Analyzing Regional Inequality in Post-Mao China in a GIS Environment

Danlin Yu and Yehua Dennis Wei

Abstract: Regional inequality in China has attracted considerable scholarly attention, but the use of geographic information system (GIS) techniques for rigorous analysis remains limited. This paper utilizes recent data and GIS and spatial statistical techniques to analyze changing patterns of regional inequality in China from 1978 to 2000. It also identifies the changing clusters of regional development in China. We illustrate that regional inequality in China is sensitive to development trajectories of the provinces, and that conventional measures of regional inequality mask geographical clustering. Patterns of change are explained by both contextual and regression analyses. Journal of Economic Literature, Classification Numbers: F21, G32, P31. 16 figures, 3 tables, 30 references.

INTRODUCTION

Regional inequality has always been a core subject of research for geographers and regional scientists, and there have been lasting debates between the convergence (e.g., neoclassical growth model), divergence (e.g., cumulative causation), inverted-U, and neo-Marxist schools. This has attracted renewed interest and interdisciplinary attention since the early 1990s, especially in geography, economics, and regional science. Despite tremendous efforts, disagreements persist and empirical findings are mixed. Scholars have argued for regional convergence (e.g., Armstrong, 1995; Barro and Sala-I-Martin, 1995), endogenous growth models, and regional divergence (Maxwell and Hite, 1992). Researchers also argued for the importance of geography (e.g., Krugman, 1995), and emphasized institutions, agglomeration, and geographic clustering in regional development.

Regional inequality is a particularly burning issue in former socialist countries where scholars and government officials debate the scope and consequences of reforms. They are quite concerned about whether reforms have intensified regional inequality, as part of an attempt to understand the process of transition and regional development in these countries. Scholars have argued that the transition exhibits multiple forms, and is characterized by path dependency, partial reform, and geographical unevenness (e.g., Grabher and Stark, 1997; more recently, see Bradshaw and Vartapetov, 2003). Although empirical findings remain mixed, many argue for polarization and the persistence or increase of regional inequality in Central and Eastern Europe (CEE) (e.g., Ozornoy, 1991; Petrakos, 2001; Dienes, 2002).

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When the People's Republic of China (PRC) was established in 1949, Chinese leader Mao Zedong inherited a poor economy with substantial regional inequality. Although China was “socialist,” Mao’s policy was inconsistent and shifted with changing domestic and international conditions (Ma and Wei, 1997). Influenced by egalitarian ideas and a socialist ideology, Mao had attempted to reduce regional inequality through the transfer of resources and through development of China's interior provinces. However, the policy of decentralization and rural industrialization allowed the growth of rural enterprises in coastal China. While some scholars have argued that Mao did reduce regional inequality in China, many others hold that regional inequality persisted during Mao's rule, because of a historical legacy, defense considerations, and regional autarky (Wei, 2000).

After 1978, China began to implement radical economic reforms and to open its economy to the outside world. Influenced by the Inverted-U theory and the “ladder-step theory,” the government argued that concentration and coastal development would accelerate national development, and that as the economy matured diffusion would eventually stimulate development of the interior and reduce regional inequality (Fan, 1995; Wei, 2000). Since the early 1990s, China has accelerated the process of globalization and economic liberalization. With rising inequality and concern over it in interior China, the government has placed a greater focus on poverty reduction and development of the interior, announcing a strategy of western development to aid the poorer regions and reduce regional inequality in China.

Research on post-Mao China has revealed the intensification of China's coastal-interior divide, although interprovincial inequality on the whole declined in the 1980s (Fan, 1995; Wei, 2000; Lu and Wang, 2002). Scholars have emphasized the importance of multiple scales of analysis and mechanisms in understanding changing patterns of regional inequality in China (Wei, 2000, 2002). They have also analyzed regional inequalities within individual provinces in China, especially in Jiangsu and Guangdong (e.g., Wei and Fan, 2000; Gu et al., 2001; Wei and Ye, in press), and trajectories of local/regional development (e.g., Ma and Cui, 2002).

Despite advances in the study of regional inequality in China during the last few years, further research is needed in several areas. First, there is a need for more rigorous data analysis. Much new ground has been broken in GIS research, but sophisticated GIS techniques are rarely used in the study of regional inequality, including in China. Second, most of the publications on interregional and interprovincial inequalities in China have study periods that ended in the early 1990s, such as Fan (1995) and Wei and Ma (1996). It has become necessary to update previous studies to understand patterns of change in the 1990s, a decade during which China experienced more rapid reform.

This paper attempts to contribute to the literature on regional inequality in China in three areas. First, we will apply recent developments in GIS to the study of regional inequality in the country. We contend that conventional measures of regional inequality mask geographical disparities and clustering. Using GIS, especially spatial analysis techniques, we will analyze clusters of regional development for a better understanding of changing regional inequality in China. Second, since most of the existing studies cover the period up to the early 1990s, we attempt to provide a fuller picture of changing regional inequality in China.

2The Inverted-U theory posits that regional development will follow an inverted-U trajectory: Rising regional inequalities and dualism are typical of early development stages, whereas regional convergence and a disappearance of severe dualism are typical of the more mature stages of regional growth and development (Williamson, 1965). The “ladder-step theory” follows the same logic, and argues that during the process of development, wealth will diffuse from richer to poorer regions, downward like steps on a ladder.
post-Mao China by extending the study period to 2000. We would like to know particularly whether the 1980s trend of decreasing interprovincial inequality continued in the 1990s. We shall demonstrate that regional inequality in China is sensitive to development processes and geographical scales, especially the development trajectories of the provinces. Finally, we will explain the changing patterns of regional inequality by considering contextual factors and incorporating recent developments in economic geography. In the sections that follow, we first investigate changing regional inequality in China through an analysis of regional inequality indicators, and then employ GIS to analyze geographical disparities and clustering. We subsequently further explain patterns of change through both contextual and regression analyses.

MULTISCALAR PATTERNS OF REGIONAL INEQUALITY

Several statistical indices are commonly employed in measuring regional inequality, particularly the coefficient of variation (CV) (Wei, 2000). Although national income was the variable most frequently used in analyzing regional inequality under Mao, for the post-Mao period, regional GDP per capita is most common. For facilitating temporal comparison, we use real GDP per capita in constant rather than current prices.

Research on regional inequality in post-Mao China documented a trend of declining interprovincial inequality during the 1980s, but the changing patterns of the 1990s remain less clear. Figure 1 shows geographical regions and provincial level administrative units (hereafter simplified as provinces) in China for reference. As evident in Figure 2, CVs for interprovincial inequality exhibit a U-shaped pattern: it declined in the 1980s, as revealed by several previous studies, but has risen substantially since 1990. More specifically, CVs for interprovincial inequality decreased from 0.96 in 1978 to 0.83 in 1990, but increased to 0.94 in 2000. An analysis of the Gini coefficient also reveals a U-shaped pattern, albeit one that is not as smooth (gradual) as the CV. Interprovincial inequality in China therefore does not appear to follow the convergence, divergence, or inverted-U patterns. Interregional inequality across the eastern, central, and western regions has been rising consistently during the study period, without any sign of convergence.

Development trajectories of individual provinces have a tremendous impact on the overall regional picture. We have calculated the location quotient (LQ) of GDP per capita for each province to depict changing fortunes of the provinces. We have classified the provinces into six groups based on their geographical location and changing patterns of LQs, as well as on cluster analysis and other classifications by scholars working on China (e.g., Wei and Ma, 1996) (Table 1). The three municipalities of Beijing, Tianjin, and Shanghai are often grouped together (Group I), although cluster analysis identified substantial disparities among their changing patterns of LQs. In general, their LQs fluctuated at high values, with Beijing staying almost the same during the reform era, whereas Tianjin's LQs declined (Fig. 3). LQs for Shanghai, however, declined from 1978 to 1990, but have been rising since then. The changing LQs of Shanghai resemble that of the CV, indicating the significant contribution of Shanghai to changing interprovincial inequality in China.

Group II includes five coastal provinces: Jiangsu, Guangdong, Zhejiang, Fujian, and Shandong. This group benefited the most from China's reforms, and their status in the
Fig. 1. China’s regions and provinces.

Fig. 2. Changes in the coefficient of variation in China.
Table 1. Grouping of Provinces Based on Location Quotients, 1978–2000

<table>
<thead>
<tr>
<th>Group</th>
<th>Provinces</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Municipalities</td>
<td>Shanghai, Beijing, Tianjin</td>
</tr>
<tr>
<td>II Coastal</td>
<td>Jiangsu, Zhejiang, Guangdong, Fujian, Shandong</td>
</tr>
<tr>
<td>III Central</td>
<td>Hubei, Hunan, Anhui, Jiangxi, Henan, Heibei, Hainan</td>
</tr>
<tr>
<td>IV Industrial</td>
<td>Liaoning, Jilin, Heilongjiang, Neimenggu, Shanxi</td>
</tr>
<tr>
<td>V Northwestern</td>
<td>Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang</td>
</tr>
<tr>
<td>VI Southwestern</td>
<td>Sichuan, Guizhou, Yunnan, Xizang, Guangxi</td>
</tr>
</tbody>
</table>

Fig. 3. Changes in location quotients for the three municipalities.

Fig. 4. Changes in location quotients of the five coastal provinces.

national economy was raised dramatically (Fig. 4). Guangdong, Zhejiang, and Jiangsu were among the most rapidly growing provinces during the reform in China, and are identified by cluster analysis as a coherent group. Fujian, while traditionally poorer, has also recorded rapid growth, and emerged to join its southern coastal peers. Shandong, another coastal
province, but in north China, grew more slowly than the other four provinces in this group; the changing pattern of its LQs resembles that of its southern neighbors.

The LQs of Hebei, Hainan, and the five central provinces of Hubei, Hunan, Anhui, Jiangxi, and Henan (Group III) had relatively slight changes during the reform. Indeed, except for Hainan, which was separated from Guangdong province in 1988 and recorded rapid growth from 1988 to 1993, their status was relatively stable during the 1990s (Fig. 5). The status of Hebei declined during the 1980s but rose in the 1990s. The status of Anhui and Hunan also rose during the 1990s, while Hunan declined the most. Even Hainan's status, with the shift of preferential policies to the Yangtze Delta in 1992, declined and stabilized at the end of the research period.

The status of the three northeastern provinces and the two northern central provinces (Group IV), which were either favored by Mao's industrialization policy or industrialized based on the natural resources (such as coal), eroded during the reform period (Fig. 6). The status of Heilongjiang declined quite substantially, as evidenced by the decrease of LQ from
1.5 in 1978 to 0.87 in 2000. Their economies, dominated by SOEs and resource-consuming heavy industry, have been slow to restructure and have faced challenges from nonstate enterprises in other coastal regions. They have also fallen behind their coastal peers in opening up to the outside world.

Groups V and VI include all nine western provinces and one coastal province, Guangxi. Their status declined substantially during the reform. Guizhou, Qinghai, and Ningxia were the biggest losers during the reform period (Figs. 7 and 8). Their problems and declining status during the 1980s caught the attention of the central government, and efforts have been made since the mid-1990s to improve their economic conditions. However, the LQs declined further in the 1990s, indicating that central government policies have not been able to stop their eroding status. Xizang (Tibet) has been the recipient of special policies from the central government since the early 1950s. With the rapid growth of the coastal provinces, however, its relative status has been declining as well.

To shed more light on regional development in China, we also calculated growth rates of provincial GDP per capita. In 1978, the municipalities (Group I) and some of the industrial provinces (Group II) had higher per capita GDP, followed by selected coastal and interior
Fig. 9. GDP per capita in 1978.

provinces (most are resource-based or political-oriented, such as Qinghai, Gansu, and Xizang), while provinces in the southwest were the poorest (Fig. 9).\textsuperscript{4} However, as shown in Table 2, the growth rates of Shanghai and Tianjin (Group I) during 1978–1990 were among the lowest, and that of Beijing was below average, whereas the southeastern coastal provinces (Group III) were the growth leaders. The slower growth of the municipalities is attributed to their slower economic reforms. During the first decade of the reform, Shanghai and Tianjin, in particular, were heavily burdened by their problematic state-owned enterprises. The eroding status of traditionally leading provinces and the emergence of a group of coastal provinces led to the decline of interprovincial inequality during the period from 1978–1990. Overall, the coastal region recorded faster growth than the interior region, leading to the rise of the coastal-interior divide.

Since 1990, not only did the coastal provinces continue to outgrow the interior provinces, but the growth in the municipalities began to accelerate. Efforts to revitalize Shanghai, for example, made it one of the fastest growing province-level units in 1990–2000. Consequently, due to the rising status of Shanghai and the continued growth of the coastal provinces, interprovincial inequality in China increased during the 1990s. By 2000, the provinces with the highest GDP per capita were all coastal, whereas the poorest provinces were located in the interior region (Fig. 10). The gap between the coastal and interior regions increased dramatically during the period from 1978 to 2000.

\textsuperscript{4}We used natural breaks (Jenks) in ArcGIS as the classification method to divide the 30 provinces/municipalities into five classes according to their GDP per capita (in current prices) in Figures 9 and 10.
Table 2. Growth Rates of the Provinces of China, 1978–2000

<table>
<thead>
<tr>
<th>Province</th>
<th>Label</th>
<th>GDP per capita(^a)</th>
<th>Average annual growth rate, (^\text{pct.})</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eastern (Coastal) Region</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liaoning</td>
<td>LN</td>
<td>680</td>
<td>1,491</td>
</tr>
<tr>
<td>Hebei</td>
<td>HeB</td>
<td>364</td>
<td>792</td>
</tr>
<tr>
<td>Beijing</td>
<td>BJ</td>
<td>1,290</td>
<td>3,038</td>
</tr>
<tr>
<td>Tianjin</td>
<td>TJ</td>
<td>1,160</td>
<td>2,345</td>
</tr>
<tr>
<td>Shandong</td>
<td>SD</td>
<td>316</td>
<td>848</td>
</tr>
<tr>
<td>Jiangsu</td>
<td>JS</td>
<td>430</td>
<td>1,300</td>
</tr>
<tr>
<td>Shanghai</td>
<td>SH</td>
<td>2,498</td>
<td>5,052</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>ZJ</td>
<td>331</td>
<td>1,105</td>
</tr>
<tr>
<td>Fujian</td>
<td>FJ</td>
<td>273</td>
<td>829</td>
</tr>
<tr>
<td>Guangdong</td>
<td>GD</td>
<td>369</td>
<td>1,276</td>
</tr>
<tr>
<td>Hainan</td>
<td>HaN</td>
<td>314</td>
<td>1,009</td>
</tr>
<tr>
<td>Guangxi</td>
<td>GX</td>
<td>225</td>
<td>412</td>
</tr>
<tr>
<td><strong>Central Region</strong></td>
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<tr>
<td>Heilongjiang</td>
<td>HLJ</td>
<td>564</td>
<td>1,092</td>
</tr>
<tr>
<td>Jilin</td>
<td>JL</td>
<td>381</td>
<td>941</td>
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<tr>
<td>Neimenggu</td>
<td>NMG</td>
<td>317</td>
<td>822</td>
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<tr>
<td>Shanxi</td>
<td>SX</td>
<td>363</td>
<td>784</td>
</tr>
<tr>
<td>Henan</td>
<td>HeN</td>
<td>232</td>
<td>598</td>
</tr>
<tr>
<td>Hubei</td>
<td>HuB</td>
<td>330</td>
<td>820</td>
</tr>
<tr>
<td>Anhui</td>
<td>AH</td>
<td>244</td>
<td>593</td>
</tr>
<tr>
<td>Hunan</td>
<td>HuN</td>
<td>286</td>
<td>592</td>
</tr>
<tr>
<td>Jiangxi</td>
<td>JX</td>
<td>276</td>
<td>647</td>
</tr>
<tr>
<td><strong>Western Region</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sichuan</td>
<td>SC</td>
<td>262</td>
<td>617</td>
</tr>
<tr>
<td>Guizhou</td>
<td>GZ</td>
<td>175</td>
<td>419</td>
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<tr>
<td>Yunnan</td>
<td>YN</td>
<td>226</td>
<td>572</td>
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<tr>
<td>Xizang</td>
<td>XZ</td>
<td>375</td>
<td>725</td>
</tr>
<tr>
<td>Shaanxi</td>
<td>SSX</td>
<td>291</td>
<td>711</td>
</tr>
<tr>
<td>Gansu</td>
<td>GS</td>
<td>348</td>
<td>757</td>
</tr>
<tr>
<td>Qinghai</td>
<td>QH</td>
<td>428</td>
<td>737</td>
</tr>
<tr>
<td>Ningxia</td>
<td>NX</td>
<td>370</td>
<td>843</td>
</tr>
<tr>
<td>Xinjiang</td>
<td>XJ</td>
<td>313</td>
<td>880</td>
</tr>
</tbody>
</table>

\(^a\)Yuan, in real prices.

Source: Compiled by the author from data contained in SSB 1999, 2001
INVESTIGATING REGIONAL DIVERGENCE WITH GLOBAL MORAN'S I

Popular regional inequality indexes such as the CV and Gini coefficient can only reveal overall inequality. Although location quotients are useful in depicting the changing status of regions, both types of indexes have limited utility in revealing spatial agglomeration and the character of interregional relations. Recent developments in GIS have provided effective tools to analyze spatial association, agglomeration and clustering, which can shed more light on regional inequality in China.

Moran's Index (or Moran's I) has been used to detect spatial autocorrelation, and to analyze spatial relationships among regions (Upton and Fingleton, 1985; Anselin, 1988; 1995; 1996). As an indication of spatial concentration, global Moran's I can be used to indicate spatial convergence or divergence: an increasing global Moran's I means that the rich group continues to accumulate wealth while the poor become poorer, and the absolute gap between them is enlarging. A decreasing global Moran's I indicates that the clusters are disappearing and a more even distribution occurs.

To calculate Moran’s I, the most important step is to determine a spatial neighbor weight matrix. In this study, we derive a weight matrix based on each province’s spatial contiguity in ArcGIS and R software. We then calculated global Moran’s I for every year from 1978 to 2000 in R.

Figure 11 depicts global Moran’s I for GDP per capita for each year from 1978 to 2000. Our analysis confirmed that the index in each year is significant (at the 10 percent level by normal approximation) and ranged from a positive 0.11 to 0.22. Unlike the U-shaped pattern of CVs, global Moran’s I increased over time, although there was a slight drop in 1989 and

\[
I = \frac{K}{n^2} \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} (P_i - \bar{P})(P_j - \bar{P}) \sum_{i=1}^{n} (P_i - \bar{P})^2
\]

Here, \( w_{ij} \) is the binary weight matrix of the general cross-product statistic, such that \( w_{ij} = 1 \) if locations \( i \) and \( j \) (two spatial units) are adjacent (share a boundary) and zero for all non-adjacent pairs, and by convention \( w_{ii} = 0 \) (a cell or region is not adjacent to itself). \( P_i \) and \( \bar{P} \) are the summary measure (in our case, the GDP per capita) in the \( i \)-th province and the average of the provinces, respectively. Values of Moran's I range from +1, which means absolute positive spatial autocorrelation—i.e., high values or low values cluster together—to 0, which means a random pattern (randomly distributed in the space), and to -1, which indicates absolute negative spatial autocorrelation, i.e., high values cluster with low values. Since the results of calculating Global Moran’s I indicate that all the values are positive and significant, we therefore deal with positive values only.

There are different ways to assign values to \( w_{ij} \) besides considering the spatial units’ spatial adjacency. The distance between two spatial units is also commonly used, but debates still exist (Anselin, 1988; Bao et al., 1995). In this paper, we only consider the adjacency of the spatial units because we use global Moran’s I to detect the spatial dependence among the provinces in China. According to Anselin (1988), under such a circumstance, the requirement of a specific weight matrix is not very stringent; and since there is no absolutely superior way of defining spatial adjacency, we opted for simple adjacency (sharing of a boundary) to obtain the spatial weights. All the weights are row standardized, with the sum of weights of any row being equal to 1.

ArcGIS and R deal with shapefiles. Although shapefiles do not contain topological information about the shapes in the file, ArcGIS can create topological information for the shapefile, and R, a popular statistical freeware, is capable of deriving the contiguity information from the shapefile.
1990 due to the Tianamen incident and economic slowdown. This indicates an increasing concentration of growth among the provinces of China.

In the 1980s, CVs declined, which indicates interprovincial convergence; global Moran’s $I$, however, revealed an opposing trend of spatial concentration. In the 1990s, spatial concentration continued, which is consistent with the increase of the CV. Moran’s $I$ increased the most during the mid-1980s and early 1990s when China implemented more radical economic reforms.
With the rise of the coastal-interior gap, by the mid-1990s the Chinese government began to take steps to reduce poverty and regional inequality, as evidenced by the Ninth Five-Year Plan (1995–2000), the China Agenda 21st (Yu and Mao, 1999), and the Western Development Strategy. Figure 11 indicates that after 1995 global Moran's $I$ increased only slightly, indicating that although spatial concentration continues, its speed has been declining. This finding is consistent with the slower rise of LQs of the emerging coastal provinces in Figure 4.

**ANALYZING SPATIAL ASSOCIATION WITH THE MORAN SCATTERPLOT**

Global Moran's $I$ reveals overall spatial associations, but does not provide information about the spatial association of individual spatial units (provinces). It may therefore mask pockets of non-stationarity among provinces that deviate from the overall pattern; it is also difficult for GIS to visualize the global index and provide a more detailed analysis. To address these issues, we utilized the Moran scatterplot to undertake a disaggregated analysis of regional development in China.

The Moran scatterplot was first developed by Anselin (1996) as an exploratory spatial data analysis (ESDA) tool to assess local instability in spatial association. The central idea of the Moran scatterplot is to treat global Moran's $I$ as a regression coefficient of the spatial lag $w_y^2$ against the observed value (in the form of departure from the mean) $y$. In the Moran scatterplot, the four different quadrants divide two types of spatial association (i.e., the positive and negative associations) into four different types of local spatial association between individual provinces. Among the positive associations, quadrant I, HH indicates high values surrounded by high values, and quadrant III, LL indicates low values surrounded by low values; among the negative associations, quadrant II, LH, and quadrant IV, HL, indicate low values surrounded by high values, and high values surrounded by low values, respectively.

In addition, since the scatterplot was derived from a linear regression equation, the extent of the fitness of the scatterplot indicates the degree of local instability. Such an interpretation of the index provides an effective way of summarizing the overall spatial pattern and detecting the individual spatial instability in the sense that a lack of fit would indicate important local pockets of non-stationarity (Anselin, 1996). Figures 12 and 13 depict the Moran scatterplots in 1978 and 2000, with a linear smoother superimposed. Figure 14 is the corresponding GIS visualization of the 2000 scatterplot. The provincial labels are listed in Table 2.

The two scatterplots and the map show clearly that most provinces fall in quadrant III, the LL type (20 out of 30 in 1978, and 18 out of 30 in 2000), indicating that at the first year of reform and the last year of the study period, spatial patterns of China's regional development were dominated by geographical clustering of poorer provinces. We also notice from the superimposed lines that in both years the scatterplots lack fitness, which suggests that there is spatial instability in regional development in China.

The changing positions of the five coastal provinces/municipalities of Shanghai, Jiangsu, Zhejiang, Guangdong, and Fujian in the scatterplots in particular warrant attention. In 1978, Shanghai was in quadrant IV (i.e., high values surrounded by low values), indicating that Jiangsu and Zhejiang, the two provinces surrounding Shanghai, had relatively lower

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*A spatial unit's spatial lag is a weighted average of the value of its neighbors. The weights are obtained from the same spatial contiguity matrix used to calculate the Moran's Index.*
Fig. 12. Moran scatterplot of GDP per capita in 1978. Legend: I = high values surrounded by high values; II = low values surrounded by high values; III = low values surrounded by low values; IV = high values surrounded by low values.

Fig. 13. Moran scatterplot of GDP per capita in 2000. Legend: I = high values surrounded by high values; II = low values surrounded by high values; III = low values surrounded by low values; IV = high values surrounded by low values.
per capita GDP (Fig. 12). Fujian was in quadrant III, which means that neither Fujian nor its neighbors were rich provinces.

However, the rapid growth of coastal China during the reform period changed their positions on the Moran scatterplot in 2000 (Fig. 13). Except for Guangdong, all the other southeastern provinces (Jiangsu, Zhejiang, and Fujian) moved to quadrant I (i.e., high values surrounded by high values). This indicates that highly developed economic clustering has occurred in southeastern China (Fig. 14), whereas most of the other provinces have remained less developed. This emerging cluster very much accounts for the increase in interprovincial inequality in the 1990s. The shift of Guangdong from quadrant III to quadrant IV reinforces the fact that there is a widening gap between coastal provinces (especially the southeastern ones) and their interior neighbors. In 1978, Guangdong was in quadrant III, grouped with its neighbors as a province with low GDP per capita. However, its faster growth dwarfed its neighbors, and Guangdong moved to the fourth quadrant; its high value surrounded by low ones.

IDENTIFYING GEOGRAPHICAL CLUSTERING WITH LOCAL MORAN’S I

Scholars have documented that the weighted average of local Moran’s $I$ is equal to global Moran’s $I$, up to a factor of proportionality (Anselin, 1995, 1996). However, the value of the local Moran’s $I$ was usually ignored for analysis in the literature. Since global Moran’s $I$ is an indicator of global spatial clustering, we intend to use the value of local Moran’s $I$ to detect how individual provinces contribute to the global index, and therefore understand how individual provinces contribute to the spatial clustering process.

As shown in Figure 11, during the reform era, global Moran’s $I$ increased almost every year, indicating a clustering trend (divergence) among China’s provinces. When we decompose global Moran’s $I$ into its local form, and compare 1978 with 2000 (Figs. 15 and 16), several interesting findings emerge. First, China’s coast-interior divide persisted, with the interior provinces exhibiting great geographical similarity in terms of GDP per capita and their spatial contributions to global Moran’s $I$. In 1978, the local Moran’s $I$ in most of the interior provinces fell within the range of 0–0.3, except for Guizhou, the poorest province, which contributes slightly more than the interior average. Coastal provinces of Shanghai and Zhejiang were the two biggest negative contributors, while Heilongjiang, Jilin, Liaoning, Hebei, and Jiangsu all had a negative local contribution of around -0.1. This indicates that at the beginning of the reform, spatial clustering was not a major spatial pattern among China’s provinces.

$^9$Local Moran’s $I$ allows for the identification of spatial agglomerative patterns, and is given as:

$$I_i = \sum_{i=1}^{n} w_{ij} * Z_j$$

Here, $Z_i$ and $Z_j$ are the standardized form of the raw data, whereas the spatial weights $w_{ij}$ are in row-standardized form (Bao et al., 1995). So local Moran’s $I$ is a product of the province in question ($Z_i$) and the average of the provinces in the surrounding locations.

$^10$The maps in Figures 15 and 16 join Hainan province and Guangdong province for the calculation of local Moran’s $I$. We did this intentionally for two reasons. First, Hainan province was separated from Guangdong Province only in 1988, so its separation from Guangdong on the 1978 map would make no sense. Second, in our case, we used topological contiguity as a standard to retrieve the spatial neighbor matrix; since Hainan spatially does not have any direct connection with the mainland, the calculation process would treat it as an island and ignore it.
provinces. Indeed, Shanghai, the most developed provincial municipality, was the largest negative contributor to the global index. Considering Shanghai’s large location quotient, it is understandable that Shanghai’s large negative contribution to the global index greatly evened the regional imbalance at the beginning of the reform.

Second, we can observe from the two maps that Beijing and Tianjin were always the major sources of spatial concentration. Their large positive contribution to global Moran’s I in both 1978 and 2000 could be explained by their specific geopolitical location. As the capital of the nation, Beijing has been the recipient of more favorable policy and more investment from the central government than many other provinces, whereas Tianjin is traditionally the gateway to Beijing, and one of the most important industrial bases of China. In addition, the large positive local Moran’s I values of these two municipalities indicate that Beijing and Tianjin have formed a spatially integrated unit. This unit stands out from Hebei, which spatially surrounds them but had negative values. However, the contributions of these two municipalities decreased during the study period, in contrast to the increase of Shanghai’s contribution, which in 2000 became the single largest positive contributor to the global index. This, as well as the increasing contributions of other coastal provinces, indicates both an increase of regional inequality and a shift of the cluster center from its traditional seat in north China to the Yangtze Delta.

Third, Guangdong’s contribution to the global index corresponds with its changing spatial behavior depicted in the Moran scatterplot. In 1978, Guangdong was a spatial unit not significantly different from its neighboring provinces (Fig. 12), and made a small positive contribution to the global index. In 2000, however, its fast growth dwarfed most of its
neighbors (excluding Hainan) and there was little clustering with its neighbors (Fig. 13). It became the largest negative contributor to the global index.

Fourth, while most of the interior provinces have similar patterns, coastal provinces vary considerably. In the last section, it was noted that coastal provinces are located in all four quadrants of the Moran scatterplot in 2000. Figure 16 shows again that all four categories can be found among the coastal provinces. In the 2000 Moran scatterplot, two high-high clusters can be identified: Beijing and Tianjin; and Shanghai, Zhejiang, Jiangsu, and Fujian. The latter group is newly emerged, and the advanced development status of its members not only distinguishes them from their neighbors, but also becomes the primary factor in the rise of the coast-interior gap. Except for Fujian, these two clusters are all large positive contributors to the global index. Fujian, like another coastal province, Shandong (which fell into the low-low quadrant in 2000 Moran scatterplot), are among the most rapidly growing provinces, but their contributions to the global index are fairly low. In 2000, their local Moran I values were only 0.007 and 0.005, respectively. This reflects the fact that rapid growth diminished their gap with the top provinces, bringing about convergence, which is reflected in their small contributions to the global index. Liaoning, an old industrial base of China, still has relatively high GDP per capita when compared with its neighbors. With slow growth, Liaoning became more similar to its neighbors, which was reflected in its small contribution to the global index (in 2000, its local Moran’s I was $-0.05$). Hebei and Hainan (included in Guangdong in calculating the local Moran’s I) are less-developed provinces; their contributions to the global indexes are low as well.

Lastly, Guizhou and Yunnan, two provinces in southwestern China, made relatively high contributions to the global index in 2000. As shown in Tables 1 and 2, they are among the...
poorest and slowest growing provinces. From 1990 to 2000, Yunnan ranked 24th and Guizhou 28th among China’s provinces in terms of GDP per capita growth rate (Table 2). The combined effect is that they lagged far behind both their neighbors and the national average, which is reflected by their relatively high contribution to the global Moran. They form a cluster with low GDP per capita in southwest China, which contrasts sharply with the east coast cluster, exacerbating regional inequality.

UNDERSTANDING REGIONAL INEQUALITY IN CHINA

The above analyses reveal that the pattern of regional inequality in China changed dramatically during the reform era. The underpinning force driving the change was the reform of the Chinese economy. In addition, geographical factors also serve as an important component in the evolution of regional inequality in China (Bao et al., 2002).

To further understand regional inequality in China, we conducted a regression analysis. Regional growth rates are often used to evaluate regional development, and we used the growth rate of GDP per capita in 1990–2000 as the dependent variable. Based on the recent literature in economics and geography (e.g., Wei and Fan, 2000; Wei and Kim, 2002; Bao et al., 2002), along with our consideration of context in China, we have chosen the following independent variables.

1. Foreign direct investment per capita is an important indicator of China’s open door policy and the process of globalization. Because some provinces of China opened in the late 1980s, foreign investment data for those provinces were not available until 1990, which is
Table 3. Results of the Regression Analysis for the Period 1990–2000a

<table>
<thead>
<tr>
<th>Variable or constant</th>
<th>Unstandardized coefficients</th>
<th>Standardized coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. error</td>
</tr>
<tr>
<td>Constant</td>
<td>15.543</td>
<td>1.067</td>
</tr>
<tr>
<td>Coast dummy</td>
<td>1.569</td>
<td>0.550</td>
</tr>
<tr>
<td>Population growth rate</td>
<td>-0.213</td>
<td>0.311</td>
</tr>
<tr>
<td>GDP per capita in 1990</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
<td>FDI per capita in 1990</td>
<td>0.097</td>
<td>0.046</td>
</tr>
<tr>
<td>Share of SOEs in FAI in 1990</td>
<td>-0.094</td>
<td>0.015</td>
</tr>
<tr>
<td>Educational level in 1990</td>
<td>-0.461</td>
<td>0.272</td>
</tr>
</tbody>
</table>

aDependent variable: Average annual growth rate of GDP per capita from 1990 to 2000. $R^2 = 0.849$; adjusted $R^2$ = 0.809; number of observations = 30; ANOVA test: $F = 21.470$ ($p = 0.000$).

why we use the data set for 1990–2000 instead of 1978–2000 for the regression analysis. It is expected that FDI per capita in 1990 will positively affect regional growth.

2. The share of state-owned enterprises (SOEs) in a region’s fixed asset investment (FAI) is usually deemed a proxy reflecting the infusion of market mechanisms and local endowments in the regional economy. In our model, the share of SOEs in 1990 is chosen for analysis. Given the poorer returns of SOE investment and declining status of the SOEs, we expect a negative relationship between the share of SOE investment and regional growth.

3. The educational level (percentage of the total population with a college education or above) is used to represent labor quality, and we expect a positive relationship with growth.

4. The population growth rate represents the contribution of labor quantity to regional growth.

5. We also use GDP per capita in 1990, the beginning year of the analysis, to test whether there is a $\beta$-convergence in regional inequality.

6. Finally, a dummy variable representing the influence of geographical location on regional growth is used, with the coastal provinces defined as 1 and the others 0. Given the advantage of the coastal regions in development, we expect the dummy variable to positively relate to the growth rate.

The results of the regression analysis are reported in Table 3. The regression model is highly significant, as revealed in the table. Our tests for multi-collinearity among the independent variables and spatial autocorrelation of the residuals suggest that the regression coefficients are reliable and the model is not misspecified.

The two population-related independent variables (population growth rate and educational level) are not significant. The variables significant at the 5 percent level include the coastal dummy variable, share of SOE investment, and FDI per capita in 1990. GDP per capita.
capita in 1990 is not significant at the 5 percent level, although it is at 10 percent. The six variables together explain 84.9 percent of the variation of GDP per capita growth during 1990 to 2000. As expected, the GDP per capita growth rate is positively associated with FDI per capita in 1990 and with the coast dummy variable, and negatively associated with the share of SOE investment in 1990.

The standardized regression coefficients suggest that the share of SOE investment in 1990 is the most important determinant of regional growth, which reinforces the notion that provinces that depend more heavily on SOEs tend to grow more slowly (Wei and Fan, 2000). The result also suggests that provinces that receive more foreign investment and are located in the coastal region tend to grow more rapidly. This finding also corresponds to the Chinese government’s coastal development strategy during the reform. The central government launched urban reforms and open-door policies first in the coastal provinces first, and later in other provinces. The coastal provinces, with their stronger economic bases and closer cultural and economic ties with foreign investors, have attracted a large amount of foreign investment, especially from Taiwan, Hong Kong, Singapore, etc. Consequently, the coastal provinces have experienced a large influx of FDI and corresponding rapid growth of non-state enterprises.

The relationship between the GDP per capita growth rate and beginning year GDP per capita is not significant at the 5 percent level but is at the 10 percent level. The positive sign also suggests that β-convergence cannot hold true in China. The two labor-related variables are not statistically significant in our model, indicating that orthodox notions of labor quality and quantity are less significant in determining uneven regional development in present-day China. We also conducted a regression analysis between the growth rate and educational level, and again found that the regression model is not statistically significant.

**CONCLUSION**

Before China’s economic reform, largely because of political and defense considerations, Mao emphasized the development of regions with ideological and strategic significance, such as the leading municipalities of Shanghai and Beijing, and heavy industrial bases such as Liaoning. Consequently, although the state was committed to the goal of reducing spatial inequalities in income and well being, new forms of inequality were created, leading to the persistence of regional inequality during Mao’s tenure as China’s leader (Wei, 2000).

Post-Mao China has implemented economic reforms, and undergone profound changes. During the reforms of the late 1970s and 1980s, China opened four special economic zones in Guangdong and Fujian, and provided favorable policies for the “growth out of plan” of non-state enterprises. These policies, sometimes referred to as the “coastal development strategy,” led to the emergence of a group of rapidly growing coastal provinces, including Guangdong, Fujian, Zhejiang, Jiangsu, and Shandong. Traditional municipalities and industrial bases, however, were troubled by problematic SOEs, rigid state control, and a late opening to the outside world.

Using recently released data, we have examined regional inequality in China with the assistance of GIS and spatial statistical tools. We found that regional inequality exhibited a U-shaped pattern during the reform period. As shown by the LQs, the status of China’s traditionally leading provinces in the national economy, including Shanghai, Beijing, Tianjin, and Liaoning, declined in the 1980s, leading to the observation that in overall terms, China’s regional inequality declined. However, during the 1990s, especially when Deng Xiaoping toured southern China in 1992 and pressed for larger-scale market reforms, marketization
was furthered and regional inequality increased. Also with the shift of the focus of reform to the Yangtze Delta and a strong industrial base, Shanghai embarked on a dramatic transformation, with radical reforms of SOEs and a massive inflow of domestic and foreign investments. Consequently, Shanghai has recorded more rapid economic growth than during the first decade of the reform, while the coastal provinces again spearheaded in reform and economic growth. As shown in Table 1, these coastal provinces have achieved dramatic economic growth during the 1990s, with Zhejiang ranked first, followed by Fujian, Jiangsu, Shandong, Guangdong, Hebei, and Shanghai.

Through an analysis of location quotients, we have determined the changing relative status of provinces in China. The eastern and southern coastal provinces have emerged as the biggest winners of the economic reform, whereas the central provinces have remained relatively unchanged. The status of traditional industrial bases (such as Liaoning and Tianjin) and poorer western provinces has declined. The gap between the emerging provinces and the poorest ones has been widening.

GIS and spatial statistical analysis also detected a trend of spatial concentration among China's provinces, although interprovincial inequality declined initially and then rose. Underdeveloped provinces retained their spatial similarity during the reform period, while more developed coastal provinces exhibited more complex spatial patterns. Northern coastal provinces declined, whereas a group of coastal provinces from Guangdong to Shandong has been rising as the "winning" cluster. Through an analysis of local Moran's $I$ values, we also discovered that Shanghai has played a very important role in China's regional inequality and spatial clustering process. The decline and rise of Shanghai alone contributed considerably to the decline and rise of China's interprovincial inequality, and the formation of the southeastern China's spatial cluster.

We have analyzed the impact of reforms on changes in regional inequality via regression analysis. Regression analysis revealed the significance of SOE reform, location, and investment variables. It shows that since the reform was furthered in the 1990s, interprovincial inequality in China has risen, reversing the declining trend in the early years of the reforms. Regression analysis also showed that although theories of regional development emphasize labor and capital, in China the share of investment commanded by SOEs is the most important factor in affecting regional inequality; labor, as defined based on educational level, is an insignificant variable. This suggests that country-specific variables, not considered by established theories, are important in understanding China's transition and spatial changes.

REFERENCES


