International Institute for
Applied Systems Analysis
Schlossplatz 1
A-2361 Laxenburg, Austria

Tel: +43 2236 807 342
Fax: +43 2236 71313
E-mail: publications@iiasa.ac.at
Web: www.iiasa.ac.at

**Interim Report** **IR-02-080**

# The Dynamics of Economic Growth 1985–2000 in Chinese Provinces

*Krister Sandberg*
*CERUM and the Department of Economics*
*Umeå University*
*SE-901 87 Umeå*
*Sweden*
*krister.sandberg@econ.umu.se*

**Approved by**

*Günther Fischer(fisher@iiasa.ac.at)*
Leader, Land Use Change Project

December 2002

# Abstract

This paper concerns the provincial growth pattern in China during the period 1985–2000. The hypothesis that provinces with similar growth rates are more spatially clustered than by pure chance is tested. In addition, we test the convergence hypothesis. We find evidence of spatial dependence between neighboring provinces and solve it by including a spatial lag, alternatively a spatial error term, in the growth equation. Other important factors explaining the provincial economic growth are foreign direct investments, infrastructure, preferential policies, and the distribution of industrial enterprises.

Keywords: GDP-growth, Provincial disparities, Spatial dependence
Classification [JEL]: O18, R11, R12

# The Dynamics of Economic Growth 1985–2000 in Chinese Provinces

*Krister Sandberg*[*]
*CERUM and the Department of Economics*
*Umeå University*
*SE-901 87 Umeå*
*Sweden*
*krister.sandberg@econ.umu.se*

## 1 Introduction

China is characterized by considerable provincial disparities, especially between the eastern and western parts. The purpose of this paper is to explain these differences in economic growth and for the first time test and solve for spatial dependence (inherent systematic dependence between the provinces unexplained by traditional variables). Since previous studies have not considered this, biased and inefficient estimates, might have been presented.

During the last decades, China has had an exceptionally high growth rate. Expressed in year 2000–prices, the Gross Domestic Product (GDP) per capita has risen from 855 Yuan in 1985 to 7,078 Yuan in 2000, an increase of over 700%. However, this increase in wealth is not equally distributed. In the year 2000, the Shanghai province had the highest GDP per capita level (27,187 Yuan), which should be compared with the poorest province, Guizhou, with only 2,818 Yuan per capita. To illustrate the present situation, the year 2000 GDP per capita levels for the Chinese provinces are presented in Figure 1 below.

The three metropolises Beijing, Shanghai, and Tianjin are highly industrialized and are today the provinces with the highest GPD per capita. The coastal provinces in the southeast have since the reforms started in 1978 (decentralization of the agricultural production, decentralization of the fiscal system, diversification of the ownership structure, and the introduction of the Open Door Policy) experienced a rapid growth in GDP per capita and are now among the richest provinces within the country. These provinces have a special status due to the preferential policies levied by the government and have become the new engines of growth in the Chinese economy. In the northeast we find the old industrialized center, collectively called Manchuria. During the pre-reform era, the highest GDP per capita in China were found within this area. Even though they have not experienced such a rapid growth as the coastal provinces in the southeast, the GDP per capita is still among the highest in China. The central provinces, between the Yellow river and the Yangtze

---

[*] The author wishes to thank IIASA, FORMAS, Associate Professor Lars Westin and Assistant Professor Johan Lundberg from CERUM, and discussant Professor Peter Rogerson at the 49th Annual North American Meetings of the Regional Science Association International in San Juan, Puerto Rico, November 14-16, 2002, for their valuable comments.

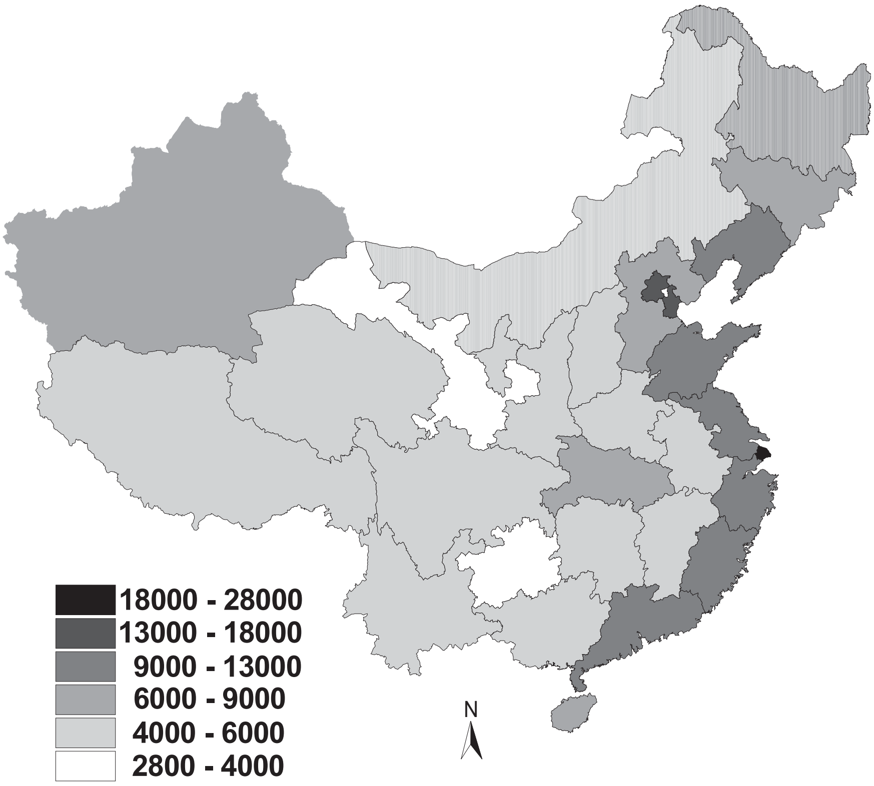

Figure 1: GPD per capita in the Chinese provinces. Year 2000. Source: China Statistical Yearbook 2001

river, have a high population density and are suited for agriculture. The southwestern provinces are also, from a climatic perspective, suited for agriculture but suffer from being inaccessible because of the mountains. These provinces have in general had a low annual GDP per capita growth since the start of the reforms. In the northwestern part of China we find provinces like Tibet, Xinjiang, and Qinghai, provinces characterized by high elevation and a low degree of transport infrastructure.

Our task is thus to determine the factors behind the spatial growth pattern, while considering the fact that provinces may be dependent on each other in positive and negative ways.

The rest of the paper is organized as follows. The next section gives a review of previous studies on provincial economic growth in China. Section three addresses the methodological issues followed by a presentation of data in the fourth section. The fifth section uses an exploratory data analysis to investigate the occurrence of spatial dependence. Estimation of the provincial economic growth follows in the sixth section. Findings are summarized in the final section.

## 2 Previous Studies

The income differences between the Chinese provinces have not always been large. In fact, they were actually reduced when the reforms started in 1978, because the now successful provinces began their rapid growth from a relatively low level. The shift over to increasing income disparities started in the second part of the 1980's, cf. (Dmurger 2001). Although growth is positive, large income disparities may in the long run cause social instability. This is also acknowledged by the government, which therefore established a Western Region

Development Office and the “Go West” strategy to boost the economy in the western part of China.

When the communists came to power in 1949, one of their particular objectives was to provide equal wealth to the whole population. This was accomplished through a strong central policy, redistribution of income and resources from wealthy to poor provinces, and large–scale investments in the poorer provinces. However, this hampered the overall growth in China, and the system was abandoned in favor of new reforms in 1978. The reforms included decentralization of the agricultural production, decentralization of the fiscal system, diversification of the ownership structure, and especially introduction of the Open Door Policy. The Open Door Policy started on a small scale in the early 1980’s when areas within the provinces of Guangdong and Fujian were given status as Special Economic Zones to attract foreign investments. This was followed in the mid 80’s by opening up other areas for increased international trade and foreign investments. In the beginning of the 90’s the Open Door Policy was extended throughout the country by creating new economic zones and areas.

The literature on the Chinese economy and its spatial income disparities, especially after the introduction of reforms in 1978, is numerous. Many contributions consider the question of convergence, both conditional and unconditional, of economic growth between provinces, e.g. (Chen and Fleisher 1996), (Tian 1999), and (Yao and Zhang 2001). In these studies geographic and policy factors, are often controlled for by including dummy variables for the coastal provinces. One exception is (Dmurger et al. 2002) that instead uses a preferential policy index based on the different degrees of openness among the provinces. They also argue that the topography, measured as the average elevation and slope of the province, is an important factor. Transportation endowment or infrastructure, usually measured as the sum of length of railway, highway, and waterway per area unit, is considered by (Yao and Zhang 2001). The length of each transport mode is then converted into equivalent highways based on the transport work of each mode. State Owned Enterprises (SOE) are generally considered less competitive than other forms of ownership, and a large share of these has had a negative effect on the income growth, as shown by e.g. (Chen and Feng 2000). (Dmurger 2001) uses the share of collectively owned enterprises of total industrial production to control for the internal reform process. (Fleisher and Chen 1997) argues that the factor productivity in non–coastal provinces is a principal reason behind low economic growth despite high rates of investment relative to provincial GDP. The importance of human capital is also acknowledged in the literature. It is often measured as enrollment in higher education divided by the working population or the total population, e.g. (Chen and Feng 2000). The role of Foreign Direct Investments (FDI) has so far been important for explaining income disparities in the Chinese economy (Graham and Wada 2001). On the other hand (Zhang and Kristensen 2001) argues that the FDI should in principle enlarge the disparities but does not find supporting evidence for their argument. (Yao and Liu 1998) studied the problem of income disparities from a rural perspective. The policy levied by the government and the uneven development of rural township and village enterprises (TVE) have contributed to the provincial disparities. (Wu 2000) study the problem from an international perspective, considering the two Chinese provinces Guangdong and Fujian together with Hong Kong and Taiwan in a factor productivity approach. (Oi 1999) explores the role of the local authorities in the economic transition from 1978 to the mid 1990’s in the counties and provinces and finds that the most important factor for local growth is the property rights to means of production. (Ying 2000), as the only study that was found considering spatial dependence, uses an exploratory data analysis to investigate whether there are spread or spillover effects from the core to the periphery provinces using non weighted GDP. The author finds evidence of economic spillovers from the Guangdong province to nearby provinces but also a pattern of polarization. It is also concluded that preferential policies plays a major role in the direction of this process.

This paper contribute to the literature on economic growth in China by not only investigating the presence of previous neglected spatial dependence but by also solving it by including a spatial lag alternatively a spatial error term in the growth equation.

## 3 Theoretical Considerations

The neoclassical growth theory is provided by (Solow 1956), (Swan 1956), and (Koopmans 1965). In order to develop it methodologically, we will below follow (Glaeser et al. 1995). The growth function is then defined as:

$$\boldsymbol{g} \quad = \quad f(\boldsymbol{x}, \boldsymbol{x}^*(\boldsymbol{Z})) \tag{1}$$

where $\boldsymbol{g}$ is a vector of annual rate of growth per capita output over the provinces, in this case GDP per capita, $\boldsymbol{x}$ is the current GDP per capita level, and $\boldsymbol{x}^*(\boldsymbol{Z})$ is the steady–state level of per capita output. At the steady–state level, the level of output per worker still increases due to exogenous labor–augmenting technological innovations, although the output per effective labor will remain constant (Chen and Feng 2000). In an economy such as that, the output, investment, and consumption can grow at the same rate. In addition to political and social institutions the steady-state level of growth is also influenced by economic and demographic factors.

Given $\boldsymbol{x}^*(\boldsymbol{Z})$, an increase in output decreases its rate of growth due to diminishing returns to scale (i.e. $(\partial \boldsymbol{g})/(\partial \boldsymbol{x})$¡0). Given $\boldsymbol{x}$, an increase in the eventual equilibrium level output $\boldsymbol{x}^*(\boldsymbol{Z})$, as a consequence of improvements in the exogenous conditions, will increase the growth rate of output (i.e. $(\partial \boldsymbol{g})/(\partial \boldsymbol{x}^*(\boldsymbol{Z}))$¿0).

Hence, in the equations to be developed for our regressions later, $\boldsymbol{x}$, is the initial GDP per capita level and $\boldsymbol{x}^*(\boldsymbol{Z})$ the explanatory variables.

In addition, another important issue to consider is the spatial pattern of regional growth. It has recently achieved attention by (Nijkamp and Poot 1998), (Bal and Nijkamp 1998), (Rey and Montouri 1999), (Wheeler 2001), and (Aronsson and Lundberg 2002).

Two types of spatial dependence are tested for in this paper. The first type is present if spatial correlation in the dependent variable between observations exists. This means that the rate of growth in one province is influenced by the rate of growth of nearby provinces and vice versa, cf. (Anselin 1988) and (Can 1992). If ignored, the OLS estimates will be biased and hence lead to incorrect inference. Adding a spatial lag to the growth equation solves the problem of the first type of spatial dependence:

$$\boldsymbol{g} \quad = \quad \rho \boldsymbol{W} \boldsymbol{g} + \boldsymbol{X} \boldsymbol{\beta} + \boldsymbol{\varepsilon} \tag{2}$$

where $\rho$ is the autoregressive coefficient. $\boldsymbol{W}$, with elements $w_{ij}$ corresponding to observation pair $i$ and $j$, is the generalized weight matrix, and $\boldsymbol{W}\boldsymbol{g}$ is the spatially lagged dependent variable.

The second type of spatial dependence arises when the error term of an observation is correlated with the error terms of observations located nearby i.e. lack of stochastic independence between observations, e.g. (Cliff and Ord 1972, 1973). If unsolved, this will violate the standard error assumptions under normality of the linear regression model, resulting in inefficient estimates. In this case the spatial dependence is incorporated in the growth equation via an autoregressive error term:

$$\begin{aligned} \boldsymbol{g} &= \boldsymbol{X\beta} + \boldsymbol{\varepsilon} \\ \boldsymbol{\varepsilon} &= \lambda \boldsymbol{W\varepsilon} + \boldsymbol{\xi} \end{aligned} \tag{3}$$

$\boldsymbol{W\varepsilon}$ is a spatial lag for the error term, $\lambda$ is the autoregressive coefficient and $\boldsymbol{\xi}$ is a vector of well behaved error terms $\boldsymbol{\xi} \backsim N(0, \delta^2 \boldsymbol{I})$.

In terms of the general framework the spatial structure is incorporated via $\boldsymbol{X}^{**}$ so that the growth is determined by the initial GDP per capita level, explanatory variables, and the spatial dependence.

$$\boldsymbol{g} = f(\boldsymbol{x}, \boldsymbol{x}^{*}(\boldsymbol{Z}), \boldsymbol{X}^{**}) \tag{4}$$

## 4 The Chinese Provincial Data

Four time periods are studied, 1985–2000, 1985–1990, 1990–1995, and 1995–2000 using data on Chinas 30 provinces. All economic variables are measured in 2000 money value. The data were collected from various China Statistical Yearbooks and (Hsueh et al. 1993). In addition, data on provincial capital coordinates and area were gathered from the LUC project database at IIASA. The variables were selected based on previous studies and the underlying economic growth theory to proxy for important factors explaining the provincial economic growth. Some descriptive statistics are presented in Table 1.

Table 1: Descriptive Statistics and Hypothesised Signs

| Variable | Unit | Mean | St.dev | Min | Max | Sign |
|---|---|---|---|---|---|---|
| GDPC_8500 | Yuan/capita | 6.64 | 1.69 | 3.41 | 11.30 | |
| GDPC_8590 | | 2.12 | 2.26 | -5.82 | 6.04 | |
| GDPC_9095 | | 10.20 | 4.02 | 3.73 | 19.42 | |
| GDPC_9500 | | 7.58 | 1.79 | 3.54 | 12.05 | |
| EDUP_1985 | Graduates/capita | 0.0009 | 0.0006 | 0.0004 | 0.003 | (+) |
| EDUP_1990 | | 0.0014 | 0.0010 | 0.0007 | 0.005 | |
| EDUP_1995 | | 0.0016 | 0.0010 | 0.0007 | 0.005 | |
| SOE_TF_1985 | SOE/Total | 0.27 | 0.12 | 0.08 | 0.67 | (-) |
| SOE_TF_1990 | | 0.24 | 0.12 | 0.08 | 0.64 | |
| SOE_TF_1995 | | 0.26 | 0.12 | 0.12 | 0.63 | |
| TPAREA_1985 | km/km$^2$ | 0.24 | 0.15 | 0.014 | 0.63 | (+) |
| TPAREA_1990 | | 0.26 | 0.17 | 0.016 | 0.71 | |
| TPAREA_1995 | | 0.29 | 0.20 | 0.019 | 0.81 | |
| DINVC_8500 | 10' rmb/capita | 1760.51 | 1576.94 | 485.40 | 7928.41 | |
| DINVC_8590 | | 1057.80 | 836.76 | 322.25 | 3929.98 | (+) |
| DINVC_9095 | | 1649.41 | 1462.16 | 403.50 | 7021.10 | |
| DINVC_9500 | | 2574.30 | 2479.02 | 730.45 | 12834.17 | |
| FDIC_8500 | USD/capita | 22.20 | 33.62 | 0.001 | 124.60 | |
| FDIC_8590 | | 4.62 | 8.82 | 0.003 | 32.94 | (+) |
| FDIC_9095 | | 24.02 | 36.58 | 0 | 132.99 | |
| FDIC_9500 | | 37.96 | 57.72 | 0 | 215.93 | |
| PREF_8500 | Index | 1.35 | 0.81 | 0.56 | 3 | |
| PREF_8590 | | 0.78 | 1.10 | 0 | 3 | (+) |
| PREF_9095 | | 1.47 | 0.79 | 0.67 | 3 | |
| PREF_9500 | | 1.80 | 0.66 | 1 | 3 | |

The dependent variable, GDPC, is the average annual growth per capita over a specific time period. For the period 1985–2000 the average annual growth per capita was 6.64%, with a range between 3.41 and 11.30. The biggest range, 3.73 to 19.42%, is found in the first five years of the 90's.

The human capital (EDUP) is here proxied by the number of graduates from Institutions of Higher Education and Specialized Secondary Schools divided by the provincial total population for the years 1985, 1990, and 1995 respectively. Over the years this share has increased from an average of 0.0009 in 1985 to 0.0016 ten years later. The sign is expected to be positive. The transport capacity is captured in the variable TPAREA for the same three years. It is measured as the total length of railways in operation, navigable inland waterways and length of highways in kilometers/km$^2$. As expected, the endowment has increased over the years, but the range between the best and the worst province has also increased. The sign for this variable is expected to be positive.

Two variables deal with capital accumulation. DINV is measured as the annual domestic investment in 10,000 rmb/capita averaged over the different time periods. The amount of Foreign Direct Investment (FDIC) is measured in USD/capita averaged over the actual time period. Both variables show an increase over time. They are both expected to turn up with positive signs.

The next two variables characterize the institutional structure in the provinces. SOE_TF, is the number of state owned enterprises divided by the total number of enterprises. The average share is about 25%, but for some regions more than 60% of the province companies are state owned. Since they are generally considered less profitable, the expected sign is negative. The other variable is the preferential policy (PREF) levied by the government upon each province. It is constructed as an index based on the degree of openness. Following (Dmurger 2002) the index is constructed in 4 groups with different weights as shown in Table 2. These weights are then averaged over the specific time periods. The sign is expected to be positive for this variable.

Table 2: Preferential Policy Index

| Variable | Weight |
|---|---|
| *No open zone* | 0 |
| *Coastal Open Cities*<br>*Coastal Open Economic Zones*<br>*Open Coastal Belt*<br>*Major Cities along the Yantze river*<br>*Bonded Areas*<br>*Capital Cities of inland provinces and autonomous regions* | 1 |
| *Economic and Technological Development Zones*<br>*Border Economic Cooperation Zones* | 2 |
| *Special Economic Zones*<br>*Shanghai Pudong New Area* | 3 |

To test if the three metropolis provinces, Beijing, Shanghai, and Tianjin have had different growth rates compared to the other provinces due to agglomeration effects a dummy variable, D_CITY, was constructed which takes the value one for these provinces, otherwise zero. The sign is expected to be positive.

## 5 Spatial Exploratory Data Analysis

Before we proceed and estimate the growth equations, let us first test the hypothesis that the provinces with similar growth rates are more spatially clustered than could be expected from pure chance. One common test used to indicate the possibility of global spatial autocorrelation is the Moran's I test. A similar, but not so well known, is the Geary's C test. To complement and validate these results, the Local Moran's I test (Anselin 1995b) is utilized.

The Moran's I test is defined as:

$$I = \frac{\mathrm{n}}{\mathrm{S}} \frac{\sum_i \sum_j w_{ij}(x_i - \mu)(x_j - \mu)}{\sum_i (x_i - \mu)^2} \tag{5}$$

where n is the number of observations while $x_i$ and $x_j$ are the observed growth rates in locations $i$ and $j$ (with mean $\mu$). S is a scaling constant given by the sum of all weights:

$$\mathrm{S} = \sum_i \sum_j w_{ij} \tag{6}$$

When using row standardized weights, which is preferable according to (Anselin 1995a), S equals n since the weights of each row adds to one. The test statistic is compared with its theoretical mean, $\mathrm{I} = -1/(\mathrm{n}-1)$. So, $\mathrm{I} \rightarrow 0$ as $\mathrm{n} \rightarrow \infty$. The null hypothesis $\mathrm{H}_0 : \mathrm{I} = -1/(\mathrm{n}-1)$ is tested against the alternative hypothesis $\mathrm{H}_a : \mathrm{I} \neq -1/(\mathrm{n}-1)$. If $\mathrm{H}_0$ is rejected and $\mathrm{I} > -1/(\mathrm{n}-1)$, this indicates a positive spatial autocorrelation. That is, high values and low values are more spatially clustered than would be assumed purely by chance. For the other event, if $\mathrm{H}_0$ is again rejected but $\mathrm{I} < -1/(\mathrm{n}-1)$, indicates negative spatial autocorrelation. Hence observations with high and low prices are systematically mixed together. Obviously the test is quite crude. One apparent drawback is that it to a large extent is determined by the a priori choice of the spatial weight matrix. However this is also a test for how well the weight matrix performs and what kind of relationship that exists.

A similar global measure is the Geary's C test, defined as:

$$C = \frac{\text{n-1}}{2\mathrm{S}} \frac{\sum_i \sum_j w_{ij}(x_i - x_j)^2}{\sum_i (x_i - \mu)^2} \tag{7}$$

The theoretical expected value for Geary's C is 1. A value of C less than 1 indicates positive spatial autocorrelation, and a value above 1 indicates negative spatial autocorrelation.

The Local Moran's I test investigates if the values (from the global Moran's I) for each province is significant or not.

$$I_i = \frac{x_i}{\sum_i x_i^2} \sum_j w_{ij} x_j \tag{8}$$

Four different weight matrices are tested in this paper, the 1st and 2nd order contiguity, QUEEN_1, and QUEEN_2, where neighbors are defined as those that share a common border, and two inverse distance matrices using distance and squared distance (arc great circle distance between the province capitals), DIST_1 and DIST_2. All matrices are row–standardized. The results from the global tests are presented in Table 3.

For the annual per capita GDP growth between 1990 and 1995 and for the longer period 1985–2000 the I value is fairly positive and significant, indicating that provinces with similar growth are more clustered together than can be assumed purely by chance. For the period 1985–2000 the I value is significant for the three first weight matrices but insignificant for DIST_2. This might be an effect of the relatively steep decent of influence when the distance increases. The provinces become thereby more isolated. For the Geary's C tests (the right side of the table), we see that it is still more or less the same time periods that are significant and the interpretation is also the same. The main conclusion

Table 3: Moran's I test and Geary's C test for Spatial Autocorrelation between the Chinese provinces (* = using 999 permutations because the normal distribution was in this case rejected by the Wald test and prevented the use of the normal approach)

| Variable | I | Mean | St.Dev | Prob | C | Mean | St.Dev | Prob |
|---|---|---|---|---|---|---|---|---|
| QUEEN_1_*8500* | 0.22 | -0.03 | 0.12 | 0.03 | 0.70 | 1.00 | 0.13 | 0.02 |
| QUEEN_1_*8590** | -0.11 | -0.03 | 0.11 | 0.24 | 1.02 | 1.00 | 0.16 | 0.39 |
| QUEEN_1_*9095* | 0.35 | -0.03 | 0.12 | 0.00 | 0.59 | 1.00 | 0.13 | 0.00 |
| QUEEN_1_*9500* | -0.00 | -0.03 | 0.12 | 0.80 | 0.89 | 1.00 | 0.13 | 0.41 |
| QUEEN_2_*8500* | 0.14 | -0.03 | 0.08 | 0.02 | 0.81 | 1.00 | 0.10 | 0.05 |
| QUEEN_2_*8590** | 0.04 | -0.03 | 0.07 | 0.16 | 0.78 | 1.00 | 0.10 | 0.03 |
| QUEEN_2_*9095* | 0.25 | -0.03 | 0.08 | 0.00 | 0.69 | 1.00 | 0.10 | 0.00 |
| QUEEN_2_*9500* | -0.01 | -0.03 | 0.08 | 0.76 | 0.92 | 1.00 | 0.10 | 0.42 |
| DIST_1_*8500* | 0.04 | -0.03 | 0.04 | 0.04 | 0.90 | 1.00 | 0.05 | 0.03 |
| DIST_1_*8590** | -0.08 | -0.03 | 0.04 | 0.08 | 0.93 | 1.00 | 0.05 | 0.14 |
| DIST_1_*9095* | 0.10 | -0.03 | 0.04 | 0.00 | 0.86 | 1.00 | 0.05 | 0.00 |
| DIST_1_*9500* | -0.01 | -0.03 | 0.04 | 0.58 | 0.93 | 1.00 | 0.05 | 0.12 |
| DIST_2_*8500* | 0.09 | -0.03 | 0.10 | 0.21 | 0.84 | 1.00 | 0.10 | 0.10 |
| DIST_2_*8590** | -0.17 | -0.03 | 0.10 | 0.05 | 1.04 | 1.00 | 0.10 | 0.33 |
| DIST_2_*9095* | 0.23 | -0.03 | 0.10 | 0.01 | 0.73 | 1.00 | 0.10 | 0.01 |
| DIST_2_*9500* | 0.00 | -0.03 | 0.10 | 0.72 | 0.92 | 1.00 | 0.10 | 0.43 |

to draw from Table 3 is that the clustering of provinces seems to be independent of the weight matrix used.

To further investigate this spatial autocorrelation, and to enhance the understanding of the problem of the growth rates in the Chinese provinces, the local test was used and the results are for simplicity presented using maps (Figure 2–Figure 9).

The results for the entire study period 1985–2000 are visible in Figure 2 and Figure 3. The QUEEN_1 and QUEEN_2 in the Moran Scatterplot (the individual I values of the global Moran's I test without considering significance levels) show a Low–Low band (provinces with low growth values surrounded by provinces with low growth values) from Tibet across China to the northeast. A half circle of High–High values (provinces with high growth surrounded by provinces with high growth) is visible in the southeast. But, looking at the Local Moran's I there are only three significant provinces, Fujian and Zhejiang with positive values and Qinghai with a negative value for the QUEEN_1 matrix. For the DIST_1 the Moran Scatterplot is almost the same as the previous ones. Local Moran's I show significant High–High values for Fujian, Zhejiang, and Jiangsu, and Low–High for the Shanghai province. For the second inverse distance weight matrix no change is made in the Moran Scatterplot. The Local Moran's I is now limited to only two High–High provinces, Fujian and Zhejiang.

To see whether the pattern is the same during the whole period or if there have been some changes during these 15 years the material was divided into 3 five–year periods.

For the period 1985–1990, using the QUEEN_1 weight matrix and looking at the Moran Scatterplot the clear pattern from the previous figures has disappeared. There are some clusters of high values in Manchuria and down in the southeast. By looking at the Local Moran's I for the same period for the significant provinces of the former map we conclude that the provinces Guangdong and Fujian lie in a hot spot cluster. If we look at the QUEEN_2 matrix the pattern is even more scattered. The Local Moran's I show significant values for the QUEEN_1 matrix, the coastal cluster of high values and then two provinces with high values on either side of a low growth province in the interior. There are also two low growth provinces close to the coast. For DIST_1 we see a High–High belt going from north to south starting in the interior of China in the Moran Scatterplot. Otherwise it is pretty scattered. The Local Moran's I show significant values only for Tibet, Xinjiang, and Shanghai. DIST_2 gives the same interpretation as DIST_1 in the Moran Scatterplot but

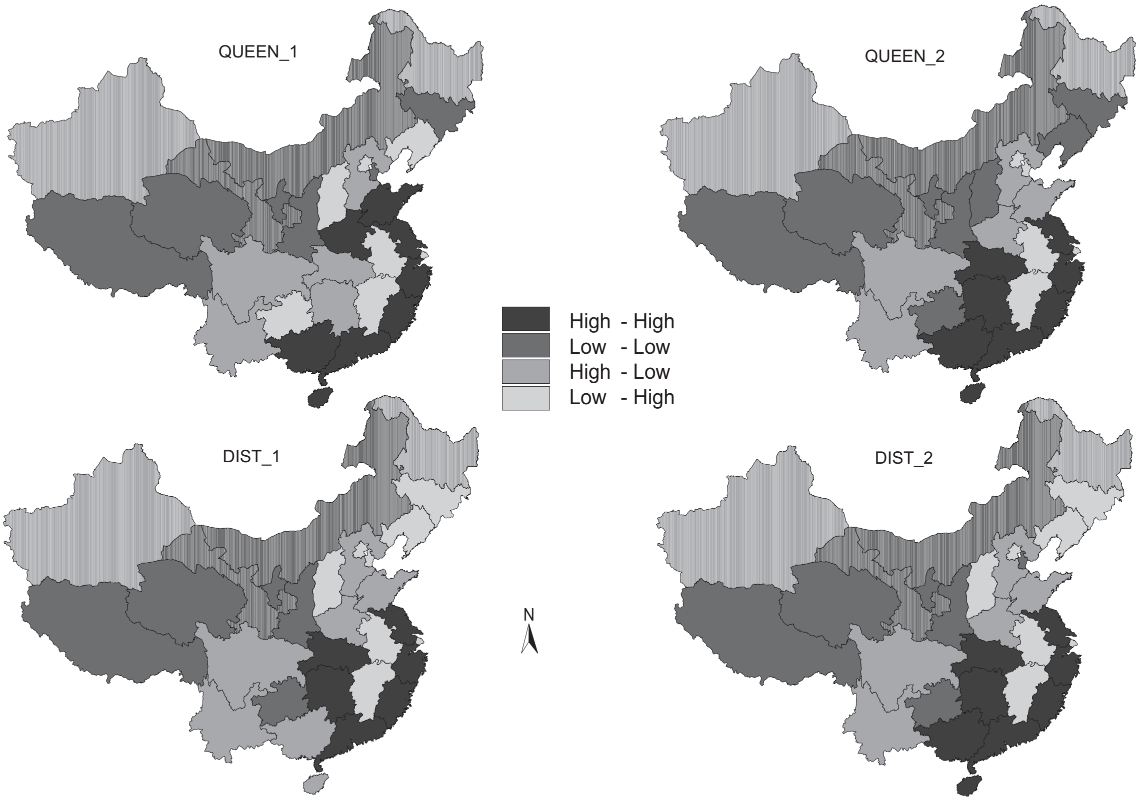

Figure 2: Moran Scatterplot 1985-2000

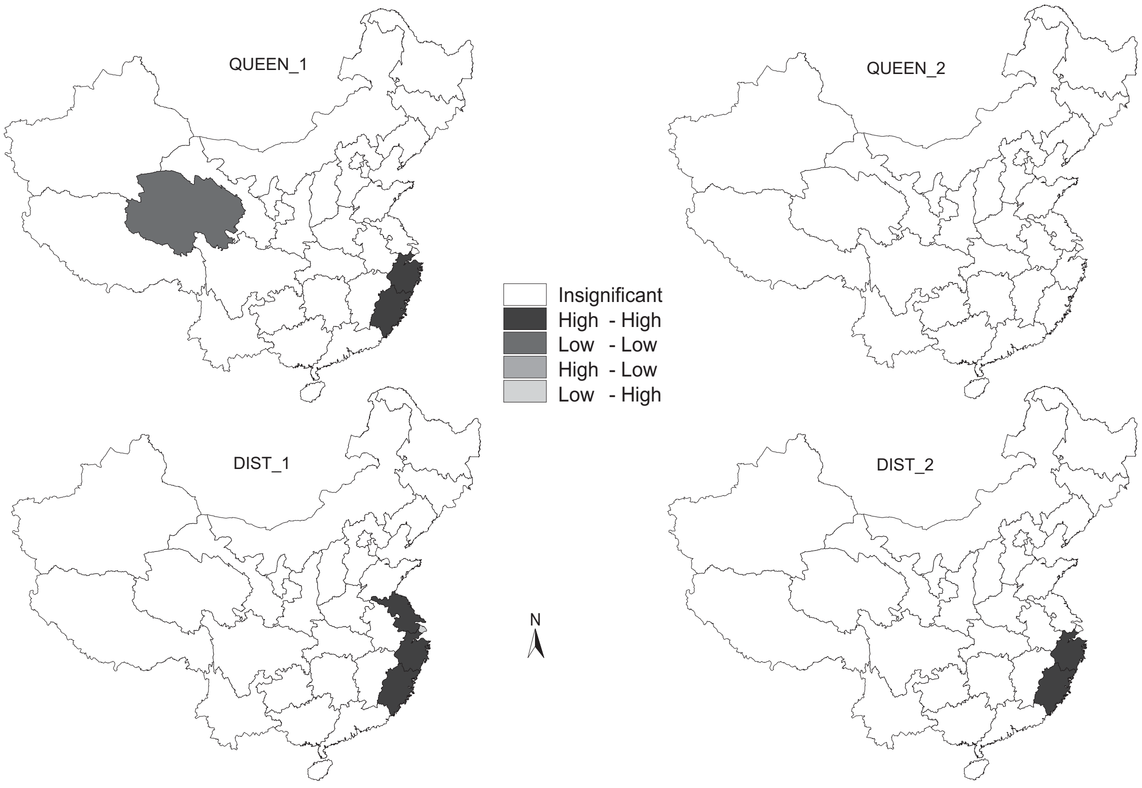

Figure 3: Local Moran's I 1985-2000

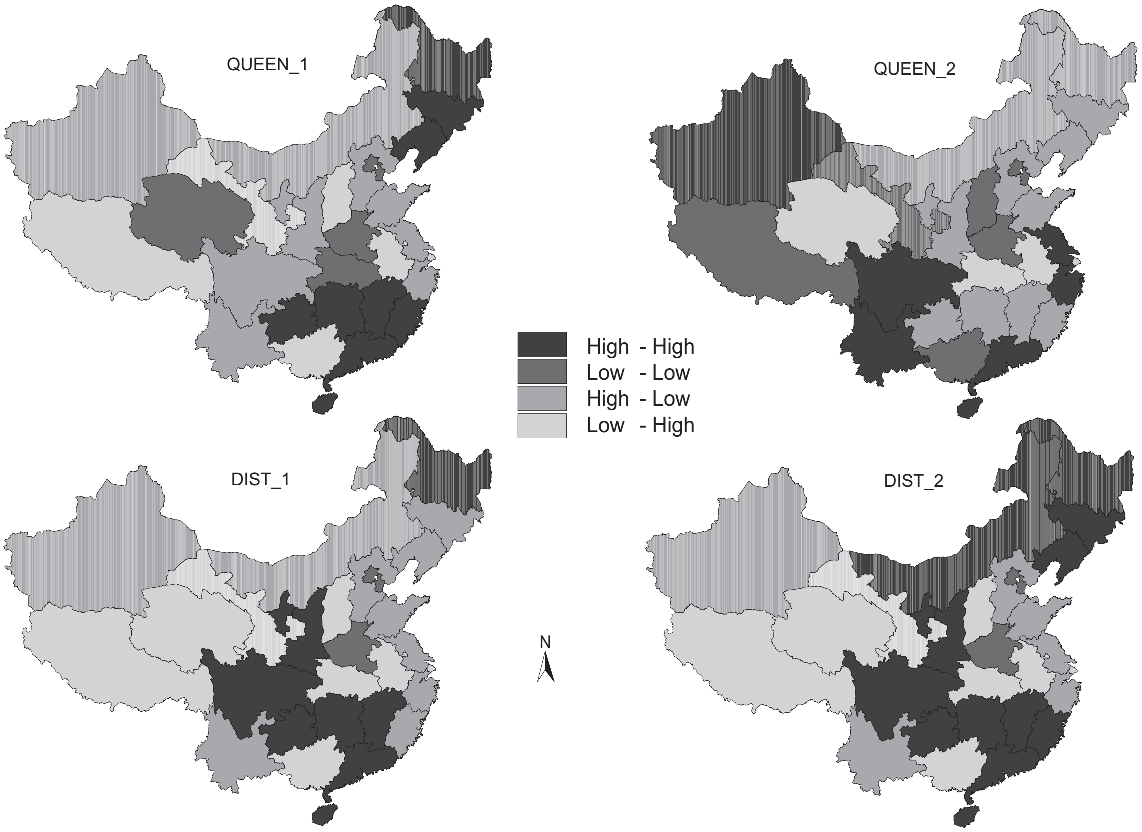

Figure 4: Moran Scatterplot 1985-1990

the High–High belt is now spread all the way up to the northeast Manchuria. The Local Moran's I is as in the former one, except that Shanghai is no longer significant. Since so few provinces where significant in the Local Moran's I test it is not surprising that we were unable to find a strong support in the Moran's I test in Table 3.

In the next five year period, 1990–1995, both global tests, Moran's I and Geary's C, were significant. Looking first at the Moran Scatterplot it reveals a Low–Low field in the central part of China and a cluster of High–High provinces in the coastal region for the QUEEN_1 and QUEEN_2 weight matrices. For the Local Moran's I test, only three hot spot provinces and two with low growth are significant with QUEEN_1. For QUEEN_2 we have four Low–Low provinces and three High–High provinces. So, we can conclude that China has one hot spot area and one area in the interior with much lower growth. The inverse weight matrix DIST_1 show a similar pattern as the contiguity matrices. Turning to the Local Moran's I the same pattern as for the QUEEN_1 is once again found. For the second inverse distance matrix the story is more or less in line with the previous results. The two interior provinces, Qinghai and Ningxia, are negative and significant, while the three coastal provinces Jiangsu, Zhejiang, and Fujian are still significant and positive.

The final period from 1995 to 2000 is interesting because the pattern has changed dramatically. By looking at the Moran Scatterplot for QUEEN_1 and QUEEN_2 we see a scattered pattern. Some clusters are although visible. There is now a Low–Low area in the south and in the Shanghai province, and a High–High area more up around the capital city of Beijing. This is even more accentuated with the second matrix. The DIST_1 gives almost the same results. The Low–Low area is extended from the south up to the interior. The High–High area is now spreading from the Beijing area all along down the coast. The Local Moran's I presents significant negative values for Hainan, Guangxi, Xinjiang, and

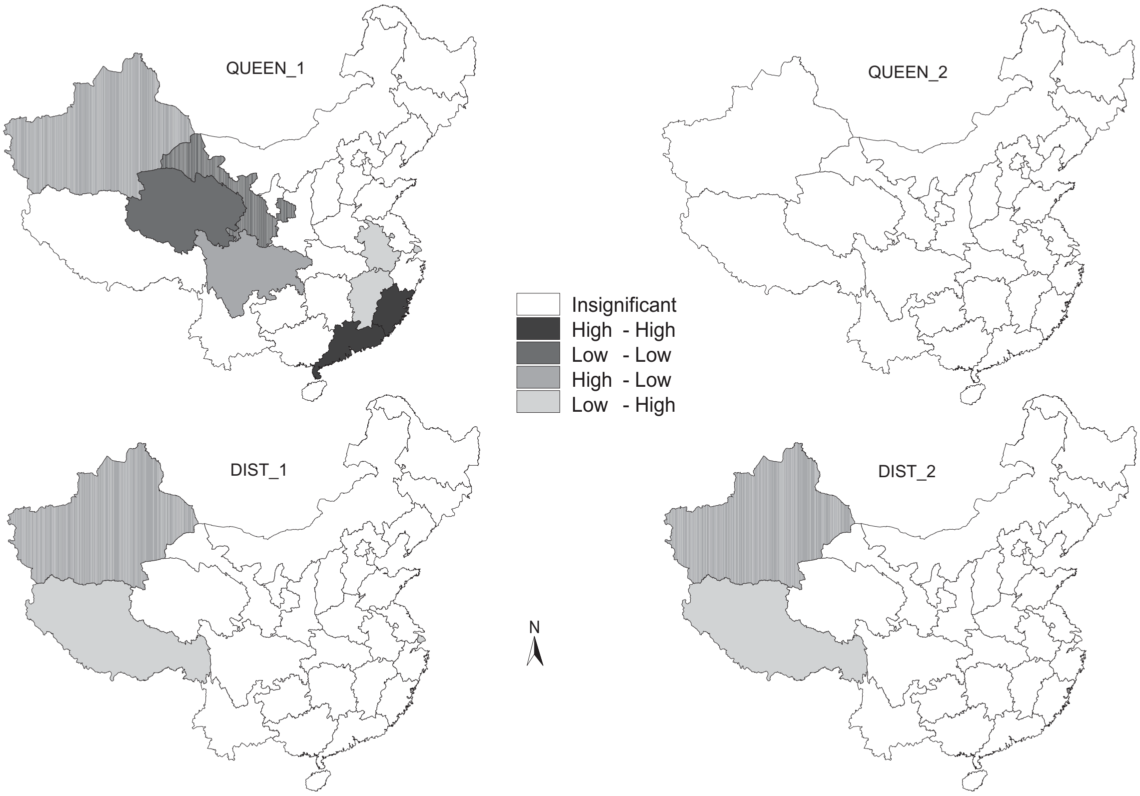

Figure 5: Local Moran's I 1985-1990

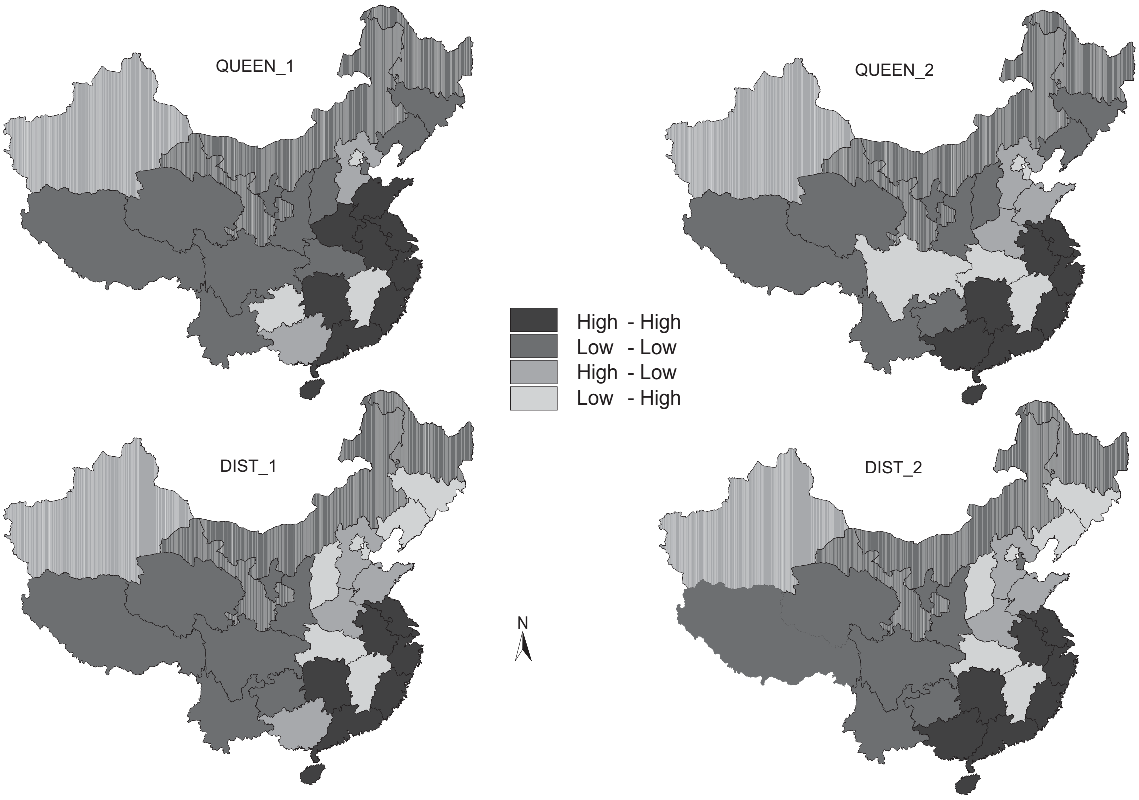

Figure 6: Moran Scatterplot 1990-1995

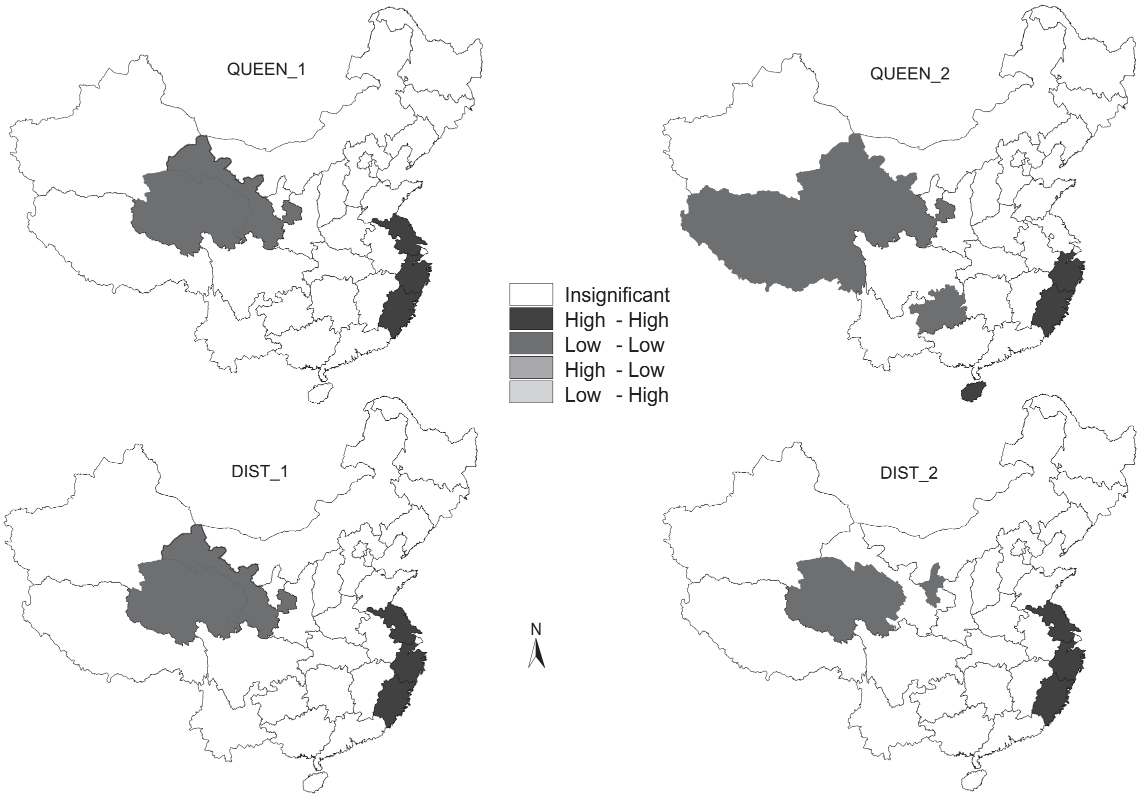

Figure 7: Local Moran's I 1990-1995

Shanxi. Tibet is significant and positive. This also applies for the DIST_2. One conclusion to draw from this is that the economies in the former productive coastal provinces of Fujian, Guangdong and others are no longer that successful in relative terms. This might be a first sign of convergence between the Chines provinces. Tests using the *New* $G_i$* (Ord and Getis 1995) were also performed. These maps are not presented here but are available upon request.

The conclusion of the findings so far is that we did find spatial autocorrelation with the global tests for the periods 1985–2000 and 1990–1995. Then, using local test it was found that the clustering of similar values probably isn't that strong as was first expected. However, some hotspots were found for all time periods, especially in the southeast region. With this knowledge we now proceed to the next step and estimate the growth equations using OLS, and from its errors test for remaining autocorrelation and further needed adjustments using Lagrange Multiplier tests.

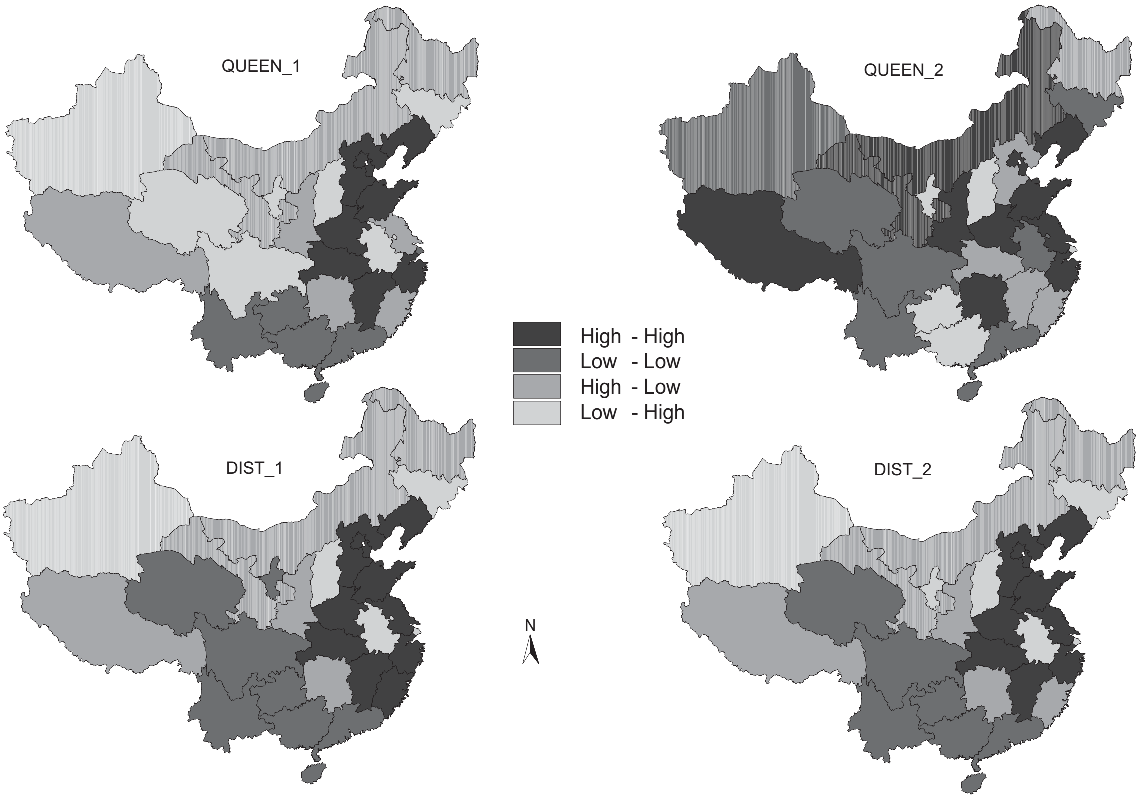

Figure 8: Moran Scatterplot 1995-2000

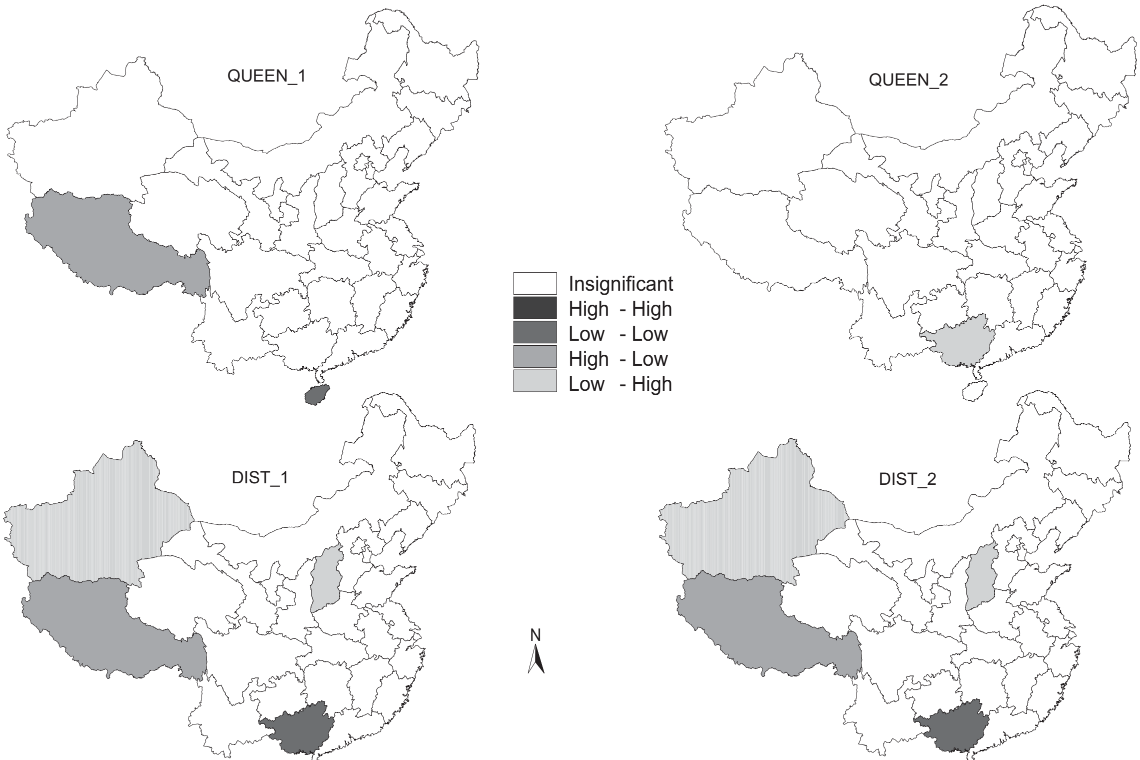

Figure 9: Local Moran's I 1995-2000

## 6 Estimation of Provincial Economic Growth

The regression part is split into two parts. In the first regression the hypothesis of unconditional convergence between the provinces is tested. A normal growth equation is regressed in the second part. In both cases spatial adjustments is added when needed according to the Lagrange Multiplier tests. These tests are Maximum Likelihood tests based on the OLS residuals. One of them tests for spatial error and the other one test for spatial lag. A significant value points in the direction what to include in the extended regression. These test results are not reported here but are available upon request.

The first growth equation has the form:

$$g_{i,t-T} = \beta_0 + \beta_1 GDPC_{i,t-T} + \varepsilon_{i,t} \tag{9}$$

where $t$ and $T$ indicates the start and finish year of the period.

The independent variable in this regression is the initial level of GDP per capita when the period begins. The results from the different periods can be seen in Table 4. Using data for the entire 15 year period gives the initial OLS results and according to the Lagrange Multiplier tests the model should be corrected with an error term correction and that the first order contiguity matrix should be used. This is done using the Spatial Autoregressive Generalized Moments (SAR–GM) estimator since it accepts non-normal distributed errors. The result is presented in the second column. The unconditional variable is negative and highly significant indicating convergence between the Chinese provinces. The autoregressive coefficient $\lambda$ is positive with a value of 0.42.

Table 4: Regression results for GDP/capita. *** and ** indicates significant values at 1% and 5% percent level

| Variable | 8500 | 8500 | 8590 | 9095 | 9095 | 9500 |
|---|---|---|---|---|---|---|
| | OLS | SAR–GM | OLS | OLS | SAR–ML | OLS |
| WEIGHT | | QUEEN_1 | | | DIST_2 | |
| $\lambda$ | | 0.42*** | | | | |
| $\rho$ | | | | | 0.56*** | |
| *Constant* | 7.05*** | 7.42** | 3.43*** | 9.95*** | 4.85** | 7.61*** |
| *GDP_t* | -0.0001 | -0.0003*** | -0.0004** | $7\cdot10^5$ | -0.0001 | $-3\cdot10^7$ |
| $R^2$ | 0.03 | 0.13 | 0.18 | 0.00 | 0.06 | 0.00 |
| $R^2$*-adj.* | -0.00 | | 0.15 | -0.03 | | -0.03 |
| *Sq.corr* | | 0.03 | | | 0.25 | |
| SIG-SQ | 2.85 | 2.12 | 4.33 | 16.73 | 12.71 | 3.31 |
| *Suggestion* | QUEEN_1 | | | DIST_2 | | |

For the first five–year period, 1985–1990, the initial level is negative and significant at the five percent level meaning that we can not reject the hypothesis of convergence across provinces. It is also concluded according to the Lagrange Multiplier tests that no spatial adjustment is needed. The R$^2$ is 18%. For the second five–year period the variable is insignificant, but this time the Lagrange Multiplier tests indicate inclusion of a spatial lag using the more narrow inverse distance weight matrix. This is estimated using Maximum Likelihood. The result from this regression is visible in the fifth column. The constant is significant, but the initial GDP/capita is still not. On the other hand the spatial lag variable is positive and highly significant, suggesting that spillover exists between neighboring provinces, so a high initial GDP per capita level in the neighboring provinces influence the growth in province $i$ in a positive way. The last period, 1995–2000, show that it is only the constant that is significant and there is no indication of spatial dependence.

We will now consider the influence from other explanatory variables. Unfortunately, due to multicollinearity problems the initial GDP per capita level could not be included in these regressions. The second regression has the form:

$$g_{i,t-T} = \beta_0 + \beta_1 EDUP_{i,t} + \beta_2 TPAREA_{i,t} + \beta_3 PREF_{i,t-T} + \\ \beta_4 DINVC_{i,t-T} + \beta_5 FDIC_{i,t-T} + \beta_6 D\_CITY_{i,t} + \beta_7 SOE\_TF_{i,t-T} + \varepsilon_{i,t} \tag{10}$$

Table 5: Regression results for GDP/capita. ***, **, and * indicates significant values at 1, 5, and 10% percent level

| Variable | 8500 | 8590 | 8590 | 8590 | 9095 | 9500 |
|---|---|---|---|---|---|---|
| | OLS | OLS | SAR–IV | SAR–IV | OLS | OLS |
| WEIGHT | | | QUEEN_1 | DIST_2 | | |
| $\rho$ | | | -0.83*** | -0.58** | | |
| *Constant* | 5.39*** | 7.69*** | 7.46*** | 8.71*** | 3.82 | 10.49*** |
| EDUP_$t$ | -568.26 | 915.38 | 1987.99 | -680.59 | -1700 | -661.62 |
| TPAREA_$t$ | 3.01 | -10.85** | -5.71 | -8.82** | 12.36** | -0.95 |
| FDIC_$t$-$T$ | -0.03 | 0.24*** | 0.24*** | 0.24*** | -0.07** | -0.001 |
| DINVC_$t$-$T$ | $8{\cdot}10^6$ | -0.001 | -0.003*** | -0.001 | $-5{\cdot}10^5$ | 0.0002 |
| SOE_TF_$t$ | -3.85* | -14.86*** | -9.55*** | -13.86*** | -2.26 | -2.61 |
| PREF_$t$-$T$ | 2.04*** | 0.75* | 1.11*** | 0.64* | 5.27*** | -0.85 |
| D_CITY | 0.10 | -2.87 | -2.91 | -2.32 | 0.22 | 2.45 |
| $R^2$ | 0.77 | 0.66 | 0.77 | 0.72 | 0.83 | 0.14 |
| $R^2$-*adj.* | 0.70 | 0.55 | | | 0.78 | -0.14 |
| *Sq.corr* | | | 0.81 | 0.78 | | |
| SIG-SQ | 0.84 | 2.30 | 1.33 | 1.60 | 3.62 | 3.64 |
| *Suggestion* | | QUEEN_ 1<br>DIST_2 | | | | |

The long period to regress is once again the 15–year period from 1985–2000. The preferential policy variable together with the constant is significant at the 1% level and SOE_TF is significant at 10%. No spatial adjustment is needed. The fit is despite this rather good, 77%.

As before, we have investigated it for the three sub periods, 1985–1990, 1990–1995, and 1995–2000. The second column show the OLS results from the period 1985–1990. The share of State Owned Enterprises of the total number of enterprises is as expected negative. Negative is also the transport capacity variable. The average Foreign Direct Investment per capita during the period and the preferential policy are both positive and significant. The $R^2$ is 57%. There is also indications of spatial dependence from two of our weight matrices, QUEEN_1 and DIST_2. The spatial regressions are both estimated using a 2SLS approach, due to the non–normal distribution of the errors, with spatially lagged variables as instruments. The results from the inclusion of these are found in column three and four respectively. The spatial lag is significant but with an unexpected negative sign. This means that the provinces are not benefiting from each other. Quite the opposite, they are competing. Most of the other variables have changed in magnitude but have still the same signs. The transport capacity is now insignificant for QUEEN_1. The standard deviation has been lowered by the inclusion of the lag variable. The DIST_2 matrix is used in the next regression. The spatial lag is once again negative but lower than the previous one. The SOE variable is still significant and negative. The transport endowment is negative and significant. The foreign direct investments are robust with a positive and highly significant value in all three regressions. The standard deviation has been lowered compared to the OLS regression.

In the first five–year period of the 1990's the preferential policy is very important for the GDP per capita growth. The transport capacity is also positive. The FDIC is however negative and significant. The fit of the regression is quite high, 83%, and there is no indication of spatial dependence.

The latter part of the 1990's is interesting in that it is only the constant that is significant. Neither are there signs of any spatial dependence. The reason for this unexpected results can perhaps be found in the maps shown earlier in Figure 8 and Figure 9. The former successful provinces are now no longer growing at a higher speed compared to the rest of the Chinese provinces. It appears that this period needs more investigation. In her book (Oi 1999) gives some hints about increased competition from 1995 onwards, more capital is needed, and that the former successful company structure with many collectively owned companies might need a new injection of more privately owned firms to grow.

## 7 Conclusions

In this paper the provincial economic growth in China during the period 1985–2000 has been investigated in two parts. The first part consisted of a search for hot spots in a exploratory data analysis. Some clusters of provinces with a high growth especially in the coastal region in the southeast, and provinces with low growth in the center and western parts of China were found. This was followed by the regression analysis in the second part.

In the regressions to check for unconditional convergence some spatial dependence were found for the periods 1990–1995 and 1985–2000. The spatial variables were in both regressions positive.

In the other regressions the important variables explaining the provincial economic growth were, the preferential policy, the enterprise structure, transport capacity and in the early periods 1985–1990 and 1990–1995 also foreign direct investments. The influence of spatial dependence is not that high. One possible explanation for this could be that the aggregation on province level is to high, resulting in a sample of only 30 observation. Another possible explanation is that the provinces are in fact independent of each other and that the movement actually happens within each province. A similar investigation on county level might have left us with different results.

## References

[1] Anselin, L. (1988). *Spatial Econometrics: Methods and Models.* Dordrecht: Kluwer Academic.

[2] ——— (1995a). *SpaceStat Version 1.80 User's Guide.*

[3] ——— (1995b). "Local Indicators of Spatial Association–LISA." *Geographical Analysis* 27 (2), 93–115.

[4] Aronsson, T., and J. Lundberg (2002). "Including Spatial Effects in an Empirical Analysis of the Local Growth pattern in Sweden 1981–1999." Memo, Sweden: Centre for Regional Science, Ume University.

[5] Bal, F., and P. Nijkamp (1998). "Exogenous and Endogenous Spatial Growth Models." *Annals of Regional Science* 32, 63–89.

[6] Can, Y. (1992). "Specification and estimation of hedonic housing price models." *Regional Science* 22, 453–474.

[7] Chen, B., and Y. Feng (2000). "Determinants of economic growth in China: Private enterprise, education, and openness." *China Economic Review* 11, 1–15.

[8] Chen, J., and B. M. Fleisher (1996). "Regional Income Inequality and Economic Growth in China." *Journal of Comparative Economics* 22, 141–164.

[9] Cliff, A., and K. Ord (1972). "Testing for Spatial Autocorrelation Among Regression Residuals." *Geographical Analysis* 4, 267–284.

[10] ——— (1973). *Spatial Autocorrelation.* London: Pion Limited.

[11] Dmurger, S. (2001). "Infrastructure Development and Economic Growth: An Explanation for Regional Disparities in China?" *Journal of Copmarative Economics* 29, 95–117.

[12] Dmurger, S., and J. D. Sachs, W. T. Woo, S. Bao, G. Chang, and A. Mellinger (2002). "Geography, Economic Policy and Regional Development in China." Discussion Paper Number 1950, March 2002, Harvard Institute of Economic Research.

[13] Fleisher, B. M., and J. Chen (1997). "The Coast–Noncoast Income Gap, Productivity, and Regional Economic Policy in China." *Journal of Comparative Economics* 25, 220–236.

[14] Glaeser, E. L., and J. A. Scheinkman, and A. Shleifer (1995). "Economic Growth in a Cross–Section of Cities." *Journal of Monetary Economics* 36, 117–143.

[15] Graham, E. M., and E. Wada (2001). "Foreign Direct Investment in China: Effects on Growth and Economic Performance." *To appear in Achieving High Growth: Experience of Transitional Economies in East Asia, Peter Drysdale, Editor, Oxford University Press, forthcoming 2001.*

[16] Hsueh, T., L. Qiang, and L. Shucheng (Eds) (1992). *Chinas Provincial Statistics, 1949–1989.* Boulder, San Fransisco, Oxford: Westview Press.

[17] Koopmans, T. C. (1965). "On the Concept of Optimal Economic Growth." *The Econometric Approach to Development Planning.* Amsterdam: North Holland.

[18] National Bureau of Statistics of China. *China Statistical Yearbook 1986–2001.* China: China Statistical Press.

[19] Nijkamp, P., and J. Poot (1998). "Spatial Perspectives on New Theories of Econoic Growth." *Annals of Regional Science* 32, 7–37.

[20] Oi, J. C. (1999). *Rural China Takes Off. Institutional Foundations of Economic Reforms.* Berkeley and Los Angeles: University of California Press.

[21] Ord, J. K., and A. Getis (1995). "Local Spatial Autocorrelation Statistics: Distributional Issues and an Application." *Geographical Analysis* 27 (4), 286–306.

[22] Rey, S. J., and B. Montouri (1999). "US Regional Income Convergence: A Spatial Econometric Perspective." *Regional Studies* 33 (2), 143–156.

[23] Solow, R. M. (1956). "A Contribution to the Theory of Economic Growth." *Quarterly Journal of Economics* 70, 65–94.

[24] Swan, T. V. (1956). "Economic Growth and Capital Accumulation." *Economic Record* 32, 334–361.

[25] Tian, X. (1999). "Market Orientation and Regional Economic Disparities in China." *Post–Communist Economies* 11 (2), 161–172.

[26] Wheeler, C. H. (2001). "A Note on the Spatial Correlation Structure of County–Level Growth in the US." *Journal of Regional Science* 41 (3), 433–449.

[27] Wu, Y. (2000). "Productivity, Growth and Economic Integration in the Southern China Region." *Asian Economic Journal* 14 (1), 39–54.

[28] Yao, S., and J. Liu (1998). "Economic Reforms and Regional Segmentation in Rural China." *Regional Studies* 32 (8), 735–746.

[29] Yao, S., and Z. Zhang (2001). "Regional Growth in China Under Economic Reforms." *The Journal of Development Studies* 38 (2), 167–186.

[30] Ying, L. G. (2000). "Measuring the spillover effects: Some Chinese evidence." *Papers in Regional Science* 79, 75–89.

[31] Zhang, J., and G. Kristensen (2001). "The paradox of unequal regional investment and equal regional economic growth." *The Annals of Regional Science* 35, 637–655.