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Spatial Convergence in China: 1952-99

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Abstract

The purpose of this paper is to examine the convergence process in China by taking into account the spatial interaction between factors. The paper shows that there has been a dramatic increase in the spatial dependence of China's per capita GDP in the last 20 years. The consequence of space plays an important role, which is reflected in the influence of a neighbour's condition on the mobility of a province's income distribution from one category to another. The dynamics of the process showed evidence that China's distribution has gone from one of convergence to stratification, and from stratification to polarization.

Keywords: China, income distribution, spatial effects, spatial econometrics

JEL classification: O18, R11, C31

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Acronyms

FDI foreign direct investment

LISA Local indicators of spatial association

MTM Markov transition matrix

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1 Introduction

The study of regional income convergence is gaining more attention as scholars explore the impacts of globalization on income disparity among countries. The issue is stressed within countries because of the accumulating evidence which suggests that increased economic growth has generated increasing regional income inequalities, especially in many developing economies. In the case of China, regional income convergence has generated a great deal of attention because it would appear that regional income disparities have increased at the same time as the country has been growing rapidly after the economic reform. For example, in 1980 the per capita GDP of Shanghai—the richest region in China—was 11.6 times as that of Guizhou, one of the poorest regions in the western part of the country, while in 1952 the difference was 7.5 times. However, by 1999, the difference had increased to 12.5 times.

If one considers that the country is at an early state of development, the situation in China confirms with the inverted U-shape relationship between regional development and regional income disparity described by Williamson (1965) when he investigated the same issue in the US. In other words, when regions grow, income inequality first increases, and then decreases over time. Hence, it would appear that increased regional income disparities may be an unavoidable characteristic at the earlier stage of regional development. Since initial concentrations of income in certain geographic regions were attributed to unequal natural resource endowments, Williamson (1965) argues that these concentrations attracted selective skilled labour migration from the peripheral regions and generated rapid income growth in the core regions. This led to the widening differentials in per capita income between the core and the peripheral regions. Over time, however, a diffusion of income-generating factors leads to the subsequent slowing down and eventual decline in regional income inequality. This is reflected in the convergence prediction of growth and income from the perspective of neoclassical economics in the sense that poor regions will grow faster and catch up with the richer regions. Therefore, neoclassical economic theory predicts the converging of regional income if all regions share similar steady states.

The new economic geography represented by Krugman (1991) and Fujita, Krugman and Venables (1999) stress the importance of geography by proposing a regional scheme of development pattern similar to Williamson (1965), in terms of a core-periphery regional dichotomy but with an explanatory emphasis on increasing returns to scale and the resulting agglomeration of economic activity. In contrast to the convergence perspective, they argue that regions with natural advantage tend to grow faster than other regions over a relatively long period because of the effect of increasing returns to scale and resulting agglomeration effects. Under such circumstances, a long-lasting regional income disparity will be the expected result (Rey 2001).

China, as a geographically diverse country, exhibits vast differences among regions in terms of natural endowments. Undisputedly, the coastal area (the eastern part of the country) enjoys the advantage of climate and geographical accessibility compared to inland regions. What is more, the coastal area was able to capture significant advantages when the country started to implement a more liberal trade policy. In this case, the coastal region can be regarded as the core area while the inland area can be considered as the periphery area. In fact, within the framework of neoclassical economic theory, there has been some research on regional income convergence in China. Whether or not a trend of regional income convergence exists is still disputed, but most analyses acknowledge the importance of the divergence between the coastal and non-coastal area, i.e., the core region and the periphery region, especially in the current period of reform.

For example, based on the Solow growth model, Weeks and Yao (2003) find conditional convergence in both the pre-reform (1953-78) and reform (1978-97) period with the convergence speed in the reform era being much faster than during the pre-reform time. Applying two methods for detecting convergence, σ-convergence and β-convergence, Jian, Sachs and Warner (1996), on the other hand, find that China's real income convergence has emerged strongly since the 1978 reform, a period strongly associated with the adoption of market economy and openness to external trade. However, they note a divergence in regional income between the coastal and non-coastal regions since 1990. Using an augmented Solow growth model, Chen and Fleisher (1996) measure regional inequality and project that overall regional inequality in the near term is likely to decline modestly but the coast/noncoast income difference is likely to increase somewhat. Fujita and Hu (2001) analyse the problem by relating it to the process of globalization and economic agglomerations in China. They argue that income disparity between the coastal area and the interior is increasing, while there was a trend towards convergence within the coastal area. Zhang, Liu and Yao (2001) and Wang and Ge (2004) suggest that China's regions, especially the eastern and the western regions, have converged to their own specific steady states over the past 40 years, while the differences between the east and the west regions have widened. Yao and Zhang (2001) propose a production model to explain regional divergence based on the hypothesis that in developing countries where technology and capital are scarce, initial economic growth depends on the economic spillover from growth centres. Furthermore, they provide alternative tests to demonstrate that regional divergence can be associated with different geo-economic clubs. In contrast to some previous studies, they find that regions in China did not converge in the reform period.

However, one element missing from the analysis of regional income convergence in China is that researchers have not considered the influence of spatial effects even though issues of different spatial scales have been considered (Ying 1999; Yao and Zhang 2001; Zhang, Liu and Yao 2001; Lu and Wang 2002; Bhalla, Yao and Zhang 2003 among others). In fact, it has been widely acknowledged that the role of spatial effects has been ignored in regional income convergence analyses. So far, only Ying (2003) and Bao *et al.* (2002) integrate spatial effects in their analyses of regional growth in China. Rey and Montouri (1999) point out that spatial effects have been largely ignored in regional analyses dealing with a cross-section or panel data of regional or national data. Sachs (1997) stresses the importance of spatial effects in the sense that physical geography itself is a factor in terms of the distance to markets, variations in topography, climate, and other geographical variables that may determine factor productivity. Krugman (1991) and Puga (1999) emphasize the importance of spatial effects within the frame of the 'new economic geography' by illuminating that two regions with similar economic characteristics in different location may end up with different economic structures and performance profiles. Benabou (1993) and Durlauf (1996) highlight the importance of space by taking into account neighbouring spillover effects in which space is understood as a relative term.

The importance of spatial effects in economic analysis has recently captured attention with regard to regional income convergence (for example, Le Gallo 2004; Bickenbach and Bode 2003; Le Gallo and Ertur 2003; Le Gallo, Ertur and Baumont 2003;

Mossi *et al.* 2003; Rey 2001c, 2004; López-Bazo *et al.* 1999; Fingleton 1999; Rey and Montouri 1999, and Armstrong 1995 among others). Parametric estimation for β- and σ-convergence (Barro and Sala-i-Martin 1995) incorporating spatial effects has been widely used. Note that empirically β-convergence is usually investigated by regressing the growth rate of per capita GDP on initial levels after the addition of other variables while maintaining the steady-state of each region as constant. A negative regression coefficient is interpreted as an indication of conditional β-convergence, implying that each region converges to its own steady-state. The concept of σ-convergence refers to a reduction of dispersion within the GDP per capita cross-sectional distribution over time. It is usually measured as the standard deviation of log GDP per capita of the sample regions (Le Gallo 2004). As Quah (1993) points out, both β- and σ-convergence cannot provide insights into the behaviour of the entire regional income distribution over time, since the two convergence measures could not provide reliable interference on the dynamics of convergence (Rey 2004). Rey (2001), Aroca, Bosch and Hewings (2001) and Baumont, Ertur and Le Gallo (2006) show the impact on the parametric approach results of taking the spatial interaction or spatial heterogeneity into account. On the other hand, Quah (1993, 1997 and 2000) and Rey (2000 and 2004) suggest that the complete distribution of the growth rate should be studied, instead of the mean and variance that are featured in the usual approaches.

At least three topics are relevant in our application of a non-parametric approach. The first is the *persistence* of the process (Durlauf 1996), referring to the measurement of stability of a region's position in the regional income distribution across the country. *Mobility* is also considered in this study and is the complement of persistence, and is taken to represent the change of a region's position in the income distribution. It is also expected that the shape of the regional income distribution will be influenced by economic policy over time. In particular, two hypotheses on the regional growth process will be explored: one is *polarization* (Esteban and Ray 1994; Quah 1997), and the other one is *stratification* or *club convergence* (Chatterji and Dewhurst 1996; Quah 1997). According to Quah (1997: 2), it is important to show how the shape of the distribution has changed over time:

> What also matters is that these features have a natural interpretation in terms of polarization: those portions of the underlying population of economies collecting in the different peaks may be said to be polarized, one group versus another. More generally, if more than two peaks emerged, it might be natural to call the situation stratification.

Two non-parametric tools commonly used to study the distribution of a random variable and its mobility across time are the Markov transition matrix approach and stochastic densities (Silverman 1986). The former measures persistence or mobility among a discrete number of states, while the later estimates the probability density function in a continuous framework. Based on Quah, non-parametric estimation is recognized (Le Gallo 2004; Bickenbach and Bode 2003; Mossi *et al.* 2003; Rey 2004; Fingleton 1999; Quah 1996). Concerned about the reliability of the estimated transition probabilities that may influence the income distribution, Bickenbach and Bode (2003) propose a series of reliability tests, which includes test of time homogeneity, time independence, spatial homogeneity and spatial independence in order to evaluate the estimated transition probabilities.

While previous literature recognizes the importance of space and geography in China's growth process, none have used techniques which had been tailored specifically to take spatial effects into account. In this paper, we expect to fill that gap and to report new information derived from the application of spatial techniques in the analysis of income convergence in China. The paper is structured as follows; the next section introduces the data sources used, followed by a description of the methodology applied. The applications to China are reported in the subsequent section. Discussion on the results is given next and the last section concludes.

2 Data

The source data for the regional GDP and population figures used in this paper is derived from the National Bureau of Statistics (NBS 1999), which provides the data series from 1952 to 1999. It is possible to calculate the GDP per capita at 1999 prices in Renminbi (RMB) *yuan*, and then convert these to 1999 US dollar value according to the official exchange rate given in the *China Statistical Yearbook 2000*. Some administrative changes have taken place in China. For example, the current Hainan province was separated from Guangdong province in 1985 while Chongqing was annexed from Sichuan province in 1996. Therefore, in order for the data to be comparable, the figure for Guangdong after 1985 includes the nominal GDP of both Guangdong and Hainan; similarly, Sichuan and Chongqing were combined after 1996 to obtain the figure for Sichuan. Data for some provinces and auto-administrative districts such as Tibet, Taiwan, and Hong Kong were not available for the entire period considered. Therefore, these are excluded from the study.

3 Results

3.1 Changes in GDP inequalities

Earlier studies recognize the importance of the space and geography in China's growth process. However, none have used techniques that have been specifically tailored to take spatial effects into account. In this paper we hope to fill that gap and report the additional information derived from the application of the spatial techniques to the analysis of growth in China.

3.2 Spatial univariate measure

The spatial dependence measure for each period t is provided by a global statistic such as Moran's I, which can be represented by Equation 1.

$$I_t = \frac{n}{S} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} z_i z_j}{\sum_{i=1}^{n} z_i^2}, \quad \forall \quad all \quad t = 1,2,...,T \tag{1}$$

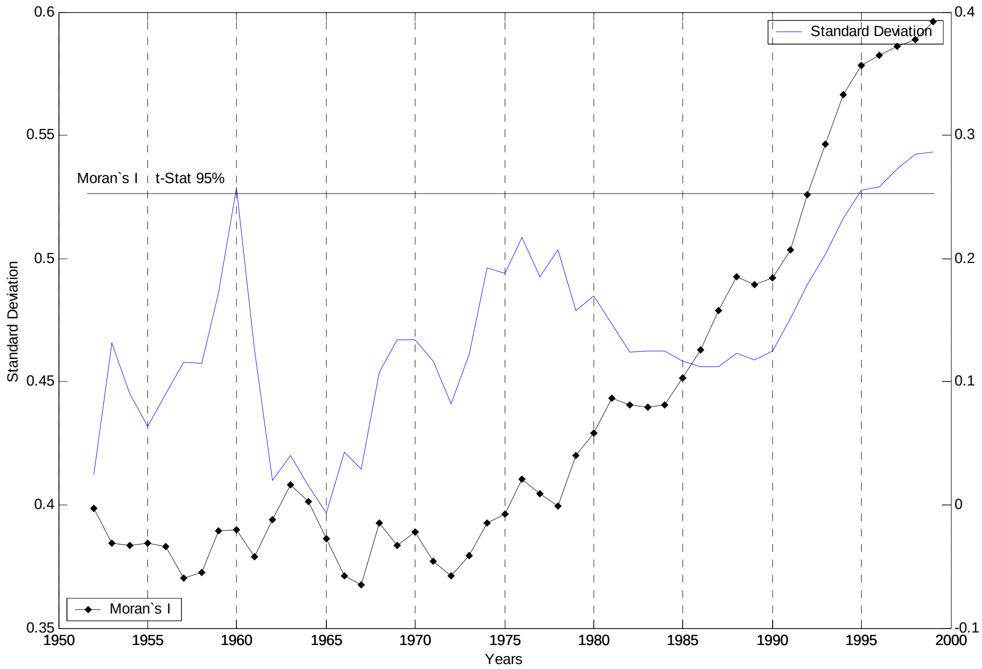
where n is the number of regions; w_{ij} are the elements of a binary contiguity matrix $W(nxn)$, taking the value 1 if regions i and j share a common border and 0 if they do not;

and z_i and z_j are normalized[1] vectors of the log of per capita GDP of regions *i* and *j*, respectively. Values around 1 represent strong and positive (clustering of similar values) spatial dependence, whereas values around -1 show negative spatial correlation (clustering of different values).

In Figure 1, the Moran's I shows that there is an increasing spatial interaction among the Chinese regions. This pattern has become stronger in the decade since 1991; it is statistically significant[2] and has been rapidly growing since 1978, the year coinciding with the start of market reforms in China (Jian, Sachs and Warner 1996).

It is also clear from Figure 1 that from 1952 to 1978 there is no evidence of spatial clustering in the growth process of the regions. On the other hand, there is a high standard deviation, particularly in 1960 and the mid-1970s. One can note that standard deviation, which is currently used to measure sigma convergence in the literature based on the Solow-Swan model (Barro and Sala-i-Martin 1995), has a different behaviour pattern to Moran's I statistics, implying that they measure different concepts. During the period 1965-78, termed as the cultural revolution by Jian, Sachs and Warner (1996), there is an important increment in the standard deviation of the regional GDP per capita that again can be interpreted as evidence of the sigma convergence. This is said by Jian, Sachs and Warner (1996: 9-10) to be the 'anti-agricultural bias of the cultural revolution' which in the next decade tends to decrease standard deviation. However, there is again a large increment in the 1990s that follows the Moran's I pattern very closely.

Figure 1
Moran's I for regional GDP per capita, China 1952-99



Source: Compiled by the authors based on data from NBS (various years).

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1 The $z_i = \ln(GDP_{it}/GDP_t)$ denotes the logarithm of the GDP per capita of region *i* in period *t*, (GDP_{it}), normalized by the country sample mean of the same variable, GDP_t (De la Fuente 1997).

2 The statistical significance was calculated according to Anselin and Bera (1998).

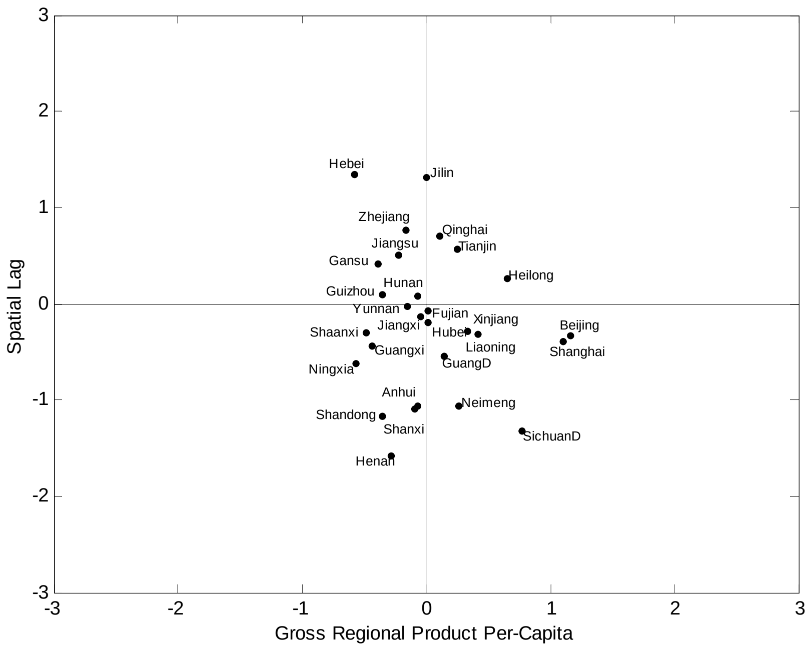
On the other hand, in this period the Moran's I statistic is stable. This indicates that there was a low level of spatial interaction among the regions, a fact that can be associated to one of the five crucial economic components of the cultural revolution mentioned by Jian, Sachs and Warner (1996), i.e., the regions were forced into near autarky.

Thought Moran's I provides important information about the aggregate spatial growth process taking place in China, it does not help to pinpoint where spatial linkages were strong. Moran scatterplots and local Moran index (Anselin 1995) are two techniques that can be used for this purpose. The Moran scatterplot is used to provide a graphical presentation of the spatial distribution of regional GDP per capita for three periods: 1957, 1978 and 1999.

Figures 2, 3 and 4, having the same axes, show the three time points associated with the evolution of the spatial pattern of the relative GDP per capita in China. Figure 2 shows that in 1957 there was no relation between the regional GDP per capita and its spatial lag, which is calculated as the average of its neighbours' GDP per capita. Figure 3 shows that in 1978 there is more dispersion compared to 1957, but still no spatial pattern can be deducted. However, in both graphs, certain regions—Shanghai, Beijing, Sichuan, Heilong—have an above-average GDP per capita in both periods. In addition, these regions in 1978 are bordering on areas with below-national average GDP, implying rich regions with poor neighbours. Figure 4 shows the 1999 situation, in which the emerging positive relation between regional GDP per capita and its spatial lag can be noted.

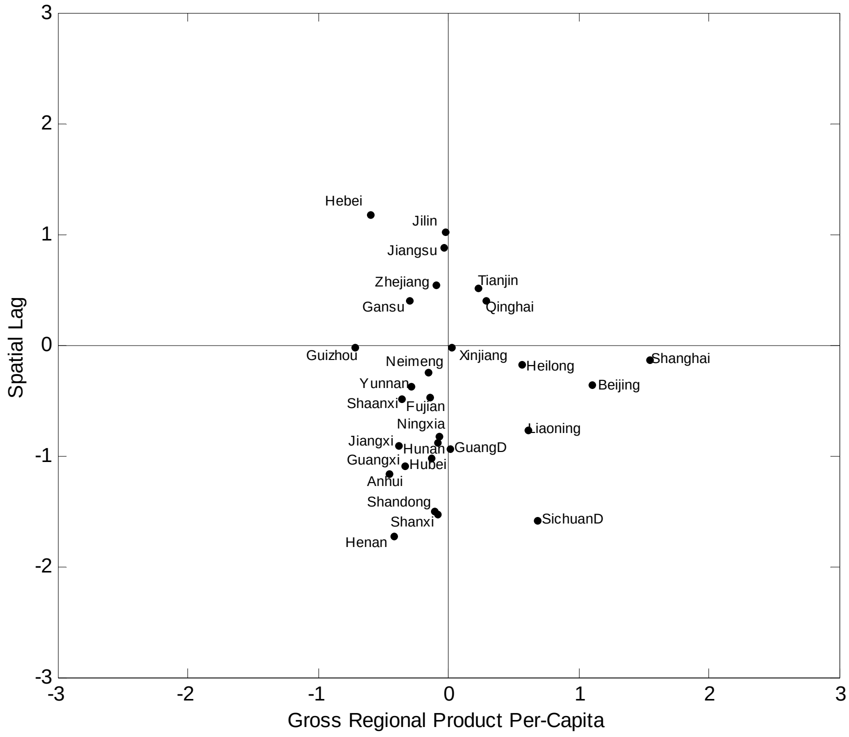
One interesting point here is the situation of Shanghai and Beijing. In 1978 these cities are in the IV quadrant, indicating that their neighbours, on average, have a GDP per capita lower than the national average, but in 1999 they are in the I quadrant, implying that their neighbours, on average, have increased their GDP per capita above the

Figure 2
Moran scatterplot for regional GDP per capita, China 1957



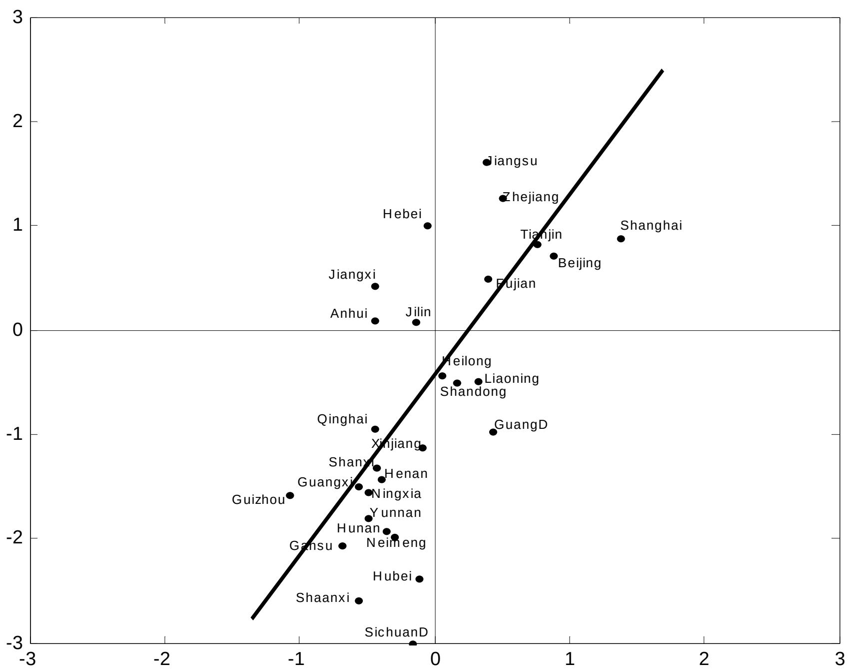
Source: Compiled by the authors based on data from NBS (various years).

Figure 3
Moran Scatterplot for regional GDP per capita, China 1978



Source: Compiled by the authors based on data from NBS (various years).

Figure 4
Moran scatterplot for regional GDP per capita, China 1999



Source: Compiled by the authors based on data from NBS (various years).

national average. It is a clear indication that these regions are a part of the explanation for the high growth of the Moran's I in the last decade and the creation of the so-called 'hot spots', i.e., economic zones growing faster than the rest of the country.

On the other side, fourteen provinces are located in the III quadrant, indicating regions having a GDP per capita below the national average and bordered with neighbouring regions with similar characteristic, i.e., depressed zones.

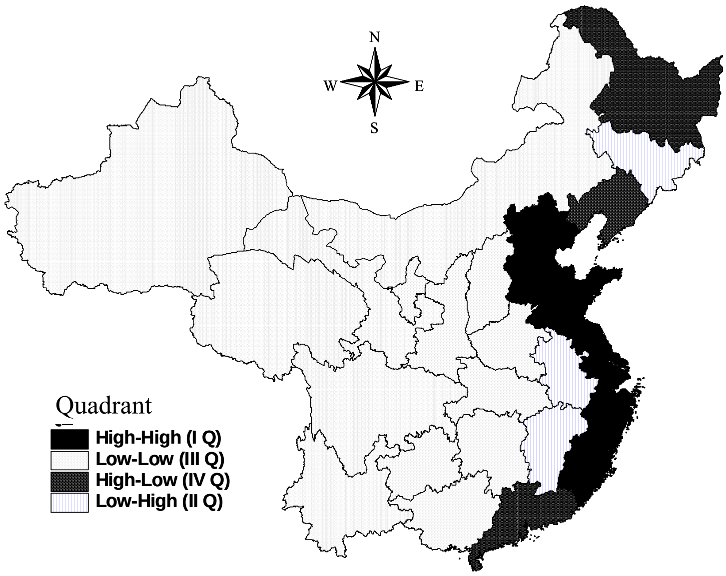
For more precise results, we calculate the local Moran:

$$I_i = \frac{z_i \sum_j w_{ij} z_j}{\sum z_i^2 / n} \qquad (2)$$

Local indicators of spatial association (LISA) can be interpreted as an indicator of spatial cluster, using the indicator itself as the basis of a test where the null hypothesis is the lack of spatial dependence. These local clusters can be identified for those observations in which the LISA is significantly different from zero. However, LISA distributions are usually unknown. Anselin (1995) suggests a method to generate an empirical distribution for LISA consisting of the conditional randomization of the vector z_j. It is conditional in the sense that z_i remains fixed. The reasoning behind the randomization procedure lies in the need to assess the statistical significance of the linkage of one region to its neighbours. Generation of a region's LISA distribution is inferred by the permutation of the neighbours that surround region *i* (obviously, region *i* is not used in the permutation). This empirical distribution provides the basis for a statement on the extremeness of the observed LISA (Aroca, Bosch and Hewings 2001).

When we put these results on the map a clear spatial pattern emerges indicating that the coast regions are conforming to 'hot spots' in China (see Figure 5).

Figure 5
Moran scatterplot map for regional GDP per capita, China 1999



Note: This is a partial map of China including only the regions for which data were available.

Source: Compiled by the authors.

3.3 Distributional description of GDP inequalities

In the previous section we have shown that the interaction of space was important in China's growth process in the last decade, therefore all the parametric approaches that were mentioned in the section on literature should take this fact into account in the last period of analysis, because we could say that the results are at least inefficient and they may even be biased.

In addition, Jian, Sachs and Warner (1996), Zhang, Liu and Yao (2001) and Fujita and Hu (2001) obtain their results according to the traditional parametric approach of convergence based on the mean (conditional and unconditional) and the variance of growth, which assumes that this will be a good representation if each observation of the growth rate is identical, independently distributed and follows a normal distribution. However, if the assumption of independency or normality does not hold, then this instrument could lead to erroneous conclusions.

Rey and Montouri (1999), Aroca, Bosch and Hewings (2001) and Baumont *et al.* (2006) show the impact on the parametric approach results of taking account the spatial interaction or spatial heterogeneity. On the other hand, Quah (1993, 1997 and 2000), López-Bazo *et al.* (1999) and Rey (2000 and 2001) suggest studying the complete distribution of the growth rate instead of the mean and variance, as is done in the non-parametric approach.

To study the Chinese growth process with special focus on the concepts described above, we examine the behaviour pattern of the distribution of income per capita across the provinces of the country. According to Quah (1997: 2), it is important to show how the shape of the distribution has changed over time:

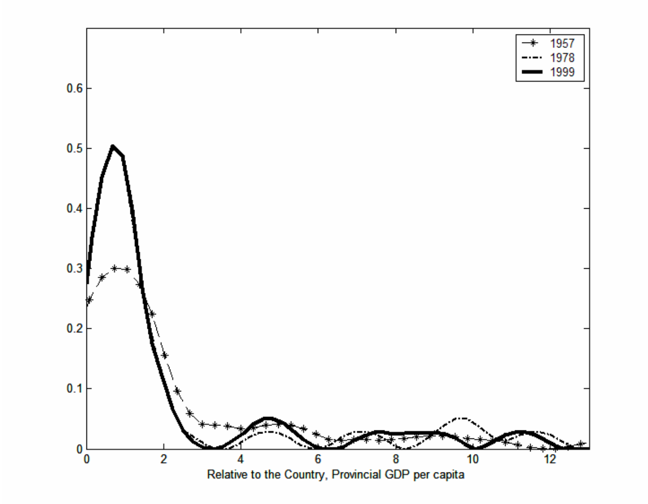
> What also matters is that these features have a natural interpretation in terms of polarization: those portions of the underlying population of economies collecting in the different peaks may be said to be polarized, one group versus another. More generally, if more than two peaks emerged, it might be natural to call the situation stratification.

Two tools are commonly used to study the distribution of a random variable and their mobility across time: Markov transition matrix and stochastic densities (see Silverman 1986). The former is believed to measure persistence or mobility among a discrete number of states, while the later was built to estimate the probability density function in a continuous framework.

First, we estimate the densities function for different years in order to determine how this function has changed over time. Figure 6 shows the empirical densities functions for 1957, 1978 and 1999. Quah (1997) uses the term 'emerging twin peaks' to describe a situation where there is a clustering of the very rich, a clustering of the very poor and a disappearance of the middle-income class.

In Figure 6, the year 1957 clearly showed a one-peak distribution with a long flat right tail. However, for the year 1978, there were several peaks emerging in the tail of the empirical density distribution for China.

Figure 6
Chinese empirical density, 1957, 1978 and 1999



Source: Compiled by the authors based on data from NBS (various years).

According to the previous definition, this could be called *stratification*. It means that a group of Chinese province are converging to different levels relative to the country's GDP per capita.

The second peak for the year 1999 emerged stronger than in 1978, while the other peaks in the distribution tail were fewer and smaller in 1999 than in 1978. If this trend continues into the future, we can predict that Quah's hypothesis of two emerging peaks to hold.

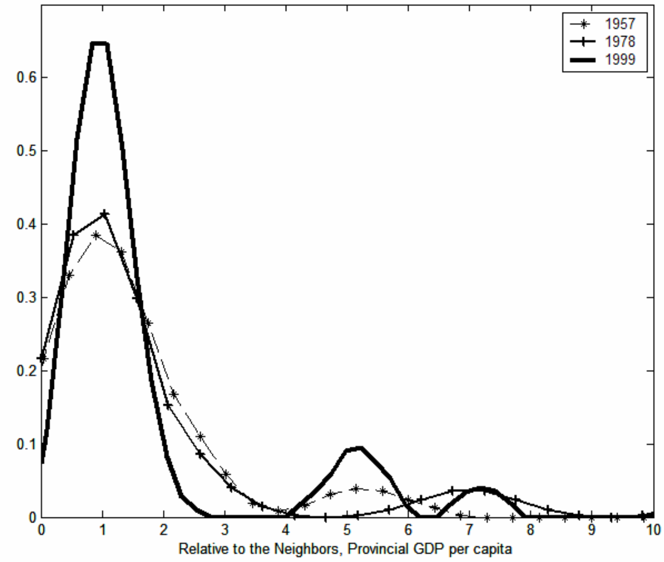
In contrast, Rey (2000) finds for the USA that the change in the distribution over the years was dramatic, 'going from the twin peaks distribution of 1929 to a more unimodal distribution' in 1994. In addition, the direction of this distribution change was favourable, and increased the income of the poorer states and relatively decreased the income of the richer. On the other side, China exhibits the opposite; it is moving from a unimodal distribution to a multimodal distribution, and possibly to a bimodal in the future.

Another interesting point is that in 1957 the unimodal distribution peaked around 1, with a high concentration ranging from 0 to 3. However in 1978 and 1999, this first peak was less than 1 and the first range went from 0 to around 2. On the other side, maximum significant values of the distribution were around 6, while in 1978 and 1999 these values were almost around 12, showing an increase in variance and a difference between the poor and the rich.

3.4 Conditioning by space

In the previous section we standardized the provincial GDP with the national average. Quah (1993) proposes alternative conditions that could help to better understand the GDP evolution. In this section we condition the income per capita distribution with space, which means that we standardize the GDP per capita of each province by the average per capita GDP of its neighbours. If there is no spatial effect on the distribution of GDP per capita, then we should find a situation similar to the one described in the previous section. In contrast, if spatial effect exists and differences in income are smoothly distributed across space, then we should find one-peak distribution.

Figure 7
Chinese empirical density conditioned by space, 1957, 1978 and 1999



Source: Compiled by the authors based on data from NBS (various years).

Table 1
Conditioned by space

t0	Lag	Obs.	t1 P	L	M	U	R
P	P	74	89.2%	10.8%	0.0%	0.0%	0.0%
	L	78	75.6%	24.4%	0.0%	0.0%	0.0%
	M	79	87.3%	12.7%	0.0%	0.0%	0.0%
	U	15	60.0%	40.0%	0.0%	0.0%	0.0%
	R	0	0.0%	0.0%	0.0%	0.0%	0.0%
L	P	32	18.8%	78.1%	3.1%	0.0%	0.0%
	L	101	13.9%	73.3%	12.9%	0.0%	0.0%
	M	89	10.1%	70.8%	19.1%	0.0%	0.0%
	U	25	0.0%	68.0%	32.0%	0.0%	0.0%
	R	0	0.0%	0.0%	0.0%	0.0%	0.0%
M	P	26	0.0%	15.4%	65.4%	19.2%	0.0%
	L	68	0.0%	13.2%	73.5%	13.2%	0.0%
	M	92	2.2%	20.7%	69.6%	7.6%	0.0%
	U	60	0.0%	0.0%	91.7%	8.3%	0.0%
	R	0	0.0%	0.0%	0.0%	0.0%	0.0%
U	P	0	0.0%	0.0%	0.0%	0.0%	0.0%
	L	15	0.0%	0.0%	40.0%	60.0%	0.0%
	M	113	1.8%	0.0%	8.0%	90.3%	0.0%
	U	119	0.0%	0.0%	0.8%	95.8%	3.4%
	R	0	0.0%	0.0%	0.0%	0.0%	0.0%
R	P	15	0.0%	0.0%	0.0%	0.0%	100.0%
	L	18	0.0%	0.0%	5.6%	0.0%	94.4%
	M	109	0.0%	0.0%	0.0%	0.0%	100.0%
	U	101	0.0%	0.0%	0.0%	8.9%	91.1%
	R	3	0.0%	0.0%	0.0%	0.0%	100.0%

Source: Calculated by the authors.

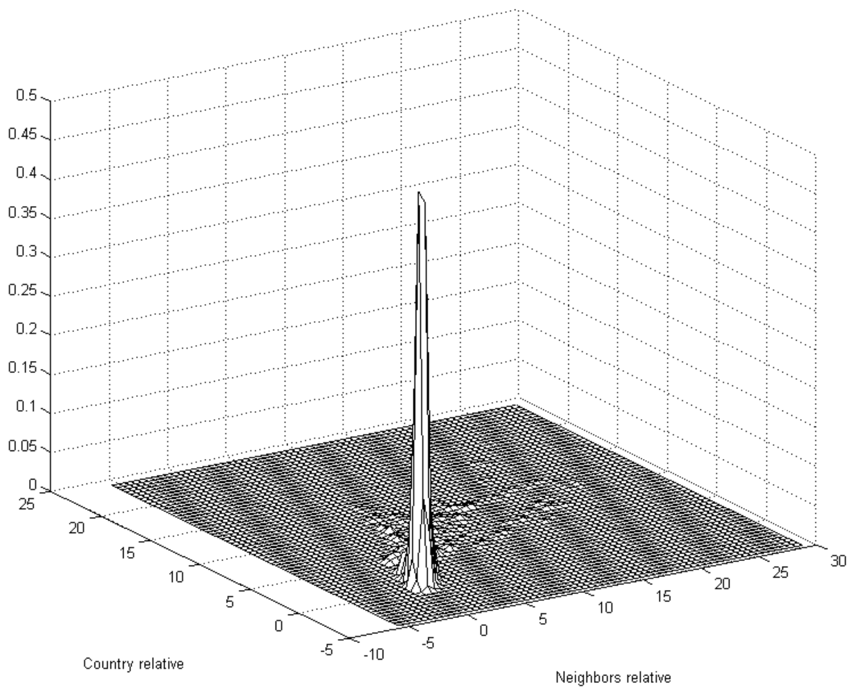
Figure 7 shows changes over time. In 1957 there was just a small rise in the distribution indicating the existence of a zone where the difference between the GDP per capita of those provinces and their neighbours was 5 times larger. However, the main peak was centred on one. In 1978, even though the distributional characteristics remained unchanged, the difference was seven times larger than before. In 1999, the distribution had a stratification shape, indicating three different zones; zones in which the difference of the per capita GDP between the provinces and its neighbours is about 7 times greater, zones with differences of about 5 times greater, and finally zones where there is no significant difference.

3.5 Transitions in the distribution

Once we have established that there have been changes in the distribution of provincial GDP per capita, we would like to find the specific provinces that have been affected and the direction of change. We have two tools for studying transition in distribution: the Markov transition matrix and the stochastic kernel. First, we estimate the Markov transition matrix (MTM) conditioned by space as in Rey (2000). We define five feasible income levels for each province: poor (P), low income (L), medium income (M), upper income (U) and rich (R).

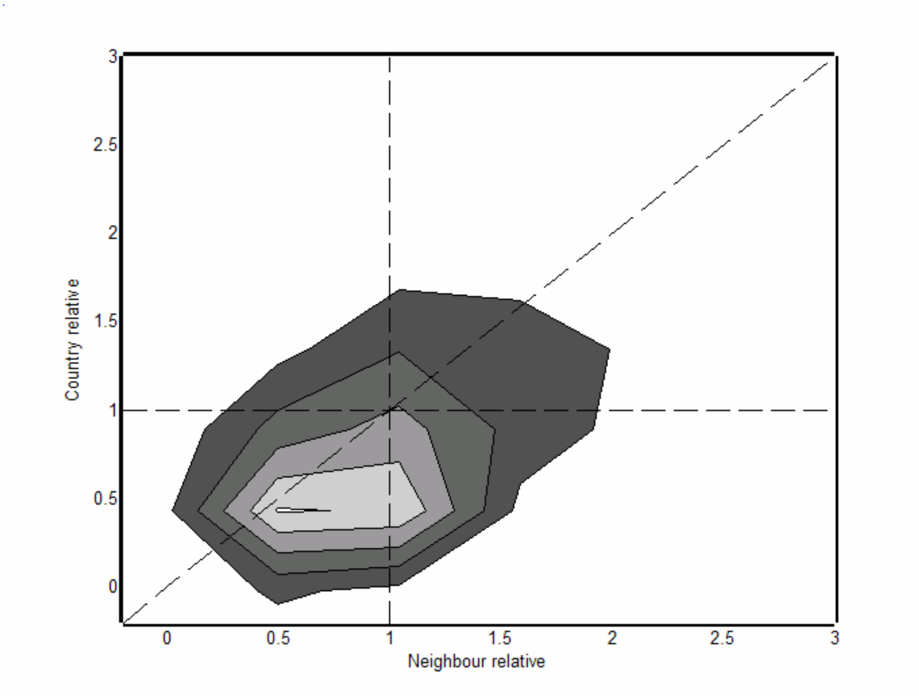
The matrix is calculated based on changes over intervals of four years. Table 1 shows that there is much more mobility among the lower-income provinces than the high-income ones. For example, if a province were rich in the initial stage, the probability of being rich at the end of the period is almost 1, regardless of the economic standing of its neighbours. However, if a province's origin state is poor, then there is more than 40 per cent of it achieving the lower-income level if its neighbouring provinces are at the upper income level. But if the neighbouring regions are poor, the province has only about 10 per cent chance of reaching the lower-income level. In general, the Markov transition

Figure 8
Stochastic Kernel for Chinese regions relative to the per capita GDP of the neighbouring provinces



Source: Compiled by the authors based on data from NBS (various years).

Figure 9
Contour for Chinese regions relative to the neighbours per capita GDP



Source: Compiled by the authors based on data from NBS (various years).

matrix shows that there is some transition especially in the low end of distribution, however the possibility is higher at the larger income level of distribution. Nevertheless, these results could be the outcome of the limited definition for income levels, because there is no further category beyond rich or lower category after poor. This fact could, thus, account for the larger mobility among the middle-income levels and lower mobility in the extreme levels.

An alternative way to deal with this problem is the stochastic kernel. Figures 8 and 9 show the results for China's GDP per capita conditioned by space. The stochastic kernel shows a high persistence with some small variability at high levels of relative income, which confirms the results from the Markov transition matrix with respect to the persistence. On the other side, the contour shows that the neighbouring effect is strong, given that the shape of the contour is biased to the lower part of the main diagonal. This implies that the provinces in comparison to the national level are in a worse position than in comparison to neighbours.

4 Conclusions

The purpose of this paper is to examine the regional income convergence process in China by using non-parametric methods that take into account the influence of spatial interaction. The methods include density function and Markov chain analysis integrated with spatial analysis. The paper shows that in China there has been an increase over the last 20 years in the spatial dependence of the per capita GDP. Consequences of the spatial effect play an important role, as is shown by the positive impact that neighbouring effect has on regional income distribution. The dynamics of the process provides evidence that China's regional income distribution has moved from convergence to stratification and from stratification to polarization. This is revealed in the widening income difference between the coastal (core) and the inner land (periphery) regions. Especially the strong probability of the rich staying rich and the poor staying poor may sustain this trend, resulting in long-lasting regional income disparities between the core and the periphery regions. China's regional income distribution may prove to be a confirmation of the new economic geography's prediction, namely a sharp polarization in the presence of high interregional transportation costs.

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