Growth of GRP in Chinese Provinces: A Test for Spatial Spillovers*

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Abstract

This paper examines the provincial pattern of growth in China during the period 1985–2000, testing the hypothesis that provinces with similar growth rates are more spatially clustered than would be expected by chance. The provincial economic growth is explained by the distribution of industrial enterprises, foreign direct investment, infrastructure, and governmental preferential policies. The neoclassical hypothesis of convergence is also tested. Indications of unconditional convergence does occur during the periods 1985–2000 and 1985–1990. In addition, conditional convergence is found during the sub-period 1990–1995. Evidence of spatial dependence between adjacent provinces has also been established, and in the econometric part, solved by a spatial lag, or alternatively a spatial error term, in the growth equation.

***Keywords* :** GRP-growth, Chinese provinces, Spatial dependence
***Classification*[*JEL*] :** O18, R11, R12

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1 Introduction

The purpose of this paper is to explain differences in economic growth among Chinese provinces where spatial dependence is tested and controlled for. Thus, our task is to determine the factors behind the spatial growth pattern, to test for conditional and unconditional convergence, as well as consider the fact that provinces may be dependent on each other in positive and negative ways in order to avoid biased and inefficient estimates.

During the last decades, China has experienced an exceptionally high economic growth. 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. This increase in wealth is, however, unequally distributed. In the year 2000, the Shanghai province had the highest level of Gross Regional Product (GRP) per capita (27,187 Yuan), compared with the poorest province, Guizhou (2,818 Yuan). In Figure 1 below, the income pattern is presented with GRP per capita levels for the year 2000.

The income differences have not always been this large. In fact, they were actually reduced somewhat when the reforms started in 1978, as the now successful provinces began their rapid growth from a lower level. According to Démurger (2001), income disparities did not start to increase until the second part of the 1980's.

When the communists came to power in 1949, one of their particular objectives was to provide equal wealth to the whole population (disparities between urban and rural areas were, however, accepted). This was accomplished through a strong central policy, redistribution of incomes and resources from wealthy to poor provinces, and large-scale investments in the poorer provinces. In 1978, this system was abandoned in favor of reforms such as decentralization of the agricultural production, decentralization of the fiscal system, diversification of the ownership structure, and especially the 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 the status of Special Economic Zones in order to attract foreign investments. In the mid 1980's, this expanded to other areas opened for increased international trade and foreign investments. New economic zones were created throughout the country in the early 1990's.

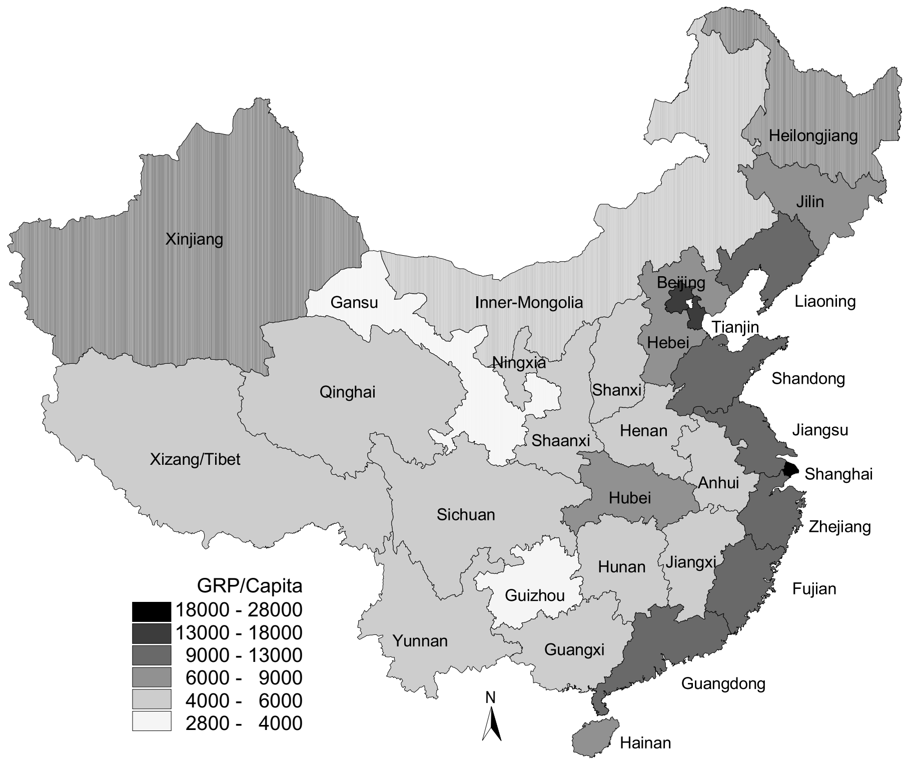

Figure 1: GRP per capita in the Chinese provinces for the year 2000. Source: China Statistical Yearbook 2001.

Today, the three metropolises, Beijing, Shanghai, and Tianjin, are industrialized and have the highest GRP per capita. The coastal provinces in the southeast have experienced a rapid growth in GRP per capita since the reforms started in 1978, and are now among the richest provinces in the country. These provinces have a special status in relation to the other provinces due to the preferential policies levied upon them by the government, and are generally considered the new engines of growth in the Chinese economy. In the northeast we find the three provinces, Heilongiang, Jilin, and Liaoning, collectively called Manchuria. This area used to be China's industrial center with the highest GRP per capita in China. Even though Manchuria has not experienced as rapid of a growth as the southern coastal provinces the GRP per capita is still among the highest in the country. The central provinces, between the rivers Yellow and Yangtze, have a high population density and are well-suited for agriculture. The southwestern provinces are also, from a climatic perspective, suited for agriculture but are hard to access due to the mountainous terrain. These provinces have had, in general, a low annual GRP per capita growth since the start of the reforms. The northwestern part of China consists of the the provinces Tibet, Xinjiang, and Qinghai. These provinces are characterized by high elevation and a low degree of transport infrastructure.

Hence, this short introduction have shown that the regional growth pattern in China may, at least to some extent, be explained by factors related to policy and resource endowments. Additionally, we are also interested in potential impacts of growth spillovers between provinces. The next two sections addresses the theory of economic growth and spatial dependence in connection with previous studies on provincial growth in China, as well as a presentation of supporting data. The forth section consists of an exploratory data analysis in search of spatial dependence. Estimations of the provincial economic growth equations are explored in the fifth section. The final section of this paper concludes with a presentation of our findings.

2 Theory of Economic Growth and Spatial Dependence - The China Case

A large part of the empirical literature on regional growth, e.g. Barro and Sala-i-Martin (1992, 1995), Persson (1997), and Sala-i-Martin (1996) are concerned with the convergence hypothesis, as predicted by the neoclassical growth theory, given by Solow (1956), Swan (1956), and Koopmans (1965). That is, provinces with an initial low growth will eventually catch up with the richer ones since their capital/labor ratio is below it's long run value and thus has higher rates of return, therefore growing faster. Given that all provinces are intrinsically the same, apart from their initial capital/labor ratios, convergence would be unconditional. If we allowed, however, the provinces to be different in various aspects, the convergence would instead be conditional. Each province would instead converge toward its own steady state level of growth.

The hypothesis of convergence, however, has been rejected in many studies of nations in favor of endogenous growth theory, Romer

(1986) and Lucas (1988), where the long-term growth rate of output per worker is determined by variables within the model, such as accumulation of human and physical capital.

The analysis of regional economic growth is a recent contribution to the economic growth literature, e.g. Nijkamp and Poot (1998), Bal and Nijkamp (1998), Rey and Montouri (1999), Vayá et al. (2000), Wheeler (2001), and Carrington (2002). Since countries and especially regions, interact with each other in various ways potential estimation problems caused by spatial dependence may occur. These problems are apparent in China, especially with its division of growth between the western and eastern part of the country. Therefore, the presence of two types of spatial dependence (Spatial Lag dependence and Spatial Error Dependence) are tested and controlled for in this paper. Spatial Lag Dependence is present if spatial correlation in the dependent variable exists between observations. This means that the rate of growth in one province influences, and is influenced by, growth rates in nearby provinces, cf. Anselin (1988) and Can (1992). If this problem is ignored, the OLS estimates will be biased and inefficient and hence lead to incorrect inference. The solution is to add a spatial lag to the growth equation:

$$\boldsymbol{g} = \rho \boldsymbol{W} \boldsymbol{g} + \boldsymbol{Z} \boldsymbol{\beta} + \boldsymbol{\varepsilon} \tag{1}$$

where, $\boldsymbol{g}$ is a (n by 1) vector of observations on the dependent variable, $\boldsymbol{Z}$ is a (n by k) matrix of observations on the exogenous variables with $\boldsymbol{\beta}$ as the associated (k by 1) vector of regression coefficients, $\boldsymbol{\varepsilon}$ is a (n by 1) vector of random error terms, ρ is the autoregressive coefficient, $\boldsymbol{W}$ is a (n by n) spatial weights matrix, with elements w_{ij} corresponding to observation pair i and j. Finally, $\boldsymbol{W}\boldsymbol{g}$ is the spatially lagged dependent variable, a weighted average of other regions.

Spatial Error Dependence is present when the error terms show correlation with the error terms of adjacent observations, i.e., lack of stochastic independence between observations, e.g. Cliff and Ord (1972, 1973). The standard error assumptions under normality of the linear regression model are violated and as a result inefficient estimates are produced. The solution is to incorporate the spatial dependence in the growth equation via an autoregressive error term:

$$\begin{aligned} \boldsymbol{g} &= \boldsymbol{Z}\boldsymbol{\beta} + \boldsymbol{\varepsilon} \\ \boldsymbol{\varepsilon} &= \lambda \boldsymbol{W}\boldsymbol{\varepsilon} + \boldsymbol{\xi} \end{aligned} \tag{2}$$

where, $\boldsymbol{W}\boldsymbol{\varepsilon}$ is a spatial lag for the error term, λ is the autoregressive coefficient, and $\boldsymbol{\xi}$ is a (n by 1) vector of well behaved error terms $\boldsymbol{\xi} \backsim N(0, \sigma^2 \boldsymbol{I})$. We will return to these two models in Section 5 below.

A review of the literature may serve as an introduction in the search for determinants behind the provincial economic growth. The literature examining the Chinese economy and its spatial income disparities is vast. Many contributions consider the question of convergence, both conditional and unconditional, e.g. Chen and Fleisher (1996), Tian (1999), and Yao and Zhang (2001). Among the explanations behind provincial growth we may find factors related to physical and human capital, institutions, and spatial spillovers.

The physical and human capital. The infrastructure as studied by Yao and Zhang (2001) is usually measured as the sum of the length of railway, highway, and waterway per area unit converted into equivalent highways, based on the transport work of each mode. Foreign Direct Investments (FDI) have thus far been important in explaining income disparities in the Chinese economy, Graham and Wada (2001). Zhang and Kristensen (2001) argue that FDI should, in principle, enlarge the disparities, but are unable to find evidence to support their argument. The importance of human capital is also acknowledged in the literature of the Chinese economy. Human capital is often measured as enrollment in higher education divided by the working population or the total population, e.g. Chen and Feng (2000).

The Chinese institutions. Geographical differences, accessibility, and governmental policy is often accounted for by dummy variables for the coastal provinces in order to explain growth divergence between coastal and non coastal provinces. An alternative solution is presented by Démurger et al. (2002). Démurger uses a preferential policy index based on the different degrees of openness among the provinces. Additionally, Démurger argues that the topography, measured as the average elevation and slope of the province, is an important factor behind growth.

State Owned Enterprises (SOEs) are generally considered less competitive than other forms of ownership. A large share of these enterprises have had a negative effect on income growth, as shown by e.g. Chen and Feng (2000). This may, however, be explained by the kind of industries they generally are involved in, such as strategically important production and defense related industries. Instead, Démurger (2001) uses the share of collectively owned enterprises of total industrial production to control for the internal reform process. Oi (1999), on the other hand, explores the role of local authorities in the economic transition from 1978 to the mid 1990's and concludes that the most important factor for local growth is the property rights to means of production.

Spillover effects. The only study we have found that consider spatial dependence in China, Ying (2000), is limited to an exploratory data analysis of the existence of dispersion or spillover effects from the core to the periphery provinces. The author not only found evidence of economic spillovers from the Guangdong province to nearby provinces, but also a pattern of polarization. It is also concluded that preferential policies play a major role in the direction of this process.

Compared to the studies above, our paper contributes to the literature on economic growth in China not only by identifying the presence of previously overlooked problems of spatial dependence, but also by solving for this problem by inclusion of a spatial lag, alternatively a spatial error term in the growth equation as needed.

3 The Chinese Provincial Data

Four time periods are defined in this study; 1985–2000, 1985–1990, 1990–1995, and 1995–2000, with data from China's 30 provinces. All economic variables are measured in year 2000 prices. Data was collected from various China Statistical Yearbooks, (National Bureau of Statistics of China, 1986–2001) and Hsueh et al. (1993). Additional data were gathered from the LUC project database at IIASA[1]. The descriptive statistics for the selected variables are presented in Table 1.

The dependent variable, GRPC, is the average annual per capita growth rate over each specific time period. For the whole period 1985–2000, the average annual per capita growth rate was 6.64%,

[1]Modeling Land-Use and Land-Cover Changes. http://www.iiasa.ac.at/Research/LUC/

Table 1: Descriptive Statistics and Expected Signs

Variable	Unit	Mean	St.dev	Min	Max	Sign
GRPC_8500		6.64	1.69	3.41	11.30	
GRPC_8590	%	2.12	2.26	-5.82	6.04	
GRPC_9095		10.20	4.02	3.73	19.42	
GRPC_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_TE_1985	SOE/Total	0.27	0.12	0.08	0.67	(-)
SOE_TE_1990		0.24	0.12	0.08	0.64	
SOE_TE_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		1760.51	1576.94	485.40	7928.41	
DINVC_8590	10' rmb/capita	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		22.20	33.62	0.001	124.60	
FDIC_8590	USD/capita	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		1.35	0.81	0.56	3	
PREF_8590	Index	0.78	1.10	0	3	(+)
PREF_9095		1.47	0.79	0.67	3	
PREF_9500		1.80	0.66	1	3	

within a range between 3.41 and 11.30. The largest spread of growth for a sub-period, 3.73 to 19.42%, was found in the first five years of the 1990's.

The proxy variable for human capital, *EDUP*, is measured as the number of graduates from Institutions of Higher Education and Specialized Secondary Schools, divided by the total population in each province for the years 1985, 1990, and 1995 respectively. This share increased from an average of 0.0009 in 1985, to 0.0016 ten years later. The coefficient sign is expected to be positive.

The transport capacity in each province is captured by the variable *TPAREA* for the same three years. It is measured as the total length of railways in operation, navigable inland waterways, and highways in kilometers/km^2. As expected, the capacity has increased over the years, as has the spread between the best and the worst province. The sign is expected to be positive.

The capital accumulation in each province is captured by two variables. *DINV* is measured as the annual domestic investment in 10,000 rmb/capita averaged over the actual time period. 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 and both are expected to result in positive signs.

The next two variables in Table 1 are included to characterize the institutional structure of the provinces. SOE_TE, is the number of state owned enterprises divided by the total number of enterprises. The average share is about 25%, but in some provinces, more than 60% of the companies are state owned. Since these enterprises are generally considered to be less profitable, the expected sign of the coefficient is negative. The preferential policy, PREF, levied by the government upon each province, is constructed as an index, based on the degree of openness. Following Démurger et al. (2002), the index is constructed in 4 groups with different weights, as shown in Table 2. These weights are then averaged over specific time periods. The coefficient sign is expected to be positive.

Table 2: Preferential Policy Index

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

In order to measure the impact of population density, or, agglomeration effects in the three metropolis provinces, Beijing, Shanghai, and Tianjin, the dummy variable D_CITY, was introduced. It is assigned the value one for these provinces. A positive coefficient sign is expected. The southeast provinces, Guangdong and Fujian, have historical as well as geographical advantages compared to the other provinces. Guangdong is a neighbor to Hong Kong, and many of the Taiwanese have close ties with the Fujian population. The role of intensive external relations is thus tested with the dummy variable, D_EXTERNAL, with an expected positive sign.

4 Spatial Exploratory Data Analysis

Before we proceed and estimate the growth equations, let us first test the hypothesis that provinces with similar growth rates are more spatially clustered than would normally be expected. One test often used to indicate the possibility of global spatial autocorrelation is the Moran's I test. A similar, but less known test, is the Geary's C test. To complement and validate these results, the Local Moran's I test is utilized.

4.1 Global Spatial Autocorrelation

The Moran's I test is defined as:

$$I = \frac{\mathrm{n}}{\mathrm{S}} \frac{\sum_i \sum_j w_{ij}(x_i - \mu)(x_j - \mu)}{\sum_i (x_i - \mu)^2} \tag{3}$$

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

$$\mathrm{S} = \sum_i \sum_j w_{ij} \tag{4}$$

When row standardized weights are used, which is preferable, 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 $\mathrm{H}_a : \mathrm{I} \neq -1/(\mathrm{n}-1)$. When H_0 is rejected and $\mathrm{I} > -1/(\mathrm{n}-1)$, indicates 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 H_0 is again rejected but $\mathrm{I} < -1/(\mathrm{n}-1)$, it indicate negative spatial autocorrelation. Hence observations with high and low values are systematically mixed together.

The second global measure is the Geary's C test, defined as:

$$C = \frac{\mathrm{n}\text{-}1}{2\mathrm{S}} \frac{\sum_i \sum_j w_{ij}(x_i - x_j)^2}{\sum_i (x_i - \mu)^2} \tag{5}$$

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.

Obviously, these tests are quite crude. One apparent drawback is the a priori choice of the spatial weights matrices. However, when repeated with different weights matrices, this becomes a test of the robustness of the weights matrix, its performance, and the kind of relationships that may be hidden in the data.

Four different weights matrices are tested in this paper to mimic the economic integration between the provinces; the 1^{st} and 2^{nd} order contiguity, denoted *QUEEN_1*, and *QUEEN_2* (where neighbors are defined as those that share a common border) respectively; and two inverse distance matrices using distance and squared distance (arc great circle distance between the province capitals), denoted *DIST_1* and *DIST_2*. All matrices are row standardized. The results from the two global tests for the four weights matrices are presented in Table 3.

Table 3: Moran's I test and Geary's C test for Spatial Autocorrelation between the Chinese provinces. (* = using 999 permutations since 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_2_*8500*	0.14	-0.03	0.08	0.02	0.81	1.00	0.10	0.05
DIST_1_*8500*	0.04	-0.03	0.04	0.04	0.90	1.00	0.05	0.03
DIST_2_*8500*	0.09	-0.03	0.10	0.21	0.84	1.00	0.10	0.10
QUEEN_1_*8590**	-0.11	-0.03	0.11	0.24	1.02	1.00	0.16	0.39
QUEEN_2_*8590**	0.04	-0.03	0.07	0.16	0.78	1.00	0.10	0.03
DIST_1_*8590**	-0.08	-0.03	0.04	0.08	0.93	1.00	0.05	0.14
DIST_2_*8590**	-0.17	-0.03	0.10	0.05	1.04	1.00	0.10	0.33
QUEEN_1_*9095*	0.35	-0.03	0.12	0.00	0.59	1.00	0.13	0.00
QUEEN_2_*9095*	0.25	-0.03	0.08	0.00	0.69	1.00	0.10	0.00
DIST_1_*9095*	0.10	-0.03	0.04	0.00	0.86	1.00	0.05	0.00
DIST_2_*9095*	0.23	-0.03	0.10	0.01	0.73	1.00	0.10	0.01
QUEEN_1_*9500*	-0.00	-0.03	0.12	0.80	0.89	1.00	0.13	0.41
QUEEN_2_*9500*	-0.01	-0.03	0.08	0.76	0.92	1.00	0.10	0.42
DIST_1_*9500*	-0.01	-0.03	0.04	0.58	0.93	1.00	0.05	0.12
DIST_2_*9500*	0.00	-0.03	0.10	0.72	0.92	1.00	0.10	0.43

The Moran's I values are positive and significant for the two periods 1990–1995 and 1985–2000, to indicate that provinces with similar growth rates are more clustered than may be assumed purely by chance. For the period 1985–2000 the significant I value is limited to the three first weights matrices. This might be an effect of the relatively steep decline of influence as the distance increases. It suggests that the provinces except for direct neighbors are relatively isolated from each other. The results from the Geary's C test (the right hand side of Table 3) confirms the previous results with some exception for the first sub period with the second and forth weights matrices. The main conclusion from this exploratory examination is that there exists clusters of provinces with similar growth rates irrespective of the weights matrix used.

4.2 Local Spatial Autocorrelation

With the help of Moran Scatterplots that show the individual I values for each province from the global Moran's I test, and Local Moran's I tests[2], Anselin (1995b), the investigation continues in search of local spatial autocorrelation, or hot/cold spots.

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

$$I_i = \frac{x_i}{\sum_i x_i^2} \sum_j w_{ij} x_j \tag{6}$$

The results are, in order to improve readability, presented in a series of maps (Figure 2–Figure 8).

The results for the long period, 1985–2000, are shown in Figure 2 and Figure 3. The Moran Scatterplots (individual I values of the global Moran's I test without significance considerations) for the four weights matrices all show the same area of Low-Low values (provinces with low growth values surrounded by provinces with low growth values) from Tibet across China to the northeast, with some minor deviations. A half circle of High-High values (provinces with high growth surrounded by provinces with high growth) is visible in the southeast.

On the other hand, the Local Moran's I in Figure 3 reveals that this pattern is not as strong as first expected. Only two provinces, Fujian and Zhejiang have significant positive values, while the province Qinghai has a significant negative value for the *QUEEN_1* matrix. Local Moran's I, for the *DIST_1*, shows significant High-High values for Fujian, Zhejiang, and Jiangsu, and Low-High for the Shanghai province. For *DIST_2*, the Local Moran's I is even more limited and reports only two High-High provinces, Fujian and Zhejiang.

To see whether this pattern is stable over the whole 15-year period, the material was once again divided into the three five-year sub-periods.

For the first sub-period, 1985–1990, (Figure 4 and Figure 5) the clear pattern from the previous figures has disappeared. The Moran Scatterplot with *QUEEN_1* only reports some clusters of high values in Manchuria and in the southeast. The Local Moran's I shows some

[2]Tests with the *New* G_i*, Ord and Getis (1995) were also performed and was found to be in line with the other test results presented below and are therefore not presented here in order to save space. They are available upon request.

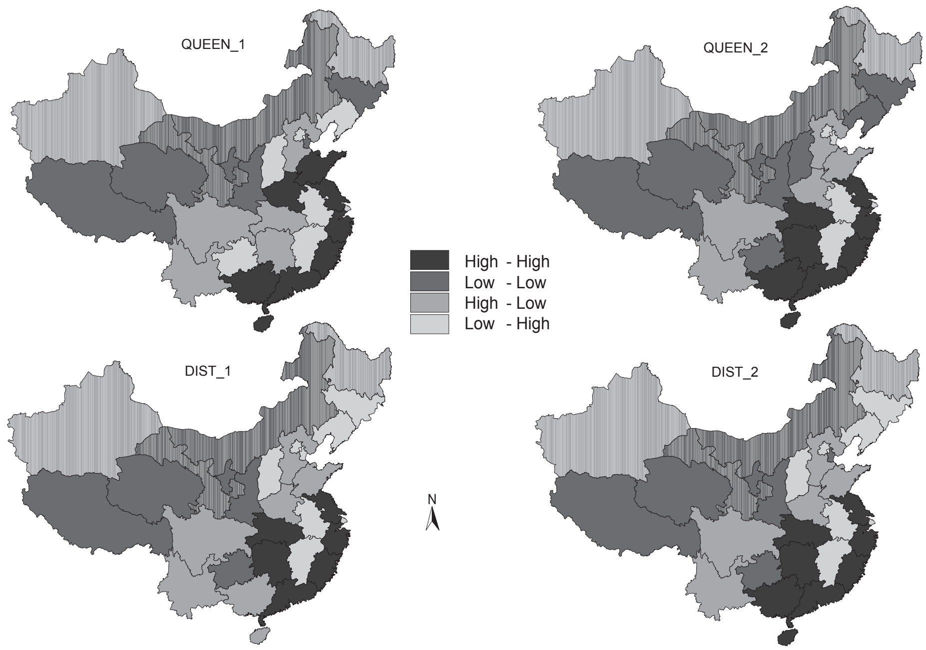

Figure 2: Moran Scatterplot 1985-2000.

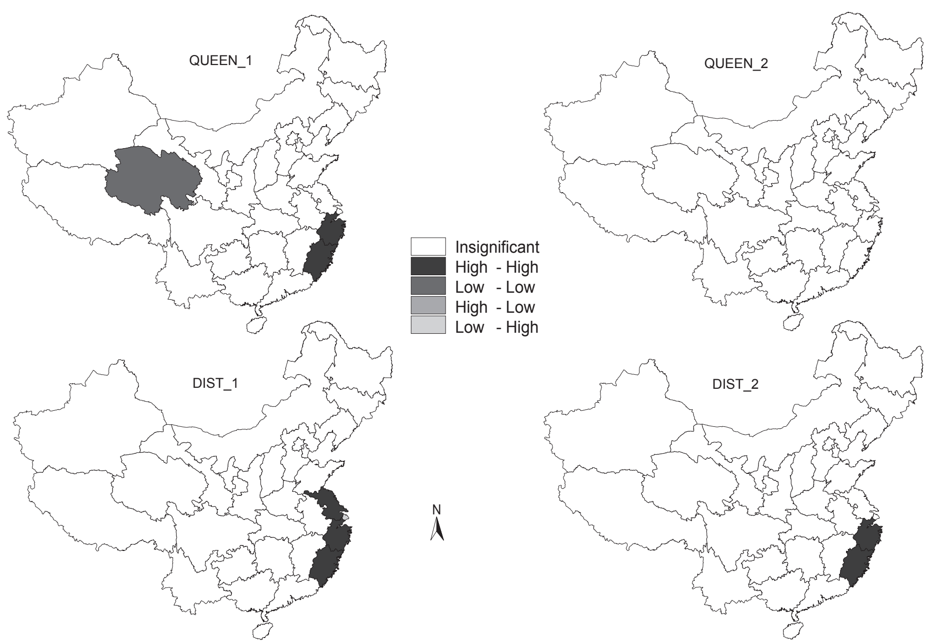

Figure 3: Local Moran's I 1985-2000.

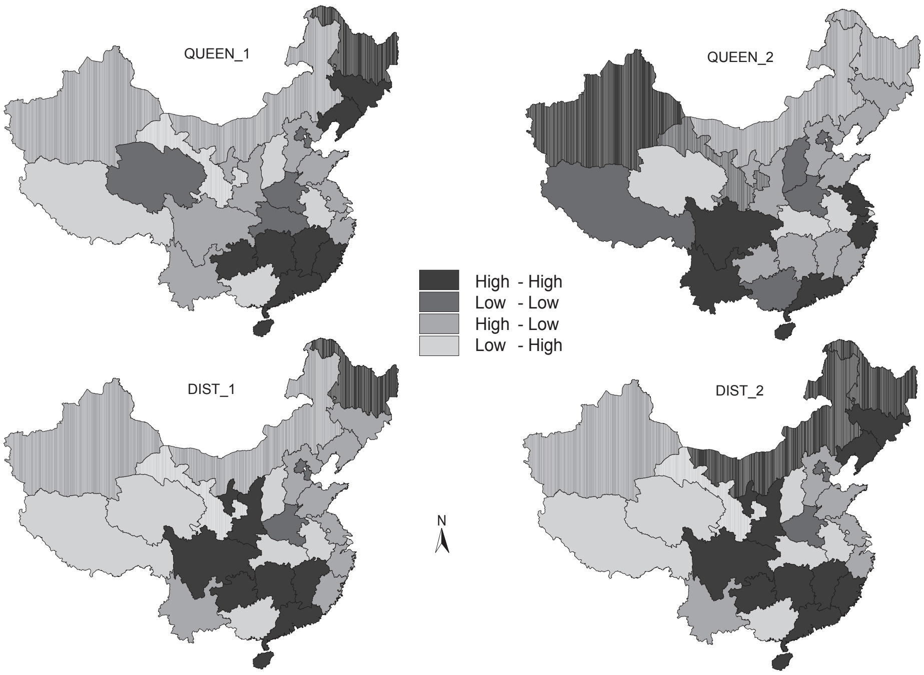

Figure 4: Moran Scatterplot 1985-1990.

significant values. There is the coastal cluster of high values, and then two provinces with high values on either side of the low growth provinces in the interior. There are also two low growth provinces close to the coast. For *DIST_1*, we see a High-High belt from north to south in the interior of China, and also a belt of High-Low values in Manchuria and down the coast of southeast China. The Local Moran's I, however, shows significant values only for Tibet, Xinjiang, and Shanghai. *DIST_2* yields a similar pattern as *DIST_1* in the Moran Scatterplot, but the High-High belt is now spread all the way up to the northeast Manchuria. The Local Moran's I is the same as the previous one with the exception of Shanghai. The fact that so few provinces are significant in the Local Moran's I test explains why we were unable to find support of global spatial autocorrelation in the Moran's I test earlier.

In the next five-year period, 1990–1995, the global tests, Moran's I and Geary's C, were significant for all weights matrices. Since the Moran Scatterplot patterns are similar to those in Figure 2, they are left out to save space. For the Local Moran's I test (Figure 6),

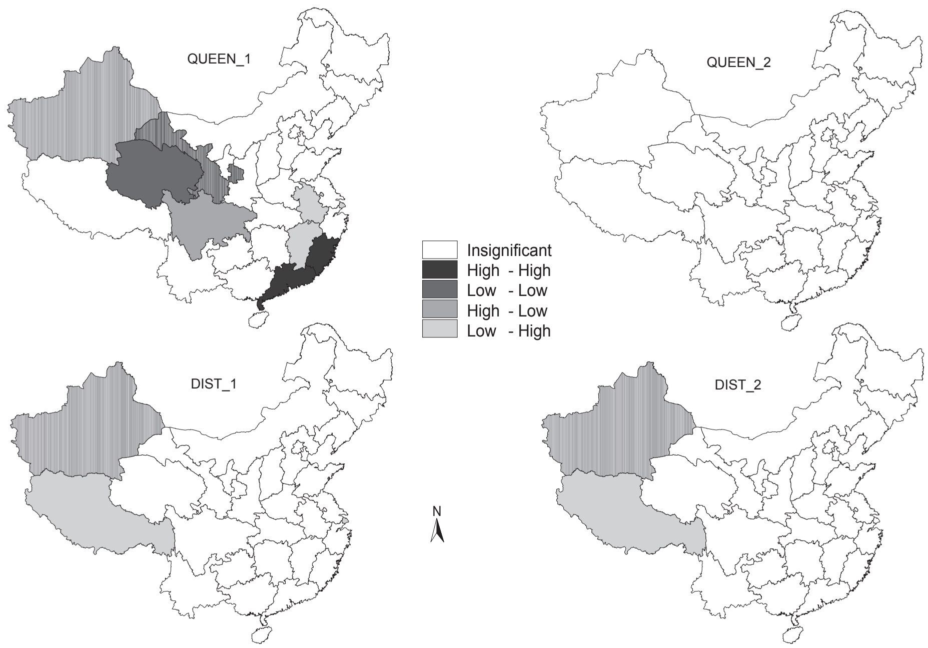

Figure 5: Local Moran's I 1985-1990.

only three hot spot provinces, and two with low growth, are significant with *QUEEN_1*. For *QUEEN_2*, four Low-Low provinces and three High-High provinces are reported. This pattern is repeated for the distance weights matrices. The three interior provinces, Qinghai, Gansu, and Ningxia, are negative and significant; while the three coastal provinces, Jiangsu, Zhejiang, and Fujian, remain significant and positive. Hence, we may conclude that China, during this period, had one hot spot area and one area in the interior with significantly lower growth.

The final period, 1995–2000, (Figure 7 and Figure 8) is of special interest because the pattern has changed dramatically. The Moran Scatterplots for *QUEEN_1* and *QUEEN_2* reports a Low-Low belt in the south and for the Shanghai province, and a High-High area around the capital city of Beijing. The *DIST_1* yields similar results. The Low-Low area is extended from the south up to the interior, and the High-High area is spread from the Beijing area down along the coast. The Local Moran's I presents significant negative values for Hainan, Guangxi, Xinjiang, and Shanxi, while Tibet is significant and positive. Hence, the economies in the former productive coastal

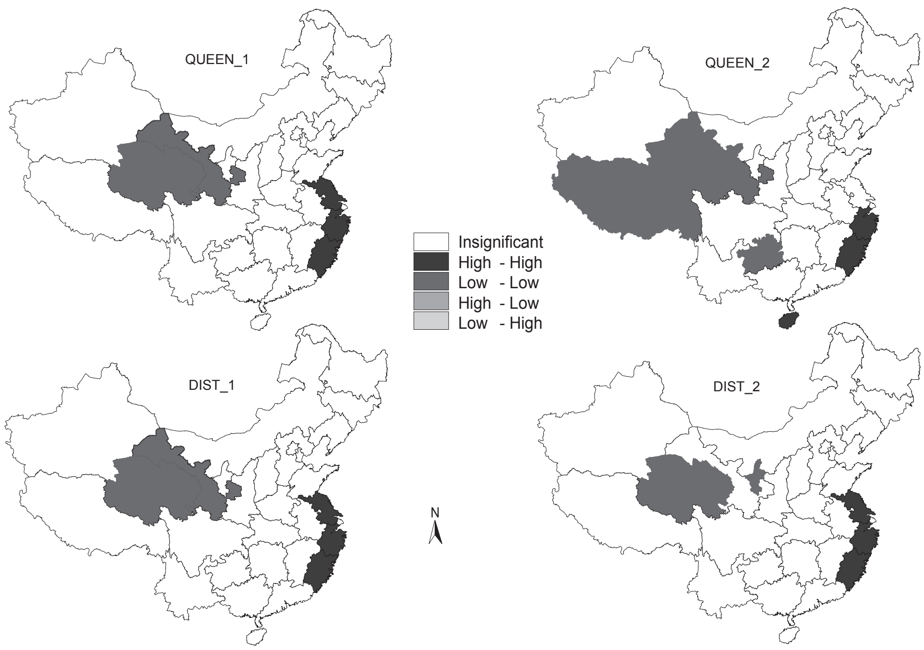

Figure 6: Local Moran's I 1990-1995.

area, such as the provinces of Fujian and Guangdong, are no longer that successful in relative terms. This may be a first sign of convergence between the Chines provinces.

To conclude the findings so far, the global tests indicate spatial autocorrelation for the periods 1985–2000 and 1990–1995. However, local tests indicate that the clusters of similar values are not as strong as first expected. Nevertheless, some hot spots was found for all time periods, especially in the southeast region. The provinces with low growth values are mostly found in the interior. A change of this pattern was hinted at in the last five-year period. With this knowledge in mind, the next step will be to estimate growth equations.

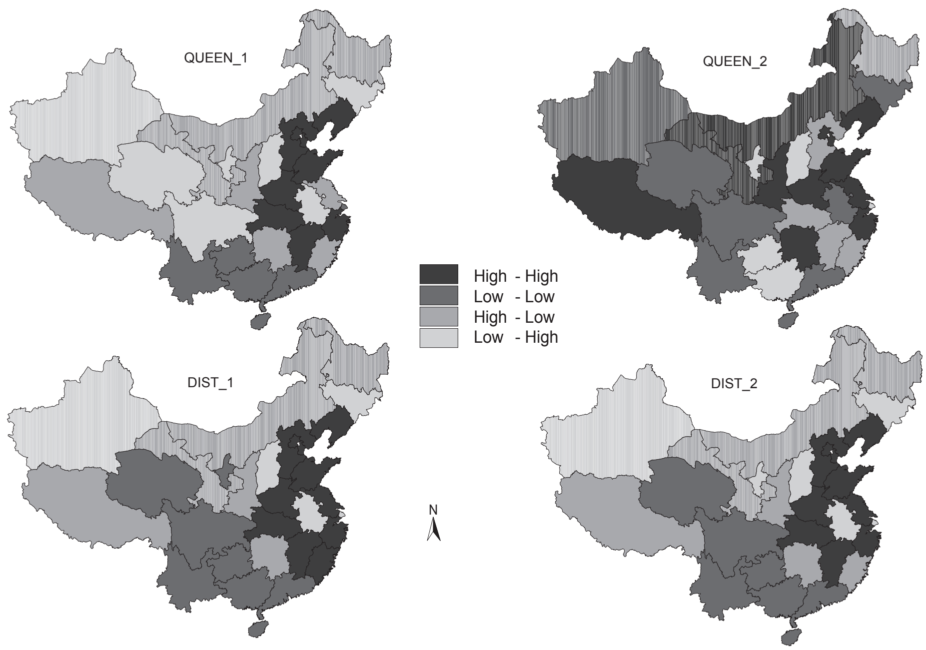

Figure 7: Moran Scatterplot 1995-2000.

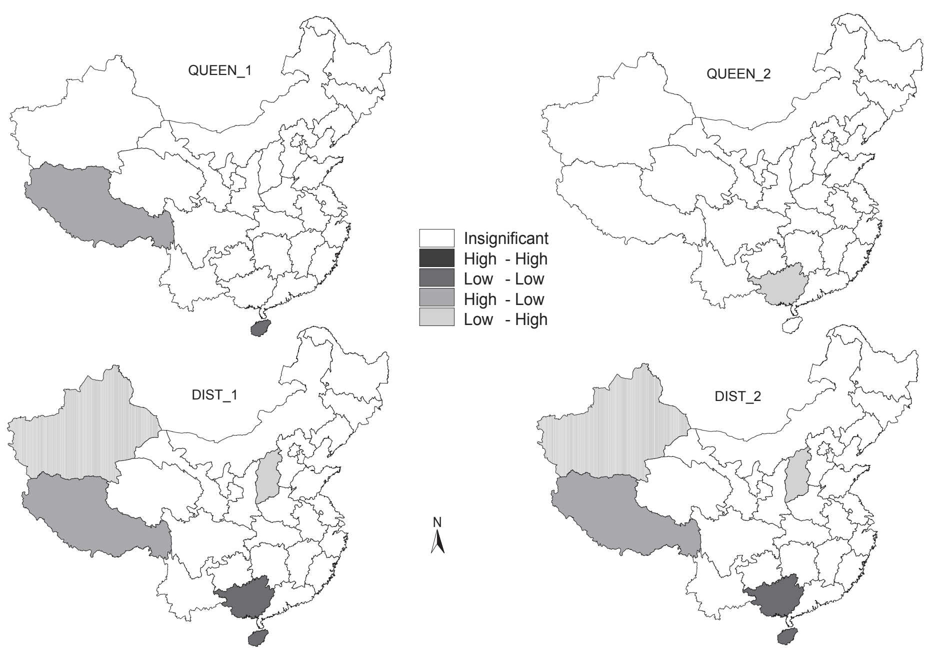

Figure 8: Local Moran's I 1995-2000.

5 Estimation of the Provincial Economic Growth Equation

The estimation of provincial economic growth is made in two regressions. The first regression makes it possible to test the hypothesis of unconditional convergence. The conditional convergence hypothesis is tested in the second regression. In both cases spatial dependence adjustments are included when needed, as indicated by the Lagrange Multiplier tests based on the OLS residuals. The Lagrange Multiplier test results are not reported here but are available upon request.

The first growth equation is expressed as:

$$g_{tT} = \beta_0 + \beta_1 GRPC_t + \varepsilon_t \tag{7}$$

where t and T indicate the initial and final year for the period in question.

The independent variable in (7) is the initial level of GRP per capita, *GRPC*, at time t for each period. The results are presented in Table 4. For the entire 15-year period, 1985–2000, the introductory OLS results are given in column one. As expected from the exploratory analysis, and according to the Lagrange Multiplier tests, the results from the OLS regression is subject to spatial error dependence. The test also indicates that the first order contiguity matrix, *QUEEN_1*, is the most appropriate matrix to capture the spatial dependence. The estimation is made with the Spatial Autoregressive Generalized Moments (SAR-GM) estimator, as it accepts non-normal distributed errors. The result is presented in the second column of Table 4. The coefficient for *GRPC* is negative and significant, thus indicating unconditional convergence between the Chinese provinces. The autoregressive coefficient, λ, is positive[3] with a value of 0.42. The R^2 is, as expected, quite low, 13%[4].

The parameter for the *GRPC* is negative and significant at the five percent level for the first five-year period, 1985–1990. Hence,

[3]The estimate for λ has no inference since it is treated as a nuisance variable.

[4]The normal measures of fit are not applicable for the spatial models. Instead pseudo measures must be used. Unfortunately they cannot accurately be compared with the measures of fit from the OLS regressions. The R^2 is, in the spatial cases, the ratio of the predicted values over the variance of the observed values for the dependent variable. Sq.corr is the squared correlation between the predicted and observed values and Sig-sq. is an estimate for the residual variance.

Table 4: Regression results for unconditional GRP/capita growth. *** and ** indicate significant values at 1% and 5% percent level. § indicate that no inference has been made.

Variable	8500 OLS	8500 SAR–GM	8590 OLS	9095 OLS	9095 SAR–ML	9500 OLS
WEIGHTS		QUEEN_1			DIST_2	
λ		0.42(§)				
ρ					0.56***	
Constant	7.05***	7.42**	3.43***	9.95***	4.85**	7.61***
GRPC_t	-0.0001	-0.0003***	-0.0004**	$7{\cdot}10^5$	-0.0001	$-3{\cdot}10^7$
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		

growth convergence across provinces is implied. There is no indication of spatial dependence, so no spatial adjustment is needed. The R^2 is 18%. For the second five-year period, 1990–1995, the Lagrange Multiplier tests indicate problems of spatial error dependence. This is solved with a spatial error term, and the more narrow inverse distance weights matrix, *DIST_2*. The results from this regression model estimated with Maximum Likelihood is shown in the fifth column. As in the previous regression, the *GRPC* parameter value is not significant and thus no sign of unconditional convergence appears. On the other hand, the spatial error variable is positive and highly significant and suggests that spillover effects exist between adjacent provinces. Thus, a high GRP per capita growth in the neighboring provinces correlate positively with the growth rate in province i. The last period, 1995–2000, differs from the previous periods in so far as that the constant is the only significant parameter. There is no indication of spatial dependence during the last period.

Hence, the unconditional convergence hypothesis is rejected for the two latter sub-periods. The unconditional convergence that was captured for the 15-year period is somewhat misleading and should merely be seen as a reflection of the convergence found in the first five-year period.

Next, we continue the analysis and consider other explanatory variables. In this way, we may test the hypothesis of conditional convergence. That is, whether regions converge towards its own steady state growth rate level. The second regression equation is expressed as:

$$g_{tT} = \beta_0 + \beta_1 EDUP_t + \beta_2 TPAREA_t + \beta_3 PREF_{tT} + \beta_4 DINV_{tT} + \beta_5 FDIC_{tT} + \beta_6 D\_CITY_t + \beta_7 SOE\_TE_{tT} + \beta_8 GRPC_t + \varepsilon_t \quad (8)$$

Table 5: Regression results for conditional GRP/capita growth. ***, **, and * indicate significant values at 1, 5, and 10% percent level.

Variable	8500 OLS	8590 OLS	8590 SAR–IV	8590 SAR–IV	9095 OLS	9500 OLS
WEIGHTS			QUEEN_1	DIST_2		
ρ			-0.82**	-0.64**		
Constant	5.44***	7.16***	7.04***	8.23***	6.90*	9.34***
EDUP_*t*	-665.00	663.00	2284.38	860.00	-1213.71	-1008.15
TPAREA_*t*	4.40	-7.39	-5.43	-7.06	12.00**	0.04
FDIC_*t*-*T*	-0.06**	0.18*	0.22***	0.20**	-0.10**	-0.02
DINVC_*t*-*T*	0.0009	-0.001	-0.003	-0.001	0.003*	-0.0003
SOE_TE_*t*	-3.08	-13.14***	-9.16**	-12.70***	-5.90	0.17
PREF_*t*-*T*	2.10***	0.58	1.05***	0.52	5.51***	-1.08
D_CITY	2.43	-1.96	-3.12	-2.13	3.44	5.73
D_EXTERNAL	2.08*	0.92	0.76	1.02	2.21	2.73
GRPC_*t*	-0.0006	-0.0008	0.0001	-0.0002	-0.002*	0.0005
R^2	0.84	0.69	0.76	0.75	0.86	0.19
R^2-*adj.*	0.77	0.55			0.80	-0.18
Sq.corr			0.82	0.79		
SIG-SQ.	0.65	2.33	1.44	1.67	3.26	3.77
Suggestion		QUEEN_1 DIST_2				

As before, the analysis is done in a model for the 15-year period as well as for the three sub periods, 1985–1990, 1990–1995, and 1995–2000. Regression results are given in Table 5. All weights matrices were tested for possible inclusion in the final model.

The results for the period 1985–2000 may be found in the first column. The preferential policy variable is positive and significant at the 1% level. Foreign direct investments have a negative impact on the provincial growth rate. On the other hand, strong external relationships operates in the opposite direction with a positive and significant value. China have three provinces that are categorized as cities, Beijing, Tianjin, and Shanghai. The city dummy variable is not significant and we may therefore not conclude that there exists a positive growth effect from agglomeration alone. Neither is there any sign of conditional convergence or problems of spatial dependence. The fit is radically improved to 84%.

The second column show the OLS results from the period 1985–1990. The share of State Owned Enterprises of the total number of enterprises has, as expected, a negative impact on growth. The average Foreign Direct Investment per capita during the period is positive and significant at a 10% level. The R^2 is 69%. There are indications of spatial lag dependence for two of our weights matrices, QUEEN_1 and DIST_2. The spatial regressions that follows, shown in columns three and four, are both estimated with a 2SLS approach, due to the non-normal error distribution, with spatially lagged variables as instruments. The spatial lag is in both cases significant but has an unexpected negative sign with a lower parameter value in the second regression. This means that the provinces do not benefit from closeness to each other. Quite the opposite, they are competitors. The preferential policy variable is positive and significant only for the QUEEN_1 regression. The SOE variable has the expected sign and a larger parameter value for the DIST_2 regression. The magnitude is slightly less than in the previous OLS regression. The foreign direct investments parameter is robust, with a positive and significant value in both regressions. The improvement between the regressions is shown through smaller standard deviations (Sig-sq.) compared with the OLS results.

In the first five-year period of the 1990's, no indication of spatial dependence is evident. The preferential policy is more important than before for the GRP per capita growth rate. The transport capacity and domestic investment per capita are also positive. Foreign direct investments are, however, negative and significant. For the first time we have evidence of conditional convergence due to the fact that the initial level of GRPC coefficient is negative and significant. The regression fit is, again, quite high, 86%.

The latter part of the 1990's is of interest, not because the richness of results, but the lack of results. There are no indications of spatial dependence, and the only significant parameter is the constant. The reason for this unexpected result is hinted at in the maps shown earlier in Figure 7 and Figure 8. The former successful provinces do not grow faster than the rest of the Chinese provinces, and an explanation for provincial economic growth must be found elsewhere. In her book, Oi (1999) provides some interesting thoughts about increased competition from 1995 onwards, increased need of investment capital, and a more efficient company structure where the many collectively owned companies might need to be exchanged for privately owned firms to maintain and increase growth.

6 Conclusions

In this paper, the provincial economic growth in China during the period 1985–2000 have been investigated. This was accomplished in two parts. The first part consists of an exploratory data analysis in search of spatial autocorrelation and hot spots. Global spatial autocorrelation was indicated for two time periods. Some clusters of provinces with a high growth, especially in the coastal region in the southeast, as well as low growth clusters in the center and western parts of China were found.

The second part of the paper is comprised of a regression analysis aiming to find explanatory variables for growth and to check for convergence. Positive spatial lag dependence was found for the periods 1990–1995 and 1985–2000. When conditional convergence was tested, several important variables were found that explain provincial economic growth, such as preferential policy, enterprise structure, and external relations. The effect of foreign direct investments changed sign over time and seems to have had the most important effect in the late 1980's. Evidence of conditional convergence was only found for the sub period 1990–1995. The influence of spatial dependence does not seem to be high. One possible explanation for this low degree of spatial dependence could be that the aggregation to province level is to high, with a sample of only 30 observations. Another possible explanation is that the provinces are, in fact, more independent of each other than we have suspected and that the major forces behind growth are found within each province between the urban and rural areas. A similar investigation of this present paper, at the more disaggregated county level (not available yet though) may shed new light on growth relationships within and between the Chineses provinces.

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