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Master's thesis

Convergence in GDP Growth Rates across the Provinces of China

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Abstract

Economic theory predicts that poorer economies will catch up with richer ones through the process of convergence. The aim of this Master's thesis is to establish if convergence in GDP growth rates exists across the provinces of China.

After performing a steady state analysis of the provinces' level of GDP per capita a regression analysis is carried out in order to establish if conditional convergence exists across the 31 provinces of Mainland China during the period 1985-2004. Based on the growth model with technology transfer we distinguish eleven variables explaining the variation in growth rate of GDP per capita. The variables are: initial GDP per capita, investments as share of GDP, population growth, productivity in the agricultural sector, school enrolment in higher and primary education, foreign direct investments, patents granted, infrastructure related to population and area of the province and a preferential policy index.

In our optimal model initial GDP per capita, investments as share of GDP, population growth, patents granted and the preferential policy index are found significant. The parameter for initial GDP is -0.0000106 implying conditional convergence. Even though the catching up process is slow the conclusion is that convergence in GDP growth rates exists across the provinces of China for the period 1985-2004.

Key words: China, conditional convergence, growth, steady state, technology transfer

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Abbreviations

AIC – Akaike Info Criterion

BA – Border Areas

BECZ – Border Economic Cooperation Zones

CC – Capital Cities of inland provinces and autonomous regions

COC – Coastal Open Cities

COEZ – Coastal Open Economic Zones

DW – Durbin-Watson Statistic

ETDZ – Economic and Technological Development Zones

FDI – Foreign Direct Investments

GDP – Gross Domestic Product

MC – Major Cities along the Yangtze River

NBSC – National Bureau of Statistics of China

OCB – Open Coastal Belt

OLS – Ordinary Least Square

RMB – Renminbi, the Chinese currency

R&D – Research and Development

SC – Schwartz Criterion

SEZ – Special Economic Zones

WTO – World Trade Organization

1 Introduction

China has enjoyed remarkable economic development since reforms of the economy were initiated in 1978. The economy has expanded, GDP growth accelerated, standards of living improved, and China has become an economic power on the global market. A scholarship from SIDA, the Swedish International Development Cooperation Agency, made it possible for us to spend ten weeks at the School of Economics at Fudan University in Shanghai and truly be at the heart of economic development. In our daily life we experienced the improved living conditions, increased opportunities and choices for the Chinese people. However, the economic development has been uneven across the country and most Chinese have not been able to fully enjoy the benefits of the flourishing economy. The differences within the country are large; highly developed provinces along the east coast and poor, underdeveloped, rural provinces in the west. Will the growth and prosperity in the east spread to the west and equalize the disparities? Will the poorer provinces ever catch up with the most developed ones, or will the gap between them widen? This master's thesis will explore the provincial differences and the provinces' economic development in relation to each other.

1.1 Research Question and Purpose

If the gap between rich and poor provinces remains or is widened, it could jeopardize sustained high economic growth in China. Economic differences and lack of opportunities could trigger social unrest and threaten social stability, which in turn could be devastating for the economy as a whole. Hence, economic and technological development in the poorer provinces is essential for future economic progress for China. Economic theory predicts that poorer economies will catch up with the richer ones through the process of convergence. The aim of this thesis is to establish if this is true for the Chinese provinces. Thus, our research question is: *Does convergence in GDP growth rates exist across the provinces of China?*

Our purpose is not to explain the high economic growth in China over the last decades. Furthermore, the main purpose is not to bring forward explanations for economic growth, and differences in growth rates between provinces, but to get the most accurate estimation of possible convergence in GDP growth rates across the Chinese provinces.

1.2 Definitions and Delimitations

China consists of 23 provinces, five autonomous regions and four municipalities (Nationalencyklopedin 2005). Chinese authorities consider Taiwan as its 23rd province, but since we will limit our study to Mainland China we choose to exclude Taiwan. For the same reason the special administrative regions Hong Kong and Macau are not included in our study. The five autonomous regions are Guangxi, Inner Mongolia, Ningxia, Xinjiang, and Tibet. They have a designated ethnic minority and enjoy more rights under the constitution than the provinces, but in reality the influence from central government is strong.

The four municipalities are large cities with the same status as provinces; they are Beijing, Chongqing, Shanghai, and Tianjin. Chongqing gained municipality status during the time period of our study, thus the data series for the province is not complete in the national statistical yearbooks. However, the provincial yearbooks present statistics even from the time when Chongqing was part of Sichuan province. This makes it possible for us to treat Chongqing as an individual province for the whole time period. The island of Hainan was part of the Guangdong province until 1988. There are only three years missing in the times series in the national yearbooks and this data is found in the yearbooks published at provincial level. Hence, our study will include 31 administrative divisions, which will all be referred to as provinces in the rest of the thesis.

1.3 Disposition

The thesis will be organised as follows; the method for fulfilling our aim and answering the research question is presented in chapter two. Methodological problems and solutions to them are put forward and discussed. Chapter three gives the reader a brief overview of the Chinese reforms, the provincial differences, and previous relevant empirical studies in the field. Chapter four lays out the theoretical framework based on neoclassical growth theory and the next chapter presents our data set. General considerations concerning the accuracy of the Chinese statistics are discussed and the variables included in the regression are introduced. The two-step analysis is carried out and the results are presented in chapter six. Finally, we discuss our findings in the concluding chapter.

2 Method

In this chapter, we introduce the method of our thesis. We describe the initial research process leading up to our two-step analysis. The nature of these two stages is explained more detailed and the model for our regression is presented. Finally, methodological problems concerning the statistical method of regression analysis and solutions to them are put forward.

2.1 Research Description

Our thesis is an empirical case study of the People's Republic of China, with a comparative angle since the differences between the provincial economies form the basis of the study. China began opening up and reforming the economy in 1978 and in our view the economic consequences of these reforms will not be visible immediately in the statistics due to the gradual nature of the reforms. Thus, we use data covering the period 1985-2004 for 31 provinces of Mainland China.

When studying the development of the post-reform Chinese economy huge differences between the provinces are encountered. China has experienced remarkable economic growth during the last decades, however all provinces have not benefited from it to the same extent. Being such a large and populous country enables us to apply economic growth theory, otherwise used for cross-country studies, for a cross-provincial study of China. Our theoretical framework is based on neoclassical and new growth theory and the data used is compiled by The National Bureau of Statistics of China (NBSC) and by each province's Bureau of Statistics, published by China Statistical Press. The statistics were compiled at the School of Economics at Fudan University in Shanghai, China. A deeper discussion about the data and problems associated with it is carried out in Chapter 5.

2.2 Two-step Analysis

The concept of convergence in GDP growth rates across the Chinese regions has been subject to previous studies. After a brief review of this research, we will extend the previous works in the field by including additional variables and prolonging the time span to year 2004. In this way we hope to contribute to the insight of China's economic future.

Our analysis is carried out in two stages; first, we calculate the steady state level of GDP per capita for each province in order to determine whether the provinces have different steady state levels of GDP and asses the relationship between the provinces' actual real GDP levels and their steady state GDP levels. This is done by using the new growth model with technology transfer. We do this in order to determine which provinces are the furthest away from their steady state level of GDP, and thus according to the concept of conditional convergence are expected to have the highest growth rates. Secondly, we perform a regression analysis to verify if the provinces are converging in GDP growth rates. Are the poorer provinces growing faster and catching up with the richer ones? We describe this second stage of our analysis further in the following section.

2.3 Regression

In line with Barro and Sala-i-Martin (1991, 1992 and 1995) the linear relationship we will examine in a regression analysis is:

$$\begin{aligned} gdp = \alpha + \beta_1 \cdot initial + \beta_2 \cdot inv + \beta_3 \cdot pop + \beta_4 \cdot agri + \beta_5 \cdot eduh + \beta_6 \cdot edup \\ + \beta_7 \cdot fdi + \beta_8 \cdot patent + \beta_9 \cdot Infra\_pop + \beta_{10} \cdot Infra\_km \\ + \beta_{11} \cdot d1 + \beta_{12} \cdot d2 + \beta_{13} \cdot d3 + \beta_{14} \cdot d90 + \beta_{15} \cdot d95 + \beta_{16} \cdot d00 + \varepsilon \end{aligned} \tag{1}$$

Our model contains variables assumed to explain the variation in the dependent variable, growth rate in real GDP per capita for each province (*gdp*). The explanatory variables are initial GDP per capita (*initial*), investments (*inv*), population growth (*pop*), productivity in the agricultural sector (*agri*), school enrolment in higher and primary education (*eduh* resp *edup*), foreign direct investments (*fdi*), patents granted (*patent*), infrastructure related to population and area of the province (*infra_pop* and *infra_km*), dummy variables for the preferential policy index (*d1*, *d2*, and *d3*), and dummy variables for each time period (*d90*, *d95*, and *d00*). The parameter α denotes a constant and ε is the residuals. The study is based on panel data, where the data set is grouped into five-year periods and each observation represents the average value for the respective time period. A more detailed description of each and every one of the variables can be found in Chapter 5[1].

In order to get the constant α and the β-parameters we estimate the regression with Ordinary Least Square-estimators (OLS) using the statistical program EViews 3.1. If necessary, the original model will be refined by excluding insignificant variables using a 10 percent level of significance. Our analyses of all estimations follow the same pattern, beginning with measuring the goodness of the fit of the models. The goodness of the fit can be measured with the R^2-value. If $R^2 = 1$ the variables included in the model explain the variation in the dependent variable perfectly, if $R^2 = 0$ the variation is not explained by the model at all. The value of R^2 increases with the inclusion of additional variables; hence by including an infinite number of variables the goodness of the fit can be brought to 1 even though the variables are not statistically significant (Hill et al 2001 p.163). Therefore, it is better to look at the adjusted R^2-value where the most extreme observations in the model are cut out. It is a better measure of the goodness of fit since it either increases or decreases when including an additional variable. Two other goodness of fit measures are Akaike info criterion (AIC) and Schwartz criterion (SC). The lower the two measures are the better is the fit of the model and in contrast to the R^2-value the criteria are "punished" when further variables are included (Hill et al 2001 p.326). We will consider all the above goodness of fit measures in order to determine the optimal model.

To rule out the presence of autocorrelation, when an error in one time period continues to affect the variables in the following period, we study the Durbin-Watson statistic (DW) derived from the EViews estimation. A DW-value around 2 means no autocorrelation in the model (Hill et al 2001 p.273). When variables in the model have different variances heteroskedasticity occurs. In that case the OLS-estimators are no longer the most effective ones and thus not resulting in the best fitted regression line. To avoid this inefficiency, White's robust estimator can be used since it is unaffected by heteroskedasticity (Hill et al 2001 p. 240). When White's robust estimator and the OLS-estimator give the same result, no heteroskedasticity exists in the model.

Other problems that can arise in regression analysis are collinearity and multicollinearity; when variables in the model to varying extent are dependent on each other (Hill et al 2001 p.189). If perfect collinearity exists, it is impossible to carry out the estimation

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[1] Detailed descriptions of the calculation and definitions of each variable can be found in Appendix 1.

of the regression, however this phenomena is easy to detect. Multicollinearity is harder to discover and when it occurs the amount of data explaining the behaviour of the dependent variable becomes small, making the interpretation of the estimation complicated. In order to detect and avoid collinearity, we create a correlation matrix for the explanatory variables and study the correlation coefficients. A coefficient between two variables greater than 0.8 means a strong linear relationship exists and one of these variables is excluded from the model (Hill et al 2001 p.190). However, collinear relationships involving more than two variables may not be discovered using this method. Auxiliary regressions, OLS-regressions where one explanatory variable is made the dependent one, can find these types of collinear relationships. If the explanatory variables explain a large part of the variation in the new dependent variable, an R^2-value higher than 0.8, this variable should be excluded from the model.

After examining the estimations in this manner, we will choose the best model naming it “the optimal model”. This model will be the basis for determining if the Chinese provinces are converging in GDP growth rates.

3 Background

We will in this chapter give the reader a brief overview of the characteristics of economic reforms in China. We present China's provinces and some basic economic indicators in order to introduce the reader to the provincial disparities within the country. We also give a short review of previous empirical studies on regional convergence within countries in general and China in particular.

3.1 Economic Reforms in China

In 1978 China embarked on a path of reforms to transform the centrally planned economy into a more market oriented system. However, the government did not have a clear plan, instead reforms were partial and often experimental (Lin et al 1996, p 201). In contrast to "shock-therapy" reforms the approach was "bottom-up" and gradual, something that left room for structural adjustments to changes; not all institutions and sectors in the economy were changed in the same way or at the same pace. An advantage with this approach is that reforms can be designed for a sector's unique settings. Some reforms that started out as local grass root experiments were, after proven successful, recognized by the central government and introduced for the entire country. The decollectivization of the agricultural sector is a perfect example; it started secretly in Anhui province in 1978 with a small number of production teams introducing a system of contracting land and resources to individual households, a measure soon blessed by local authorities (Lin 1988 p.201). The success of the system, it being far more productive than the old, was recognised by the central government and spread rapidly across China as the *household responsibility system*.

In many cases the central government delegated reform policies to local governments in order to benefit from better information about local conditions. The introduction of the dual price system is one example; planned prices existed alongside market prices and decisions about them were left largely to local authorities (Montinola et al 1996 p.62). To ensure the commitments of local governments to reforms, a system of fiscal federalism was introduced. It is important to realise that this type of federalism is not associated with political freedom and democratization like the western definition of federalism; instead it depends on the relationships among levels of governments (Montinola et al 1996 p.60-61). Authority was decentralized in a clear hierarchical way and the power structure was maintained through a system of fiscal revenue sharing. This meant that the local governments did no longer have to transfer the entire province's income to the central government; the profits retained were used at their own discretion (Montinola et al 1996 p.64). A system of extra budgetary funds was introduced; incomes of which were wholly retained by the local governments. The fiscal revenue system hardened budget constraints since the local governments also were responsible for the provinces' possible losses.

Along with the provinces' increased assets came increased responsibility for the provision of public goods. Powerful fiscal incentives for the local governments to promote economic growth within their jurisdiction were created by the transfer of both resources and obligation to lower levels of governments. As budget constraints were hardened increased revenues and employment became priorities of local politicians. The increased fiscal authority of local governments induced competition between jurisdictions in order to create the most favourable environment for economic growth and prosperity (Montinola et al 1996 p.73). The effect was a multitude of experiments with different reform policies across provinces. This resulted in widespread coping and imitating; bad strategies were discarded in favour of policies proven more successful in other provinces. Due to bad policy choices and some local governments' hostility towards reforms and liberalizations some provinces lagged behind the others.

The *Open-door policy* was initiated to open up parts of China and to attract foreign investors (Wang and Hu 1999 p.177). It was introduced with the establishment of four *special economic zones* (SEZs) in 1980; Shenzhen, Zhuhai, Shantou in Guangdong province and Xiamen in Fujian province. Theses areas were strategically situated close to Hong Kong and Taiwan respectively; enabling the inflow of FDI to Mainland China. The SEZs were followed in 1984 by the establishment of fourteen *costal open cities* (COCs), including all major ports along the Chinese coast. These areas enjoyed the authority to grant tax reduction for foreign investors, approve large scale investment projects, and retain a higher proportion of earned foreign exchange (Wang and Hu 1999 p. 178). The coastal areas could thus offer a better environment for potential investors than the inland provinces could. Along with the natural and historical advantages of the coast, the central government's policies ensured that most of China's foreign investments were placed here. This can be seen as proof of central government favouring the costal provinces during the entire reform period; further inducing regional disparities (Wang and Hu 1999 p. 174-175). Following China's accession to the World Trade Organization (WTO) preferential policies have expanded to include cities in all provinces, making it easier for FDI to reach the whole country.

3.2 The Provinces of China Today

Due to China's large size there are great geographical differences between the provinces. The most western parts of the country are sparsely populated rural areas, distanced from the highly developed more urbanized costal provinces. The early preferential treatment of the costal provinces has given them advantages in levels of FDI, technology and human capital due to further gone market liberalization. These characteristics can be seen in Table 3.1, showing basic indicators for China's provinces. It is easy to spot that GDP levels are higher; in fact 55 percent of the sum of all provinces' GDP per capita in 2004 is accumulated in the provinces along the east coast. Most foreign capital is invested in these provinces; more than 81 percent of total FDIs to China. School enrolment rates in institutions of higher education as share of provincial population indicates the level of human capital and in this case the inland provinces are lagging behind as well. The backwardness in these provinces is something the central government is trying to change with the recent campaign to *Open up the West* (Goodman 2004). This major project of nation-building was initiated in 2000 and aims at encouraging endogenous economic growth, reduce inequalities and ensure social and political stability in interior provinces.

Table 3.1: Basic Economic Indicators Reflecting the Diversity between the Provinces of China, 2004.

Province	Population Density (person/km^2)	GDP per capita (RMB)[2]	Foreign Direct Investment** (% of national total)	School Enrolment in Higher Education (% of population)
Beijing	878.2	8251	3.90	3.35
Tianjin*	906.2	8235	2.73	2.79
Hebei*	362.2	3704	1.96	1.02
Shanxi	213.8	2624	0.38	1.04
Inner Mongolia	19.9	3272	0.16	0.83
Liaoning*	288.8	4687	5.03	1.38
Jilin*	144.9	3141	0.34	1.34
Heilongjiang*	81.4	3996	0.57	1.22
Shanghai*	2809.7	12300	9.74	2.39
Jiangsu*	721.7	5960	18.82	1.34
Zhejiang*	462.7	6851	8.87	1.21
Anhui	464.8	2142	0.65	0.78
Fujian*	285.4	4958	4.63	0.93
Jiangxi	253.5	2347	2.87	1.14
Shandong*	600.0	4853	10.72	1.03
Henan	581.9	2609	0.96	0.72
Hubei	323.4	3017	3.20	1.48
Hunan	319.0	2410	1.81	0.95
Guangdong*	466.5	5555	17.98	0.88
Guangxi	207.2	1953	0.75	0.57
Hainan	233.7	2705	0.75	0.71
Chongqing	380.7	2455	0.47	0.91
Sichuan	159.8	2161	0.73	0.73
Guizhou	221.8	1173	0.08	0.46
Yunnan	112.1	1928	0.15	0.49
Tibet	2.3	2220	0.00	0.54
Shaanxi	179.9	2238	0.59	1.58
Gansu	57.7	1712	0.04	0.76
Qinghai	7.5	1951	0.04	0.55
Ningxia	89.1	2252	0.03	0.70
Xinjiang	12.3	3223	0.03	0.83

Source: Compiled and calculated with statistics from National Bureau of Statistics of China 2005.

* Provinces along the east coast.

** Data is for 2003, compiled and calculated with statistics from National Bureau of Statistics of China 2004

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[2] Renminbi (RMB) is the official name of the Chinese currency, however Yuan is used. in daily life.

3.3 Review of Empirical Studies

A large number of studies have been made on the concept of convergence across countries of the world, as well as within individual countries. Absolute convergence is the prediction that a poor economy will grow faster than a rich one. Conditional convergence is the concept that an economy far away from its steady state level of GDP per capita will grow faster than an economy closer to its steady state.[3]

Since there are large difference between the countries of the world considering technology, preferences and institutions, it is not possible to find empirical evidence of absolute convergence in the whole world. There are differences between regions within a country as well but as Barro and Sala-i-Martin point out these differences are probably smaller than across countries (1995, p.382). They suggest that absolute convergence is more likely to appear across regions within a country, since they share a central government and thus have similar institutions, than across countries.

There is a broad literature on studies of convergence within states. Important work has been done by Barro and Sala-i-Martin (1991, 1992 and 1995). They investigate convergence across regions within the US and Japan. They have also done an extensive study on convergence across regions of eight European countries. In their studies they find evidence of β-convergence[4] consistent with neoclassical growth models (Barro and Sala-i-Martin 1995, p.413). Since the convergence applies when no explanatory variable other than the initial level of GDP per capita is held constant, it is absolute; poor regions grow faster than rich ones. Barro and Sala-i-Martin also find a striking similarity of the speed of β-convergence across the regions. Estimates of β are found to be around 2-3 percent per year, implying that it will take 25-35 years to eliminate one-half of the initial gap in per capita income. Convergence studies have been made in several other countries, e.g. Canada, Australia, India, Germany, Sweden and Austria (Sala-i-Martin 1996 p.1034). They all come to similar conclusions; there is regional convergence and the speed of convergence is close to 2 percent per year.

Jian et al (1996) examine convergence in real per capita income among the Chinese regions during the period 1952-1993. They try to find evidence for both β-convergence and σ-

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[3] The concept of convergence is discussed in chapter 4.3.

[4] The authors name the concept of convergence β-convergence and it can be either absolute or conditional.

convergence[5]. The conclusions are that no strong convergence or divergence occurs during the period 1952-1965, the initial phase of central planning. Furthermore, the regional inequality widened during the Cultural Revolution, 1965-1978, a result of the central government favouring the already richer industrial regions. After the initiation of economic reforms in 1978, regional incomes began to equalize sharply as a consequence of rise in rural productivity, and was particularly strong in the areas open to integration with the outside world. The authors find that convergence continued within these costal provinces in the beginning of the 1990s (Jian et al. 1996 p.18-19). These regions grew markedly faster and as a result regional incomes have started to diverge again. Looking ahead they predict that further economic liberalization will lead to convergence.

Démurger et al (2002 p.18-19) find no evidence of absolute convergence across the Chinese provinces during the planned and reform periods (1952-1991), and for the last years of their study (1992-1998) they identify divergence. Wang and Ge (2004 p.729) estimate a regression in line with Barro and Sala-i-Martin, to investigate convergence in Chinese regional growth during 1985-1999. In the analysis infrastructure, investments, and population growth is included. They also reject the hypothesis of absolute convergence between the Chinese provinces; however there is evidence for conditional convergence. They find that the provinces divided into three regions; east, mid and west, all converge to different equilibria respectively. Through an inverse U-shape analysis they discover that regional disparity between the mid and the west is shrinking, while the gap is widening between the east and the rest of the country.

With these insights to the disparities of the Chinese provinces and previous research, we will now proceed by introducing our theoretical framework based on neoclassical growth theory.

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[5] σ-convergence is the reduced dispersion of GDP per capita across a group of economies, see chapter 4.4.

4 Theoretical Framework

Differences in income levels and development across and within countries of the world have always been a puzzle for economists. Why are some countries growing faster than others? Will poor economies ever catch up with the richer economies or will they always be left behind? This is something academics have tried to explain for decades. In this chapter, we will present the fundamental ideas of growth theory. First, the Solow model is described along with neoclassical enhancements of the model. Then the concept of convergence is introduced and described with the help of basic econometrics. The chapter is concluded with a short summary.

4.1 The Solow Model

Robert Solow introduced his model of economic growth in the article *"A Contribution to the Theory of Economic Growth"* in 1956. The model explains how the variables in the production function behave in the long run, and it has contributed greatly to our understanding of growth and why it differs between economies. In the model, it is assumed that international trade is absent and technology is given exogenously (Jones 2002 p.20-21). There is only one commodity produced and that is output as a whole; the community's real income, Y (Solow 1956 p.66). Output is produced using two factors of production, capital, K and labour, L; and the production function is expressed in Cobb-Douglas form:

$$Y = K^{\alpha} L^{1-\alpha} \tag{2}$$

We can rewrite the production function in terms of output per worker, as we want to compare economies with each other:

$$y = k^{\alpha} \tag{3}$$

According to Solow (1956 p.67), constant returns to scale is a natural assumption to make in theory of growth. Therefore, limited resources like land are excluded from the model, as they would lead to decreasing returns to scale. The part of income that is not consumed is saved and invested. The rate of savings is constant over time, *sY*. Net investment is the increase in the community's stock of capital. In the production process, the capital is depreciated at the rate *d* (Jones 2002 p.23). This implies that the change in the capital stock, the capital accumulation, is:

$$\dot{K} = sY - dK \tag{4}$$

In line with earlier reasoning, we rewrite equation 4 in terms of capital per worker. The growth rate in the labour force, $\dot{L}/L$, is for simplicity assumed to be equal to the growth rate in population, *n*. We then get the following capital accumulation equation per worker:

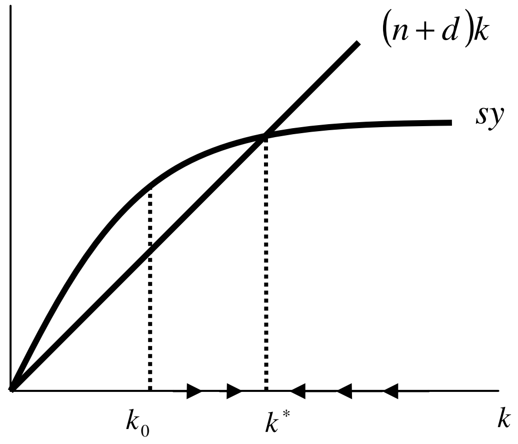
$$\dot{k} = sy - (n + d)k \tag{5}$$

As can be seen, population growth rate has a negative impact on the accumulation of capital since a higher fraction of saving is needed simply to keep capital-labour ratio constant when the population is growing. To find out how the variables behave over time, we have to find the equilibrium; the *steady state*. This is found where all parameters are constant. By combining equations 3 and 5, we get the steady state output per worker in the economy:

$$y^* = \left(\frac{s}{n + d} \right)^{\alpha/(1-\alpha)} \tag{6}$$

The model implies that in steady state the growth in GDP per capita is decided by the change in capital per worker. Figure 4.1 below shows that in the equilibrium of the model the amount of capital per worker is constant and thus there is no growth in GDP per capita in steady state. At any point to the left of this equilibrium the amount of investment per worker exceeds the amount needed to maintain capital per worker constant (Jones 2002 p.28). Capital per worker is thus increasing and the economy is moving towards the equilibrium where *k*=*k**. At points to the right of equilibrium the investments are too low and capital per worker decreases until *k*=*k**.

Figure 4.1: The Basic Solow Diagram



Source: Jones 2002 p.28

In this simple model, the answer to the question why some economies are richer than others is found in the savings rate of the economies, i.e. ceteris paribus, a high savings rate equals high income (Jones 2002 p.32).

Solow later developed his model to include technology, A, in the production function (Jones 2002 p.36). Technology is defined as the efficiency in which a given set of inputs are used in production. The technology is given exogenously, i.e. determined outside the scope of the model, and grows at a constant rate. This gives us the following production function;

$$Y = K^{\alpha}(AL)^{1-\alpha} \tag{7}$$

and consequently the following production function in terms of output per worker:

$$y = k^{\alpha}A^{1-\alpha} \tag{8}$$

The growth rate of technology, $\dot{A}/A$, is give by the parameter, g. The capital accumulation is the same as in the model without technology expressed in equation 5. By taking logs and differentiating equation 8 we get:

$$\frac{\dot{y}}{y} = \alpha\frac{\dot{k}}{k} + (1-\alpha)\frac{\dot{A}}{A} \tag{9}$$

The capital accumulation equation tells us that y and k have to grow at the same rate. Furthermore, the model implies that this growth rate will be the same as the growth rate in technology. The variables in this model are growing at the rate of technological progress; the situation is called a *balanced growth path.* In contrast to the model without technology the variables are growing in steady state.

Since k is no longer constant in the long run, we have to write the differential equation in terms of another variable in order to solve the steady state. The new variable represents the ratio of capital per worker to technology, $\tilde{k} \equiv K/AL$. Using this, we rewrite the production function in terms of $\tilde{k}$:

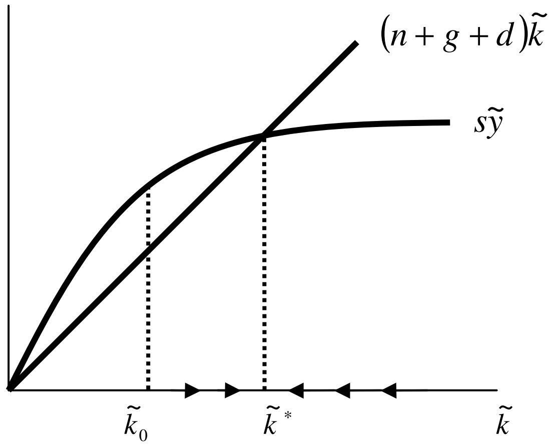
$$\tilde{y} = \tilde{k}^{\alpha} \tag{10}$$

The capital accumulation equation is rewritten in the same way:

$$\dot{\tilde{k}} = s\tilde{y} - (n + g + d)\tilde{k} \tag{11}$$

The development of $\tilde{k}$ along a balanced growth path is illustrated in figure 4.2 below. At $\tilde{k}_0$ the capital technology level is below the steady state level and investments exceed the amount needed to keep the ratio constant (Jones 2002 p.39). The economy will move towards equilibrium at which point the economy grows at the same rate as technological progress, along a balanced growth path.

Figure 4.2: The Solow Diagram with Technology



Source: Jones 2002 p.39

The equation describing output per worker in steady state will be:

$$y^*(t) = A(t)\left(\frac{s}{n + g + d}\right)^{\alpha/(1-\alpha)} \tag{12}$$

The economy grows at the same rate as technological progress implying that the economy is growing in steady state, and not constant as in the basic model. This balanced growth path is generally referred to as steady state, thus in the rest of the analysis we will do the same. Observe that changes in investment rates and population growth rates will not affect the long run growth rate of output per worker; policy changes will only effect the long run level of output per worker. The main conclusion from the Solow model with technology is that sustained economic growth can only be achieved through technological progress.

4.2 Neoclassical Growth Theory

The neoclassical growth models evolve the classical Solow model by including additional explanatory variables. Some of the economists behind this development are Gregory Mankiw, David Romer and David Weil (Jones 2002 p.54-55). The authors recognised that economies differ in educational level and labour skills. By including human capital, *H*, the “fitness” of the model is improved. The production function is then:

$$Y = K^{\alpha}(AH)^{1-\alpha} \tag{13}$$

We assume that in an economy human capital is accumulated by individuals spending time learning skills, instead of working. The fraction of an individual’s time spent learning skills is denoted u and L is the total amount of labour. Skilled labour is then generated according to the following equation:

$$H = e^{\psi u} L \tag{14}$$

Consistent with this, all labour is unskilled if $u = 0$. In the literature on labour economics, there is a broad consensus that an additional year of schooling increases the wages earned by a worker by approximately 10 percent (Jones 2002 p.56). Thus, Ψ is presumed to be 0.1 and as the increase is proportional the exponential e is used. In line with the assumption that individuals save and invest a constant fraction of their income, we assume that u is constant and given exogenously.

Following the reasoning in the previous section, we can write the steady state equation as:

$$y^*(t) = \left(\frac{s_K}{n+g+d}\right)^{\alpha/(1-\alpha)} hA(t) \tag{15}$$

Equation 15 summarizes why some economies are rich and others are poor. High investment rates in physical capital, large fractions of time spent accumulating skills, low population growth rates, and high levels of technology are factors explaining why some economies are rich. The per capita output of an economy grows at the rate of technological progress, g, in steady state. Implicitly technology is growing at the same rate in all countries. This assumption is reasonable since technology consists of ideas that are not constrained by national or regional boundaries. A general assumption is that the world technology grows at an annual rate of 2 percent (Jones 2002 p.96). Even though technological ideas in theory can travel freely across borders, countries and regions have different ability to make use of the technology. This explains differences in levels of technology across countries and regions.

Since technology is exogenously given in this model, it is impossible to know the actual technology level. However, we can estimate *A* using the data we have by calculating backwards using the production function:

$$A = \left(\frac{y}{k}\right)^{\alpha/1-\alpha}\frac{y}{h} \tag{16}$$

Estimations show a strong correlation between high levels of output and high levels of technology; rich countries tend to have high levels of technology while poor countries have low (Jones 2002 p.61). This implies that rich countries not only have high levels of physical and human capital, but they use them more productively. However, the correlation is not perfect; some countries have higher levels of *A* than expected considering their low levels of GDP per worker. This can be explained by the fact that these estimates of *A* are like residuals in growth accounting; they include all differences in production, not just the differences due to the inputs. Included in the estimates of technology are for example differences in the quality of educational systems, and the general health of the labour force. Hence, total factor productivity levels, rather than technology levels, is a more appropriate way of referring to these estimates.

4.3 Convergence in Growth Rates

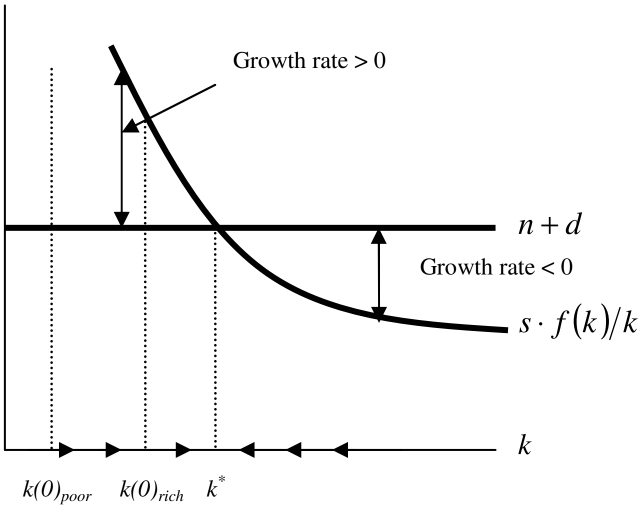
The neoclassical development of the Solow model explains the differences in income levels across economies well, even though weaknesses exist. We will now discuss the ability of the model to describe differences in growth rates. In early growth theory literature the hypothesis of poor economies' ability of catching up with the rich ones was brought forward. Moses Abramovitz (1986) presents the phenomena, referred to as convergence:

> "So – the larger the technological and, therefore, the productivity gap between leader and follower, the stronger the follower's potential for growth in productivity; and, other things

> being equal, the faster one expects the follower's growth rate to be. Followers tend to catch up faster if they are initially more backward." (p.386-387)

The object of the theory of convergence is not to question if there are differences in income levels, but to examine if these differences are diminishing over time. The concept of *absolute convergence* implies that poor economies should have higher growth rates than rich economies. Due to decreasing returns to scale in real capital, countries with lower levels of real capital are expected to have higher returns to real capital and thus easier attract foreign capital. According to neoclassical growth models more backward economies, with lower initial values of capital per person, have higher growth rates of capital per person. Assume two countries sharing the same production function and with the same saving rates, population growth, and capital depreciation and thus striving towards the same steady state (Barro and Sala-i-Martin 1995 p.23-26). The only difference between the economies is the initial level of capital per person. Since the economies have the same underlying parameters, the dynamics of capital per capita are determined by the same $s \cdot f(k)/k$ and $n + d$ curves, implying that the growth rate is larger for the economy with initially lower levels capital per capita; this is illustrated in Figure 4.3. The vertical distance between the saving curve and the effective depreciation line gives the growth rate of k. When $k < k^*$, k increases towards k^* since the growth rate is positive. When $k > k^*$ the growth rate is negative and thus k decreases towards k^*. Along a transition from an initially low capital per person ratio the growth rate of k declines towards zero.

Figure 4.3: Transitional Dynamics



Source: Barro and Sala-i-Martin 1995 p.23

Nevertheless, the concept of absolute convergence is not supported by worldwide cross-country empirical evidence (Jones 2002 p. 65-66). The picture is different for more homogenous economies, e.g. industrialized countries. Barro and Sala-i-Martin (1992) find evidence of absolute convergence across the states of USA over various periods from 1840 to 1988. Corresponding results are found by the same authors for regions in Europe and Japan (Barro and Sala-i-Martin 1991, 1995). If economies have the same levels of technology, rates of investments, human capital accumulation, and population growth, the initially poorer economies will grow faster than the initially richer ones (Jones 2002 p.68).

That the theory of absolute convergence does not apply to the world as a whole can be explained by the fact that countries have different levels of steady state. If we drop the assumption that all economies have the same parameters and strive towards the same steady state, convergence can be found across more heterogeneous groups of economies (Barro and Sala-i-Martin 1995 p.28). The further below its own steady state an economy is, the faster it is expected to grow. Economies in or above their steady state are expected to grow at a slower rate. This type of convergence is referred to as *conditional convergence*. Important to observe is that this is a confirmation of what the neoclassical growth model predicts: economies with similar steady state will exhibit convergence. The economies of the world are not converging to the same steady state, but to their own (Jones 2002 p.70).

4.4 Two Concepts of Convergence

In the literature empirically investigating convergence across economies, the work of Barro and Sala-i-Martin (1991, 1992, and 1995) has been accepted as the general approach. The hypothesis that poor economies tend to grow faster than richer ones, is defined by Barro and Sala-i-Martin as β-convergence (1995, p.383). β-convergence can be absolute or conditional and is distinguished from the concept of σ-convergence, which is defined as reduced dispersion of GDP per capita across a group of countries or regions. The first type of convergence tends to induce the second kind, but even though β-convergence is a necessary condition for σ-convergence, it is not a sufficient one. In our analysis we will focus on β-convergence and therefore σ-convergence will not be discussed further.

In accordance with Barro and Sala-i-Martin (1995, p.384-387), we initiate the definition of β-convergence with the following equation taken from basic neoclassical growth models:

$$\log\left(y_{it} / y_{i,t-1}\right) = a - \left(1 - e^{-\beta}\right) \cdot \log\left(y_{i,t-1}\right) + u_{it}, \tag{17}$$

where i denotes the country/province and t the year. According to theory, the intercept a equals $x + \left(1 - e^{-\beta}\right) \cdot \left[\log\left(\hat{y}_i^*\right) + x \cdot (t-1)\right]$, where $\hat{y}_i^*$ is the steady state level of $\hat{y}_i$. u_{it} is assumed to have the mean zero, the variance σ_{ut}^2, and be distributed independently of $\log\left(y_{i,t-1}\right)$, u_{jt} for $j \neq i$, and lagged disturbances. The disturbances reflect unexpected changes in preferences or production conditions. As it is more likely that provinces within a country are more similar in respect to technology and preferences than countries are, we assume that the coefficient a is constant. This implies that the steady state value, $\hat{y}_i^*$, and the time trend, $x \cdot (t-1)$, are assumed to be identical for all economies. If a is the same in all places and $\beta > 0$, then equation 17 implies β-convergence. Consequently, poor economies tend to grow faster than rich ones.

To explain how to practically estimate the speed of β-convergence we assume, for simplicity that we only have observations at two points in time, 0 and T. Equation 17 will thus be modified to:

$$(1/T) \cdot \log\left(y_{iT} / y_{i,0}\right) = a - \left[\left(1 - e^{-\beta T}\right)/T\right] \cdot \log\left(y_{i,0}\right) + u_{i0,T} \tag{18}$$

In the equation, the average of the error terms, u_{it}, between 0 and T is represented by; $u_{i0,T}$, and the intercept, a, is defined as; $x + \left[\left(1 - e^{-\beta T}/T\right)\right] \cdot \log\left(\hat{y}^*\right)$. Since growth rates decline as GDP increases, the GDP growth rate is predicted to be smaller the longer the time span over which the growth rate is averaged. This is the case if we estimate a linear relation between the GDP growth rate and the log of initial GDP. As T approaches infinity, the coefficient, $\left[\left(1 - e^{-\beta T}\right)/T\right]$, approaches zero, and as T approaches 0 the coefficient tends to β. By taking account of the value of T in each case, estimates of β are obtained from the nonlinear form of equation 18. Similar estimates of β should be generated, regardless of the length of the averaging interval for the data, using this method.

4.5 Technology Transfer as Explanation of Convergence

An explanation to why convergence may occur is the transfer of technology across economies. Technology is how inputs are transformed into output in the production process (Jones 2002 p.79). The technology of production is improved through new ideas that make it possible to produce more or better output with the same inputs. Ideas are nonrivalrous, meaning that anyone with the knowledge to use the idea can do so once it has been created. The development of an idea costs both money and time, while using, imitating or copying is relatively cheap; implying increasing returns to scale. Poor economies can imitate the technology of richer economies without having to bear the extensive costs of innovation. However, the spread of ideas is restricted by varying degrees of excludability through e.g. patent laws, copyright rules, and firm-specific knowledge.

The transfer of technology occurs when individuals in an economy learn to use more advanced capital goods through spillover effects from FDI, reversed engineering etc. (Jones 2002 p.126-127). The more skilled a labour force is the more advanced technology can be used in the economy. Skills are defined as the variety of intermediate goods an individual has learned to use. Hence, human capital is accumulated according to:

$$\dot{h} = \mu e^{\psi u} A^{\gamma} h^{1-\gamma} \tag{21}$$

The time spent accumulating skills instead of working, is denoted u in the equation and A is the world technology frontier; the index of the most advanced capital good invented to date. It is also assumed that $\mu > 0$ and $0 < \gamma \leq 1$. The skill level is increased proportionally with the additional time spent accumulating skills. Furthermore, equation 21 implies that the change in skill is a weighted average of the frontier skill level, and the individual's skill level. We rewrite equation 21 to illustrate the growth rate of human capital:

$$\frac{\dot{h}}{h} = \mu e^{\psi u} \left(\frac{A}{h} \right)^{\gamma} \tag{22}$$

The smaller the ratio *A/h,* i.e. the closer an individual's skill level is to the frontier, the slower the individual accumulates skill. The technology frontier is assumed to expand at a constant rate because of advanced economies' investments in research and development.

Along a balanced growth path all variables grow at the same rate, g. The growth rate of the economy is determined by the growth rate of human capital, which in turn is tied down by the growth rate of the world technological frontier (Jones 2002 p.128). Thus, the income level in steady state can be estimated through the following equation:

$$y^*(t) = \left(\frac{s_K}{n+g+d} \right)^{\alpha/1-\alpha} \left(\frac{\mu}{g} e^{\psi u} \right)^{1/\gamma} A^*(t) \tag{23}$$

This model is a “new growth theory” development of the neoclassical growth model. The differences in individual’s skill levels and hence how much of the world technology a country can make use of explains why some countries are rich and others poor. Economies grow because they learn to use new technology. In developing countries individuals have invested less time learning to use advanced capital goods than individuals in developed countries closer to the world technology frontier. The further away from the technology frontier an individual is, the faster he or she can accumulate new skills. Consequently, poor countries far away from the frontier are expected to grow faster than economies close to the frontier causing income levels to converge over time.

4.6 Summary

The models presented in this chapter all predict a catching up process where poorer economies converge in GDP growth rates with richer economies. Absolute convergence is when economies with initial low levels of GDP grow faster than economies with high initial levels of GDP. However, evidence of *absolute convergence* is hard to find across heterogeneous economies. This can be explained by the fact that countries have different levels of steady state. If the assumption that all economies have the same parameters and strive towards the same steady state is dropped, *conditional convergence* can be identified. This means that the further below its own steady state an economy is, the faster it is expected to grow. Economies in or above their steady state are expected to grow at a slower rate. Barro and Sala-i-Martin transform convergence across economies into a linear relationship, making it possible to investigate the existence of absolute or conditional *β-convergence* across economies through a linear regression analysis.

Convergence can be explained by the process of technology transfer; knowledge to use new ideas and production methods is spread across economies through imitation and copying. The technology level is de facto the same across the world and not restricted by national boarders. The difference between economies lies in their ability to adapt new ideas and technology in order to increase output with the same levels of input. A more skilled labour force enables an economy to use more advanced technology, and the process of human capital accumulation is therefore important. On the basis of this theoretical framework we will now continue by introducing our data set and the variables included in the forthcoming analysis.

5 Data and the Variables in the Regression

The sources and statistics used for our analysis are described in this chapter and general considerations concerning the accuracy of the data are briefly discussed. Problems encountered in compiling our data and solutions to these are brought forward. Finally, we present the variables included in our regression along with the motives for choosing them before concluding the chapter with a short summary.

5.1 General Statistical Considerations

In all statistical work it is important to remain critical to the data presented. This is even more important in our specific case study as China is a dictatorship. Data series like unemployment rates have always been, and still are, questionable as they are gravely underestimated; the reasons for this are of course political.

Due to the totalitarian regime’s attempt to control the activities of this great country, the monitoring and reporting of statistics in China has always been extensive, resulting in a large quantity of statistical material available. The availability of statistics on both national and provincial level is a great advantage, however there are disadvantages too. The major one being manipulation of data in order to satisfy the regime and fulfil commitments, in all levels of society, starting from grass-root level up to the very political elite. Rawski (2001) points out that this kind of falsification still exists and that present data contains numerous inconsistencies. Concerns are raised about the fact that few economists have hesitated to utilize standard yearbook data for analytic and comparative research (Rawski and Xiao 2001, p.298). Rawski argues that official data for GDP growth have been exaggerated since 1998 in order to reflect official objectives instead of economic outcomes (Rawski 2001, p.353). Another reason for inconsistent data is the authorities’ attempts to expand statistical indicators to keep pace with the rapid changes in the Chinese economic structure (Rawski and Xiao

2001, p.299). In order to show results and effects of structural changes, statistics are “upgraded” and adjusted faster than the actual effect is shown.

The increasing openness towards the rest of the world has increased the Chinese authorities’ awareness of the importance of accurate statistical reporting. In recent years efforts have been made by NBSC to align published data with standard categories of national income accounting and other international conventions, enhancing the research value of reported statistics (Rawski and Xiao 2001, p.298). This has lead to an increasing acceptance of the accuracy of Chinese statistics by academics worldwide. Marton (2000 p.202-203) states that, by developing country standards, Chinese demographic, social, and economic statistics are abundant and fairly reliable and can provide a reasonable good sense of actual conditions. In line with this, we asses our data sufficiently credible for the analysis. However, it is important to remain critical and keep the disadvantages in mind throughout the entire process.

5.2 The Data Set

We use data covering the period 1985-2004 for 31 provinces of Mainland China in our analysis. The quantitative nature of our thesis has meant extensive data collection from various issues of *China Statistical Yearbook*, 1986-2005, published by the NBSC. For additional data not available in the national statistical yearbooks, we have used the statistical yearbooks for every province, compiled by each province’s Bureau of Statistics and published by China Statistical Press. National yearbooks for 1992 and 1994 are missing and for those years all data is collected from provincial publications. Issues of the statistical yearbooks from 1996 and onwards are accessible online, but early years are only available in print. During our stay at the School of Economics at Fudan University in Shanghai we gained access to more statistical data, than we would have been able to obtain at home in Sweden.

The administrative units of Hainan and Chongqing were created during the time period of our study. Chongqing broke free from the Sichuan province and got status as a municipality in 1997. Data for Chongqing up to 1997 is compiled from the provincial statistical yearbooks and subtracted from Sichuan’s statistics. Before 1988, the island of Hainan was part of the Guangdong province. There are only three years missing in the times series in the national yearbooks and this data can be found in the yearbooks published at provincial level. We therefore choose to treat Chongqing and Hainan as individual provinces during the whole period covered in our study.

When compiling the data, we found conflicting statistics in different issues of the statistical yearbooks, due to later adjustment of the aggregated national total. In that case, we have chosen to use data for the years where we can obtain complete data for all provinces and not only the national total. Consequently, the sum of the provincial data does not always coincide with the reported national total. In order to revise the statistics, we compared data published at national level with the provincially published. When finding conflicting numbers in national and provincial yearbooks we use the data published in the national yearbook, since it is compiled with the same method in all provinces. An additional argument for the superiority of the statistics in the national yearbooks is that the varying ways of measuring in the provinces might make the statistics in the provincial yearbooks incomparable.

The rest of the chapter will be devoted to the variables included in our regression. The variables will be presented and their expected behaviour will be discussed.

5.2.1 Gross Domestic Product

The dependent variable in our regression analysis is the growth rate in real GDP per capita for each time period and its variation is what the other variables should explain. Initial real GDP per capita is the variable in focus in the regression since its parameter gives us the answer to our research question. The real GDP per capita for all provinces 1985 can be seen in Table 5.1. The richest province, Shanghai has almost ten times higher real GDP per capita than Guizhou, the poorest one. If the parameter for initial GDP is negative, it implies that the higher a province’s initial GDP is, the slower the GDP growth rate is. Consequently, poorer provinces are growing faster than the richer, catching up with them in the long run.

Table 5.1: Real GDP per capita for the Chinese Provinces, 1985 (unit: RMB)

Province	Real GDP per capita	Province	Real GDP per capita
Shanghai	3366.72	Fujian	607.41
Beijing	2026.04	Qinghai	604.18
Tianjin	1867.70	Inner Mongolia	589.69
Liaoning	1151.84	Chongqing	547.42
Jiangsu	931.05	Ningxia	537.59
Zhejiang	907.67	Hunan	535.11
Heilongjiang	850.95	Anhui	527.17
Guangdong	804.40	Jiangxi	500.00
Jilin	738.12	Gansu	498.58
Hubei	726.97	Shaanxi	487.51
Hainan	724.00	Henan	484.27
Shandong	717.73	Sichuan	458.03
Xinjiang	656.65	Yunnan	408.13
Shanxi	655.50	Guangxi	397.93
Tibet	632.16	Guizhou	363.38
Hebei	614.40		

Source: Compiled with statistics provided by National Bureau of Statistics of China 1986

5.2.2 Investments and Population Growth

De Long and Summers (1993) find a strong link between equipment investments and economic growth in developing economies. Where equipment investments are high, growth is rapid, respectively slow growth is found where investments in equipment are low. In our analysis we therefore use investments in fixed assets as share of GDP for each province and expect this to have a positive effect on GDP growth rate.

Population growth in China is limited through the one child policy, allowing each couple to have no more than one child in order to avoid “social punishment”. Nevertheless, the population is growing which should have a negative impact on the economic growth. The one child policy is implemented more strictly in the urban areas and population should therefore be of interest for our analysis.

5.2.3 Technology

That the technological progress has great influence on economic growth is undoubtedly true. The problem is how to measure the process where societies develop through new inventions and more efficient ways of using resources. Griliches (1990, p.1669) defines the technological progress and invention as an outward shift of the production possibilities frontier. Ideally, we want to find a measure of the output of technological change. Unfortunately, a perfect measure does not exist and we are forced to pure speculation or the use of only distantly related measures and proxies (Griliches 1990, p.1666).

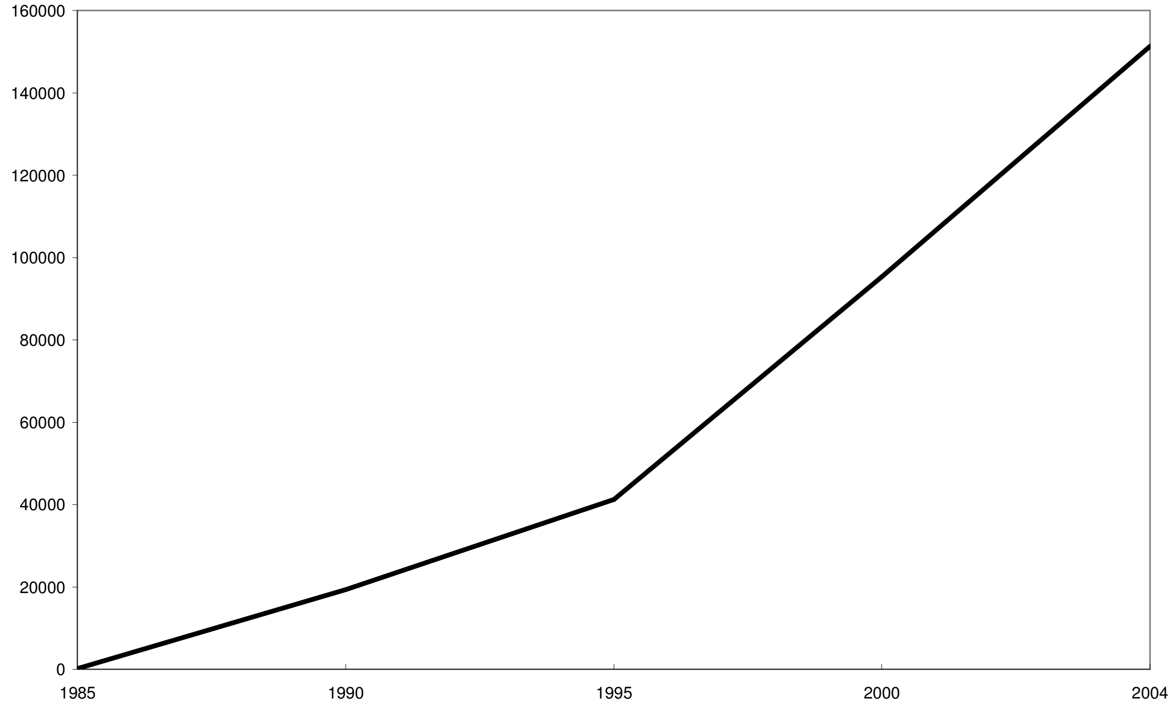
Typically measures of technological change have focused on three aspects of the innovative process; measuring inputs, intermediate output and direct output of the innovative process (Acs et al 2002, p.1069). A common choice of input data is to use expenditure for the R&D-sector. The disadvantage with this being that it only reflects budgeted resources allocated towards trying to produce innovation, not innovations actually made. The second approach, to focus on intermediate output; the actual number of inventions being patented, has the benefit of showing the number of innovation having passed the scrutiny of patent offices (Griliches 1990, p.1669). There is a large quantity of patent statistics which are easily accessible, but there are limitations too. Many innovations do not appear in the statistics since some innovations are not patentable, while others are never patented. Among the patented innovations large differences in quality exists. Some innovations have larger economic and technological impact than others, something that patent statistics do not reflect (Acs et al 2002, p.1070). In order to grasp the economic value of different innovations a literature-based innovation output measure is preferable. Information of the economic value of an innovation is gathered by studying the “new product”-sections of trade and technical journals. The advantage is that the indicator documents the commercialisation of technical ideas. However, small firms might be less keen on announcing their new products and can thus be under-represented. The major downside of this method is that it is very time consuming and expensive to create this measure and it is therefore not broadly available.

For China, provincial data on inputs and direct output of the R&D sector are not available. That leaves us with using patent statistics as a measure of technological change in the provinces. Empirical studies (e.g. Acs et al 2002 and Griliches 1990) find high correlation between R&D expenditures and the number of patents granted. The implication of these findings is that when no R&D expenditure data is available, the more plentiful patent data can be used instead to indicate inventive input and output. Hence, there is strong support for the use of patent counts in studies examining technological change.

It is important to remember that the increase in patents granted can have a number of underlying reasons. Changes can reflect an increase in innovation, but also an increase in the public and official awareness of the importance of patents and intellectual property rights.

This is more true for China than most other countries. In 1944, China promulgated its first Patent Law, but it was abolished in 1949 when the Communist regime was established (Yang 2003, p134). Throughout the whole period of Mao Zedong's rule innovations, like everything else, were property of the state. Not until the opening up of the Chinese economy in 1978 the formation of a systematic intellectual property system could take place (Yang 2003, p.136). The first official steps were taken when China became a member of the World Intellectual Property Organisation in 1980. In 1992, the *Implementation Regulations on the Patent Law* was introduced and has been changed several times since. An enormous expansion of patents granted in China can be seen in Figure 5.1.

Figure 5.1: Number of Patents Granted in China, 1985-2004



Source: Compiled with statistics from various issues of national statistical yearbooks 1986-2005 provided by National Bureau of Statistics of China.

The increase in patents granted can reflect the increase in applications due to the possibility of actually protecting your invention. However, in order to show the world that China is taking appropriate measures to enhance protection of intellectual property rights, standards might be lowered in order to reach an "acceptable" level of patents granted. Bearing this in mind, we use statistics on patents granted in the Chinese provinces, seeing that no other data on technological progress is available. We expect the parameter for the patent variable to be positive.

5.2.4 Foreign Trade and Foreign Direct Investments

Openness in trade with the rest of the world is viewed as an important mechanism for steady economic growth in developing countries (Sun and Dutta 1997, p.847). In China the remarkable economic growth has been largely export-led, but unfortunately statistics on international trade are only available for half of our time period. The measure used to grasp the interaction with the rest of the world is therefore the inflow of FDI to China.

The inflow of FDI influences a country's economic development not only through an addition to the capital stock but also through technological transfer (Démurger et al 2002 p.17). Domestic firms face increased competition forcing them to raise their productivity and efficiency. The demonstration effects generated by FDI allow the firms to improve technology used and enhance their operations. FDI has been found to be an effective channel for technology transfer, mainly benefiting the Chinese coastal provinces since FDIs are concentrated there. An empirical study by Berthélemy and Démurger (2000) on a sample of 24 Chinese provinces 1985-1996 verifies the fundamental role played by FDI in provincial economic growth. In line with this, the variable FDI is expected to have positive impact on GDP growth rate in our regression.

The opening up of China's economy emerged gradually through the establishment of different kinds of preferential policies from the central government. Some provinces enjoyed the benefits from foreign trade and FDI sooner than others and to a larger extent. In order to incorporate this in our analysis, we include a preferential policy index (PPI) developed by Démurger et al (2002). Each province is given a weight on a 0 to 3 scale based on the number of designated open economic zones, their importance, and the extent of the preferential treatment (Démurger et al 2002 pp.24-25). A more detailed description of the index is given in Appendix 1. Démurger et al's PPI covers the period 1978-1998. The whole country has opened up significantly with the accession to the WTO in 2001, and according to these circumstances we have upgraded the index with help of information from the website of *China Association of Development Zones* (2006). The index is included in the regression as dummy variables for each index-value. We expect that all dummies influence growth in GDP per capita positively and a higher index-value has stronger positive effect on the growth rate.

5.2.5 Human Capital

The skill of a population, a country's human capital is important for economic growth as it plays a major role in the productivity of nations (Heckman 2002, pp.2-3). Human capital might be even more important than physical capital when it comes to creating a prosperous economy. Accumulation of human capital does not only directly result in an increased productivity of a worker; it also allows a society to allocate resources more effectively and respond to new opportunities.

The Chinese investment in physical capital to human capital is much higher compared to the rest of the world, implicating an under-investment in education of the labour force (Heckman 2002, p.1). Furthermore, the rate of return to education is estimated to be 7 percent in 1997, far below the rate of return to physical capital in industry estimated to be as high as 20 percent (Heckman 2002, p.6). Thus, incentives to accumulate skills are low for the individual worker; an additional year of schooling does not pay off with higher wages. Resources should flow to their most productive use in order to make the economy flourish. Consequently, the large difference between the rates of return to education and physical capital retards the economic growth of China (Heckman 2002, p.1). Even though knowledge is limited, Heckman speculates that the true rate of return to education in China might be as high as 30 or 40 percent (2002, p.14).

Schooling in China is mostly funded at local level, resulting in great differences between rich and poor provinces (Heckman 2002, p.5). Thus, a person's skill level is mainly determined by his or her place of birth. Access to education is not uniform across the provinces of China and creates serious regional disparities. Berthélemy and Démurger (2000, p.153) find evidence of the role of human capital in explaining Chinese provincial growth. They suggest that human capital contributes to growth by facilitating the adoption of foreign technologies.

Provincial data on investments in education is not available for the whole time period of our study. We therefore include the average school enrolment in primary schools and institutions of higher education for every province as a measure of human capital. In this way we want to capture the basic skill level of the population in a province, as well as the top-level of the human capital. We expect both variables to increase GDP growth rates.

5.2.6 Agriculture

Even though China is developing rapidly with growing industry and service sectors, the vast majority of the population is occupied in the low-productive agricultural sector. In the poorer provinces the agricultural sector is dominating while the richer provinces have a larger share of industrial production and a larger service sector. We include the productivity of the agricultural sector; output per worker engaged in farming, forestry, animal husbandry and fishery, in our regression. Table 5.2 shows the average output per worker in the agricultural sector for each province.

Table 5.2: Productivity in the Agricultural Sector, average 1985-2004 (unit: RMB)

Province	Output per Worker	Province	Output per Worker
Beijing	7281.305	Jiangxi	1872.455
Shanghai	7134.062	Anhui	1630.094
Tianjin	4906.982	Hunan	1573.504
Hainan	4376.018	Henan	1507.666
Xinjiang	4144.263	Ningxia	1486.950
Liaoning	3910.406	Tibet	1436.682
Heilongjiang	3353.434	Shanxi	1407.972
Jiangsu	3257.302	Guangxi	1404.374
Jilin	3138.158	Sichuan	1380.197
Fujian	3071.101	Qinghai	1328.964
Guangdong	2884.606	Gansu	1256.730
Inner Mongolia	2629.994	Shaanxi	1254.723
Zhejiang	2520.245	Chongqing	1074.329
Shandong	2405.845	Yunnan	1012.872
Hubei	2369.289	Guizhou	840.538
Hebei	2180.755		

Source: Calculated with statistics from various issues of China Statistical Yearbook 1986-2005 provided by National Bureau of Statistics of China

The productivity in the agricultural sector is lower in the poorer provinces where agriculture is the major source of income since the access to technology, facilitating and improving efficiency, is limited. Increased productivity always induces economic growth and the variable is therefore expected to have a positive parameter.

5.2.7 Infrastructure

The concept of infrastructure in economic growth theory is very broad and is sometimes referred to as social infrastructure (Jones 2002, pp.136-154). It is the fundamental economic structure provided in an economy, such as communications, energy and water supply, and political and judicial institutions. China, being a dictatorship ruled by the Chinese Communist Party since 1949, has a more stabile political environment than most countries. There are no indications of a change in the near future; the central government's top goal is to create and maintain a stabile and harmonious society. Many of China's institutions are undergoing major changes in order to adapt to the surrounding world. The changes are undertaken with great caution in order to maintain stability. To grasp differences in infrastructure between the provinces we therefore chose to measure a more traditional definition of infrastructure; the total length of highways in a province. We relate the length of highways both to the provinces' area and total population. These variables are expected to be positive for GDP growth rate since well-developed infrastructure provides a good environment for economic growth.

5.3 Summary

In sum, the dependent variable GDP growth rate will be explained by a number of variables in our regression. We expect the parameter for initial GDP to be negative indicating that convergence exists across the Chinese provinces. Investments are positive for GDP growth rates while population growth influences economic growth negatively. Technology is included in our model through the measure of patents granted and is expected to increase GDP growth. FDI and PPI are included to reflect the interaction with the rest of the world. Openness and trade are assumed to encourage economic development and the parameters for the two variables are thus expected to be positive. Human capital; school enrolment in primary and higher education, productivity in the agricultural sector, and the length of highway related to both total population and total area of the provinces are all expected to have positive impact on the variation of GDP growth rates.

6 Analysis

In this chapter we carry out of our two-step analysis and present our findings. First, we paint a picture of each province's relation to its steady state of GDP per capita through a steady state analysis. Based on this we proceed with a regression analysis in order to verify if economic theory on convergence is true for the provinces of China. The presentation of the regression analysis is divided into three parts; the original model, refined models, and the optimal model. Finally, we relate our findings to the concept of convergence.

6.1 Steady State Analysis

To asses the relationship between the provinces' actual GDP levels and their steady state Levels of GDP per capita we calculate the steady state level for each province by using the new growth model with technology transfer:

$$y^*(t) = \left(\frac{s_K}{n+g+d} \right)^{\alpha/1-\alpha} \left(\frac{\mu}{g} e^{\psi u} \right)^{1/\gamma} A(t) \tag{23}$$

In the equation s_K is the share of investments of GDP, n is the population growth rate, g the growth rate in technology and d the depreciation rate of the capital stock. Human capital per capita is $h = e^{\psi u}$ and in absence of satisfying provincial data we calculate this for the nation as a whole[6]. Average years of schooling for the population aged 25 and over, u, are compiled from the Barro-Lee database (Barro and Lee 2000). Since u is expressed in years we assume that the constant μ is equal to 0.01. One additional year of schooling is assumed to generate a 10 percent increase in an individual's skill level, thus $\psi = 0.1$.

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[6] In reality, there are differences between the provinces in level of education and thus the steady state levels of GDP might diverge more if the actual levels of human capital were possible to assess. We assume same the levels of human capital for all provinces in this stage and the differences in educational levels are reflected through school enrolment rates in the regression, the next stage of our analysis.

According to growth theory with technology transfer *A* is the most advanced technology level in the world to date. Obviously, the Chinese technology level is related to the world's technology level and depends on it. However, the channels for new technology adoption in China are few and therefore the technology that enters China is the highest available level for provincial dispersion. We treat China as "the world" and assume that the Chinese technology level is the world technology as our study is carried out across the Chinese provinces. Thus, we calculate *A* backwards using China's production function:

$$A(t)=\left(\frac{y_t}{k_t}\right)^{\alpha/1-\alpha}\frac{y_t}{h_t} \tag{16}$$

With the basic Cobb-Douglas assumption $\alpha = 0.33$ we calculate *A(2004)* and *A(1985)*. The level of technology for 2004 is 1227.3 and the growth rate in technology, *g*, is 0.77 percent. This is a much lower rate than the general assumption that the world technology grows at an annual rate of 2 percent (Jones 2002 p.96). If we assume that the technology level in China is growing at the same rate as world technology, the Chinese technology level is found to be 1565.1 in 2004. In order to expose differences in the two approaches both alternative *A(2004)*:s are used when we proceed with the steady state calculations. We find that the latter approach generates unrealistically low steady state levels of GDP per capita, and we therefore reject it.

In the calculations of the provincial steady-state levels of GDP per capita for 2004, γ is assumed to be 0.5 and two different depreciation rates, *d*, are used; $d = 0.1$ and $d = 0.05$. As can be seen in Table 6.1, the relation between the provinces' results is roughly the same independent of which value of *d* we use. When the slower depreciation rate is used, the steady state levels for all provinces are roughly 2 000-3 000 RMB higher than when the faster rate is used. The provinces are ranked according to distance between actual real GDP per capita and the steady state level of GDP per capita and arranged into three groups with ten provinces in each. Shanghai is not included in any group since it is the province closest to its steady state level. With the faster depreciation rate, Shanghai's actual real GDP per capita lies above its steady state level. Even though this is not an unrealistic scenario as Shanghai is the most developed part of China, we find it more likely that the province is not yet producing efficiently enough to be above steady state. Furthermore, Inner Mongolia and Yunnan are the only provinces that change positions between groups when using the different depreciation rates. Investments in fixed assets in China are mainly focused on real estate and other long lasting assets and we therefore find the depreciation rate of 0.05 better for our analysis.

Table 6.1: Actual Real GDP per capita and Steady State Level of GDP per capita for the Provinces of China Grouped According to Distance to Steady State Level of GDP per capita, 2004. (Unit: RMB)

	Actual Real GDP per capita	**Steady State Level** d = 0.05	**Distance to Steady State**	**Actual Real GDP per capita**	**Steady State Level** d = 0.1	**Distance to Steady State**
Shanghai	12300.40	14990.28	**-2689.88**	12300.40	11707.93	**592.47**
Close						
Tianjin	8234.58	15036.66	-6802.08	8234.58	11538.24	-3303.66
Beijing	8251.16	15596.75	-7345.59	8251.16	12313.77	-4062.61
Jiangsu	5959.93	13360.43	-7400.50	5959.93	10157.45	-4197.53
Fujian	4958.44	12697.81	-7739.37	4958.44	9774.93	-4816.49
Zhejiang	6850.71	14807.25	-7956.55	6850.71	11217.22	-4366.51
Liaoning	4687.23	13217.63	-8530.40	4687.23	9967.68	-5280.45
Guangdong	5555.17	14126.71	-8571.54	5555.17	10917.02	-5361.84
Shandong	4853.16	13676.71	-8823.55	4853.16	10393.01	-5539.85
Heilongjiang	3995.72	13099.61	-9103.89	3995.72	9896.57	-5900.85
Hubei	3016.56	12361.09	-9344.54	3016.56	9428.01	-6411.46
Middle						
Hunan	2409.84	11917.66	-9507.83	2409.84	9054.28	-6644.44
Henan	2609.09	12189.52	-9580.42	2609.09	9344.85	-6735.76
Anhui	2142.31	11898.45	-9756.14	2142.31	9114.06	-6971.75
Jiangxi	2346.98	12343.74	-9996.76	2346.98	9437.16	-7090.18
Sichuan	2161.07	12466.78	-10305.71	2161.07	9450.63	-7289.56
Jilin	3140.62	13557.04	-10416.42	3140.62	10281.46	-7140.84
Guangxi	1953.11	12466.11	-10513.00	1953.11	9559.87	-7606.76
Hebei	3703.84	14459.53	-10755.69	3703.84	11039.11	-7335.28
Shanxi	2623.72	13524.31	-10900.59	2623.72	10380.52	-7756.81
Yunnan	1927.88	12820.63	-10892.75	1927.88	9871.91	-7944.03
Far away						
InnerMongolia	3271.84	14218.43	-10946.59	3271.84	10796.87	-7525.03
Xinjiang	3223.50	14297.96	-11074.46	3223.50	11178.70	-7955.21
Gansu	1711.93	13020.03	-11308.10	1711.93	10010.01	-8298.08
Guizhou	1172.74	12668.81	-11496.07	1172.74	9776.50	-8603.76
Chongqing	2455.41	13969.69	-11514.29	2455.41	10513.13	-8057.73
Shaanxi	2238.35	14262.27	-12023.91	2238.35	10898.32	-8659.97
Hainan	2705.03	14946.92	-12241.89	2705.03	11601.91	-8896.89
Tibet	2220.43	15555.63	-13335.20	2220.43	12084.24	-9863.81
Ningxia	2251.68	16160.83	-13909.15	2251.68	12604.60	-10352.93
Qinghai	1951.49	16296.68	-14345.18	1951.49	12588.80	-10637.30

Source: Calculated with statistics from various issues of national and provincial statistical yearbooks 1986-2005, provided by National Bureau of Statistics of China and the respective provincial Bureau of Statistics.

The boundaries between the three groups are established arbitrary in order to get the same number of provinces in each group. The average of the provinces' distance to steady state in each group respectively is about -8 000, -10 000, and -12 000; we name the groups *Close, Middle* and *Far away*. How the provinces in each group are located geographically can be seen in Figure 6.1. The geographical trend is obvious; the two municipalities Beijing and Tianjin, and all provinces along the coast, except Jilin and Hebei are part of the group *Close*. The *Middle* group includes all provinces in central China, except Hubei that is part of the first group and Guizhou that is *Far away*. The group *Far away* comprises, as expected, the westernmost provinces of China and the island of Hainan. More or less, the further east a province is located the closer it is to its steady state level. For the continuation of our analysis, this implies that the provinces in the last two groups are expected to grow faster than the provinces in the first group. We will examine this further through the regression analysis in the next section of the chapter.

Figure 6.1: Geographic Location of the Provinces of China, Grouped by Distance between Actual Real GDP per capita and Steady State Level of GDP per capita.

In Table 6.1 we see that the steady state levels for the Chinese provinces lie between roughly 12 000 RMB per capita and 16 000 RMB per capita. The distance between actual real GDP per capita in 2004 and the provinces' steady state levels ranges between Shanghai's 2 700 RMB below steady state to Qinghai, being 14 300 RMB away from their steady state level. The large differences between the provinces' economies can be seen as a result of the reform strategies being unequal between provinces. The experimental approach in the reform process and the fact that reforms were largely carried out at provincial level did create losers as well as winners. Due to bad policy choices and some local governments' hostility towards reforms and liberalizations these provinces lagged behind the others and this is reflected in our steady state analysis. Authorities in the poorer provinces have not yet been able to implement the policies proven more successful in other provinces alternatively the results of the reforms are not yet visible in our data.

In Table 6.2, we rank the Chinese provinces according to steady state level of GDP per capita and show the average investments as share of GDP 1985-2004 for each province. It is surprising that the poor provinces Tibet, Ningxia, and Qinghai are the provinces with the highest approximated steady states levels of GDP per capita. The reason is that these provinces invest a larger share of their GDP than the other provinces; this does not mean that they invest more in actual numbers, but the high share is a result of the low provincial GDP. The high rate of investments results in a higher numerator in the first part[7] of our steady state calculation, equation 23, resulting in a higher steady state value. In recent years the investments have been over 70 percent of GDP in the provinces in question and this has raised their average for the whole period. It is likely that these high investment rates will drop as GDP in these provinces increases over time. The fact remains that these provinces would be far away from their steady state even if their investment rates were more similar to the other provinces' rates[8].

However, it is not just investment rates alone that determine the steady state level of GDP per capita. Tianjin has a higher steady state level of GDP per capita than Shanghai even though its investment rate is lower. A higher population growth in Shanghai implies a lower quotient in the first part of our steady state calculation resulting in a lower steady state level

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[7] $\frac{s_K}{n+g+d}$

[8] With an investments rate of 0.35, the three provinces are still over 11 000 RMB away from their steady state levels of GDP per capita.

of GDP per capita. Low population growth rate does not automatically mean a high steady state value since investment rates have a much larger impact in the calculations.

Table 6.2: The Provinces of China Ranked According to Steady State Level of GDP per capita, in Contrast to the Ranking in Table 6.1. Average investments as share of GDP for 1985-2004 are shown in order to explain high steady state level.

	Actual Real GDP per capita*	Steady State Level*	Investments as Share of GDP	Rank in Table 6.1
Qinghai	1951.49	16296.68	0.49	31
Ningxia	2251.68	16160.83	0.50	30
Beijing	8251.16	15596.75	0.50	3
Tibet	2220.43	15555.63	0.46	29
Tianjin	8234.58	15036.66	0.40	2
Shanghai	12300.40	14990.28	0.43	1
Hainan	2705.03	14946.92	0.42	28
Zhejiang	6850.71	14807.25	0.37	6
Hebei	3703.84	14459.53	0.30	19
Xinjiang	3223.50	14297.96	0.40	23
Shaanxi	2238.35	14262.27	0.35	27
InnerMongolia	3271.84	14218.43	0.34	22
Guangdong	5555.17	14126.71	0.37	8
Chongqing	2455.41	13969.69	0.31	26
Shandong	4853.16	13676.71	0.32	9
Jilin	3140.62	13557.04	0.31	17
Shanxi	2623.72	13524.31	0.32	20
Jiangsu	5959.93	13360.43	0.30	4
Liaoning	4687.23	13217.63	0.28	7
Heilongjiang	3995.72	13099.61	0.28	10
Gansu	1711.93	13020.03	0.30	24
Yunnan	1927.88	12820.63	0.29	21
Fujian	4958.44	12697.81	0.29	5
Guizhou	1172.74	12668.81	0.29	25
Sichuan	2161.07	12466.78	0.26	16
Guangxi	1953.11	12466.11	0.27	18
Hubei	3016.56	12361.09	0.26	11
Jiangxi	2346.98	12343.74	0.26	15
Henan	2609.09	12189.52	0.26	13
Hunan	2409.84	11917.66	0.24	12
Anhui	2142.31	11898.45	0.25	14

Source: Calculated with statistics from various issues of national and provincial statistical yearbooks 1986-2005, provided by National Bureau of Statistics of China and the respective provincial Bureau of Statistics.

* Unit: RMB

The first step of our analysis is now completed and we can conclude that the Chinese provinces differ in levels of GDP in steady state as a result of the reform strategies being unequal between provinces. Some provinces have lagged behind and the object for the next stage of our analysis is to examine whether these provinces are catching up with the richer ones; does convergence in GDP growth rates exist across the provinces of China?

6.2 Regression Analysis

Starting with our original model we estimate the linear relationship of our variables. The model will be refined by excluding insignificant variables using a 10 percent level of significance. This will result in an optimal model; the model that in the best way explains the variation in the dependent variable.

6.2.1 The Original Model

Based on arguments presented in previous chapters our original multiple-regression model takes on the following form:

$$\begin{aligned} gdp &= \alpha + \beta_1 \cdot initial + \beta_2 \cdot inv + \beta_3 \cdot pop + \beta_4 \cdot agri + \beta_5 \cdot eduh + \beta_6 \cdot edup \\ &+ \beta_7 \cdot fdi + \beta_8 \cdot patent + \beta_9 \cdot Infra\_pop + \beta_{10} \cdot Infra\_km \\ &+ \beta_{11} \cdot d1 + \beta_{12} \cdot d2 + \beta_{13} \cdot d3 + \beta_{14} \cdot d90 + \beta_{15} \cdot d95 + \beta_{16} \cdot d00 + \varepsilon \end{aligned} \tag{1}$$

The data set is grouped into four five-year periods; 1985-1990, 1990-1995, 1995-2000, and 2000-2004. Each observation represents the mean for the respective time period, resulting in 124 observations. The variables in the model are discussed individually in the previous chapter and are therefore presented only briefly here[9]. The dependent variable *gdp* is the growth rate of real GDP per capita, *initial* is the initial real GDP per capita in 1985[10], *inv* is the share of investments of GDP, and *pop* is the population growth rate. Productivity in the agricultural sector, output per worker, is labelled *agri* and enrolment in institutions of higher education and primary schools as share of provincial total population are *eduh* and *edup* respectively. Infrastructure is measured in two different ways; *Infra_pop* is the length of highways per capita and *Infra_km* is the length of highways per square kilometre. The dummy

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[9] Descriptions of the calculations of each variable included in the regression can be found in Appendix 1.

[10] If we use the initial GDP per capita for each time period, the variable *Initial* is insignificant in our model. This is problematic, but since more short term factors have influence in a short time span, it is likely that a five-year time period is too short to grasp convergence. We therefore choose to use initial GDP per capita in 1985 in all time periods.

variables *d1*, *d2*, and *d3* represent the PPI. Finally, we include dummy variables for each time period in order to encompass specific factors in a time period not explained by the other variables.

The results of the OLS-estimation of the original model are presented in Table 6.3. The R^2-value, the goodness of the fit of the model, is 57.2 percent and it is high because the model contains many variables regardless of their significance. The more correct adjusted R^2-value shows a lower goodness of fit; 50.8 percent. The additional goodness of fit measures, AIC and SC, also show that the model explains the variation in the dependent variable satisfactorily. We rule out the presence of autocorrelation since the DW-value is 2.1.

Table 6.3: Results of OLS-estimation of the Original Model, Equation 1. Variables with their coefficients and probability values are presented along with goodness of fit measures and the DW-value.

Variable	Coefficient	Probability		
Constant (α)	0.055774	0.0187	R^2	0.571916
Initial GDP	-0.0000254	0.0065	Adjusted R^2	0.507903
Investments	0.076029	0.0300	Akaike info criterion	-4.420634
Population	-1.220476	0.0021	Schwartz criterion	-4.033982
Agriculture	0.00000249	0.4586	Durbin-Watson stat	2.128104
Education high	1.440101	0.3782		
Education prim	0.020241	0.9072		
FDI	-0.000379	0.9936		
Infra/km^2	0.007154	0.7945		
Infra/capita	-1.592976	0.3346		
Patent	0.00000114	0.2856		
D1	0.028383	0.0050		
D2	0.026987	0.0015		
D3	0.037239	0.0072		
D90-95	0.037267	0.0000		
D95-00	-0.017559	0.0719		
D00-04	-0.001233	0.9227		

Most of the variables are insignificant in this first estimation, only initial GDP, investments, population growth, and all dummy variables for the PPI are significant at a 10 percent level. Investments and population have the expected effects; a one unit increase in investments increases the GDP growth rate with 0.076 and a one percentage point higher population growth results in a 1.22 drop in GDP growth rate. The positive coefficients of the three dummy variables for the PPI mean that the GDP growth rate increases when a province has a preferential policy. Receiving preferential policies giving an index-value 1 has a 0.028

impact on the GDP growth rate, index-value 2 a 0.027 impact and index-value 3 influences the GDP growth rate the most, with a coefficient of 0.037. Moving from one index-value to the next does not affect the GDP growth rate equally, since the steps between the index-values are not the same size. The largest effect is to move from no preferential policy to having a SEZ. Second largest is the effect of moving from no preferential policy to receiving one of the lowest kind. It is worth mentioning that moving from index-value 1 to value 2 has a small negative effect, this does not mean that having a 2 is negative but that the positive effects from the new preferential policy might not yet be fully visible in our statistics. For many of the provinces the move from index-value 1 to 2 occurred recently with the Chinese WTO accession.

Strangely FDI has a small but negative coefficient, implying that increased FDI result in a lower GDP growth rate. However, the variable is highly insignificant and therefore excluded from the model along with the equally insignificant variable enrolment in primary schools. Even though the probability-value for infrastructure per capita is not as high as for previously discussed insignificant variables, we choose to exclude this variable as well since population growth has a too large impact on the variable making the coefficient negative. Population growth is already included in the model through the population variable. We estimate our refined model with these changes; the results are presented and discussed in the following section.

6.2.2 Refined Models

When we refine our original model the dummy variables for each time period remain in the model despite insignificance, thus the formal function is:

$$\begin{aligned} gdp &= \alpha + \beta_1 \cdot initial + \beta_2 \cdot inv + \beta_3 \cdot pop + \beta_4 \cdot agri + \beta_5 \cdot eduh + \beta_6 \cdot patent \\ &+ \beta_7 \cdot Infra\_km + \beta_8 \cdot d1 + \beta_9 \cdot d2 + \beta_{10} \cdot d3 + \beta_{11} \cdot d90 + \beta_{12} \cdot d95 + \beta_{13} \cdot d00 + \varepsilon \end{aligned} \tag{24}$$

The estimation of the model is presented in Table 6.4 below. The variables agriculture, enrolment in higher education, infrastructure per square kilometre and patent are still not significant at a 10 percent level. However, the goodness of fit of this model is better than the original model even though the R^2-value is lower, as the adjusted R^2-value is 51.6 percent. Both AIC and SC values show better results in this model implying a higher rate of explanation. No autocorrelation is present in the model according to the DW statistic.

Table 6.4: Results of OLS-estimation of the Refined Model, Equation 24. Variables with their coefficients and probability values are presented along with goodness of fit measures and the DW-value.

Variable	Coefficient	Probability		
Constant (α)	0.058135	0.0000	R^2	0.567475
Initial GDP	-0.0000261	0.0013	Adjusted R^2	0.516358
Investments	0.064224	0.0379	Akaike info criterion	-4.458700
Population	-1.215484	0.0017	Schwartz criterion	-4.140281
Agriculture	0.00000246	0.4388	Durbin-Watson stat	2.120664
Education high	1.492331	0.3374		
Infra/km^2	0.014783	0.5412		
Patent	0.00000111	0.2789		
D1	0.029300	0.0033		
D2	0.028576	0.0004		
D3	0.037897	0.0023		
D90-95	0.036331	0.0000		
D95-00	-0.018887	0.0385		
D00-04	-0.003781	0.7586		

As can be seen in Table 6.4 the changes in the coefficients are small in comparison with the original model. Nevertheless, the insignificant variables all become significant when estimations are made of refined models were only one of the variables is included in the following formal way:

$$\begin{aligned} gdp &= \alpha + \beta_1 \cdot initial + \beta_2 \cdot inv + \beta_3 \cdot pop + \beta_4 \cdot agri / eduh / patent / Infra\_km \\ &+ \beta_5 \cdot d1 + \beta_6 \cdot d2 + \beta_7 \cdot d3 + \beta_8 \cdot d90 + \beta_9 \cdot d95 + \beta_{10} \cdot d00 + \varepsilon \end{aligned} \tag{25}$$

Table 6.5 gives an overview of the results from the OLS-estimations of the above models[11].

Table 6.5: Overview of the Results of the OLS-estimations of the Refined Models, Equation 25. Coefficient and probability value of the variable included uniquely in each estimation respectively are presented along with goodness of fit measures and the DW-value for each estimation.

Variable	Coefficient	Probability	R^2	Adjusted R^2	AIC	SC	DW
Agriculture	0.00000499	0.0566	0.5489	0.5089	-4.465	-4.215	2.10
Education high	2.69483	0.0162	0.5574	0.5182	-4.484	-4.234	2.11
Infra/km^2	0.038317	0.0572	0.5488	0.5089	-4.465	-4.215	2.15
Patent	0.00000162	0.1030	0.5449	0.5047	-4.456	-4.206	2.18

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[11] Tables with more specific information on the results of the estimations can be found in Appendix 2.

Note that patent has a probability-value slightly above 10 percent and the coefficient is very small. The model with school enrolment in higher education is the best fitted according to all of our goodness of fit measures. Since all variables are significant on their own but not together there are reasons to suspect that these variables might be mutually dependent. We therefore proceed with investigating the existence of multicollinearity. We begin with creating a correlation matrix with the four variables, presented in Table 6.6.

Table 6.6: Matrix Showing the Correlation Coefficients between the Variables Agriculture, Higher Education, Infrastructure and Patent.

	Agriculture	Education high	Infra/km^2	Patent
Agriculture	1.000	0.822	0.699	0.409
Education high	0.822	1.000	0.716	0.420
Infra/km^2	0.699	0.716	1.000	0.544
Patent	0.409	0.420	0.544	1.000

The table shows that enrolment in higher education and productivity in the agricultural sector are correlated with 0.822, confirming the presence of multicollinearity. The length of highways per square kilometre also shows worrying correlation coefficients with agriculture and higher education. To get more information on their mutual dependence we continue with estimating auxiliary regressions. One of the explanatory variables is made the dependent one in order to find out if the other variables explain the variation in it. The results are shown in Table 6.7.

Table 6.7: R^2-values of Auxiliary Regressions where Each Indicated Variable is Dependent on the Other Explanatory Variables in Equation 25.

Dependent Variable	R^2
Agriculture	0.856792
Education high	0.885704
Infra/km^2	0.751498
Patent	0.410096

According to the results, agriculture and enrolment in higher education are highly dependent on the other variables in the regression. The R^2-values are above 0.8 and the variables should therefore be excluded. Patent is the variable least dependent on the other variables and despite the lowest goodness of fit and the slightly too high probability according to Table 6.5, the model including only patent appears to be the optimal one.

6.2.3 The Optimal Model

In line with the above reasoning the model that in the best way explains the variation in the GDP growth rate for the Chinese provinces takes this form:

$$\begin{aligned} gdp &= \alpha + \beta_1 \cdot initial + \beta_2 \cdot inv + \beta_3 \cdot pop + \beta_4 \cdot patent \\ &+ \beta_5 \cdot d1 + \beta_6 \cdot d2 + \beta_7 \cdot d3 + \beta_8 \cdot d90 + \beta_9 \cdot d95 + \beta_{10} \cdot d00 + \varepsilon \end{aligned} \tag{26}$$

The OLS-estimation of this model is presented in Table 6.8[12] and we accept that the probability-value is slightly above the 10 percent level of significance. 50.5 percent of the variation in GDP growth rates is explained according to the adjusted R^2-value and we find this to be satisfying. AIC and SC also confirm that the model is well fitted. The DW-value of 2.18 rejects the presence of autocorrelation and multicollinearity has been ruled out previously. Before we interpret the coefficients we check for heteroskedasticity in the model. Estimations of the model using White's robust estimator give the same result as the OLS-estimation, hence heteroskedasticity does not exist.

Table 6.8: Results of OLS-estimation of the Optimal Model, Equation 26. Variables with their coefficients and probability values are presented along with goodness of fit measures and the DW-value.

Variable	Coefficient	Probability		
Constant (α)	0.057141	0.0000	R^2	0.544940
Initial GDP	-0.0000106	0.0182	Adjusted R^2	0.504670
Investments	0.062319	0.0360	Akaike info criterion	-4.456300
Population	-1.169109	0.0026	Schwartz criterion	-4.206113
Patent	0.00000162	0.1030	Durbin-Watson stat	2.176090
D1	0.023249	0.0137		
D2	0.026842	0.0007		
D3	0.036220	0.0002		
D90-95	0.037881	0.0000		
D95-00	-0.011365	0.1721		
D00-04	0.011759	0.2521		

According to the estimation of the model, the constant is 0.057 and the GDP growth rate increases with 0.0623 if investments are raised with one unit. A one percentage point increase in population growth is negative with 1.169 for the GDP growth rate. The variable patent, meant to mirror the technological progress in the provinces, influences the GDP growth rate positively, but with a very small coefficient. The dummy variables for the PPI are

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[12] The complete result of the OLS-estimation of the optimal model, equation 26, is found in Appendix 3.

all positive, but in contrast to the original model the coefficients rank the index-values according to our expectations. Having an index-value of 2 is better than 1 and having 3 is better than 2; a step up in the index-hierarchy always has a positive effect. The dummy variable for the time period 1995-2000 has a negative coefficient; external factors during this period affect the GDP growth rate negatively. This does not mean that the GDP growth was negative in this period, but that the growth rate was slower than in the time period 1985-1990. The coefficient for initial GDP is the parameter most essential for answering our research question and it is discussed in the next section.

6.3 Convergence

The parameter β_1 indicates conditional β-convergence in GDP growth rates across the provinces of China since the other variables included in the model are determinants of the steady state level of GDP. The negative coefficient for the variable initial means that provinces with high initial GDP per capita have a lower GDP growth rate. All OLS-estimations have resulted in a significant negative β_1, this is shown in Table 6.9.

Table 6.9: Estimation Results of the Parameter β_1 in all Estimated Models

Estimated Model	β_1	Probability
Original Model (Eq. 1)	-0.0000254	0.0065
Refined Model (Eq. 24)	-0.0000261	0.0013
Optimal Model (Eq. 26)	-0.0000106	0.0182

The results imply convergence in GDP growth rates; provinces that were relatively poor in 1985 have grown faster than the richer provinces. In our optimal model the speed of convergence is 0.0000106; an increase in GDP per capita with 100 RMB implies a 0.00106 percentage point slower GDP growth rate. The catching up process is slow as indicated by the low value of β_1; an economy far away from its steady state grows only marginally faster than an economy close to its steady state. Nevertheless, convergence in GDP growth rates exists across the provinces of China for the period 1985-2004.

7 Concluding Discussion

In the first part of the previous chapter we conclude that the Chinese provinces have different levels of GDP per capita in steady state. The distance between the actual real GDP and the steady state level of GDP per capita varies between the provinces. The fact that the economies differ from each other is a result of the experimental nature of the reform process. Different policy choices in the provinces have resulted in diverse basic conditions for economic growth. Thus, the provinces of China are a heterogeneous group and do not strive for the same steady state ruling out *absolute convergence*. The provincial settings create individual steady states and according to economic theory the economies the furthest from their steady state level will grow at a faster rate; *conditional convergence* will occur.

In our regression the parameter for initial GDP, β_1, represents conditional β-convergence since all explanatory variables included reflect the diverse provincial conditions. All OLS-estimations result in a negative β_1 implying convergence in GDP growth rates across the Chinese provinces 1985-2004. Considering the impact of the other explanatory variables, the parameter β_1 implies that the provinces with lower initial GDP have enjoyed higher GDP growth rates than the provinces with a high level of GDP in 1985. Since the other explanatory variables are those that determine the steady state level of GDP, the conclusion can be made that the province furthest away from its steady state GDP level has grown at a higher rate than provinces closer to their steady state. One unit higher level of initial GDP, 1 RMB, decreases the GDP growth rate by 0.0000106 in our optimal model.

Convergence is present but small, indicating that the pace of the catching up process is slow. Having one unit higher level of GDP in the beginning of the period studied does not have that serious negative effect for the GDP growth rate as could be expected. Other empirical studies of convergence within states have found convergence rates around 0.02, confirming that our β_1 is low. However, empirical studies on China made for years earlier than 1985 find no evidence of either absolute or conditional convergence across the provinces. Compared to these studies our results paint a brighter picture of the future of China's poor provinces. There is a catching up trend and if this continues and accelerates through imitation and the spread of technology across the country, productivity and GDP will increase. Recently, emphasis has been made on development of the western provinces and a successful implementation could speed up the catching up process further. If the Chinese authorities fail to promote growth even further in the poorest parts of China, it will be devastating for the economy as a whole causing growth to slow down and this in turn can create social instability threatening the harmonious society.

It is possible that our results reflect the fact that provinces enjoying strong economic growth in the beginning of the reform period were “rewarded” with preferential treatment inducing further economic development. Provinces with already high levels of GDP were enabled to attract more investments, from both foreign and domestic sources, and thus had more resources to spend on new technology and human capital accumulation. The effect of these uneven preferential policies on GDP growth rates might be strong in the beginning of our time period, but weakening over time leading to a small rate of convergence. With this interpretation the likelihood of continued convergence is high, since the advantages from preferential policies are diminishing over time. For a long time SEZs were the only parts of China allowed to interact with the rest of the world, becoming gateways between China and the world. Chinese production, and thus economic development, was concentrated in these areas since from here, and only here, the products could reach the world market. Today, with China being a member of WTO, these rights are not so exclusive anymore. SEZs are still important since high development and economic stability gives investors higher incentives to invest here. Investments are still at the highest level in the SEZs and foreign investments in particular are shunted into the rest of the country through these “gates”. However, the opening up of other cities in the rest of China will hopefully narrow the gap between backward provinces and the high-tech east coast over time.

Four variables were found to explain the variation in GDP growth rates satisfactorily combined with the same set of additional explanatory variables. These four variables were agriculture, enrolment in higher education, patent and highways per square kilometre. However, when including all four variables in the same model none of them were significant. After performing auxiliary regressions, three of the variables were excluded since they were too dependent on the other variables. Patents granted remained and we established our optimal model. Initial GDP, investments, population growth, patent, and the PPI dummy variables are significant in this model. That patent is included is in line with early reasoning in the thesis; technological transfer is an explanation of convergence. Patents granted was the best available measure of technological progress and its parameter is small in the optimal model. The value of the parameter might increase with a more precise measure of technology. Economic theory states that technological progress is the engine of economic growth and there is a strong probability that the variable has a greater impact on GDP growth rates than shown in our regression.

Our optimal model explains 54 percent of the variation in GDP growth rates according to the R^2-value and 50 percent when consulting the adjusted R^2-value. The goodness of fit is acceptable but there are obviously other factors influencing the rate at which the GDP grows. Variables that we include in the original model in the beginning of our analysis and found insignificant might become significant if the time span is prolonged. Additional variables, such as the size or the productivity of the industrial sector, government spending and household expenditure, can be added in order to improve the goodness of the fit. Furthermore, more precise measures might be possible to find with more time and resources at hand. The provincial data on human capital is scarce in the beginning of our time period, average years of schooling and educational funds are not available for all provinces and this limits both the steady state analysis and the regression. This information is available for recent years and we are confident that data concerning human capital and technology will be much more accessible in the future. Academics around the world have put more emphasis on finding alternatives to the traditional economic indicators. Traditionally, China possesses extensive statistical materials in all levels of society and when this developing country fully adapts western standards of data reporting all statistical analyses on China will become more accurate and precise.

With the data at hand, we can conclude that convergence in GDP growth rates exists across the provinces of China and that the provinces the furthest away from their steady state grew faster during the period 1985-2004. Hence, if the trend continues, the income gap between the Chinese provinces will diminish.

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Appendix 1: Formal Presentation of the Variables Included in the Regression.

Agricultural Sector

To measure the size of the agricultural sector in each province, we want to establish the sector's total factor productivity in every province. We use output per worker, calculated with data for output in farming, forestry, animal husbandry and fishery and the rural labour force engaged in farming, forestry, animal husbandry and fishery.

Foreign Direct Investments (FDI)

Foreign Direct Investments are presented in US Dollars as share of GDP. We convert GDP into US Dollars by using the average exchange rate for each year. The sum of all provinces' FDI does not equal the national total FDI, due to the share of FDI directed at "Ministries and other departments".

Gross Domestic Product (GDP)

Gross Domestic Product for the provinces is presented from 1988 and onwards in China Statistical Yearbook. Prior to 1988, Gross National Income is reported. National total GDP is not the sum of the provinces GDP, due to the decentralized accounting approach. All data is presented at current prices. We use the latest Consumer Prices Index, to convert the nominal GDP to real GDP in 1985 prices. In order to obtain real GDP per capita we divide the real GDP with the population for each year.

Human Capital

Provincial school enrolment rates in primary schools and in institutions of higher education as share of the total population in each province is used to measure the human capital.

Infrastructure

Total length of highways as share of the province's area in km^2 and as share of the province's total population is used to measure the infrastructure.

Investments

Investments in fixed assets are calculated as share of GDP for each province.

Patent

The average numbers of patents granted during the time periods are used to reflect differences in technology across provinces.

Population

The sum of the provinces' populations does not equal the national total population since military personal is included in the national total but not in the provincial data. Population growth rate is calculated for each province.

Preferential Policy Index

The Preferential Policy Index was created by Démurger et al (2002) and is based on the number of open economic zones in a province and the extent of the preferential treatment. The open economic zones are classified according to their importance in the following way:
Weight = 3: SEZ and Shanghai Pudong New Area
Weight = 2: ETDZ and BECZ
Weight = 1: COC, COEZ, OCB, MC, BA, and CC
Weight = 0: No open zone
The index relies on available information on open economic zones across China and does not take into account other factors, such as the business environment, and covers the period 1978-1998. The whole country has opened up significantly with the accession to the WTO in 2001 and we have upgraded the index with help of information from the website of *China Association of Development Zones* (2006). The whole index can be seen in Table A1. Dummy variables are created to reflect the index in the regression; *d1* = index value 1, *d2* = index value 2, *d3* = index value 3.

Time Period Dummies

The time period 1985-2004 is divided into five-year periods and a dummy is created for every period in order to reflect possible external events during that time period that could have an impact on the variables in the regression. *d90* represents the period 1990-1995, *d95* the period 1995-2000 and *d00* the period 2000-2004.

Table A1: Preferential Policy Index 1985-2004

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Beijing	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2
Tianjin	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Hebei	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Shanxi	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2*	2	2	2
Inner Mongolia	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Liaoning	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Jilin	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2
Heilongjiang	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2
Shanghai	1	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Jiangsu	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Zhejiang	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Anhui	0	0	0	0	0	0	0	1	2	2	2	2	2	2	2	2	2	2	2	2
Fujian	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Jiangxi	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	2*	2	2	2	2
Shandong	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Henan	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	2*	2	2	2	2
Hubei	0	0	0	0	0	0	0	1	2	2	2	2	2	2	2	2	2	2	2	2
Hunan	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	2*	2	2	2	2
Guangdong	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Guangxi	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Hainan	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Chongqing**	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2
Sichuan**	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2	2
Guizhou	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	2*	2	2	2	2
Yunnan	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2
Tibet	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	2*	2	2	2
Shaanxi	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	2*	2	2	2	2
Gansu	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2*	2	2
Qinghai	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	2*	2	2	2	2
Ningxia	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	2*	2	2	2
Xinjiang	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2

Source: Démurger et al 2002. * Index upgraded with information from *China Association of Development Zones* 2006.

** All data for Chongqing is obtained from *China Association of Development Zones* 2006. Sichuan's index-values are adjusted accordingly.

Appendix 2: Results of OLS-estimations of Refined Models, Equation 25.

Results from OLS-estimations of models including the variables agriculture, higher education, infrastructure and patent individually, equation 25. Variables with their coefficients and probability values are presented along with goodness of fit measures and the DW-value.

Table A2.1: OLS-estimation, Refined Model with Agriculture, Equation 25.

Variable	Coefficient	Probability		
Constant	0.061068	0.0000	R^2	0.548867
Initial GDP	-0.00002	0.0066	Adjusted R^2	0.508944
Investments	0.049750	0.0877	Akaike info criterion	-4.464965
Population	-1.218629	0.0016	Schwartz criterion	-4.214779
Agriculture	0.00000499	0.0566	Durbin-Watson stat	2.103667
D1	0.027473	0.0056		
D2	0.027274	0.0005		
D3	0.036981	0.0001		
D90-95	0.035459	0.0000		
D95-00	-0.016129	0.0748		
D00-04	0.008165	0.4474		

Table A2.2: OLS-estimation, Refined Model with Higher Education, Equation 25.

Variable	Coefficient	Probability		
Constant	0.063423	0.0000	R^2	0.557405
Initial GDP	-0.0000228	0.0018	Adjusted R^2	0.518237
Investments	0.053700	0.0623	Akaike info criterion	-4.484073
Population	-1.236756	0.0013	Schwartz criterion	-4.233887
Education high	2.694828	0.0162	Durbin-Watson stat	2.105543
D1	0.026854	0.0049		
D2	0.029649	0.0002		
D3	0.046962	0.0000		
D90-95	0.037041	0.0000		
D95-00	-0.015023	0.0767		
D00-04	-0.000588	0.9610		

Table A2.3: OLS-estimation, Refined Model with Infrastructure/km^2, Equation 25.

Variable	Coefficient	Probability		
Constant	0.053721	0.0000	R^2	0.548796
Initial GDP	-0.0000161	0.0058	Adjusted R^2	0.508866
Investments	0.071583	0.0195	Akaike info criterion	-4.464807
Population	-1.280280	0.0010	Schwartz criterion	-4.214621
Infra/km^2	0.038317	0.0572	Durbin-Watson stat	2.152669
D1	0.022201	0.0171		
D2	0.025048	0.0014		
D3	0.032494	0.0012		
D90-95	0.038066	0.0000		
D95-00	-0.011271	0.1709		
D00-04	0.010025	0.3335		

Table A2.4: OLS-estimation, Refined Model with Patent, Equation 25.

Variable	Coefficient	Probability		
Constant	0.057141	0.0000	R^2	0.544940
Initial GDP	-0.0000106	0.0182	Adjusted R^2	0.504670
Investments	0.062319	0.0360	Akaike info criterion	-4.456300
Population	-1.169109	0.0026	Schwartz criterion	-4.206113
Patent	0.00000162	0.1030	Durbin-Watson stat	2.176090
D1	0.023249	0.0137		
D2	0.026842	0.0007		
D3	0.036220	0.0002		
D90-95	0.037881	0.0000		
D95-00	-0.011365	0.1721		
D00-04	0.011759	0.2521		

Appendix 3: Complete Results of the OLS-estimation of the Optimal Model.

Table A3.1: The Complete Results of the OLS-estimation of the Optimal Model, Equation 26, taken from EViews.

```
Dependent Variable: GDP
Method: Least Squares
Date: 05/04/06   Time: 12:58
Sample: 2 125
Included observations: 124
========================================================================
     Variable          Coefficient    Std. Error    t-Statistic    Prob.
========================================================================
        C               0.057141      0.009874      5.787143     0.0000
     INITIAL           -1.06E-05      4.43E-06     -2.396697     0.0182
       INV              0.062319      0.029359      2.122656     0.0360
       POP             -1.169109      0.380342     -3.073836     0.0026
     PATENT             1.62E-06      9.83E-07      1.643838     0.1030
        D1              0.023249      0.009285      2.504050     0.0137
        D2              0.026842      0.007675      3.497204     0.0007
        D3              0.036220      0.009340      3.878130     0.0002
       D90              0.037881      0.006767      5.598024     0.0000
       D95             -0.011365      0.008271     -1.374176     0.1721
       D00              0.011759      0.010215      1.151136     0.2521
========================================================================
R-squared               0.544940    Mean dependent var         0.086417
Adjusted R-squared      0.504670    S.D. dependent var         0.035505
S.E. of regression      0.024988    Akaike info criterion     -4.456300
Sum squared resid       0.070558    Schwarz criterion         -4.206113
Log likelihood          287.2906    F-statistic                13.53192
Durbin-Watson stat      2.176090    Prob(F-statistic)          0.000000
========================================================================
```