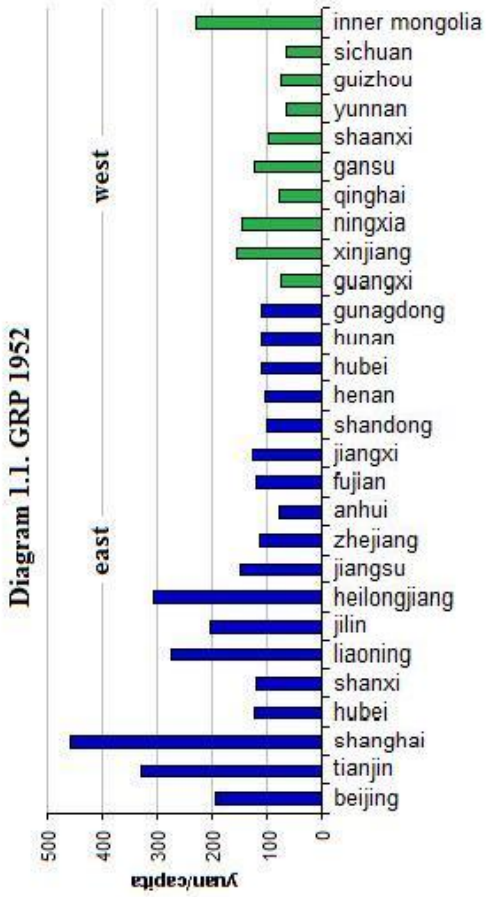
Diagram 1.1. GRP 1952
west
east
inner mongolia
sichuan
guizhou
yunnan
shaanxi
gansu
qinghai
ningxia
xinjiang
guangxi
gunagdong
hunan
hubei
henan
shandong
jiangxi
fujian
anhui
zhejiang
jiangsu
heilongjiang
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hubei
shanghai
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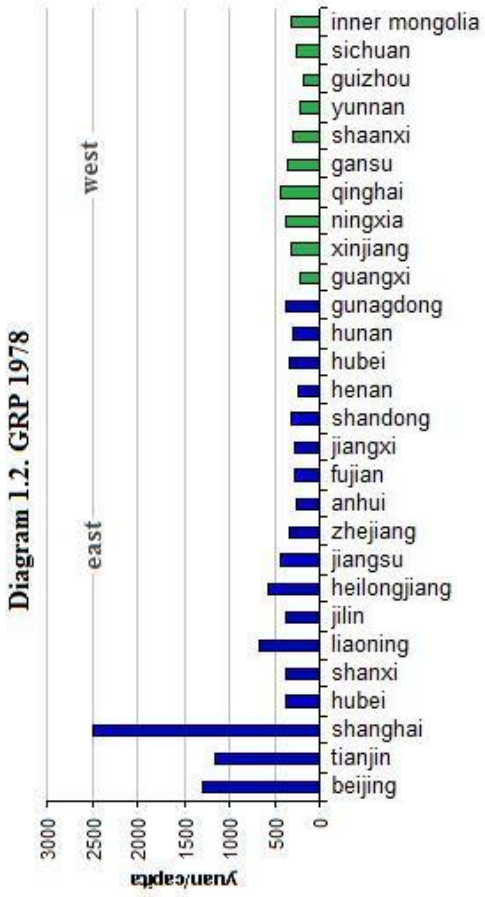


Diagram 1.2. GRP 1978
west
east
inner mongolia
sichuan
guizhou
yunnan
shaanxi
gansu
qinghai
ningxia
xinjiang
guangxi
gunagdong
hunan
hubei
henan
shandong
jiangxi
fujian
anhui
zhejiang
jiangsu
heilongjiang
jilin
liaoning
shanxi
hubei
shanghai
tianjin
beijing
3000
2500
2000
1500
1000
500
0
yuan/capita

## 1.3 The Structure of the Thesis

The study will be organised as follows: Chapter 2 gives a presentation of previous studies made on the subject of convergence. It will also give a general description of the method used and the data the study is based on.

Chapter 3 presents a brief overview of the historical context of the period investigated. The political policies during the 55-year period are presented and will be further discussed in the analysis part in relation to the results.

In chapter 4 the theoretical framework of the analysis is presented. The results are then presented in chapter 5, followed by an analysis in chapter 6 and finally a conclusion in chapter 7.

# 2. Method and Material

*This chapter will give an introduction to previous studies on convergence and further explain how we intend to contribute to the field. A description of the choice of method used and the presentation of the data used will be presented.*

## 2.1. Previous Studies about Convergence

The theory of convergence has been empirically tested between countries, but also across regions within countries. According to Barro and Sala-i-Martin (1991:154) convergence is more likely to occur between regions than countries, since the regions share similar characteristics.

The inspiration for the research question comes from the research that Barro and Sala-i-Martin have done regarding convergence across the US states, the Japanese prefectures and regions within France, Germany, the UK, Italy, Belgium, the Netherlands and Denmark (Barro and Sala-i-Martin1992: 28). These studies have shown that absolute convergence can be seen across regions and that the rate of convergence is about 2% per year, which means that it would take approximately 35 years for the regions to converge by 50%. In these cases the authors have also found evidence of conditional convergence where the regions tend to converge at similar rates (Barro, Sala-i-Martin 1991:153). The same study also found that, theoretically, a greater degree of labour mobility, could lead to a higher rate of convergence.

There are major differences in income levels between the Chinese regions and several studies have been made to investigate the inequalities. Ljunggren (2008:112) states that the disparities in China are dependent on the reforms that were initiated in the late 1970's, that showed a strong bias towards development of the eastern regions. According to Ljunggren the income gaps in China has increased since then. Kim and Knaap (2001) have looked at the issue and claim that disparities existed before the reform and still did in 2001. Yan, referred to by Ge and Wang (2003), believes that the income gap has decreased since the 1978 reform. In this article, Ge and Wang considered absolute and conditional convergence between the regions in China where they divided China into three smaller regions: east, mid and west. Their study covered the period 1985-2000 and they found no evidence of absolute convergence, but signs of conditional convergence within the areas defined as east, mid and west. According to them the income gap between the areas remained constant during the

whole period studied. Kanbur and Zhang (2005) have evaluated the underlying reasons for inequality among the regions. They found that the pattern of inequality coincided with the political policies that encouraged growth.

## 2.2. Choice of Method

This is an empirical study based on secondary data. Whether there is a relationship between initial gross regional product (GRP) and regional growth rate will be statistically determined by using an ordinary least square (OLS) regression model.

## 2.3. Data

The data on the different regional economical indicators used comes from chinadataonline.org that is a website set up by the China Data Centre at the University of Michigan. It is authorised by the Chinese "National Bureau of Statistics", which would imply that the data is fairly reliable. One should be aware that China is a dictatorship and does have a history of exaggerating data in its own favour (Naughton 2007: 70) but the data should give a valid approximation of the state of the economy and its development. In this study the data is found to be reliable enough since a study of the development of GRP is undertaken instead of looking at specific years. Where regional data for certain years has been missing an estimate has been calculated by using an average percentage value from the bordering regions.

The data used for the United States of America to calculate the technological level comes from measuringworth.org. Additional data on both China and the US comes from Penn World Tables, Barro-Lee's "International Data on Educational Attainment" and the Chinese Ministry of Education. All regressions have been done using Eviews.

# 3. Background

*Throughout the 20th century Chinese policy makers have had a great deal to say concerning the course of the country's development and regional economics. The growth regressions in this study will be based on periods of major political changes. This part of the study is meant to give an overview of the political agendas since the 1950's, the regional privileges and the developments within the Chinese society that might have affected the growth rate across the country.*

## 3.1. Policies and Growth in China

### 3.1.1. 1952-1978: The Command Economy

In 1952 China had just underwent a communist revolution (in 1949) when Mao Zedong took over power. The socialist system was inspired by the Soviet-model with rapid industrialisation by 5-year plans. The first 5-year plan started in 1953 and meant that investments grew, especially in the northeast parts of China instead of along the coastline where the most developed industry had been located before. Efforts were made to improve education and production increased. Collectives in the rural areas were formed, private ownership was abolished and by 1956 China was a Soviet-inspired socialist state (Naughton 2007: 55ff). The system was a command economy and meant that everyone belonged to a certain work unit. The people belonging to an urban work unit got higher wages and benefitted from better social welfare institutions than those in rural areas (Naughton 2007:116). The only way to keep the rural population in the low-income agricultural sector was by controlling migration. The hukou system – a system where everyone has a residence permit connected to a special area (urban or rural) where they are allowed to work and take part of the social benefits connected to the area – was introduced in the 1958 to monitor (and control) the rate of rural to urban migration (Kjellgren 2000: 105). The hukou system has meant that migration within China has virtually been zero during 1960-80. The system still exists, but the rate of illegal migration has increased throughout the 1980's and 90's to do manual labour in the cities, although they get lower wages and are denied the benefits connected with an urban status (Naughton 2007: 124).

The relationship between China and the Soviet Union deteriorated in 1956 when the successor of Stalin, Khrushchev, revealed the crimes of Stalinism. This caused a slow-down in the

Chinese rate of change and a short-lived liberal period (known as "the Hundred Flowers") set in to stabilise society and the economy after the political reforms (Spence 1990: 563 ff). The period of liberalisation took a u-turn in 1958, when Mao's obsession with beating the Soviet Union's development path, lead to the initiation of the Great Leap Forward (GLF) (Ljunggren 2008: 34). The GLF meant that the rate of change towards becoming a socialist economy increased. Communes were created in the countryside that functioned as labour pools for projects in the area. Monetary compensation for doing a good job was rejected and the industry produced goods with advanced technology along with low technology, labour intensive goods. Based on false reports and on a very good agricultural year in 1958 the government decided to cut down on the resources available for food production and at the same time increase the amount of grain that was to be delivered to the state. The amount of land allocated to the production of commercial agricultural goods was decreased. The goals for industrial production were constantly pushed upwards. The misallocation of resources made the GLF a disaster for Chinese society as it resulted in mass starvation and decreased production (Naughton 2007: 69 ff).

The distress that the GLF had resulted in was handled through a policy shift and a crisis package in 1961 to increase living standards. A new policy shift came in 1964 where industrial investment was heavily developed in the southwestern provinces (mostly for strategic reasons to protect the industry from American and Soviet forces). The expanding industrial effort was maintained until the beginning of the Cultural Revolution that took place during 1966-1976. The Cultural Revolution was a radicalisation of the system started by students, but encouraged by Mao who felt threatened by the other members of the communist party and wanted a turnaround of policies to strengthen his own power and status as a revolutionary leader (Naughton 2007: 75). Once again was the effort to industrialise at the expense of agricultural production too great and there was not enough food to support the industrial workers. At the end of the era political struggles among Mao's successors took overhand and the development and follow through of new policies was neglected. The confusion in the leadership lasted until after Mao Zedong's death in 1976 when reforms towards opening up and rehabilitating the economy could finally be discussed. In 1978 Deng Xiaoping became the new premier of China and reforms towards a market economy began (Naughton 2007: 97ff).

Even though a lot of questionable policies were introduced under the leadership of Mao, there were also positive effects from the socialist system in the welfare of the people.

Improvements of the health system were made and basic education was received by all which increased the life expectancy and the literacy rate in the country (Naughton 2007: 82).

### 3.1.2. 1978-1999 Liberalisation

"Let some people get rich first."
Deng Xiaoping[2]

During the Mao-era, China's economy was constantly inferior and inefficient when it came to productivity and income. When Deng Xiaoping came to power in 1978 Mao's brutal utopianism was replaced with Deng's vision to open up to the world. By changing the economic policies to more liberal, yet very restricted, views on competition from actors outside the state owned sector, Deng hoped that China eventually would catch up with the industrialised economies (Ljunggren 1008:39).

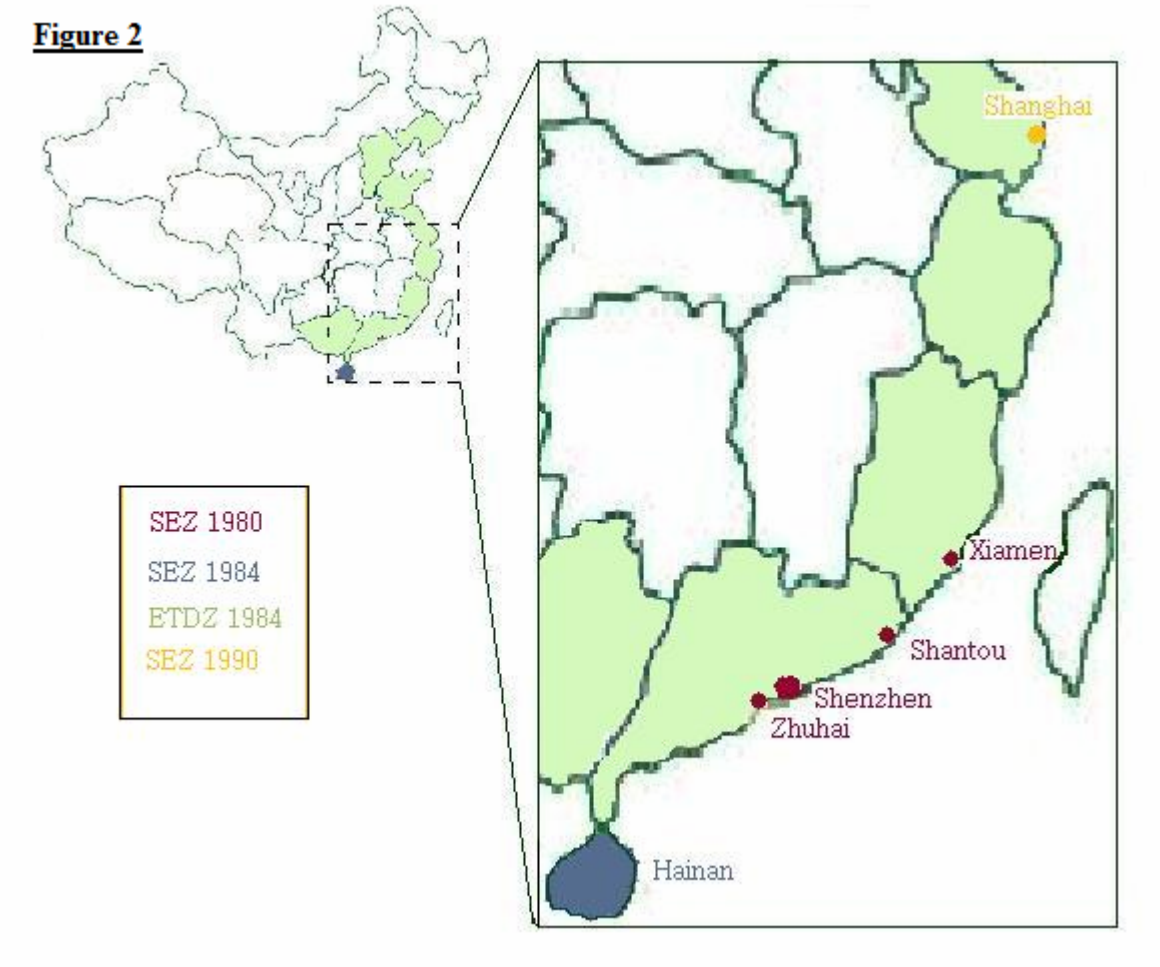
The first major change was made through reforms in the rural areas, where the agricultural collectives in some areas could be turned into Town and Village Enterprises (TVE's). This enabled families to run their own farms by renting a piece of land from the collective. This had positive impacts on production and on the productivity of labour, since the division of labour was now managed within the farm (Naughton 2007: 87). In 1980, China took another step towards becoming more compatible with the industrialised economies, by initiating four Special Economic Zones (SEZ's) – Shenzhen, Zhuhai, Shantou and Xiamen - along the southeast coastline. In the SEZ's foreign companies could trade with Chinese enterprises at market prices, the Chinese enterprises then sold the foreign goods in the Chinese market at government regulated prices (Naughton 2007: 92). Successful results of the SEZ's, with increased international investments, lead to one more SEZ in 1984 – the island Hainan – followed by an opening of 14 Economic and Technological Development Zones (ETDZ) that offered similar provisions as the SEZ. In 1990 the last SEZ was opened in eastern Shanghai - Pudong (Naughton 2007: 409).

The SEZ's and the ETDZ's were placed along the coast since this was strategic for foreign trade. High growth was created in the previously neglected eastern regions, partly due to the

[2] Fan, Maureen, Washington Post 2007

underperformance during the command economy (Naughton 2007: 29). The map below (figure 2) displays the location of the SEZ's and the ETDZ's.

**Figure 2**




The reform era is often divided into two periods, where the first one was a dualist system with "reform without losers" (Naughton 2007: 97). The government sector still took upon itself to have a social responsibility to distribute income and maintain the social welfare system for the work units. The dualist system, that had been in place since the communist revolution (with differing market regulations, income level and other social welfare indicators for rural and urban residents), was upheld until the mid-1990's. At this time the Chinese government adopted a "socialist market economy" and the reform entered its second phase, "the reform with losers". This meant that the previous guarantee of lifetime employment was abolished through a downsizing of the state sector (Naughton 2007: 100). At this point the preferential treatment that the eastern provinces had enjoyed had given them an advantage over the western regions. As the migration regulations loosened, farmers from western China moved to the east to work in the cities. The government acknowledged the increasing gap between incomes in different regions and began realising that it was time to let all people get rich.

### 3.1.3. 1999-2007 The Opening of the West

While the eastern parts of China experienced rapid growth and improved living standards after the economic reforms of 1978, the western parts did not experience the same growth rate. The Chinese government hoped that the preferential treatment of the eastern regions eventually would lead to technological diffusion and growth in the western parts of China aswell. However, in the middle of 1990 a statistical analysis showed that growth in the eastern parts failed to diffuse to the west (Holbig 2004). In 1999 the Chinese government initiated the "Open up the west" campaign to decrease inequality within the country. By making adjustments in the regional development policies, Chinese officials hoped to increase the political and social stability, encourage endogenous growth and reduce socio-economic inequities. This meant that in contrast to the characteristics of the previous years' low state intervention, China now chose to make decisions on a more central level again (Goodman 2004). The largest part of the Chinese population lives in the eastern regions, and this is where most major cities are situated (Naughton 2007: 19). Migrants have been moving to the cities during the 1980's and 90's and the new policies were meant to reverse the flow of migration.

Even tough there are some positive effects, the outcome of the campaign has not been as successful as might have been hoped. This is possibly due to the absence of any organised mode of procedure. With numerous of actors on central, regional and local level, the decision procedure has been hard to overview and control. Further, the boundaries for western China have changed over time. The first definition of western China (which is the one referred to in our study) includes the west and central regions, while in year 2000 the central regions became more of a developmental bridge between the west and east (Holbig 2004).

Chinas development towards becoming an open economy took a leap when China in 2001, after 15 years of negotiation, entered the World Trade Organisation (WTO). Along with the membership followed several requirements to favour free trade (that earlier had stopped China to enter since they could not fulfil them). China had to implement new parts in its legal system. Among other changes was the implementation of a law regulating intellectual property rights, impartial execution of laws and increased transparency in the process of making new laws. China will also remove some of its technical barriers to trade and harmonise the technology used to international standards. Other barriers to trade will also be decreased (tariffs and quotas on imports) (Nell 2003: 9ff). Today China's legal system is

broadly compatible with WTO law, which has positive effects on the Chinese economy as trade increases, but at the same time competition intensifies which has lowered the profits of some state owned enterprises (Nell 2003: 34f). Historically the state owned sector has drained the state budget. Although privatisation has taken place there are still some large state owned companies left that are not profitable (Kjellgren 2000: 58).

# 4. Theory

*In order to evaluate the result of the growth policies in China during the time studied, the historical polices will be evaluated from a growth perspective. The Solow growth model, which is the basic model for understanding economic growth, will be presented along with an extension including technology transfer. These models are the basis to the theoretical cause of convergence, which will be discussed in the last part of this chapter.*

## 4.1. Growth Model

First Solow's growth model will be introduced, where the fundamental ideas behind economic growth will be presented. This will also give an explanation for why countries grow at different rates and an idea of how an economy can affect their own growth rates. In order to put this information in relation to the Chinese economy an extended model with technology transfer will be presented.

### 4.1.1. Solow Growth Model

In the article "A Contribution to the Theory of Economic Growth", published 1956, Robert Solow introduced his ideas about long run economic growth. The content of this article has later been recognised as the Solow growth model and is built around two equations: the production function and the capital accumulation function.

The production function explains how inputs are combined to create output. According to Solow, production in a closed economy is dependent on two input variables: physical capital (K) and labour (L). In the model only one commodity is produced (Y) and it can either be consumed or saved. The production function is expected to have a Cobb-Douglas form and is given by equation 1 (Jones 2002: 22):

$$Y = K^{\alpha} L^{1-\alpha} \qquad \text{(equation 1)}$$

It is assumed that the production function has constant returns to scale, that is, if both L and K increases with 10%, Y increases by 10%. Further it is also assumed that capital is subject to diminishing returns to scale. Given a fixed stock of labour, the marginal contribution of the last unit of capital will be decreasing (ibid).

The production function can be rewritten in terms of per capita output:

$$y = k^{\alpha} \qquad \text{(equation 2)}$$

Equation 2 implies that production per capita is directly dependent on physical capital per

capita, which leads to the next key equation for this theory that shows how capital accumulate:

$$\dot{K} = s_K Y - dK \qquad \text{(equation 3)}$$

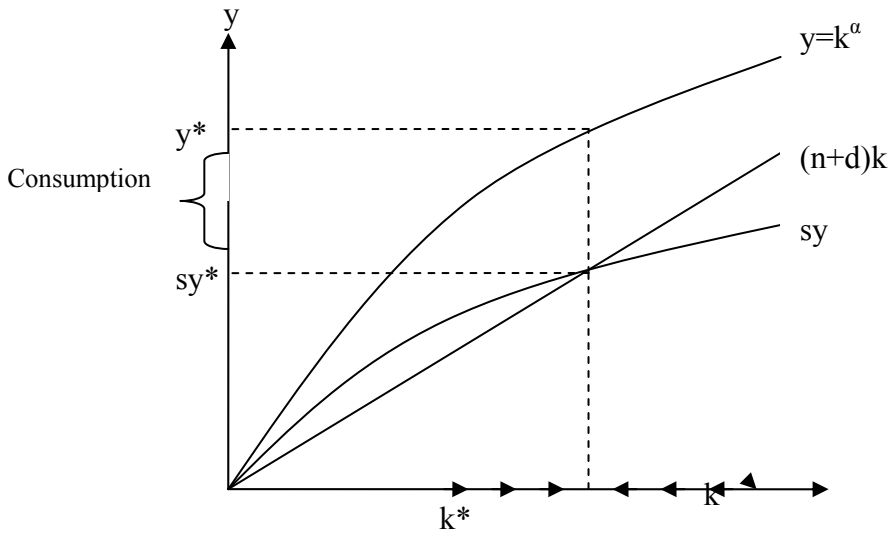
The change in physical capital is the difference between savings and the amount of depreciation that occurs during the production process. In a closed economy savings ($s_K Y$) equals investments and it is assumed that the rate of savings are constant over time. Also the rate of depreciation (d) is assumed to be constant over time. Assuming that the growth in the labour force ($\dot{L}/L$) is equal to the growth of the population (n) the capital accumulation function can be written in per capita terms:

$$\dot{k} = sy - (d+n)k \qquad \text{(equation 4)}$$

The function shows that high population growth and depreciation tend to decrease the amount of capital per person, while savings have a positive impact. At the point when capital per capita no longer changes (sY=dK) the economy has reached a steady state condition. By combining equation 2 with equation 4 the steady state output per capita (equation 5) can be solved and a diagram can be created to display the result.

$$y^* = \left(\frac{s}{d+n}\right)^{\frac{\alpha}{1-\alpha}} \qquad \text{(equation 5)}$$

**Diagram 4.1. The Solow Diagram**




Equation 5 predicts that a high savings rate and low population growth leads to high per capita output and by looking at the situation in the world today empirical evidence can be find

for this statement (Todaro and Smith 2006: 263). The steady state level differs between countries since all countries have different institutional structures, different levels of human capital, investment levels etc. When an economy is in its steady state, capital per capita and output per capita are constant over time (Jones 2002: 29). Notice that the total output, Y, and total amount of capital, K, can still be growing but the growth of the population and the speed of depreciation will keep the per capita values constant. If an economy is located below its steady state the investments will be higher than the depreciation which will increase the capital per capita until the economy reaches its equilibrium at k*. If the investments are too low the adjustment will work the other way around. Hence, the economy will always be moving towards its steady state.

According to the simple Solow model there will be no further growth in per capita terms when the economy reaches its steady state. Since this assumption has been falsified empirically (economies do tend to grow), the model has been extended to include technology as a factor that determines long run growth in the steady state. In the long run the economy grows along a balanced growth path that is equal to the growth rate of technology.

### 4.1.2 The Extended Solow-model with Technology Transfer

Several extensions of the Solow-model have been done where new variables that suggest endogenous growth have been introduced. In order to decide which model to use when analysing economic growth in the Chinese regions one need to take into account the characteristics of the Chinese economy. China is a partly open economy that has had a very high growth rate during the past 30 years, which is generally understood as a result of more liberal policies and increased investment (Naughton 2007: 145). During the command economy China was relatively closed to ideas from abroad, which caused the Chinese economy to fall behind in the accumulation of technology. According to Naughton (2007: 381) one of the reasons for the liberalisation of the economy was a wish to increase Foreign Direct Investment (FDI) that could introduce new technology and hence increase productivity. Since technology diffusion seems to have been important for Chinese growth we have chosen to use the Solow model with technology transfer to calculate the steady state levels for the Chinese economy. This model takes into account how well the economy in question can utilise the available world technology. The production function is given by equation 6.

$$Y = K^{\alpha}(hL)^{1-\alpha} \quad \text{(equation 6)}$$

The same assumptions are made in this model as in the Solow model when it comes to capital accumulation, but this one also includes the accumulation of skill:

$$\dot{h} = \mu e^{\psi u} A^{\gamma} h^{1-\gamma} \quad \text{(equation 7)}$$

Where μ is the economy's over-all ability to use the existing technology, u is the average time spent in school, ψ stands for the quality of the education and γ measures the relative importance of technology to human capital. The per capita steady state level is calculated using equation 8.

$$y^* = \left(\frac{s_K}{n+g+d}\right)^{\frac{\alpha}{1-\alpha}} \left(\frac{\mu}{g} e^{\psi u}\right)^{\frac{1}{\gamma}} A^* \quad \text{(equation 8)}$$

In equation 8 it can be seen that in conformity with the simple Solow model (see equation 5), savings have a positive impact on output per capita while population growth and depreciation affects it negatively. The second term in the equation explains the importance of human capital that enables the third part of the equation (the world technology, A*) to be adapted in the economy.

In order to increase its steady state level, an economy can change its level of human capital but not the technology of the world. This is a limitation of the model that makes this model suitable for understanding growth in a developing economy, but not in a more developed economy that produces its own technology (Jones 2002: 125).

## 4.2. Convergence

The theory of convergence states that economies that have an initially lower GDP per capita level will eventually catch up with economies that have an initially higher GDP level (Abramovitz 1986). In the Solow model this catch-up effect is due to diminishing returns to capital, where economies with initially low levels of capital per worker gain more from increasing its capital-labour ratio at the margin than economies with initially higher capital-labour ratios (Barro and Sala-i-Martin 2004: 17). In the extended model, the tendencies for the economies to converge are caused by the capital-labour ratio, but also by diminishing returns to technology. Since imitation is cheaper than innovation the economy will have a higher marginal utility of technology the further away from the technological frontier they are (Barro et al. 2004: 20). As the amount of un-copied innovations decreases, the cost of

imitations tends to increase and the economy's rate of growth diminishes (Barro and Sala-i-Martin 1995: 34).

The theory of absolute convergence assumes that all economies grow towards the same income level, which means that poor countries should have higher growth rates than rich countries during the transition path. The theory of absolute convergence among all economies does not obtain empirical evidence since it seems as though the richer economies of the world are growing faster than the poor economies (Barro and Sala-i-Martin 2004: 45). However, evidence of absolute convergence have been found between economies that exhibit similar patterns in the factors affecting their growth rates and thus have about the same steady state level, for example the OECD countries (Burda and Wyplosz 2005: 438). In the case of the Chinese regions one could expect absolute convergence to be noticeable since regions within a country often are more similar than different countries and absolute convergence has been found in previous studies at regional level (Barro and Sala-i-Martin 1991:154).

A theory that has gained empirical support across samples of countries with diversified economies is the theory of conditional convergence. The theory assumes that countries have different steady state levels and that they tend to converge towards their own steady state level. The differences in steady state levels depend on factors that affect the steady state function, such as the savings rate of the economy, the population growth and the technological diffusion (Barro and Sala-i-Martin 2004: 17). Countries that are far away from their potential GDP level should, according to the theory of conditional convergence, grow faster than those economies closer to their steady state. This theory could explain why absolute convergence can be seen among the OECD countries but not across all economies.

**Diagram 4.2. Transition dynamics**

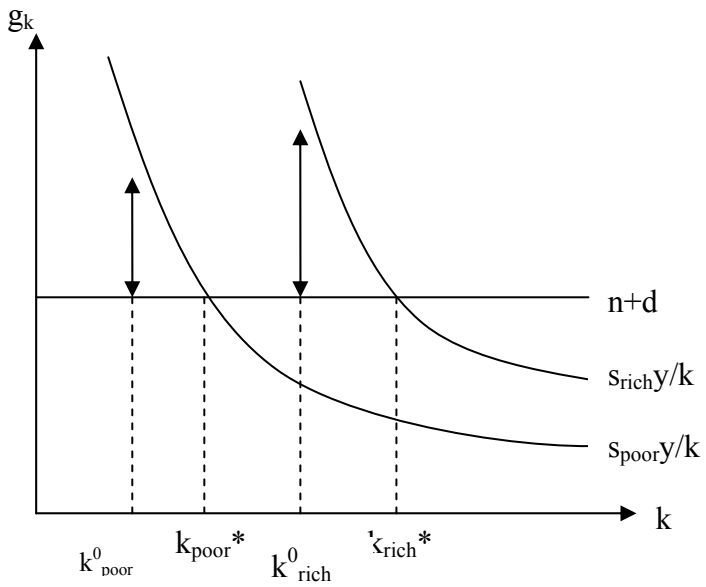



Figure 2 shows the dynamics of diminishing returns in relation to growth rates. Because of the decreasing returns to capital the sy/k-curve will slope downwards. Population growth and depreciation is not dependent on k, thus it is plotted as a horizontal line in the diagram. If a rich economy has a higher savings rate relative to its capital stock per capita than a poor, the rich economy can still have a higher growth rate since they proportionally are further away from their steady state (Barro and Sala-i-Martin 2004:48). This simplified model only shows the effect of diminishing returns to capital on the growth rate. In the extended Solow model the technological level utilised (determined by the human capital) in the economy has the same impact on growth as the savingss rate in figure 2.

It is possible for countries to move from one steady state level to a higher one through changing the composition of the countries production function, for example by increasing investment (Jones 2002: 41). In figure 2 this would be depicted as a shift from the $s_{poor}y/k$-curve to the $s_{rich}y/k$-curve. This would be a one time shift in the steady state level where the growth rate would temporarily increase during the transition phase, but as the economy reaches its new steady state level the growth rate returns to its original level. According to growth theory the only way to increase the steady state growth rate would be to increase the technological growth rate, either by expanding the R&D sector, or by increasing the efficiency of the sector. In the case of China one could expect the high growth rate to be the result of a shift in the level of the steady state (due to the increasing investment rate driven by

increased FDI), but also as an increase in the steady state growth rate since the economy has improved its ability to acquire and implement new technology.

The rate of convergence can be calculated and a further explanation on the empirical calculations and results will be given in the next part.

# 5. Empirical Study

*To check for convergence statistical methods will be used. The regression functions used for the various kinds of convergence will be presented in this chapter along with the results for convergence in China.*

## 5.1. Calculating Convergence

### 5.1.1. Absolute Convergence of Real GRP and Steady State GRP

In order to find evidence of absolute convergence a linear regression model is estimated using the OLS-method according to the formula:

$$y=a+bx+e \qquad \text{(equation 9)}$$

Where initial GRP is the explanatory variable (x) and the growth rate is the dependent variable (y). The value of b indicates whether there is a negative relationship between the initial GRP level and the growth rate and thus showing evidence of absolute convergence. In the calculations Yuan (the Chinese currency) have been used to measure GRP. If b takes on a negative value it should be interpreted as a region growing at a growth rate that decreases by b per year for every extra Yuan of initial income.

The same test is run on the steady state values and their growth rate.

Where absolute convergence is found the number of years it takes for a poor region to converge with a richer one can be calculated using equation 10:

$$T = \frac{\log\left(GRP_R \div GRP_P\right)}{\log\left((1+g_P) \div (1+g_R)\right)} \qquad \text{(equation 10)}$$

Where the index R stands for the rich region and P for the poor, g is the growth rate.

### 5.1.2. Conditional Convergence

Conditional convergence means that the regions are moving towards their own steady state (calculated using equation 8). The rate at which the GRP is moving towards its steady state is calculated using equation 11 (Barro and Sala-i-Martin 1991).

$$\left(\frac{1}{T}\right)\log\left(\frac{y_{it}}{y_{i,t-T}}\right) = x_i^* + \frac{(1-e^{-\beta T})}{T}\log\left(\frac{y_i^*}{y_{i,t-T}}\right) + u_{it} \qquad \text{(equation 11)}$$

This equation shows the log of the real growth rate of the economy, $\left(\frac{1}{T}\right)\log\left(\frac{y_{it}}{y_{i,t-T}}\right)$. The first term in the right hand side of the equation, $x_i^*$, shows the growth rate of the economy in its steady state (which presumably is 0,02 as that is the growth rate of the US. Since we assume that the US is in its steady state and is the worlds' leading technological actor, it is further assumed that a country that is in steady state is growing at the same pace as the world technology). The term $\frac{1}{T}\log\left(\frac{y_i^*}{y_{i,t-T}}\right)$ shows the growth rate of the economy if the economy had been growing from its initial income level at time 0 to its steady state income. The term $1\text{-}e^{-\beta T}$ show how much of the real growth rate that is determined by the economy's convergence towards its steady state. If there is no convergence towards steady state, i.e. the economy is at its steady state level and is growing along a balanced growth path, β will equal 0, since $e^0=1$ the second term of the equation will disappear and the economy will be growing at rate $x_i$*. Nevertheless, the larger the value of βT is, the closer $e^{-\beta T}$ will be to zero and the larger the impact of the growth towards steady state will have for the real growth rate. If e is raised to a negative value the indication for the economy is that it is growing at a pace higher than the growth rate at steady state, and if e is raised to a positive value the economy is growing slower than it would at its steady state.

In this model the variable that determines the rate of convergence is β. The larger β is, the faster the economy is growing towards its steady state. An economy that is close to its steady state will have a lower growth rate than an economy far away from its steady state since the value of $\log\left(\frac{y_i^*}{y_{i,t-T}}\right)$ will be smaller the closer the economy is to the steady state level.

When the value of β is known, the time it takes for the economy to close half of the gap towards the steady state level can be calculated by setting this expression equal to 0,5. The time (T) that it takes is thus:

$$T = \frac{-\ln(1-0,5)}{\beta} \qquad \text{(equation 11)}$$

Using equations 9, 10, 11 and 12 we proceeded by doing the calculations. The half-life of the convergence in the cases where the results do not show signs of correlation will not be calculated. The results acquired are presented in appendix 4 and interpreted in part 5.2. In part 6 the results will be analysed in relation to their historical context and the economic development in China.

## 5.2. Results

The results we got are presented in table 5.1. where they are presented in the order China/East/West. Y stands for yes, i.e. convergence can be seen, and N stands for no. Where the results were inconclusive it has been denoted by -. The results will be further explained in the following text.

**Table 5.1.**

| | **1952-1978** | **1978-1999** | **1999-2007** | **1952-2007** |
|---|---|---|---|---|
| Absolute convergence | N/N/Y | Y/Y/Y | N/N/N | N/N/N |
| Conditional convergence | -/-/- | Y/Y/Y | -/-/- | Y/Y/Y |
| Steady state convergence | Y/N/Y | Y/Y/Y | Y/Y/Y | Y/Y/Y |

### 5.2.1. Absolute Convergence

The results for absolute convergence are presented in appendix 4. For the entire period (1952-2007) the convergence coefficient is negative, which would imply absolute convergence, but this relationship cannot be established at any significance level (the p-value is 18,8%) and the coefficient of determination, $r^2$, is low. However, for the sub-period 1978-1999 convergence can be found at a 10% significance level but the explanatory rate of the model is still fairly low ($r^2$=0,122).

When the data is divided into the eastern and western provinces, convergence cannot be seen in any of the areas during the whole time period. During 1978-1999 absolute convergence can be found at a 5% significance level in eastern China. During 1952-1978 the relationship between initial income and growth is positive which implies divergence across the eastern regions but this cannot be established at any significance level.

In the western provinces convergence can be established at a 1% significance level during 1952-1978 with a fairly high explanatory rate of the model ($r^2$=0,653). During 1978-1999, convergence can be found at a 10% significance level, but with a lower explanatory rate. During 1999-2007 there is a positive relationship between the variables, but it is not established at any significance level.

Overall, the period of 1978-1999 shows the strongest signs of absolute convergence. However, even though a negative relationship between initial GDP and growth rate can sometimes be established the correlation coefficients are generally low, none are higher than -0,00023, which implies that although there are evidences of absolute convergence during certain time periods, the impact that initial GDP has on the growth rate is low. It would have taken 22 years for the poorest region to converge with the richest. But since the economy has changed this is no longer valid.

### 5.2.2. Conditional Convergence

Evidence of conditional convergence has been found throughout China for the whole time period at a 1% significance level. The rate of conditional convergence towards the regions individual steady states is 0,49% per year in China, and at 0,53% in eastern China and 0,41% per year in western China. The $r^2$ values are relatively high for China and eastern China, but lower for western China. Evidence of conditional convergence can also be found at a 1% significance level in China during the time period 1978-99, where the growth rate towards steady state is 1,36% per year. The regions in eastern China show conditional convergence at a rate of 1,58% per year during this period. During the period 1999-2007 western China was found to have experienced conditional convergence of 0,90% per year at a 1% significance level.

Although conditional convergence seems to have occurred, the results were ambiguous as certain periods showed negative β-values, which indicate divergence from the regions steady

states. The regressions also show negative $r^2$ values. These indicate that the model is not suitable in order to explain the studied phenomenon for these periods. When using e-views a negative $r^2$ value indicates that the regression has a worse fit than a model only consisting of the sample mean would have (Eviews). This occurs due to the fixed intercept at 0,02 (2% growth in steady state).

### 5.2.3. Convergence of Regional Steady State Levels

Convergence was found among the regions steady state levels during all time periods except for 1952-1978 in eastern China where the correlation coefficient turned out to be non-significant at a 10% level. The model seems to be a pretty good fit as the $r^2$-values are generally relatively high. The impact the initial steady state level has on the growth rate of the steady state is thus significant, but rather low as the correlation coefficients show low values.

# 6. Analysis

*In this section the empirical results will be discussed and compared to the growth policies in China. The analysis is divided in three parts where absolute convergence, conditional convergence and steady state convergence will be considered. The underlying factors of convergence, or the lack of convergence, will be discussed.*

## 6.1. Absolute Convergence

The reason for studying absolute convergence is that absolute convergence leads to a decreased gap between the regions. However, even if the gap decreases in percentage points, the absolute gap in monetary terms may still increase which leads to increased income inequality. For example, if two regions grow by 5% each and one region has initial income of 100 Yuan and the other 1000 Yuan, the second economy will grow more in monetary terms although they have the same percentage growth. If absolute convergence does exist the inequalities will eventually disappear, but if the convergence happens at a low pace people may not notice the improved equality in the short run.

In our study we found that the Chinese regions have not experienced absolute convergence through the period 1952-2007. This result differs from the results of Barro and Sala-i-Martins results from the US and European regions where convergence was found at a 2% rate per year. The difference is interesting as one might expect a similar result and the question arises: Why are the Chinese regions not converging? One explanation could be that although we are looking at fairly long time span the political policies in China have gone through radical changes throughout the period (the great leap forward, the cultural revolution, the reforms in ’78, becoming a socialist market economy etc.) which, for example the US, has not.

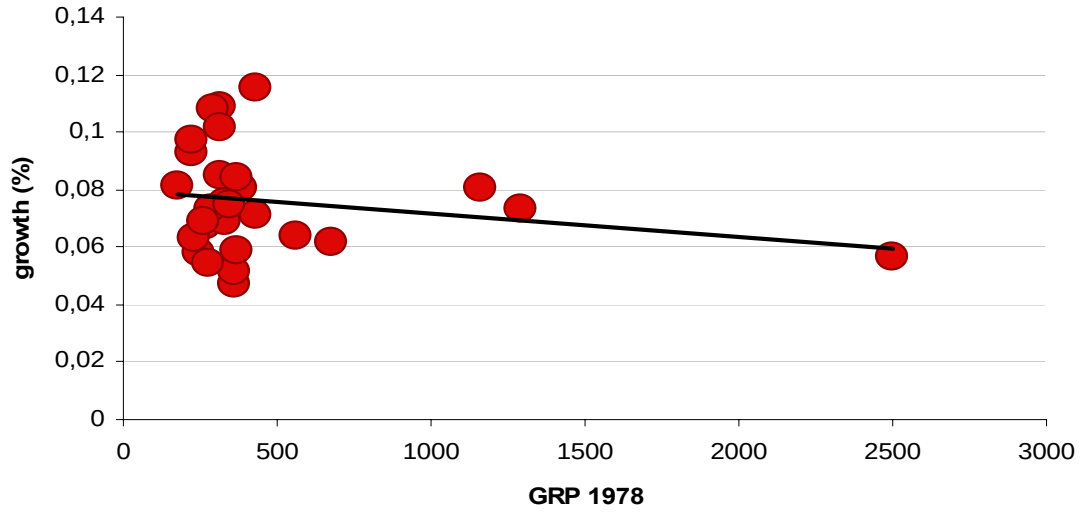
According to the theory of convergence the underlying reasons for converging are that the economies are homogenous in the factors affecting the production function. In China these factors have differed across the regions, for example the savings rate has been very unequal, the technological levels have been different and the years in education have been higher in eastern China. The assumption that regions within a country should be similar may not be true for China.

Since the regions show different production abilities their steady state levels should be different, hence it is not surprising to see that the result differ from that in the US or Europe where the regions are more homogenous. Also, Barro and Sala-i-Martin point to migration as

a factor speeding up the rate of convergence. In the US and Europe migration can help equalise income since labour can move from areas with low demand to areas with high demand for labour with higher wages. In China the hukou system has made it close to impossible for people to migrate from poor regions with low wages to richer regions. This has upheld the differences in wages and living standards across the regions, which has slowed down convergence. Also, the lack of population movement has inhibited the spread of technology, and thus the western regions have not been able to implement the new technology that the eastern regions have acquired from abroad. In the past decade the authorities have not had as strict control over migration within China as they previously had and illegal migrants have come from the rural areas to the urban areas in search for work. Although the migrants are usually employed as manual labour the diffusion of both income and technology could increase further in the future. Even today remittances from family members working in the cities are sent back to the countryside, which decreases the income gap slightly.

The only period in time where evidence of absolute convergence could be seen across the Chinese regions was between 1978 and 1999. The evidence for absolute convergence was not that strong and the poorer regions only increased their growth rate by 0,00275% per Yuan.

**Diagram 6.1. Absolute convergence in China 1978-199**




*In diagram 6.1., three of the regions show a much higher initial GRP. To check our result we removed these observations, but we received a similar result.*

This correlation was stronger in the eastern regions than in the western, but the correlation coefficient was lower in the east than in the west. The reason for the convergence during this period can probably be related to the overall increase in GDP that was driven by increased investments after the reform. The reform created incentives for investment both in fixed capital and human capital, hence the investment rate increased throughout China and the average years of education increased in every region. Although the engine behind the growth lay in the eastern regions, the western regions also increased growth and investment, and due to decreasing returns to scale the initially poorer regions could benefit more, which would explain the signs of convergence.

The strongest result for absolute convergence was found in the western regions during 1952-1978 where the poorer regions grew at a rate that was 0,023% higher per Yuan less of initial income. This is probably due to the increased investments in this area in combination with decreasing returns to capital.

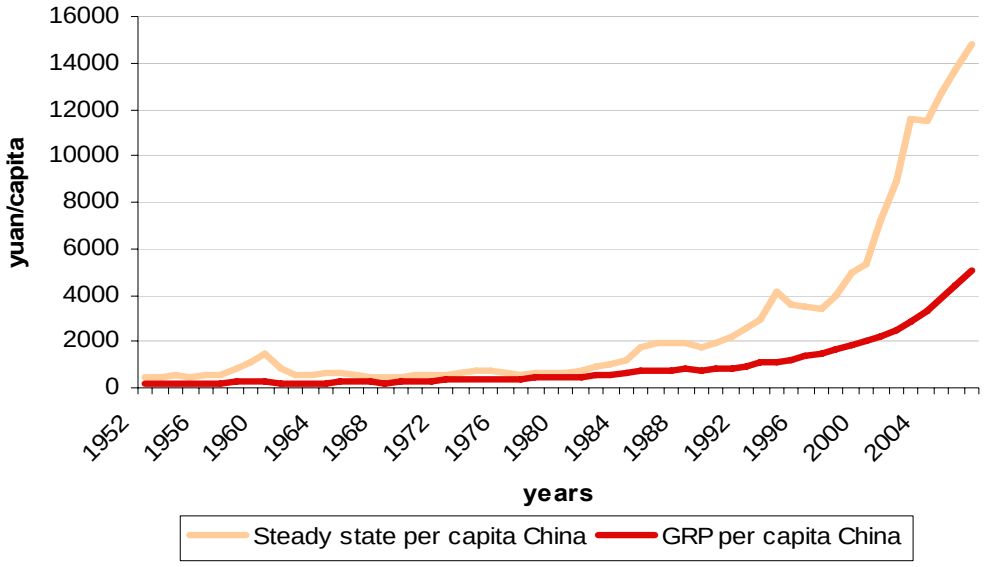
## 6.2. Conditional Convergence

The evidence for absolute convergence was weak so there are no clear evidence that the different policies have made the regions move towards a common steady state. Further, convergence of the regions towards their own steady states have been calculated, based on the regions' individual savings rate, educational effort, population growth and openness. This is investigated to establish whether the regions that are further away from their steady states grow faster than the regions that are close to their steady states, at which rate they are converging on average, and how long it takes for the regions to reduce the gap to the steady state by half.

The results for conditional convergence are interesting as a result of existing conditional convergence can help to determine future policies (if they affect the level of the steady state they will also affect the real GRP since these would be interlinked). The results show that conditional convergence can be seen across China during 1952-2007. The average rate of convergence towards the steady state in China is 0,49% per year during this period. At this rate it would take 140 years for half of the gap between the present GRP level and the steady state level to close. This result is below the results found in various studies of industrialised countries, for example in the US by Barro and Sala-i-Martin that found a conditional convergence rate of 2% per year. This could be caused by the rate of change in China during

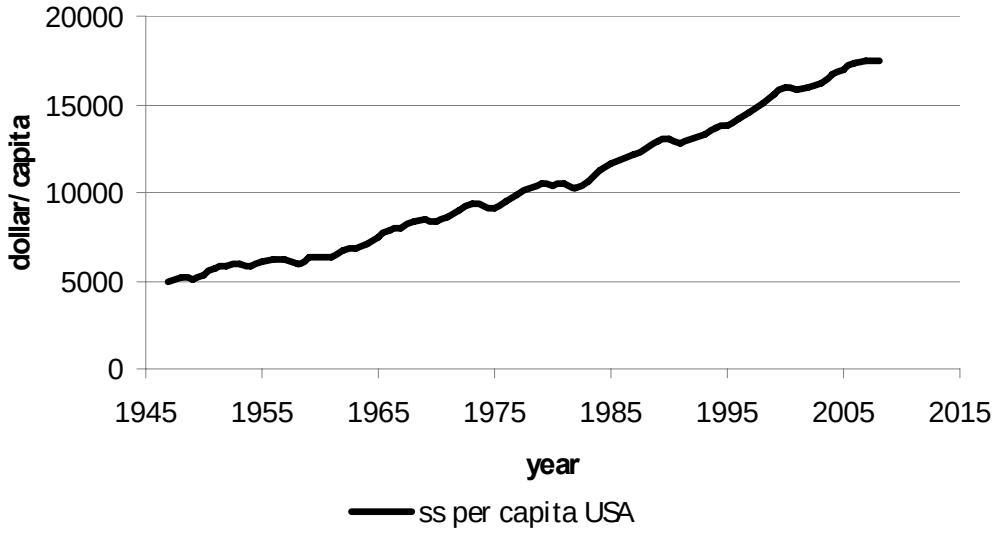
the time looked at. The steady state levels in China have grown at an exponential rate from 1952 to 2007. As can be seen in diagram 6.2., the average GRP per capita is "chasing" the steady state level, but the high rate of increase in steady state makes it almost impossible for the real GRP to catch up. Even if the economy has reached and outperformed it 1952 steady state level in 2007 the new steady state levels of 2007 are still above the real GRP.

**Diagram 6.2. GRP per capita in China**



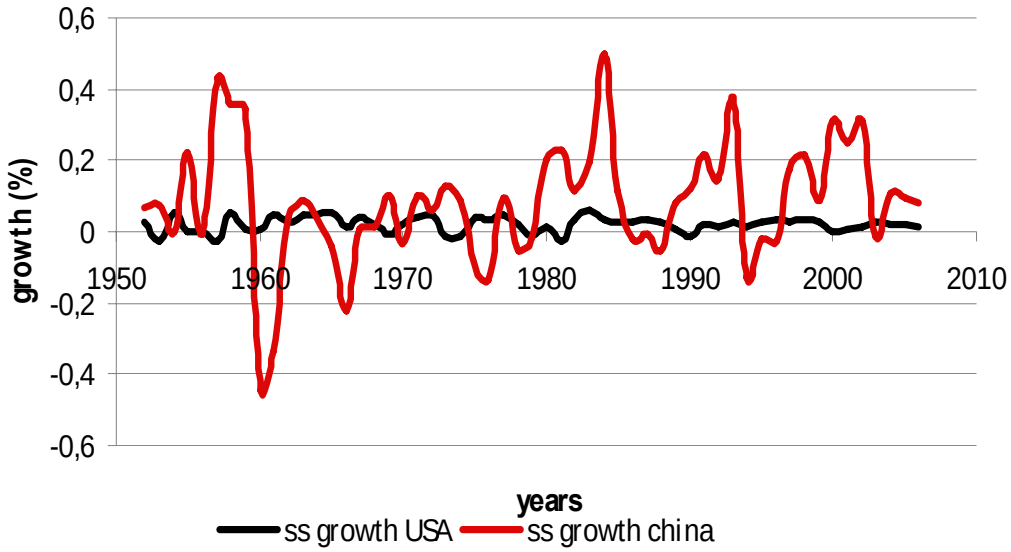

The exponential pattern of the Chinese steady state growth can be contrasted to that of the United States that has followed a linear pattern during the same period.

**Diagram 6.3. USA's GDP per capita**



The predictability of the American GDP level has probably caused the convergence to be as strong as it is (2%) while the unpredictability of the Chinese economy could be a reason for the weak signs of convergence. To illustrate this further diagram 6.4. will show the growth rate of the steady state levels for China and for the US where it can be seen that the growth rate in China is fluctuating a lot more than that in the US.

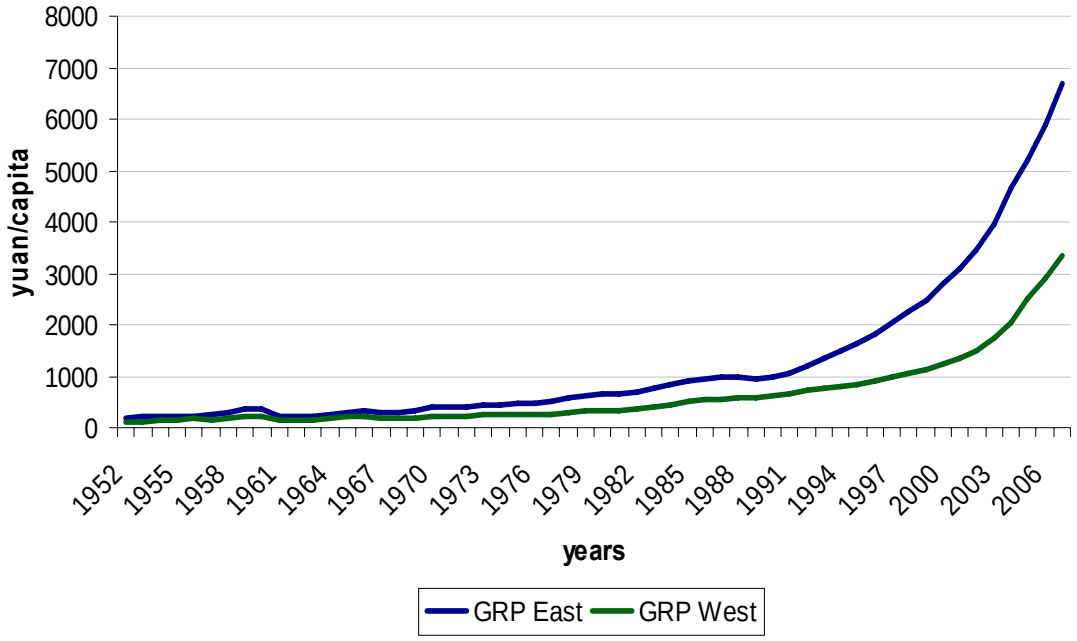
**Diagram 6.4. Steady state growth**




In the results different rates of convergence in eastern and western China was found and also different values for different time periods. In eastern China the rate of convergence was at 1,58% per year during 1978-1999, and 0,46% per year during 1952-2007. At these rates it would take approximately 44 years respectively 130 years for 50% of the gap to close. The reason for the convergence during 1978-1999 could be that the eastern regions, according to Naughton (2007), underperformed during the command economy and could exploit its potential after the 1978 reform, which meant that they could keep up its real growth rate with the high steady state growth. The signs of convergence during 1952-2007 indicate that the eastern GRP is growing towards its steady state but at a slow rate. The reason for the lack of convergence during 1952-78 could be due to the often negative growth rate in the steady state level, while real GRP did not fluctuate as much. The puzzling results received between 1999-2007 could be caused by the very rapid increase in the steady state level (16% per year), while the GRP level has grown at a high rate (13% per year), but still lower than the steady state? We think that eastern China is still in a transitional phase, moving from a low GRP level to a higher, and if we had had a longer time span to look at we might have seen a levelling out of the increase in steady state in the future, followed by a levelling out in GRP.

Western China shows conditional convergence during 1978-1999. The lack of convergence during 1999-2007 could be due to the very high steady state growth rate. Although a trend shift can be seen around year 2000 where the rate of growth increased, seen in diagram 6.4. In the diagram it looks as though the western parts have just begun its growth toward a higher income level. While eastern China has moved further along its transition path.

**Diagram 6.5. GRP**



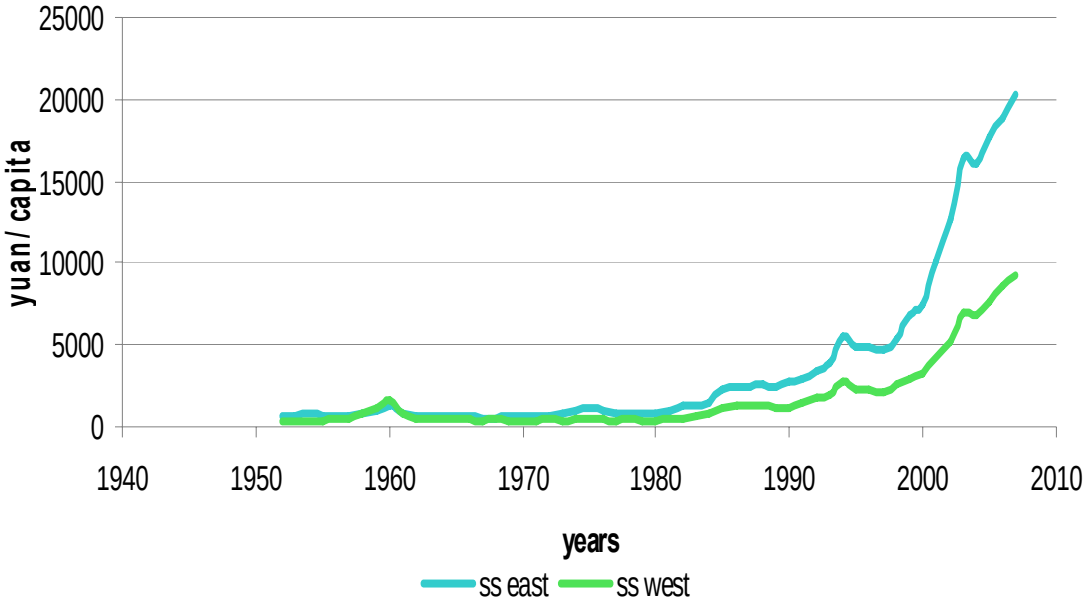

## 6.3. Steady State Convergence

Conditional convergence was found and we want to know if this will eventually lead to absolute convergence. Since the steady state level is a theoretical potential level for what GRP could be when the present amount of resources are utilised efficiently, the steady state GRP is affected at an earlier stage by changes in production inputs than real GRP. In reality there are time lags present that delay the effects of the changed circumstances for the real GRP. For example, if there is a high rate of investment it might take a while for the investments to pay off, thus the potential GRP is higher than the real GRP at the present date.

Evidence for steady state convergence was found, which implies that the GRP levels will eventually have the same steady state level. Since conditional convergence was found, real GRP will eventually converge. This, however, will take a long time since the correlation coefficients for initial steady state GRP and steady state growth rates are low.

A higher convergence rate was found among the western regions steady state levels than among the eastern, but since the results showed convergence among all the regions the western and eastern steady state levels will eventually converge. Diagram 6.5. illustrates the development of steady state levels among the eastern and western regions and as can be seen the western regions show a similar growth path as the eastern, but the western regions have begun growing at a later date than the eastern. If we assume that the Chinese regions cannot maintain a 13% growth rate infinitely, the growth rates would eventually level out and move along a balanced growth path (where growth is approximately the same as the technological growth). Since there is steady state convergence and the west and east show similar growth patterns (but with a time lag for the west) they will probably level out at a similar new steady state level.

**Diagram 6.6. Steady state**



# 7. Conclusion

The purpose of this study was to investigate if there are any results for convergence across the Chinese regions. In contrast to the results found by Barro and Sala-i-Martin in the US and Europe, the evidence for convergence in China seem to be weaker and, when found, at a lower convergence rate. The results for China showed absolute convergence during 1978-1999, and for western China during 1952-1978 as well, but not over the entire period, and not in the most recent period of investigation. Correlation could be seen between the political policies in the areas and during the times where convergence was present. Absolute convergence in China seems to have occurred when investment has been targeted in specific areas and diffused to bordering regions. Western China received investments during 1952-1978, but not enough to affect the whole economy. The reforms in 1978 affected the Chinese society thoroughly since it put China on a course towards a socialist market economy. The increasing investments made in China and the increasing foreign trade affected not only the eastern parts but also diffused to the western regions, but with less impact. This does not have to mean that the regions are not moving towards a common income level. Evidence of conditional convergence and steady state convergence were found, which indicates that the Chinese regions will eventually reach the same GRP levels. The inequalities between the regions will decrease in the long run.

China is in a transitional phase between a lower and a higher income level. Due to this it is hard to recognise what parts of the growth rate that is caused by a level shift and what is caused by convergence. Also, the high rate of increase in the steady state level complicates the regional convergence towards steady state.

The Chinese regions are still growing rapidly, even the richer ones. This could be caused by the fact that all regions still have growth potential left since the income level is below that of the developed countries. The Chinese society can still implement already existing technology and thus increase the efficiency in the economy. Efficiency has been increased through privatisations, but there are still state owned companies left that use the same production methods as during the command economy. China also has a large labour pool of workers in the rural areas that could be utilised in the urban areas more efficiently.

The restrictions on migration could also have had effects on the lack of income and technology equalising. Migration is a means of spreading labour to where it is demanded, and

ideas will be transferred as people migrate. The diffusion of technology is also hindered by the lower rate of openness and infrastructure in the western areas. Since the beginning of the "open up the west" reform investment in infrastructure has increased in the west, but it takes time before this shows effects on the real GRP. The rate of openness should also have increased since they joined the WTO. The increasing growth rate from 1999 could be an effect of the increasing effort to transfer technology.

The preferential treatment experienced by the western provinces since 1999 might have lacked in impact as the policies do not give the western regions an advantage in relation to the eastern, it only levels out the playing field.

The study has considered inequality between regions, but not within regions. It has not shown the development in equality in real monetary terms, but as a percentage growth rate. For future research other measure of inequality could be investigated, for example regional gini-coefficients. To check for the inequalities in real income one could also look at how the income gap between the poorest regions and the richest ones has developed over time.

In conclusion, the evidence for convergence has not been very strong. This does not have to have negative effects on the Chinese economy as the convergence theory might not be the best one when dealing with inequality in transitional economies. However, all regions in China are growing at a high rate, and the western regions show the same growth pattern as the eastern but with a time lag. This means that even though the regions are not converging the polarisation is not increasing. The rich are getting richer, but so are the poor.

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# APPENDIX 1

**Calculating the technological level, A.**

It is assumed that the United States of America is the most advanced country technologically and that the country is in its steady state. In order to calculate a value for A one needs to look at how much of the US GDP that cannot be attributed to the other factors in the production function with technological transfer. For the US the model with technological transfer might not be the most optimal model since it is better suited to explain growth in developing countries, but since this is the model used throughout the study it is used here as well to get a suitable value for A.

The value of A is calculated according to the formula:

$$A^* = \frac{y^*}{\left(\frac{s_K}{n+g+d}\right)^{\frac{\alpha}{1-\alpha}}\left(\frac{\mu}{g}e^{\psi\mu}\right)^{\frac{1}{\gamma}}}$$

Where the following set values have been used:

g= 0,02 ( =(US $GDP_{2007}$-US $GDP_{1952}$)^(1/55)-1)

d= 0,05

ψ= 0,1

μ= 0,2

γ= 0,5

α= 1/3

The remaining data have been gathered and calculated from Measuringworth, Penn World tables and Barro-Lee and gives the following values:

| Year | Technological level (A) | Year | Technological level (A) | Year | Technological level (A) |
|---|---|---|---|---|---|
| **1952** | 7,794 | **1971** | 7,813 | **1990** | 7,552 |
| **1953** | 7,842 | **1972** | 7,824 | **1991** | 7,798 |
| **1954** | 7,688 | **1973** | 7,902 | **1992** | 7,699 |
| **1955** | 7,576 | **1974** | 7,815 | **1993** | 7,618 |
| **1956** | 7,598 | **1975** | 8,284 | **1994** | 7,503 |
| **1957** | 7,754 | **1976** | 7,634 | **1995** | 7,515 |
| **1958** | 7,535 | **1977** | 7,045 | **1996** | 7,584 |
| **1959** | 7,547 | **1978** | 6,604 | **1997** | 7,63 |
| **1960** | 7,717 | **1979** | 6,187 | **1998** | 7,742 |
| **1961** | 7,527 | **1980** | 5,895 | **1999** | 7,886 |
| **1962** | 7,519 | **1981** | 5,92 | **2000** | 7,944 |
| **1963** | 7,433 | **1982** | 6,141 | **2001** | 8,108 |
| **1964** | 7,48 | **1983** | 6,338 | **2002** | 8,21 |
| **1965** | 7,408 | **1984** | 6,298 | **2003** | 8,249 |
| **1966** | 7,533 | **1985** | 6,691 | **2004** | 8,043 |
| **1967** | 7,696 | **1986** | 6,896 | **2005** | 8,392 |
| **1968** | 7,796 | **1987** | 6,989 | **2006** | 8,517 |
| **1969** | 7,699 | **1988** | 7,214 | **2007** | 8,565 |
| **1970** | 7,874 | **1989** | 7,287 | | |

# APPENDIX 2

**Calculating u**

Data over average years in school in China was available from Barro-Lee for the years 1974-2004. Looking at data from Ljunggren and the Ministry of Education in China the average for the remaining years was approximated.

To calculate the number of years in education for each province regional statistics was looked at (from chinadataonline) of school enrolment and the percentage of students entering secondary school after graduating from primary. By comparing each regions value with a calculated average and then multiplying the quota with the average years in school in China a regional average could be determined.

$$u_R = \frac{P_R}{P_C} \times \frac{S_R}{S_C} \times u_C \qquad \text{(equation A1)}$$

Where $u_R$ denotes the regional average years of education, P the percentage entering primary school, S the percentage entering secondary school. The index R denotes the regional value and the C the average value in China.

# APPENDIX 3

**Determining μ**

μ is a value used to measure the economy's ability to utilise the world technology. It takes on a value greater than 0 and its value is arbitrarily chosen to make the value of the technological level (also chosen at one's own discretion) fit in the production function, hence, A and μ together determine the level of technology that is used in the economy's production. In order to find an appropriate value for μ one must take into consideration how efficiently the economy can make use of the world technology. This depends on factors such as infrastructure, migration and openness.

In this study measures of openness have been used to approximate μ. The values of openness have been gathered from Penn World Tables where country level data is available. In Penn Word Tables openness has been calculated by dividing the value of imports and exports by the gross domestic product (GDP). To find regional values for openness the values of exports and imports per region in relation to GRP have been looked at and compared to the average value of the trade/GRP quota in China. This value has been multiplied by the Penn World Tables openness value in China to find regional values for openness. In order to get a value for openness that is comparable to the μ-value of the United States (set at 0,2) the Chinese openness index to has been adjusted to be proportional to that of the US, hence the formula used to calculate regional openness can be written as follows:

$$x_R = \left(\frac{P_{China}}{P_{USA}}\right)\mu_{USA}\left(\frac{R}{\left(\sum R\right)/N}\right)$$

Where $x_R$ = regional openness, P= value of openness from Penn World tables, R=the regional export+import/GRP value, N= number of regions in China and $\mu_{USA}$ is the value set for ability to utilise technology in the US used when calculating the world technological level (A).

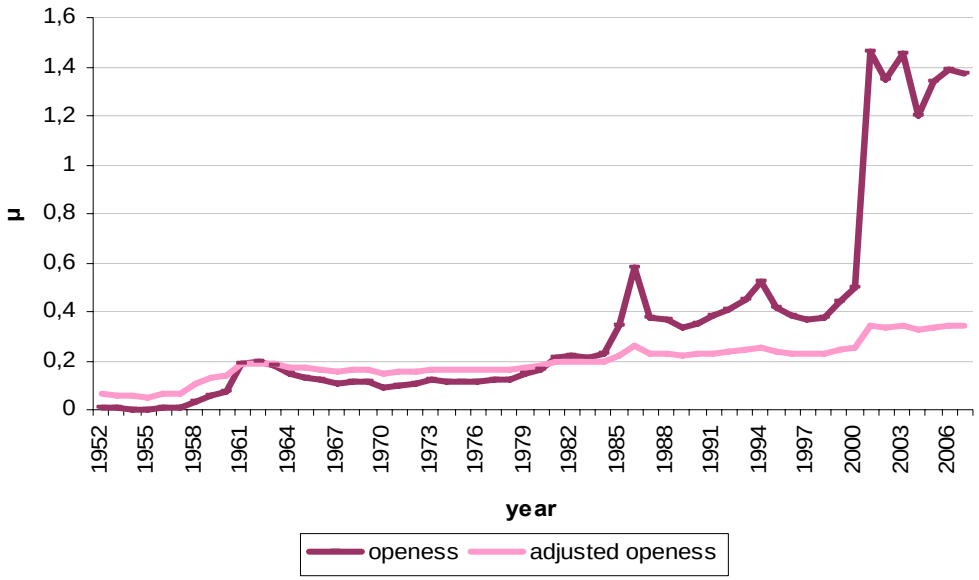
The values for openness calculated have been used as estimates of how prone the regions are in relation to each other to utilise existing technology. However, using the value for openness as an approximation for μ seems to be misleading as μ includes more variables. In order not to overestimate the importance of openness the value of openness has been used to indicate the

relative values of μ between the regions, but the scale has been adjusted so that the resulting steady state values become somewhat more realistic. The model used for adjusting openness to μ looks as follows:

$$\mu_R = (0{,}02\, x_R)^{0{,}3}$$

The results from this transformation is that the lower values for μ increase and the higher decrease. Multiplying by a constant is meant to adjust for the importance of openness when measuring μ. Raising openness to a constant smaller than 1 is meant to represent diminishing rates of return for openness in relation to technological utilisation. This seems realistic as there might have been an overrepresentation of openness in relation to technology transfer into China in recent years, as the economy's capacity to utilise new technology may have reached bottle necks in other areas (for example, the infrastructures ability to spread technology, or the richer the regions get there might not be such a big surplus of unutilised technology left so that increased openness has a substantial effect on the technology entering the economy). In line with the same reasoning it is also assumed that there is a risk of underestimating μ if only openness is considered during the command economy. Technology can diffuse into an economy by other means than trade. The diagram below shows the effect of the adjustment on the openness values for Beijing:

**Diagram A1. μ, Beijing**



# APPENDIX 4

### 1.3.1 Results for absolute convergence

| Period and area | Correlation-coefficient | p-value | $R^2$-value | Time to convergence between the poorest and richest region |
|---|---|---|---|---|
| **China 1952-2007** | **-0,00002254 (0,0000167)** | **0,188** | **0,0658** | |
| 1952-1978 | 0,00000552 (0,0000287) | 0,849 | 0,00142 | |
| 1978-1999 | -0,00001342 (0,00000707) | 0,0687*** | 0,122 | 312 |
| 1999-2007 | -0,00000205 (0,00000289) | 0,485 | 0,0190 | |
| **East 1952-2007** | **-0,00003330 (0,0000203)** | **0,121** | **0,143** | |
| 1952-1978 | 0,00003661 (0,0000305) | 0,247 | 0,0828 | |
| 1978-1999 | -0,00001893 (0,00000693) | 0,0148** | 0,318 | |
| 1999-2007 | -0,00000099 (0,00000285) | 0,734 | 0,00743 | |
| **West 1952-2007** | **-0,00004904 (0,0000289)** | **0,129** | **0,264** | |
| 1952-1978 | -0,00022955 (0,0000592) | 0,0047* | 0,653 | |
| 1978-1999 | -0,00009401 (0,0000445) | 0,0677*** | 0,358 | |
| 1999-2007 | 0,00002657 (0,0000348) | 0,5549 | 0,0680 | |

* significant at a 1% level
** significant at a 5% level
***significant at a 10% level

### 1.3.2 Results for conditional convergence

| Period and area | Correlation-coefficient | p-value | $R^2$-value | β-value | Years to half-life |
|---|---|---|---|---|---|
| **China 1952-2007** | **0,2372 (0,0130)** | **0,0000*** | **0,418** | **0,00492** | **140** |
| 1952-1978 | 0,0355 (0,0451) | 0,439 | -0,152 | 0,00139 | |
| 1978-1999 | 0,2477 (0,0120) | 0,0000* | 0,452 | 0,01355 | 51 |
| 1999-2007 | 0,3140 (0,0150) | 0,0000* | -0,1626 | 0,04711 | |
| **East 1952-2007** | **0,2539 (0,0169)** | **0,0000*** | **0,4673** | **0,00533** | **130** |
| 1952-1978 | -0,0357 (0,0531) | 0,5104 | -0,1361 | -0,00135 | |
| 1978-1999 | 0,2829 (0,0230) | 0,0000* | 0,5435 | 0,01584 | 44 |
| 1999-2007 | 0,3079 (0,0151) | 0,0000* | -0,03228 | 0,04600 | |
| **West 1952-2007** | **0,2037 (0,0162)** | **0,0000*** | **0,2317** | **0,004141** | **167** |
| 1952-1978 | -0,03503 (0,0873) | 0,6977 | -017997 | -0,001324 | |
| 1978-1999 | 0,1717 (0,0261) | 0,0001* | 0,3394 | 0,008970 | 77 |
| 1999-2007 | 0,3243 (0,0325) | 0,0000* | -0,3627 | 0,04900 | |

* significant at a 1% level
** significant at a 5% level
***significant at a 10% level

### 1.3.3 Results for steady state convergence

| Period and area | Correlation-coefficient | p-value | $R^2$-value | Time to convergence between the poorest and richest region |
|---|---|---|---|---|
| **China 1952-2007** | **-0,0000255 (0,00000562)** | **0.0031*** | **0.442** | **75** |

| | | | | |
|---|---|---|---|---|
| 1952-1978 | -0,0000402 (0,000012) | 0.0204* | 0.302 | 58 |
| 1978-1999 | -0,0000222 (0,0000222) | 0.0412** | 0.151 | 64 |
| 1999-2007 | -0,00000446 (0,0000124) | 0.0013* | 0.333 | 54 |
| **East 1952-2007** | **-0,0000199 (0,00000628)** | **0.0060*** | **0.385** | **63** |
| 1952-1978 | -0,0000202 (0,0000202) | 0.1307 | 0.137 | |
| 1978-1999 | -0,0000214 (0,0000116) | 0.0834*** | 0.176 | 64 |
| 1999-2007 | -0,00000535 (0,00000126) | 0.0006* | 0.530 | 21 |
| **West 1952-2007** | **-0,0000395 (0,0000131)** | **0.0164**** | **0.534** | **61** |
| 1952-1978 | -0,0000833 (0,0000228) | 0.0064* | 0.627 | 106 |
| 1978-1999 | -0,0000879 (0,0000244) | 0.0069* | 0.619 | 30 |
| 1999-2007 | -0,0000170 (0,00000836) | 0.0764*** | 0.341 | 22 |

* significant at a 1% level
** significant at a 5% level
***significant at a 10% level

The residuals have been tested in all regressions to test for the accuracy of the results (if the estimator is the best linear unbiased estimate, BLUE). In two cases (absolute convergence China 1999-2007 and conditional convergence China 1999-2007) it was found, using a Jarque-Berra test, that the residuals were not normally distributed, hence inference based on the results are not reliable (Westerlund 2005: 134). In two cases (absolute convergence west 1999-2007 and steady state convergence China 1952-1978) heteroscedasticity was found using a White's test. This means that the estimators are no longer the most efficient since they don't have the lowest variance (Westerlund 2005: 96). The heteroscedasticity has been adjusted for by using White's variance-covariance matrix to get valid interference.

# APPENDIX 5

**The Chinese provinces included in the study:**

**East**

| Name (pinyin) | Chinese name[3] | Status |
|---|---|---|
| Anhui | 安徽 | Province |
| Beijing | 北京 | Municipality |
| Fujian | 福建 | Province |
| Guangdong | 广东 | Province |
| Hebei | 河北 | Province |
| Heilongjiang | 黑龙江 | Province |
| Henan | 河南 | Province |
| Hubei | 湖北 | Province |
| Hunan | 湖南 | Province |
| Jiangsu | 江苏 | Province |
| Jiangxi | 江西 | Province |
| Jilin | 吉林 | Province |
| Liaoning | 辽宁 | Province |
| Shandong | 山东 | Province |
| Shanghai | 上海 | Municipality |
| Shanxi | 山西 | Province |
| Tianjin | 天津 | Municipality |
| Zhejiang | 浙江 | Province |

**West**

| Name (pinyin) | Chinese name | Status |
|---|---|---|
| Gansu | 甘肃 | Province |
| Guangxi | 广西 | Autonomous Region |
| Guizhou | 贵州 | Province |
| Neimenggu (Inner Mongolia) | 内蒙古 | Autonomous Region |
| Ningxia | 宁夏 | Autonomous Region |
| Qinghai | 青海 | Province |
| Shaanxi | 陕西 | Province |
| Sichuan | 四川 | Province |
| Xinjiang | 新疆 | Autonomous Region |
| Yunnan | 云南 | Province |

[3] Source: Kjellgren 2000


Heilongjiang
Jilin
Liaoning
BEIJING
Tianjin
Hebei
Inner Mongolia
Xinjiang
Gansu
Ningxia
Shanxi
Shandong
Qinghai
Henan
Jiangsu
Shaanxi
Shanghai
Tibet
Anhui
Hubei
Sichuan
Zhejiang
Jiangxi
Hunan
Guizhou
Fujian
Yunnan
Guangxi
Taiwan
Guangdong
Hainan

# APPENDIX 6

| Regional GRP (1978 price level) | | | | |
|---|---|---|---|---|
| **Region** | **1952** | **1978** | **1999** | **2007** |
| ***East*** | | | | |
| Beijing | 193 | 1290 | 4215 | 13107 |
| Tianjin | 331 | 1160 | 4592 | 13776 |
| Shanghai | 460 | 2498 | 7625 | 17188 |
| Hebei | 123 | 364 | 2020 | 5344 |
| Shanxi | 120 | 365 | 1312 | 4536 |
| Liaoning | 275 | 680 | 2741 | 6879 |
| Jilin | 204 | 381 | 1673 | 4739 |
| Heilongjiang | 306 | 564 | 1877 | 4246 |
| Jiangsu | 150 | 430 | 2781 | 8688 |
| Zhejiang | 114 | 331 | 2894 | 8691 |
| Anhui | 78 | 244 | 1324 | 3173 |
| Fujian | 121 | 273 | 2684 | 6299 |
| Jiangxi | 125 | 276 | 1256 | 3201 |
| Shandong | 102 | 316 | 2725 | 8304 |
| Henan | 103 | 232 | 1619 | 4735 |
| Hubei | 111 | 332 | 1719 | 4009 |
| Hunan | 112 | 286 | 1163 | 3003 |
| Guangdong | 112 | 369 | 2810 | 7439 |
| ***West*** | | | | |
| Guangxi | 75 | 225 | 991 | 2867 |
| Xinjiang | 154 | 313 | 1598 | 4007 |
| Ningxia | 147 | 370 | 1174 | 3690 |
| Qinghai | 78 | 428 | 1119 | 3093 |
| Gansu | 122 | 348 | 1002 | 2681 |
| Shaanxi | 98 | 291 | 1023 | 3442 |
| Yunnan | 64 | 226 | 1150 | 2622 |
| Guizhou | 76 | 175 | 639 | 1708 |
| Sichuan | 66 | 262 | 1102 | 2915 |
| Inner Mongolia | 231 | 317 | 1469 | 6510 |

| Average GRP | | | | |
|---|---|---|---|---|
| | **1952** | **1978** | **1999** | **2007** |
| **China** | 152 | 477 | 2082 | 5746 |
| **East** | 174 | 577 | 2613 | 7075 |
| **West** | 111 | 296 | 1127 | 3354 |

# APPENDIX 7

| Regional Growth Rates | | | | |
|---|---|---|---|---|
| **Region** | **1952-2007** | **1952-1978** | **1978-1999** | **1999-2007** |
| ***East*** | | | | |
| Beijing | 0,0797 | 0,0758 | 0,0580 | 0,1524 |
| Tianjin | 0,0701 | 0,0494 | 0,0677 | 0,1472 |
| Shanghai | 0,0681 | 0,0673 | 0,0546 | 0,1069 |
| Hebei | 0,0709 | 0,0425 | 0,0850 | 0,1293 |
| Shanxi | 0,0683 | 0,0437 | 0,0628 | 0,1678 |
| Liaoning | 0,0603 | 0,0355 | 0,0686 | 0,1219 |
| Jilin | 0,0589 | 0,0243 | 0,0730 | 0,1390 |
| Heilongjiang | 0,0490 | 0,0238 | 0,0589 | 0,1074 |
| Jiangsu | 0,0765 | 0,0412 | 0,0930 | 0,1530 |
| Zhejiang | 0,0820 | 0,0418 | 0,1088 | 0,1473 |
| Anhui | 0,0697 | 0,0449 | 0,0839 | 0,1155 |
| Fujian | 0,0746 | 0,0319 | 0,1150 | 0,1125 |
| Jiangxi | 0,0607 | 0,0308 | 0,0748 | 0,1241 |
| Shandong | 0,0834 | 0,0446 | 0,1080 | 0,1494 |
| Henan | 0,0721 | 0,0317 | 0,0969 | 0,1436 |
| Hubei | 0,0675 | 0,0432 | 0,0814 | 0,1117 |
| Hunan | 0,0616 | 0,0367 | 0,0691 | 0,1259 |
| Guangdong | 0,0793 | 0,0470 | 0,1015 | 0,1294 |
| ***West*** | | | | |
| Guangxi | 0,0684 | 0,0430 | 0,0731 | 0,1420 |
| Xinjiang | 0,0611 | 0,0277 | 0,0807 | 0,1218 |
| Ningxia | 0,0604 | 0,0363 | 0,0565 | 0,1539 |
| Qinghai | 0,0692 | 0,0676 | 0,0468 | 0,1356 |
| Gansu | 0,0578 | 0,0411 | 0,0516 | 0,1309 |
| Shaanxi | 0,0669 | 0,0428 | 0,0617 | 0,1637 |
| Yunnan | 0,0698 | 0,0497 | 0,0805 | 0,1085 |
| Guizhou | 0,0583 | 0,0328 | 0,0636 | 0,1308 |
| Sichuan | 0,0713 | 0,0545 | 0,0708 | 0,1293 |
| Inner Mongolia | 0,0626 | 0,0123 | 0,0758 | 0,2045 |

| | Average regional growth rates | | | |
|---|---|---|---|---|
| | **1952-2007** | **1951-78** | **1978-99** | **1999-2007** |
| **China** | 0,0678 | 0,0416 | 0,0758 | 0,1359 |
| **East** | 0,0696 | 0,0420 | 0,0812 | 0,1325 |
| **West** | 0,0646 | 0,0408 | 0,0661 | 0,1421 |

# APPENDIX 8

| Regional Steady State GRP (1978 price level) | | | | |
|---|---|---|---|---|
| **Region** | **1952** | **1978** | **1999** | **2007** |
| ***East*** | | | | |
| Beijing | 151 | 1002 | 10569 | 39097 |
| Tianjin | 2647 | 2466 | 12803 | 39984 |
| Shanghai | 961 | 1603 | 17378 | 38539 |
| Hebei | 291 | 669 | 3806 | 9806 |
| Shanxi | 192 | 129 | 2927 | 10379 |
| Liaoning | 1414 | 1195 | 6345 | 22252 |
| Jilin | 357 | 331 | 3910 | 12121 |
| Heilongjiang | 812 | 196 | 2501 | 10393 |
| Jiangsu | 187 | 610 | 10105 | 34888 |
| Zhejiang | 73 | 336 | 7934 | 25111 |
| Anhui | 157 | 86 | 2761 | 13611 |
| Fujian | 660 | 1408 | 8794 | 22540 |
| Jiangxi | 310 | 277 | 2145 | 10398 |
| Shandong | 408 | 1323 | 7610 | 24536 |
| Henan | 101 | 359 | 1698 | 6466 |
| Hubei | 1113 | 574 | 2574 | 9811 |
| Hunan | 553 | 435 | 2214 | 6918 |
| Guangdong | 652 | 1400 | 17988 | 29513 |
| ***West*** | | | | |
| Guangxi | 190 | 805 | 2877 | 8228 |
| Xinjiang | 1609 | 463 | 4705 | 15243 |
| Ningxia | 340 | 979 | 4969 | 10800 |
| Qinghai | 107 | 546 | 2143 | 6283 |
| Gansu | 42 | 286 | 1992 | 10004 |
| Shaanxi | 132 | 174 | 2414 | 8345 |
| Yunnan | 46 | 591 | 2753 | 9476 |
| Guizhou | 20 | 259 | 1930 | 5903 |
| Sichuan | 13 | 126 | 2625 | 9180 |
| Inner Mongolia | 329 | 253 | 3502 | 9488 |

| Average Steady State GRP | | | | |
|---|---|---|---|---|
| | **1952** | **1978** | **1999** | **2007** |
| **China** | 495 | 674 | 5499 | 16404 |
| **East** | 613 | 800 | 6892 | 20353 |
| **West** | 283 | 448 | 2991 | 9295 |

# APPENDIX 9

| Regional Steady State Growth Rates | | | | |
|---|---|---|---|---|
| **Region** | **1952-2007** | **1952-1978** | **1978-1999** | **1999-2007** |
| ***East*** | | | | |
| Beijing | 0,1064 | 0,0756 | 0,1187 | 0,1776 |
| Tianjin | 0,0506 | -0,0027 | 0,0816 | 0,1530 |
| Shanghai | 0,0694 | 0,0199 | 0,1202 | 0,1047 |
| Hebei | 0,0660 | 0,0325 | 0,0863 | 0,1256 |
| Shanxi | 0,0753 | -0,0150 | 0,1601 | 0,1714 |
| Liaoning | 0,0514 | -0,0064 | 0,0827 | 0,1698 |
| Jilin | 0,0662 | -0,0028 | 0,1247 | 0,1519 |
| Heilongjiang | 0,0474 | -0,0532 | 0,1288 | 0,1949 |
| Jiangsu | 0,0997 | 0,0465 | 0,1430 | 0,1675 |
| Zhejiang | 0,1120 | 0,0604 | 0,1624 | 0,1549 |
| Anhui | 0,0845 | -0,0231 | 0,1798 | 0,2207 |
| Fujian | 0,0663 | 0,0296 | 0,0912 | 0,1249 |
| Jiangxi | 0,0660 | -0,0043 | 0,1024 | 0,2181 |
| Shandong | 0,0773 | 0,0463 | 0,0869 | 0,1576 |
| Henan | 0,0785 | 0,0499 | 0,0767 | 0,1820 |
| Hubei | 0,0404 | -0,0252 | 0,0741 | 0,1821 |
| Hunan | 0,0470 | -0,0092 | 0,0806 | 0,1530 |
| Guangdong | 0,0718 | 0,0298 | 0,1293 | 0,0638 |
| ***West*** | | | | |
| Guangxi | 0,0710 | 0,0572 | 0,0625 | 0,1404 |
| Xinjiang | 0,0417 | -0,0467 | 0,1167 | 0,1583 |
| Ningxia | 0,0649 | 0,0415 | 0,0804 | 0,1019 |
| Qinghai | 0,0768 | 0,0646 | 0,0673 | 0,1439 |
| Gansu | 0,1046 | 0,0765 | 0,0969 | 0,2235 |
| Shaanxi | 0,0783 | 0,0108 | 0,1333 | 0,1677 |
| Yunnan | 0,1019 | 0,1036 | 0,0760 | 0,1671 |
| Guizhou | 0,1088 | 0,1034 | 0,1003 | 0,1500 |
| Sichuan | 0,1273 | 0,0928 | 0,1554 | 0,1694 |
| Inner Mongolia | 0,0630 | -0,0100 | 0,1332 | 0,1327 |

| | Average Steady State Growth Rates | | | |
|---|---|---|---|---|
| | **1952-2007** | **1951-78** | **1978-99** | **1999-2007** |
| **China** | 0,0755 | 0,0265 | 0,1090 | 0,1582 |
| **East** | 0,0709 | 0,0138 | 0,1128 | 0,1596 |
| **West** | 0,0838 | 0,0494 | 0,1022 | 0,1555 |