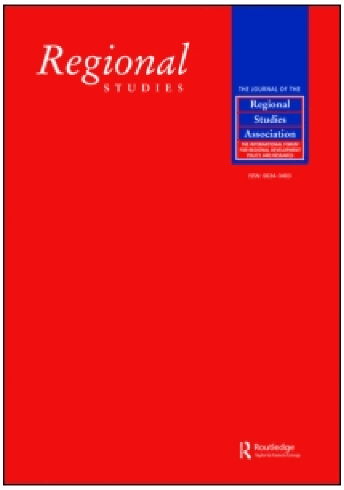

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Spatial Analysis of Selected Manufacturing and Service Sectors in China's Economy using County Employment Data for 1990 and 2000

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Spatial Analysis of Selected Manufacturing and Service Sectors in China's Economy using County Employment Data for 1990 and 2000

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HANINK D. M., EBENSTEIN A. Y. and CROMLEY R. G. Spatial analysis of selected manufacturing and service sectors in China's economy using county employment data for 1990 and 2000, *Regional Studies*. This paper provides a comparative analysis of the spatial distribution of employment in forty-one economic sectors in China in 1990 and in 2000. Sectors are approximately split between manufacturing and services. Spatial distributions of employment by sector are analysed at the county level, and relative sectoral specialization at the county level is also considered. Manufacturing and service clusters are identified in both years using factor analysis, and the resulting factor scores are used in mapping their spatial extent. In general, geographical concentration in Chinese manufacturing accelerated between 1990 and 2000, while services became more spatially uniform in their distribution.

China   Spatial analysis   Service sector   Cluster   Localization economies

HANINK D. M., EBENSTEIN A. Y. and CROMLEY R.G. 对中国经济中特定制造业及服务业的空间分析—基于1990年与2000年的城镇就业数据，区域研究。本文对1990年与2000年中国41个经济部门的就业空间分布进行了比较研究。部门大多涉及制造业及服务业。研究分析了部门就业在县级城镇的空间分布，同时也考虑了县级部门专业化的程度。通过要素分析，研究发现两年中都存在制造业和服务业产业集群；研究同时使用结果因子得分界定了其空间范围。总体而言，1990年至2000年间中国制造业的产业聚集度有所加速，而服务业的空间分布则趋于均匀。

中国   空间分析   服务业部门   集群   本地化经济

HANINK D. M., EBENSTEIN A. Y. et CROMLEY R. G. Une analyse géographique des secteurs de l'industrie et des services choisis de l'économie chinoise à partir des données sur l'emploi au niveau du comté pour 1990 et pour l'an 2000, *Regional Studies*. Cet article cherche à fournir une analyse comparative de la distribution géographique de l'emploi dans quarante et un secteurs économiques chinois pour 1990 et pour l'an 2000. Les secteurs se répartissent de façon approximative entre l'industrie et les services. On analyse des distributions géographiques de l'emploi par secteur d'activité au niveau du comté et on considère aussi la spécialisation sectorielle relative au niveau du comté. Employant une analyse factorielle, on identifie des regroupements des industries et des services pour les deux années en question, et on se sert des scores qui en résultent afin d'élaborer leur portée géographique. En règle générale, la concentration géographique de l'industrie chinoise s'est accélérée en 1990 et en 2000, tandis que la distribution des services est devenue plus uniforme sur le plan géographique.

Chine   Analyse géographique   Services   Regroupement   Economies de localisation

HANINK D. M., EBENSTEIN A. Y. und CROMLEY R. G. Raumanalyse ausgewählter Produktions- und Dienstleistungssektoren der chinesischen Wirtschaft mit Hilfe von Beschäftigungsdaten auf Bezirksebene für die Jahre 1990 und 2000, *Regional Studies*. Dieser Beitrag enthält eine vergleichende Analyse der räumlichen Verteilung der Beschäftigung in 41 Wirtschaftssektoren Chinas in den Jahren 1990 und 2000. Die Sektoren werden grob auf produzierende und Dienstleistungssektoren aufgeteilt. Die räumliche Verteilung der Beschäftigung je nach Sektor wird auf Bezirksebene analysiert, wobei auch die relative sektorale Spezialisierung auf Bezirksebene berücksichtigt wird. Für beide Jahre werden mit Hilfe einer Faktorenanalyse Herstellungs- und Dienstleistungscluster identifiziert; die daraus resultierenden Faktorenwerte werden zur Abbildung ihres räumlichen

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Umfangs genutzt. Im Allgemeinen beschleunigte sich die geografische Konzentration der chinesischen Produktion im Zeitraum von 1990 bis 2000, während sich die Dienstleistungen räumlich gleichmäßiger verteilten.

China Raumanalyse Dienstleistungssektor Cluster Lokalisierungsökonomien

HANINK D. M., EBENSTEIN A. Y. y CROMLEY R. G. Análisis espacial de sectores exclusivos de manufactura y servicios en la economía de China usando datos de empleo de los condados para 1990 y 2000, *Regional Studies*. En este artículo llevamos a cabo un análisis comparativo de la distribución espacial del empleo en cuarenta y un sectores económicos de China en 1990 y 2000. Los sectores se han dividido aproximadamente entre manufactura y servicios. Hemos analizado las distribuciones espaciales del empleo por sector para cada condado y también hemos considerado la especialización sectorial relativa para cada condado. Identificamos las aglomeraciones de manufactura y servicios para ambos años usando un análisis de factores y las puntuaciones resultantes de los factores sirven para representar la extensión espacial. En general, la concentración geográfica en el sector manufacturero de China se aceleró entre 1990 y 2000, mientras que los servicios se volvieron más uniformes espacialmente en su distribución.

China Análisis espacial Sector de servicios Aglomeración Economías de localización

JEL classifications: O14, O53, R11

INTRODUCTION

The unprecedented growth of the Chinese economy since its reforms began in the late 1970s has been accompanied by an apparent spatial concentration in its coastal areas. That concentration has several sources (VEECK *et al.*, 2007). One is simply the earlier coastal focus of the Chinese economy in the late imperial era that resulted from its interaction with foreign states, especially European ones and Japan. In many circumstances, the foreign presence at a series of treaty ports worked with the geographical factors of major river/coastal access to ensure spatial concentration. Farther north, the Japanese exploited natural resource deposits in industrializing the coast and also the interior of Manchuria. While early Communist policy in China emphasized the interior of the country, the coast was emphasized during the beginning of the reform era through preferential deregulation policies (ZHAO and TONG, 2000; DÉMURGER *et al.*, 2002). Even though current policy is emphasizing geographical dispersal, much of coastal China is still at a spatial-economic advantage – with respect to its internal market because of its population concentration, and with respect to its external market because of its export infrastructure (FUJITA *et al.*, 2004).

Given that history, both strong government policy and now markets have given rise to the spatial configuration of the contemporary Chinese economy, and it is not surprising that its geography has generated significant interest. So far, however, almost all spatial analyses of the Chinese economy have been at fairly large geographical scales of analysis (important exceptions are indicated below). In addition, virtually every spatial analysis of the Chinese economy has focused on manufacturing, with little work being done on services. While the Chinese external economy is manufacturing-centred, its domestic growth is more broadly based and services are a major component (BOSWORTH and COLLINS, 2007).

This paper extends the spatial analysis of the Chinese economy in two ways: (1) by analysing sectoral employment at the county scale across the country for both 1990 and 2000; and (2) by including services in the analysis. It compares individual sectors between the two years and also describes clusters of those sectors in the Chinese economy in the context of agglomeration theory. Spatial analysis is emphasized at both the individual sector and the cluster level. The next part of the paper reviews the related literature on geographical analyses of the Chinese economy, emphasizing research on agglomeration, or spatial industrial concentration, and research which employs explicitly spatial methods of analysis. The data and methods used in this paper are described in the subsequent section. The individual sectors are analysed following that, and then sectoral clusters are defined and analysed for 1990 and for 2000. The paper concludes with a brief summary of results and their implications for policy.

SELECTED-RELATED RESEARCH

PANNELL (1988) was one of the first to describe the geographical impacts of China's economic reforms. He described the effects of the earlier (1950s) attempts to decentralize the economy, as well as the rapid increase in density of economic activity along the coast during the early 1980s in the first part of the reform era, especially around Shanghai. KIM and KNAAP (2001) considered the same era, 1952–1985, in their examination of the spatial characteristics of the Chinese economy. They analysed five broad sectors: agriculture, industry, construction, commerce, and transportation, and also worked at the provincial scale. They found that geographical concentration, as measured by the share of total material product, was ongoing along the coast in all the sectors, except industry, even during the period when policy encouraged decentralization, and industry began to (re)concentrate along the coast in the 1980s.

DÉMURGER *et al.* (2002) have attributed most of a recent (1996–1999) growth premium in the coastal provinces of China to policy effects that promoted integration in the global economy. Geographical (coastal) advantage was therefore enhanced by policy, resulting in increasing spatial concentration. Démurger *et al.* also found a policy bias in favour of the provincial-level cities: Beijing, Tianjin, and Shanghai in the coastal region; and Chongqing in the interior. That urban bias was also found by LU and WANG (2002).

Using shift–share analysis across provinces, LI (2008) found a strong regional effect in coastal productivity, despite its specialization in low-productivity sectors. Such an effect could be traced to policy preferences that offset sectoral disadvantages. HE *et al.* (2008) argued, however, that the spatial expression of the Chinese economy results from a more complex mix of conditions than just policy impacts. In addition to policy, they found that locational advantages with respect to markets, comparative advantage with respect to costs, and provincial competition are each important in different industries in ways that undermine simple explanations of spatial structure in the Chinese economy.

Several studies of the Chinese space economy have placed the coastal concentration in the context of industrial agglomeration theory. That theory suggests that production efficiencies occur within geographical concentrations due to decreases in transport costs between suppliers and purchasers, labour market pooling, infrastructural specialization, and intellectual spillovers (ELLISON *et al.*, 2007). Agglomeration theory is typically taken as more relevant to manufacturing than to services (ELLISON *et al.*, 2007). Spatial concentrations of manufacturing are expected to be more intensive than are spatial concentrations of services if only because of supply–demand linkages between producers. Additionally, manufacturing concentrations can even occur away from population concentrations and be based more on natural resource endowments. While some services can benefit from the same sort of agglomeration factors that affect manufacturing, such as labour pooling, they are typically much more associated with consumer demand and, therefore, tend to match population concentrations more closely. While intensive geographical concentrations in services are expected, therefore, they are further expected to be less intensive than in manufacturing. Of course, non-market services are a special case, with some having simple population service patterns and some being tied to administrative hierarchies in their spatial distribution.

Theoretically, manufacturing agglomerations could be anchored by either low production costs, locating on or near raw material or energy sources, for example, or by markets, and therefore located in proximity to population centres or at places of access to the international market. Initial cost or revenue factors of initial advantage induce concentrations of linked industries or industries with similar market interests (PRED, 1966; KRUGMAN, 1993). Service agglomerations, however, should be anchored almost entirely by markets, and therefore should be found primarily in population centres, with non-market services forming the exception.

FUJITA and HU (2001) found that the agglomeration of Chinese producers across several industries in the coastal region was a market-based response that was unleashed by the government's economic liberalization. It was accelerated by the inflow of foreign direct investment (FDI) that was guided to the coast by traditional international connections via Hong Kong and Shanghai, and also encouraged in its locational pattern by government policy. The link between FDI and China's coastal agglomerations was also emphasized by HE (2003), who described the activities of investors from Hong Kong, Japan, Taiwan, and the United States in a geographical context. FAN and SCOTT (2003) studied agglomeration in China at both the provincial and the county scales. They agree that market reform effects include geographical concentration and that its intensity among industries seems to track positively with the pace of their liberalization. They also found that the resurrection of older social networks was contributing to the geographical pattern of Chinese industry.

WEN (2004) uses the 'New Economic Geography' (usually attributed to KRUGMAN, 1991) as a foundation for assessing Chinese coastal agglomerations. That approach relies largely on increasing returns to monopolistic competition, so that the regional domestic market rather than the export market should prove to underlie agglomeration. Wen did find that provincial share of gross domestic product is a significant covariate of provincial population share. HE *et al.* (2007), however, are critical of the New Economic Geography's ability to account for spatial economic patterns in contemporary China. They found that while agglomeration efficiencies are important, other factors such as transport costs, natural resource endowments, international trade factors, and protectionist policies at the provincial level also contribute to geographical concentration in various industries.

HE *et al.* (2007) also note the importance of scale of analysis (for example, province versus county) in the measure of agglomeration effects in China. They found that geographical concentration is apparent in some industries at the county level, but those same industries appear dispersed at the provincial scale. Several more local agglomerations have been examined. ZHOU and XIN (2003) and CAI *et al*. (2007) found positive knowledge spillover effects in the information communication technology agglomeration (Zhongguancun) in Beijing, especially with respect to multinational enterprises in the area. WEI *et al.* (2007) have analysed the industrial concentration in Wenzhou City, located in coastal Zhejiang Province, as a model case of agglomeration effects, while KIM and ZHANG (2008) have studied the link between domestic and foreign producers in the electronics agglomeration of coastal Qingdao.

Although several papers concern the spatial configuration of the Chinese economy, relatively few utilize explicitly spatial methods of analysis. YING (2000) used spatial autocorrelation statistics to describe the provincial-level spillover effects in output growth during the period 1978–1994. Later, YING (2003) described the same effects more specifically for 1978–1998 through a spatial regression model which contained a significant spatial-lag effect. YE and WEI (2005) investigated the welfare distribution effects of the Wenzhou cluster using a spatial autocorrelation statistic. YU and WEI (2008) employed a variety of spatial statistical methods in their analysis of the economy of Greater Beijing. They found that local government spending has an economic effect that was unobserved when model errors were not controlled for spatial dependence. HE *et al.* (2007) used spatial autocorrelation statistics in their analysis of the distribution of manufacturing employment across China's counties, while HE *et al.* (2008) used those statistics to assess the spatial distribution of each of twenty-six manufacturing industries across provinces.

DATA AND METHODS

The sources of data analysed in this paper are China's censuses for 1990 and for 2000, as compiled by All China Marketing Research Co., a licensed affiliate of the State Statistical Bureau of China (WEI *et al.*, 2002). The data were developed for use in a geographic information system (GIS)-friendly format by the University of Michigan's China Data Center in 2005, and made available for the analyses described in this paper by the Harvard Geospatial Library. The analyses in this paper concern the spatial distribution of China's employment in twenty manufacturing and twenty-one service sectors in 1990 and 2000. The sectors were chosen based on comparability of sectoral definitions between China's censuses for 1990 and 2000. In addition to sectoral definition, there are two other issues of comparability between the two censuses that affect the analysis. One is in the number of reporting units. Excluding Taiwan, there were 2369 county units (counties and county-level cities) in the 1990 census and 2873 in the 2000 census. That discrepancy, of course, limits precise comparison on a county-by-county basis, but does not limit comparison of spatial tendencies or larger regional distributions between the two years. (Many data sets covering the Chinese economy have temporal inconsistencies (for example, FUJITA and HU, 2001; concerning data issues, see also FAN and SCOTT, 2003.) The other issue of comparability is that the sectoral employment data for 1990 are the result of complete enumeration, while the comparable sectoral data for 2000 are from a 9.5% sample. Again, precise comparison is limited, but more general ones are not. The employment data in the 2000 census are considered reliable (CHAN, 2003), especially because care was taken with respect to counting the floating population at place of actual residence (LAVELY, 2001). That population was important but proportionately much smaller in 1990.

The methods used in the paper can be classified into two groups: aspatial and spatial. The aspatial methods include relatively standard measures used to describe concentration. One is the coefficient of variation (CV) which is calculated in this case as the standard deviation of employment in a sector divided by that sector's mean employment. If the distribution of each sector's employment were uniformly distributed across the counties of China, then the standard deviation of that distribution would be zero and $CV = 0$. The more concentrated a sector's employment among counties, the greater should be the standard deviation of that employment and the larger the CV statistic. The other measure used to describe concentration is the index of diversity (ID), an approximation of the Gini coefficient, which is calculated as one-half the sum of the absolute difference in percentages of observed county employment in a sector and the percentage that would occur if employment were uniformly distributed by county. As in the case of the CV statistic, the minimum value of ID is zero, corresponding to a uniform geographical (by county) distribution of actual sectoral employment while increasing values indicate increasing concentration. Both the CV and ID are considered aspatial because while they can imply geographical concentration or dispersion, they do not contain any actual locational information or reveal any interaction among spatial units. The CV and ID are dimensionless, standardized, statistics and therefore allow some comparison between the 1990 and 2000 distributions, despite their different numbers of observations.

Both the CV and ID statistics are global in that they are descriptors of the full set of observations. Location quotients (LQ) are local descriptors, however, and used in the analysis to identify sectoral specializations at the county scale. Each sector in each county has an LQ calculated as the percentage share in that sector of total county employment divided by the percentage share in that sector of all employment in China. While LQ provides information about a geographical unit, it can still be classified as an aspatial measure because it does not contain any information about interaction among those units. FAN and SCOTT (2003) used LQs based on a number of establishments, rather than employment, in their county-level analysis of manufacturing agglomeration in China.

Factor analysis, an aspatial method of modelling a correlation matrix, is used to derive sectoral clusters. As defined by PORTER (2003), clusters are geographic concentrations of linked industries that can be defined by their co-locational correlation in employment. Factor analysis is helpful in identifying clusters because it reduces a large correlation matrix to its fundamental dimensions, or 'factors', which reveal consistent sets of associated industries/sectors (KELTON *et al.*, 2008). The association between an individual sector and a factor is indicated by that sector's loading, which is essentially a correlation between the sector and the factor (YATES, 1987). Those sectors with the higher loadings on a factor effectively define a cluster. The factor model used in the analysis below uses a varimax rotational procedure that ensures the clusters so defined are uncorrelated with each other. The factors define clusters at the national level, and do not reveal any geographical pattern within China. However, that pattern of the clusters can be found by an examination of factor scores, which indicate the strength of association between individual observations, counties in this case, and the clusters (factors). The factor scores, like LQ statistics, are effectively aspatial in that they do not contain any information about interaction among the units of observation. Clusters in manufacturing were identified by FAN and SCOTT (2003) using LQs as well, but they used statistical cluster analysis of the their correlation coefficients as a grouping method.

The spatial methods used in the analysis below are global and local spatial autocorrelation analysis using Moran's *I* (FOTHERINGHAM *et al.*, 2000). The global version of that statistic is calculated as:

$$I = \frac{N \sum_i \sum_j W_{i,j}(X_i - \bar{X})(X_j - \bar{X})}{(\sum_i \sum_j W_{i,j}) \sum_i (X_i - \bar{X})^2} \qquad (1)$$

where N is the number of spatial observations ($i, j = 1, \ldots, N$), such as counties; X is the variable of interest, such as employment; and W is a set of spatial weights that define the potential interaction of the places. If spatial weights are defined as 1 (shared boundary), or zero (no shared boundary), only neighbouring places are entered into the cross-products term in the numerator, and the same weighting is used for the total sum of squares in the denominator. That dichotomous weighting is used in the analysis below, but with the weights standardized to sum to one for each county.

Moran's *I* can be interpreted in a way similar to an aspatial correlation coefficient such as Pearson's *r*, and can be used to describe the sign and strength of spatial autocorrelation in a variable across an entire spatial data set. Because Moran's *I* is sensitive to *W*, however, comparisons of nominal values are not always useful. In the analysis below, therefore, while specific comparisons of sectors in 1990 or in 2000 can be made, only more general ones are possible across 1990 and 2000 because of the disparate number of counties. Note that while Moran's *I* is subject to significance testing using a normal *Z*-statistic transform under some conditions, classical tests are often inappropriate and randomization procedures are used instead. As indicated above, spatial autocorrelation analysis has been used by YING (2000) and HE *et al.* (2008) in their studies of China's economy.

ANSELIN (1995) described a Moran's *I* for an individual ('row-only') observation as one of a class of local indicator of spatial association (LISA) statistics. Because such local measures can be mapped, local Moran's *I* statistics are effective in identifying so-called spatial hot spots which are local geographical concentrations of relatively high autocorrelation within larger spatial aggregations. YE and WEI (2005) used both global and LISA statistics in their analysis of spatial inequality at the county level in Zhejiang Province, and both HE *et al.* (2007) and YU and WEI (2008) used global spatial autocorrelation statistics and LISA statistics in their analyses of the spatial distribution of sectoral employment across China.

SECTORS

Following RAISER *et al.* (2004), the forty-one sectors that are comparable across the 1990 and 2000 censuses can be divided into three groups: manufacturing, market services, and non-market services – largely government and political activities (Table 1). Non-market services contained three of the largest employers in both time periods: Education and teaching, which are listed as distinct sectors in both censuses, and Government. Education was the largest employer among the sectors considered here in 1990, but Construction was the largest in 2000. (Farming was the single largest sector of employment in China in both years, but it is not considered in this paper.) Civil engineering construction, as distinguished from Construction, was also a leading sector, ranking third in both 1990 and 2000. Other market services that were leading employers were Catering and Enterprise management. Textiles, Sewing, Machinery, and Traffic and transport equipment were leading sectors in the manufacturing category in both 1990 and 2000. Rank stability across the two time periods is strong, as indicated by a Spearman rank correlation coefficient of 0.919.

Table 1. Sector employment rankings (1–41), 1990 and 2000

Sector[a]	1990	2000
Manufacturing		
Textiles	5	7
Sewing	8	8
Leather and fur	21	15
Timber processing	22	18
Furniture	19	16
Paper	16	22
Printing	20	24
Cultural, educational, and sporting goods	32	20
Pharmaceuticals	27	26
Chemical fibres	35	36
Rubber products	26	31
Plastic products	18	17
Ferrous metals	13	19
Non-ferrous metals	31	29
Metalwork	10	12
Machinery	4	11
Traffic and transport equipment	9	10
Electrical equipment	11	13
Electronics and telecommunications equipment	17	14
Instruments	29	27
Market services		
Geological prospecting	30	37
Civil engineering construction	3	3
Line and pipeline installation	28	30
Catering	12	6
Real estate management	34	32
Consulting	38	34
Sports	41	40
Culture and art	23	25
Technical services	36	28
Financial services	14	21
Insurance services	40	35
Enterprise management	15	9
Construction	7	1
Non-market services		
Post and telecommunications	24	23
Social welfare	37	38
Education	1	2
Government services	6	5
Party committees	33	33
Social organizations	25	39
Teaching	2	4
Religious	39	41

Note: [a]Sectors are listed in the order as published in the 1990 Census.

In 1990, however, half of the leading ten sectors were in manufacturing, but only three in that category were among the ten leaders in 2000, when each of the leading six sectors (and the ninth) were in either market or non-market services. Individually, the more pronounced shifts in ranking occurred in Social organizations (twenty-fifth in 1990, thirty-ninth in 2000) and in Cultural, educational, and sporting goods (thirty-second in 1990, twentieth in 2000). Technical services increased by eight places from 1990 to 2000, while Machinery, Geological prospecting, and Financial services each declined seven places (Table 1).

Table 2. Aspatial concentration in manufacturing sectors in 1990 and 2000 as measured by the coefficient of variation (CV) and index of dissimilarity (ID)

	1990		2000	
Sector	CV	ID	CV	ID
Textiles	3.3	65.1	3.7	63.3
Sewing	2.9	58.8	4.5	63.5
Leather and fur	3.7	67.8	7.7	76.8
Timber processing	3.7	59.8	2.6	52.9
Furniture	2.0	48.7	3.5	52.4
Paper	2.5	56.5	3.4	58.3
Printing	3.7	59.6	3.7	58.4
Cultural, educational, and sporting goods	8.4	80.3	14.1	80.4
Pharmaceuticals	4.3	71.4	2.4	63.1
Chemical fibres	5.5	89.9	4.4	48.3
Rubber products	4.7	75.5	3.1	70.6
Plastic products	3.3	69.1	7.5	69.1
Ferrous metals	5.6	79.8	3.7	72.9
Non-ferrous metals	5.2	82.7	4.0	71.8
Metalwork	3.7	64.5	5.0	64.2
Machinery	4.3	66.8	2.6	62.9
Traffic and transport equipment	5.4	71.4	2.4	55.7
Electrical equipment	4.9	75.5	6.0	71.1
Electronics and telecommunications equipment	6.6	83.5	11.1	76.6
Instruments	6.8	83.6	6.0	75.2

Based on the CV statistic, Cultural, educational, and sporting goods employment was the most unequally distributed in the manufacturing sector in 1990 (Table 2). Employment in Instruments, Electronics and telecommunications equipment, Chemical fibres, and both Ferrous and Non-ferrous metals also had high levels of geographical unevenness among the manufacturing sectors. Employment in Furniture was the most evenly distributed in the manufacturing sectors in 1990, followed by Paper and then by Sewing. While specific positions vary, those industries shown to be more unevenly distributed measured by CV are also more unevenly distributed when measured by the ID statistic. Using that measure, Chemical fibres employment is the most unevenly distributed, while Electronics and telecommunications equipment employment is ranked second. Furniture is also measured as the most evenly distributed manufacturing sector in 1990 using the ID statistic.

Half the manufacturing sectors increased in their geographical unevenness as measured by the CV statistic from 1990 to 2000. Based on the CV, Cultural, educational, and sporting goods and also Electronics and telecommunications equipment employment increased their unevenness considerably, and were in first and second place, respectively, in that regard in 2000. The former sector's ID, however, only increased marginally between 1990 and 2000, and the latter's actually declined. Such disagreement can occur between the two measures because CV is more

Table 3. Aspatial concentration in service sectors in 1990 and 2000 as measured by the coefficient of variation (CV) and index of dissimilarity (ID)

Sector	1990		2000	
Market services				
Geological prospecting	3.7	73.2	3.2	69.8
Civil engineering construction	2.9	55.8	1.5	43.4
Line and pipeline installation	5.6	81.5	2.4	62.5
Catering	2.4	45.1	1.5	38.7
Real estate management	5.7	72.3	3.6	61.5
Consulting	5.8	72.3	3.2	59.7
Sports	7.6	81.6	6.7	77.6
Culture and art	4.3	47.9	3.0	55.7
Technical services	8.2	67.6	3.4	63.3
Financial services	1.7	34.5	1.2	35.4
Insurance services	1.9	41.7	1.5	46.3
Enterprise management	4.3	57.1	1.8	49.1
Construction	2.1	52.5	1.5	44.5
Non-market services				
Post and telecommunications	2.5	41.3	1.5	40.6
Social welfare	2.4	51.5	1.8	48.4
Education	1.9	33.7	0.9	29.7
Government services	2.0	33.8	1.0	30.0
Party committees	1.2	27.5	1.3	37.7
Social organizations	3.1	57.8	1.8	48.7
Teaching	1.5	31.3	0.8	27.1
Religious	4.3	52.5	4.9	74.4

sensitive to spikes in the geographical distribution which contribute significantly to the standard deviation, a squared value, but less so to the ID value, which uses non-squared absolute differences in its calculation. The Leather and fur and Plastic products sectors had large increases in employment concentration between 1990 and 2000 according to the CV; other sectors increasing were Textiles, Sewing, Furniture, Paper, Metalwork, and Electrical equipment. Increased concentration was less marked in manufacturing when measured by change in ID statistics between 1990 and 2000. In addition to Cultural, educational, and sporting goods, only Sewing, Leather and fur, Furniture, and Paper employment increased in geographical unevenness. Increases in CV and ID statistics for employment over spatial observations are often associated with the importance of agglomeration economies in the relevant sectors (FAN and SCOTT, 2003; HE *et al.*, 2007).

Based on both the CV and ID statistics, the more unevenly distributed service sectors in 1990 included Technical services, Sports, Consulting, and Real estate management, while the more uniformly distributed were Party committees, Teaching, Financial services, and Insurance services (Table 3). With the exception of Religious employment, each sectoral CV statistic decreased between 1990 and 2000. The decline in geographical concentration was not as uniform when measured by the ID statistic, but only three sectors in addition to Religious employment (Culture and art, Financial services, and Insurance services) experienced increasing geographical concentration as measured by ID. In 2000, Sports employment was the most unevenly distributed among the services, while the non-market services of Teaching, Education, and Government were the most uniformly distributed.

A comparison of the CV and ID statistics for manufacturing sectors (Table 2) and those for services (Table 3) indicates a general conformity in the distribution of Chinese employment in 1990 and 2000 with agglomeration theory. In general, both CV and ID statistics tend to be higher in the manufacturing sectors in China in both 1990 and 2000 and that distinction is more marked in the latter time period. That trend for manufacturing is indicative of increasing agglomeration-based locational patterns in China over the time period, while the pattern with respect to services points to a geographical spread in purchasing power between 1990 and 2000.

Both the CV and ID statistics can indicate relative concentrations, but only in counties considered independently. Moran's I, however, can indicate whether such concentrations are spatially extensive in that they spill-over across observations. Given that the measures are conceptually as well as computationally different, it is not surprising the Moran I coefficients calculated for sectoral employment in 1990 and 2000 are typically weakly but negatively correlated or virtually uncorrelated with the CV statistics (Pearson's $r = -0.144$ and -0.167, respectively) and the ID statistics (Pearson's $r = 0.088$ and -0.154, respectively). Moran's I was calculated for both sectoral employment and for the LQ of sectoral employment in order to identify spatial autocorrelation for both level and relative specialization (LQ) of activity in the sectors. While the Moran I statistics are subject to significance testing, as indicated above, they are used here as descriptors of the strength of the spatial autocorrelation. Because of the large number of observations in the data sets, nearly all the reported statistics would be considered significant at the 99% level of confidence.

Leather and fur employment exhibited the greatest spatial autocorrelation among the manufacturing sectors in 1990 (Table 4). Sewing, Cultural, educational, and sporting goods, and Plastic products also had high levels of spatial autocorrelation. Instruments, Pharmaceuticals, Ferrous metals, Non-ferrous metals, and Rubber products had virtually no spatial autocorrelation in their employment distributions. The pattern of spatial autocorrelation among the manufacturing sectors was similar when spatial autocorrelation was measured with respect to specialization, but the Moran I statistics indicate generally more intensive levels. For example, Sewing employment has a Moran's I of 0.43 in 1990 while specialized county units have a Moran's I of 0.55 for that year. Other marked increases can be observed in Timber processing,

Table 4. Spatial autocorrelation of employment and of employment specialization in manufacturing sectors in 1990 and 2000 as measured by Moran's I *statistic*[a]

	1990		2000	
Sector	Employment	Employment specialization	Employment	Employment specialization
Textiles	0.25	0.35	0.39	0.48
Sewing	0.43	0.55	0.38	0.58
Leather and fur	0.45	0.40	0.29	0.49
Timber processing	0.17	0.59	0.23	0.23
Furniture	0.30	0.34	0.33	0.38
Paper	0.18	0.20	0.30	0.18
Printing	0.10	0.23	0.37	0.42
Cultural, educational, and sporting goods	0.42	0.44	0.32	0.47
Pharmaceuticals	0.05	0.14	0.43	0.37
Chemical fibres	0.10	0.06	0.20	0.06
Rubber products	0.08	0.12	0.43	0.26
Plastic products	0.39	0.45	0.34	0.58
Ferrous metals	0.05	0.07	0.25	0.17
Non-ferrous metals	0.08	0.01	0.09	0.04
Metalwork	0.23	0.50	0.39	0.49
Machinery	0.10	0.24	0.52	0.43
Traffic and transport equipment	0.03	0.07	0.43	0.31
Electrical equipment	0.13	0.31	0.36	0.48
Electronics and telecommunications equipment	0.14	0.27	0.37	0.63
Instruments	0.04	0.07	0.50	0.41

Note: [a]Specialization is measured as the location quotient of sectoral employment.

Table 5. Spatial autocorrelation of employment and of employment specialization in service sectors in 1990 and 2000 as measured by Moran's I *statistic*[a]

	1990		2000	
Sector	Employment	Employment specialization	Employment	Employment specialization
Market services				
Geological prospecting	0.05	0.06	0.07	0.11
Civil engineering construction	0.12	0.23	0.49	0.47
Line and pipeline installation	0.02	0.01	0.35	0.42
Catering	0.12	0.27	0.53	0.52
Real estate management	0.03	0.15	0.60	0.52
Consulting	0.03	0.11	0.56	0.56
Sports	0.01	0.02	0.33	0.48
Culture and art	0.01	0.72	0.36	0.17
Technical services	0.00	0.06	0.37	0.30
Financial services	0.10	0.31	0.40	0.26
Insurance services	0.07	0.17	0.51	0.38
Enterprise management	0.03	0.23	0.57	0.52
Construction	0.33	0.15	0.53	0.52
Non-market services				
Post and telecommunications	0.03	0.25	0.48	0.35
Social welfare	0.16	0.24	0.36	0.17
Education	0.08	0.44	0.37	0.16
Government services	0.04	0.32	0.29	0.17
Party committees	0.06	0.46	0.12	0.20
Social organizations	0.21	0.47	0.22	0.15
Teaching	0.12	0.59	0.46	0.42
Religious	0.66	0.80	0.33	0.40

Note: [a]Specialization is measured as the location quotient of sectoral employment.

Metalwork, Electrical equipment, and Electronics and telecommunications equipment. There was virtually no spatial autocorrelation in county specialization in Non-ferrous metals or Chemical employment.

In 2000, each of the sectors' employment had high levels of spatial autocorrelation. Instruments, which had virtually no spatial pattern in 1990, had a high level of spatial autocorrelation in 2000. The same result appears for employment specialization. Timber processing is an exception, as is Paper and, marginally, Metalwork specialization. Non-ferrous metals and Chemical employment specialization remained free of spatial pattern. The general increase in spatial autocorrelation from 1990 to 2000 in terms of both sectoral employment level and employment specialization may indicate that sectoral districts were experiencing a spatial diffusion, or spillover, of activity during the decade. That result corresponds at a more local scale to recent findings of conditional convergence at the larger provincial scale found by DÉMURGER *et al.* (2002) and WANG and GE (2004), as well as the trend of decreasing inequality in per-capita gross domestic product during the 1990s (FAN and SUN, 2008).

If that interpretation is correct, then the spatial spillover in services was profound during the period. In 1990, few of the service sectors exhibited meaningful spatial autocorrelation in employment levels (Table 5). Religious employment and employment in Construction and in Service organizations were exceptions. Sectoral employment specialization generally had much more cohesive spatial patterns, however, with sectors such as Culture and art and Religious employment having very high levels of spatial autocorrelation. (Relative specialization was at a high level in western China and in Tibet in those sectors.) In 2000, employment levels in every sector except Geological prospecting had high levels of spatial autocorrelation. County-level employment specializations maintained or increased in spatial autocorrelation over the period, as well, but the autocorrelations of specializations in non-market sectors decreased. The developing geographical patterns of employment levels in market services reinforces the suggestion made above that purchasing power was undergoing a rapid geographical spread during 1990 and 2000. As that spread occurred, service employment diffused along with it and began to show more spatial uniformity than existed earlier. Unlike the CV and ID statistics in which high values indicate intensities of geographical concentration, the global Moran *I* statistic measures the degree of spatial uniformity (recall the low and negative correlations among the measures noted above). As with the CV and ID statistics, the general pattern portrayed is that manufacturing is more spatially concentrated than services and that, over time, most services are undergoing an apparent diffusion process in their distribution at a faster rate than is observed in most manufacturing sectors.

CLUSTERS

Clusters were identified for employment levels and employment specialization in 1990 and 2000 using common factor analysis. They were identified based on both levels and specialization because the measures can identify concentration in two ways: absolute and relative, respectively. Factor analysis yields as many factors as there are original variables in decreasing order of their contained variance from the original data set. Each of the original variables is related to each of the derived factors, with the degree of that relationship indicated by a variable's factor loading, or correlation. Derived factors that contained at least 10% of the variance contained in the original

Table 6. Factor composition of sectoral employment, 1990[a]

Factor composition	Sector loading
Common factor 1	
Printing	0.723
Civil engineering construction	0.677
Post and telecommunications	0.698
Catering	0.628
Real estate management	0.634
Consulting	0.786
Sports	0.748
Social welfare	0.677
Education	0.733
Culture and art	0.890
Technical services	0.933
Financial services	0.649
Insurance services	0.647
Government services	0.790
Party committees	0.731
Social organizations	0.740
Enterprise management	0.825
Teaching	0.684
Common factor 2	
Textiles	0.655
Pharmaceuticals	0.681
Rubber products	0.727
Ferrous metals	0.655
Non-ferrous metals	0.636
Metalwork	0.695
Machinery	0.830
Traffic and transport equipment	0.663
Electrical equipment	0.742
Instruments	0.684
Real estate management	0.610
Common factor 3	
Sewing	0.765
Leather and fur	0.814
Furniture	0.624
Cultural, educational, and sporting goods	0.799
Plastic products	0.642

Note: [a]Factors are in decreasing order of proportion of variance. Only sectors with loadings greater than or equal to 0.6 are listed.

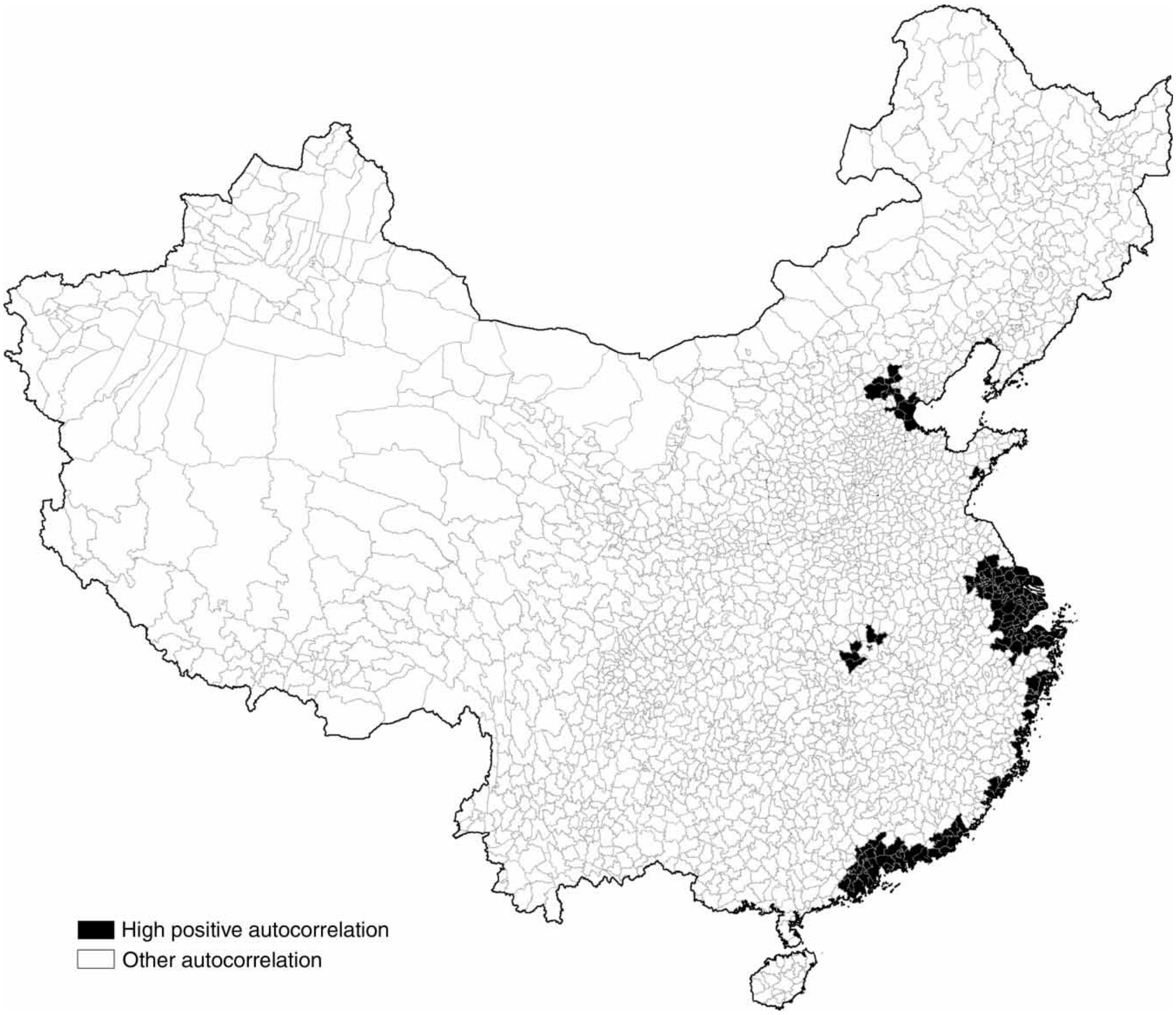

Fig. 1. Spatial clusters of 1990 employment encompassed in levels factor 3 scores

set of forty-one sectoral variables were retained for interpretation based on their composition of sectors with loadings of at least 0.6. Those criteria (contained variance and loading) for interpretation are arbitrary to a degree, but as shown below, they are empirically effective in defining coherent clusters of sectors. The largest factor omitted from the sets of those described contained only 7% of the variance in the original data. The first factor contains about 31% of the total variance in employment levels for 1990. It seems to define a broad service cluster as it consists almost exclusively of market and non-market services (Table 6). The only exception is that it also contains Printing from manufacturing, but that sector, like most services, is typically responsive to market demand in its locational pattern. The second factor, containing about 25% of the total variance, is an apparent manufacturing cluster (except for Real estate management) that is heavily concentrated in durable goods and backward linkages in metals, but also Textiles and

Table 7. Factor composition of sectoral employment specialization, 1990[a]

Factor composition	Sector loading
Common factor 1	
Printing	0.728
Metalwork	0.629
Machinery	0.812
Electrical equipment	0.715
Common factor 2	
Education	0.767
Financial services	0.625
Insurance services	0.684
Teaching	0.819
Common factor 3	
Sewing	0.777
Leather and fur	0.669
Cultural, educational, and sporting goods	0.636

Note: [a]Factors are in decreasing order of proportion of variance. Only sectors with loadings greater than or equal to 0.6 are listed.

Pharmaceuticals. The third factor, with nearly 17% of the total variance, also defines a manufacturing cluster, but one focused on non-durable goods. Moran's *I* coefficients for the factor scores are 0.026, 0.132, and 0.652, respectively, indicating a very high level of spatial autocorrelation within the national non-durable goods cluster in 1990. The actual spatial pattern underlying that high level of spatial autocorrelation can be found through local Moran's *I* analysis of the factor scores and is represented in Fig. 1. The so-called 'hot spots' of the cluster (spatial concentrations of high local Moran's *I*-values) are largely on the coast, and occur especially around the major manufacturing centres of Guangdong Province in the south and around greater Shanghai, and in smaller concentration around Beijing (see the reference map in Appendix Fig. A1).

The first factor for employment specialization in 1990 contained nearly 16% of the variance in that data. Only four manufacturing sectors have high loadings on the factor (Table 7). It identifies a cluster of specialization in durable goods (and printing). The second factor, with about 11% of the variance, consists of the two market services of Finance and insurance and the two related non-market services of Education and teaching. The third factor defines a cluster of two non-durable goods associated with apparel: Sewing and Leather and fur, and also Cultural, educational, and sporting goods. These factors, based on LQs rather than employment levels, appear to have fairly tight clusters of activities with well-defined geographies. Moran *I* coefficients for the factor scores are 0.238, 0.581, and 0.647, respectively. The local Moran's *I* map of the first specialization factor scores indicates an important hot spot centred on Shanghai, traditionally a centre of heavy manufacturing in China (Fig. 2). The local Moran's *I* map of the second specialization factor scores has two patterns (Fig. 3). One is a spatial concentration that extends across northern China. That concentration is more likely defined by relative specialization in educational activity than in the

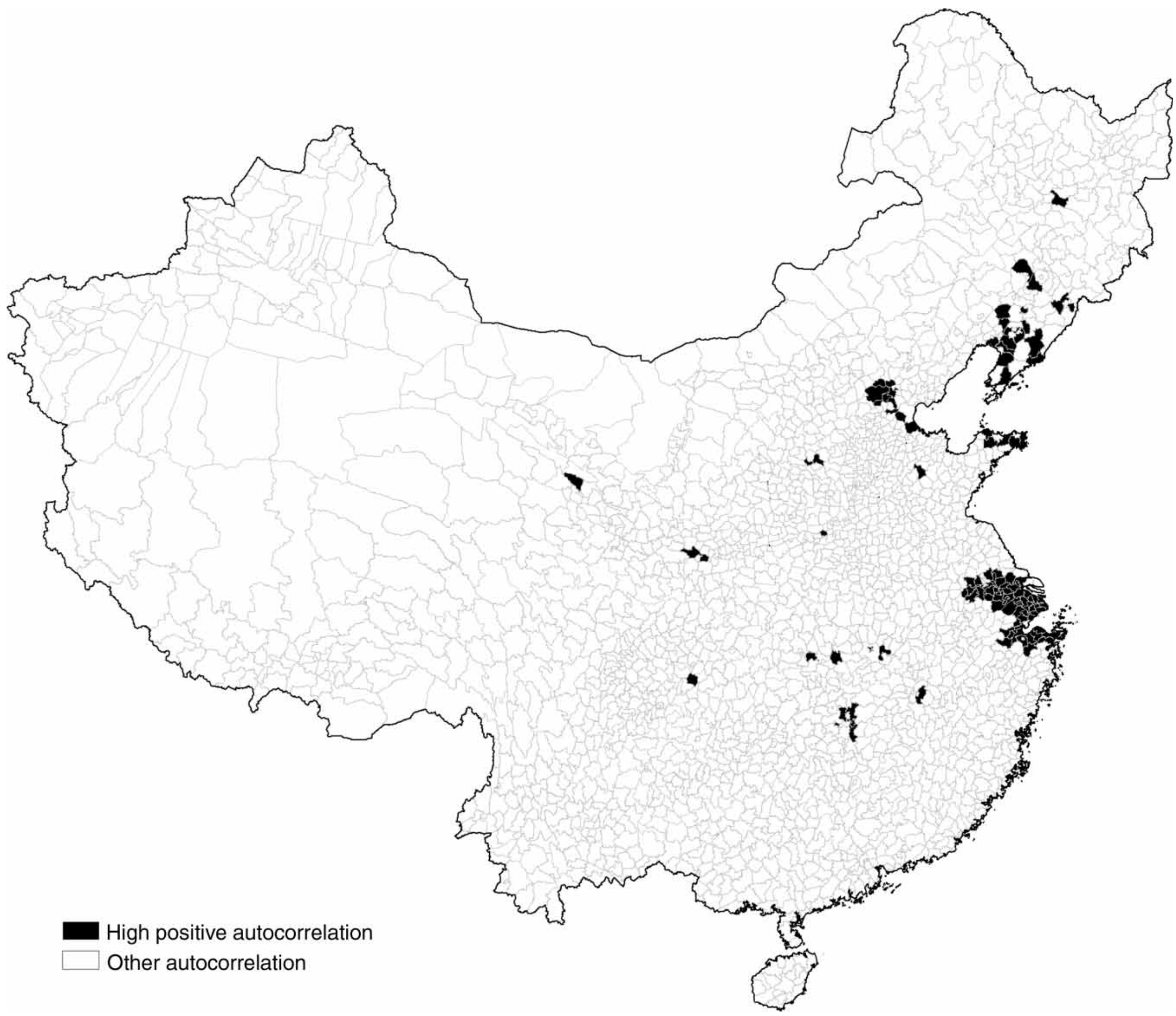

Fig. 2. Spatial clusters of 1990 employment encompassed in specialization factor 1 scores

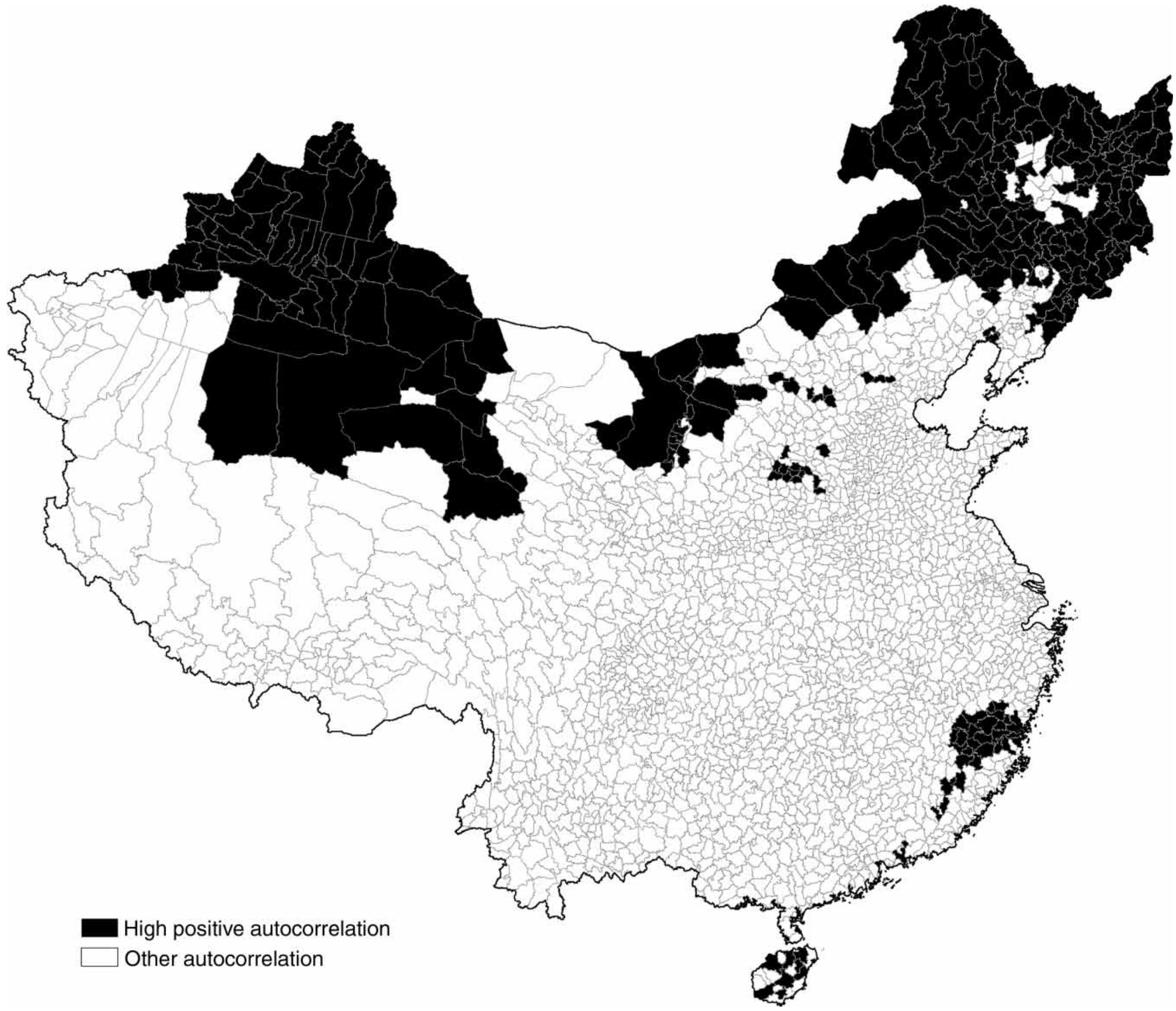

Fig. 3. Spatial clusters of 1990 employment encompassed in specialization factor 2 scores

financial sectors in the factor. Those financial sectors, however, are more likely the contributors to the hot spot that is centred in Zhejiang Province along China's central coast. That is the location of the Xiamen Special Economic Zone, which emerged after economic liberalization as a financial centre with a special relationship with Taiwan (VEECK *et al.*, 2007). It is perhaps China's most important centre for international finance. The third specialization factor scores indicate a hot spot that ranges along the coast almost continuously from just north of Shanghai to Guangdong Province (Fig. 4) – a geography that is consistent with the production for export that is associated with the non-durable goods cluster. There is also a spatial cluster in Xizang (Tibet), which results especially from high *relative* concentrations of Sewing and Leather and fur employment, as it has fairly low relative concentrations of employment in Cultural, educational, and sporting goods.

Only two of the derived factors contained more than 10% of the employment data's variance for 2000. The first employment level factor contained about 26% of the variance. With the exception of Catering, all the important sectors for the factor are in manufacturing (Table 8). The first factor's scores have a Moran *I* coefficient of 0.339, and the local Moran's *I* map shows important hot spots around Shanghai and in Guangdong Province (Fig. 5). The second employment level factor contains about 21% of the variance in the data. It defines a cluster that is a mix of market and non-market services (Table 8). Its factor scores' Moran *I* coefficient is 0.539, indicating considerable spatial autocorrelation in their distribution. The spatial clusters in this case are highly localized, with hot spots centred on the major metropolitan areas of Beijing, Shanghai, the growth centre of Guangzhou in Guangdong Province, and in a very limited area around Xiamen (Fig. 6). The third employment level

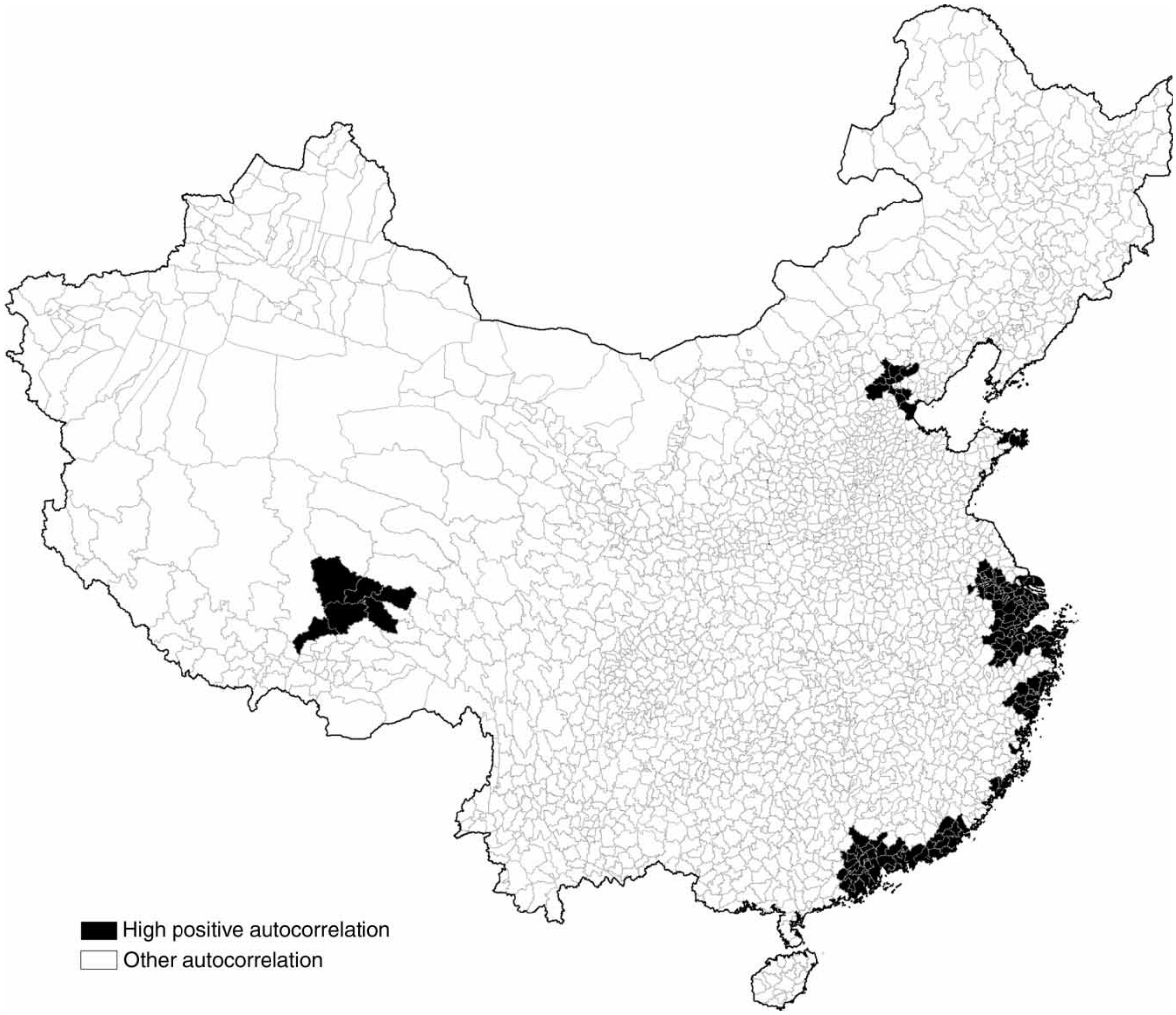

Fig. 4. Spatial clusters of 1990 employment encompassed in specialization factor 3 scores

factor for 2000 only contained about 8% of the data's variance, but underscores the geographical nature of China's economic growth. The two construction sectors are the only ones that have high loadings on the third factor, and its scores have a Moran *I* coefficient of 0.476. The local Moran's *I* map of those scores indicates hot spots around Guangzhou, Beijing, and in Shangdong Province (Fig. 7). It also indicates a spatially extensive cluster of construction centred on Shanghai that extends well toward the interior.

Two factors containing more than 10% of the variance in the employment specialization data were also derived for 2000 (Table 9). Comparing factor analyses over time is difficult, but in general, the factor structure for 2000 for the specialization data was less well defined than for the comparable 1990 data. That may indicate ongoing sectoral diversification – in the relative sense – in China's spatial economy. The first factor for the 2000 data contains about 16% of the variance. It is composed of market and non-market services and is roughly comparable with the second specialization factor derived for 1990 in its composition, but much broader with nine important sectors rather than four. The Moran *I* coefficient for the factor scores is 0.380, with spatial clusters (not mapped here) largely across northern China. The second specialization factor, containing 12% of the variance, consists completely of manufacturing sectors. It approximates a combination of the first and third common factors derived for the 1990 data. The Moran *I* statistic for the second factor's scores is 0.747, indicating a very high degree of spatial autocorrelation. The local Moran's *I* map shows spatial clusters around Beijing-Tianjin, in Shandong Province, in a large area centred on Shanghai, and a coastal strip that runs south from Shanghai and connecting a larger area in Guangdong province - essentially China's contemporary manufacturing corridor (Fig. 8).

Table 8. Factor composition of sectoral employment, 2000[a]

Factor composition	Sector loading
Common factor 1	
Sewing	0.821
Leather and fur	0.840
Furniture	0.859
Paper	0.852
Printing	0.766
Cultural, educational, and sporting goods	0.966
Plastic products	0.978
Metalwork	0.917
Electrical equipment	0.931
Electronics and telecommunications equipment	0.959
Instruments	0.852
Catering	0.629
Common factor 2	
Post and telecommunications	0.832
Catering	0.616
Real estate management	0.883
Consulting	0.936
Social welfare	0.613
Culture and art	0.711
Technical services	0.842
Financial services	0.791
Insurance services	0.838
Enterprise management	0.755

Note: [a]Factors are in decreasing order of proportion of variance. Only sectors with loadings greater than or equal to 0.6 are listed.

SUMMARY AND CONCLUSION

This paper describes some of the locational characteristics of a set of forty-one sectors individually and as clusters using employment data from the Chinese censuses of 1990 and 2000. Both aspatial and spatial measures were used in the analyses of both sectoral employment levels and of relative specialization in sectoral employment. At the level of the individual sector, it appears that manufacturing sectors generally became more unevenly distributed over the ten-year time span, with relevant coefficient of variation (CV) and index of diversity (ID) statistics indicating increasing geographical concentration and localization. Most service sectors, however, do not fit that generalization, but instead seem to have spatially diffused over the period in an apparent indication of the geographical spread of purchasing power in the Chinese economy. That conclusion is drawn from the marked general increase in observable spatial clustering in the service sectors between 1990 and 2000.

Both service-focused and manufacturing-focused clusters of employment were derived for 1990 and

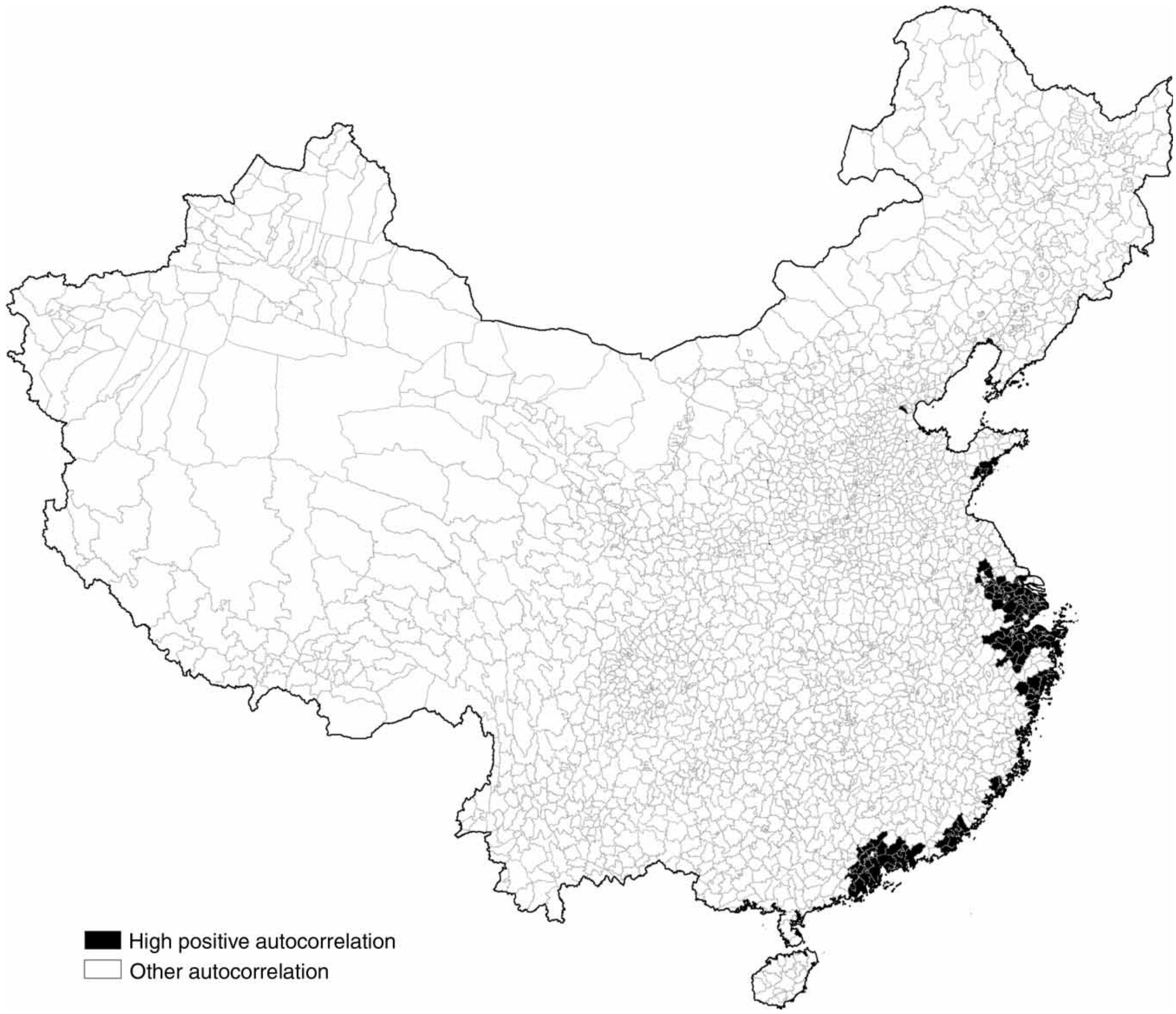

Fig. 5. Spatial clusters of 2000 employment encompassed in levels factor 1 scores

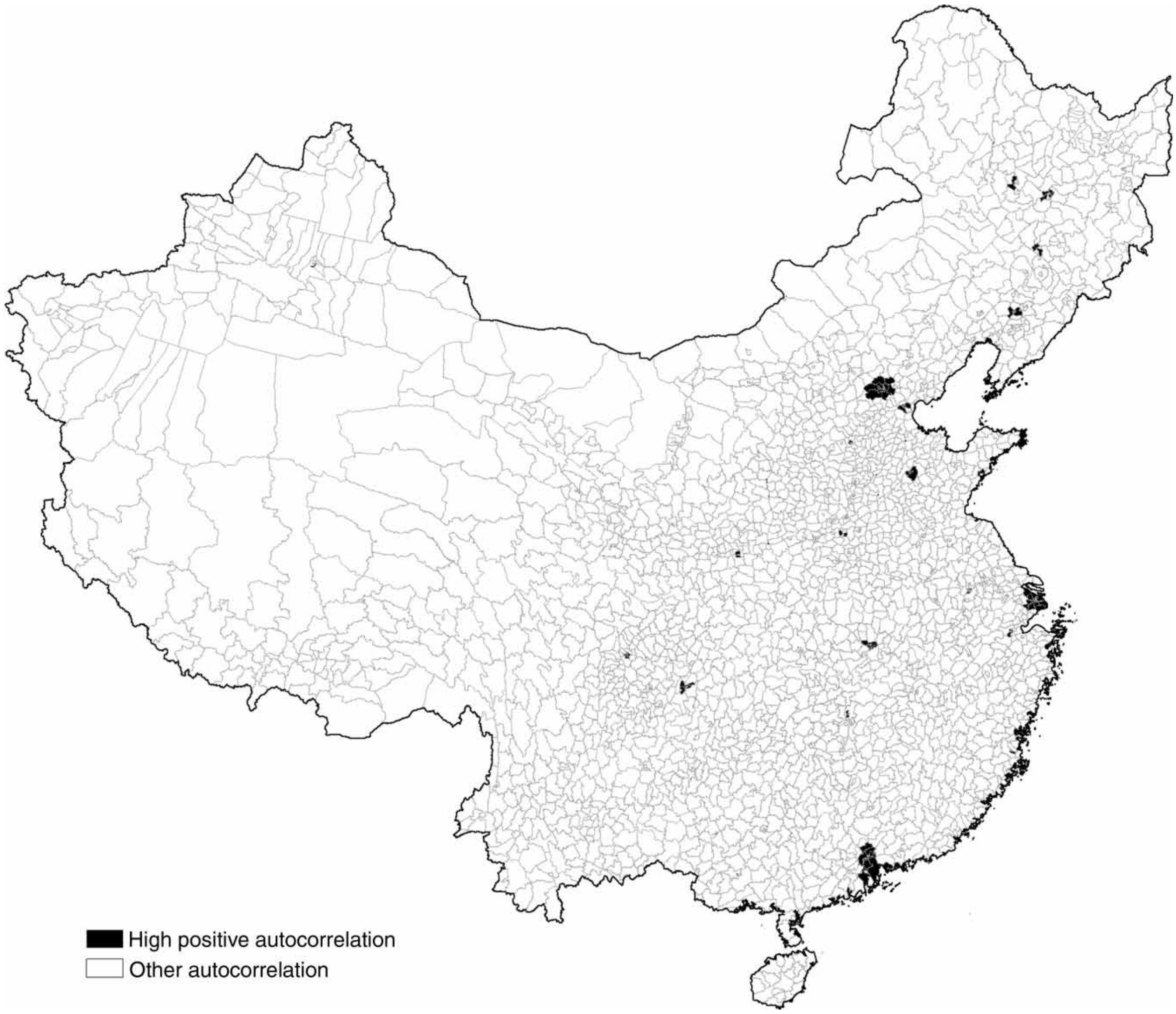

Fig. 6. Spatial clusters of 2000 employment encompassed in levels factor 2 scores

2000. As identified by factor analysis of employment levels, the most important cluster in China in 1990 was largely in services, a durable goods manufacturing cluster and a non-durable goods manufacturing cluster were also identified. The non-durable goods cluster had a marked level of spatial autocorrelation in its factor scores, with hot spots along the coast. Based on employment specialization, more limited clusters of durable goods manufacturing, services, and non-durable goods manufacturing were identified. Each had high levels of spatial autocorrelation in its factor scores, and again hot spots were identified largely in the coastal region of the country. Three employment level clusters were identified in 2000. The first was in manufacturing and the second was in services. Both exhibited high levels of spatial autocorrelation in their factor scores, and coastal hot spots were again apparent. The third cluster consisted only of construction activities, which also had coastal hot spots. A broad service cluster and a manufacturing cluster were identified based on employment specialization in 2000. The manufacturing cluster's spatial distribution was largely coincident with China's coastal manufacturing corridor.

Maps of the hot-spots in the clusters reflect the well-known coastal bias that has emerged in the Chinese economy which was reinforced by the economic liberalization that began in the late 1970s. That economic liberalization was accelerated during the 1990s by Deng Xiaoping's extension of the Open Door Policy (which encouraged foreign direct investment (FDI)) from Guangdong and Fujian provinces to most of China. Despite its geographical breadth, that policy extension worked to increase the concentration of FDI in coastal areas from which access to international markets was facilitated and where foreign investors already had experience (DÉMURGER *et al.*, 2002; HE, 2003). The accelerated influx of FDI served, along with the increasing privatization of the coastal province economies (HAN and PANNELL, 1999), in turn to accelerate agglomeration in those areas as a response to market-based competitive pressures to improve efficiency. In short, government policy began the acceleration of agglomeration effects in China's

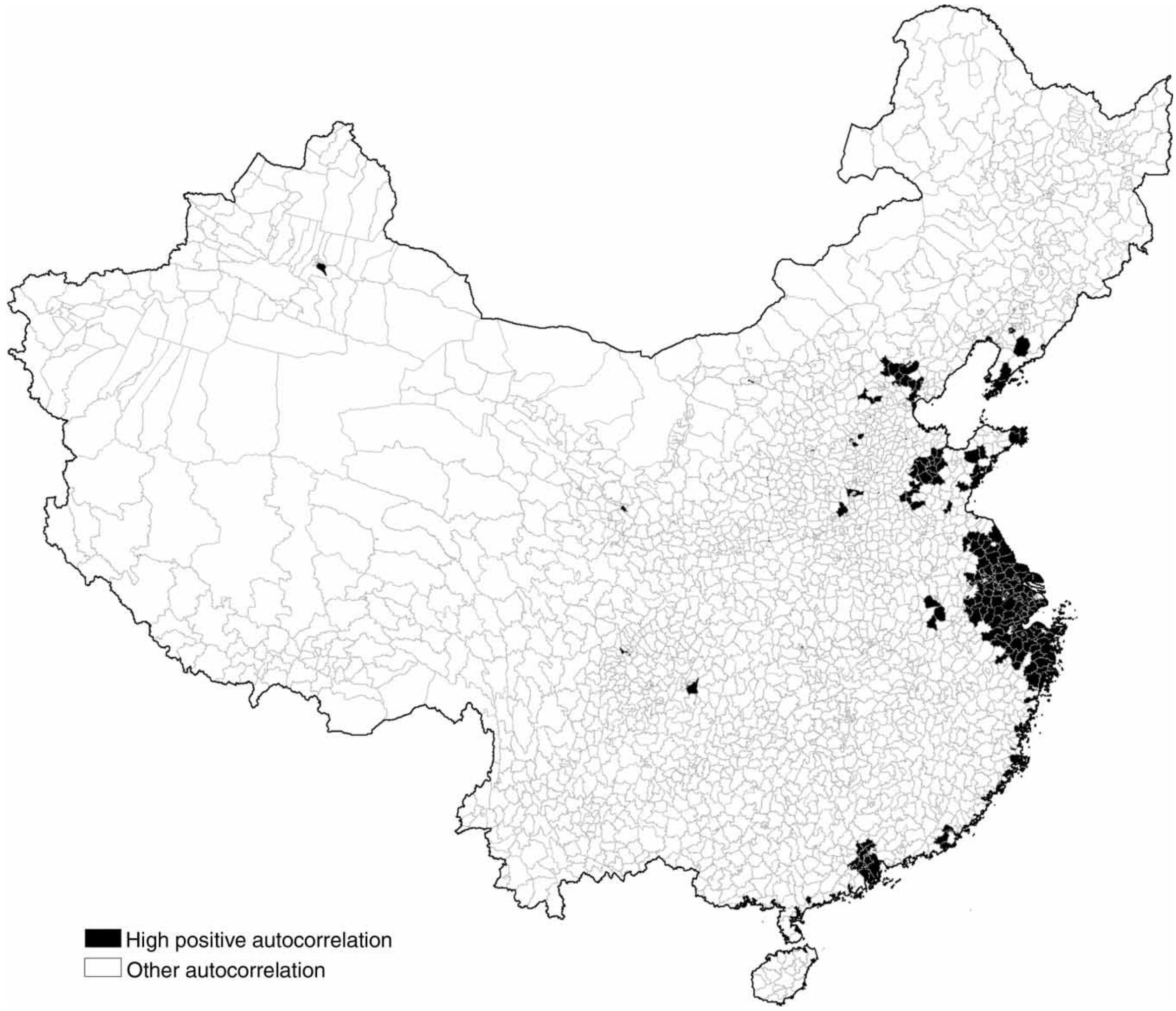

Fig. 7. Spatial clusters of 2000 employment encompassed in levels factor 3 scores

Table 9. Factor composition of sectoral employment specialization, 2000[a]

Factor composition	Sector loading
Common factor 1	
Post and telecommunications	0.845
Catering	0.702
Real estate management	0.613
Consulting	0.663
Technical services	0.615
Financial services	0.875
Insurance services	0.844
Enterprise management	0.784
Teaching	0.631
Common factor 2	
Sewing	0.648
Cultural, educational, and sporting goods	0.627
Plastic products	0.781
Metalwork	0.684
Electrical equipment	0.668
Electronics and telecommunications equipment	0.645

Note: [a]Factors are in decreasing order of proportion of variance. Only sectors with loadings greater than or equal to 0.6 are listed.

economy which continued to grow under market economy conditions between 1990 and 2000.

While the agglomerations around the earlier centres of Beijing and Shanghai and the more recent centres focused on Guangdong and Xiamen seem to be expanding spatially, they remain effectively within a coastal concentration which contributes to China's social and income inequality (ZHAO and TONG, 2000; FAN and SUN, 2008). The coastal concentration is often linked to an enabling government policy of liberalization that allowed market forces to generate agglomeration economies along the coast (FUJITA and HU, 2001; DÉMURGER *et al.*, 2002; FAN and SCOTT, 2003), so policy remedies are often viewed as the necessary mechanism of decentralization and, therefore, reduction of inequality (ZHAO and TONG, 2000). China has, in fact, redirected its geographical policies toward its west, in order not only to reduce inequality, but also in the interest of reducing the pressure of continuing rapid growth along the coast (VEECK *et al.*, 2007).

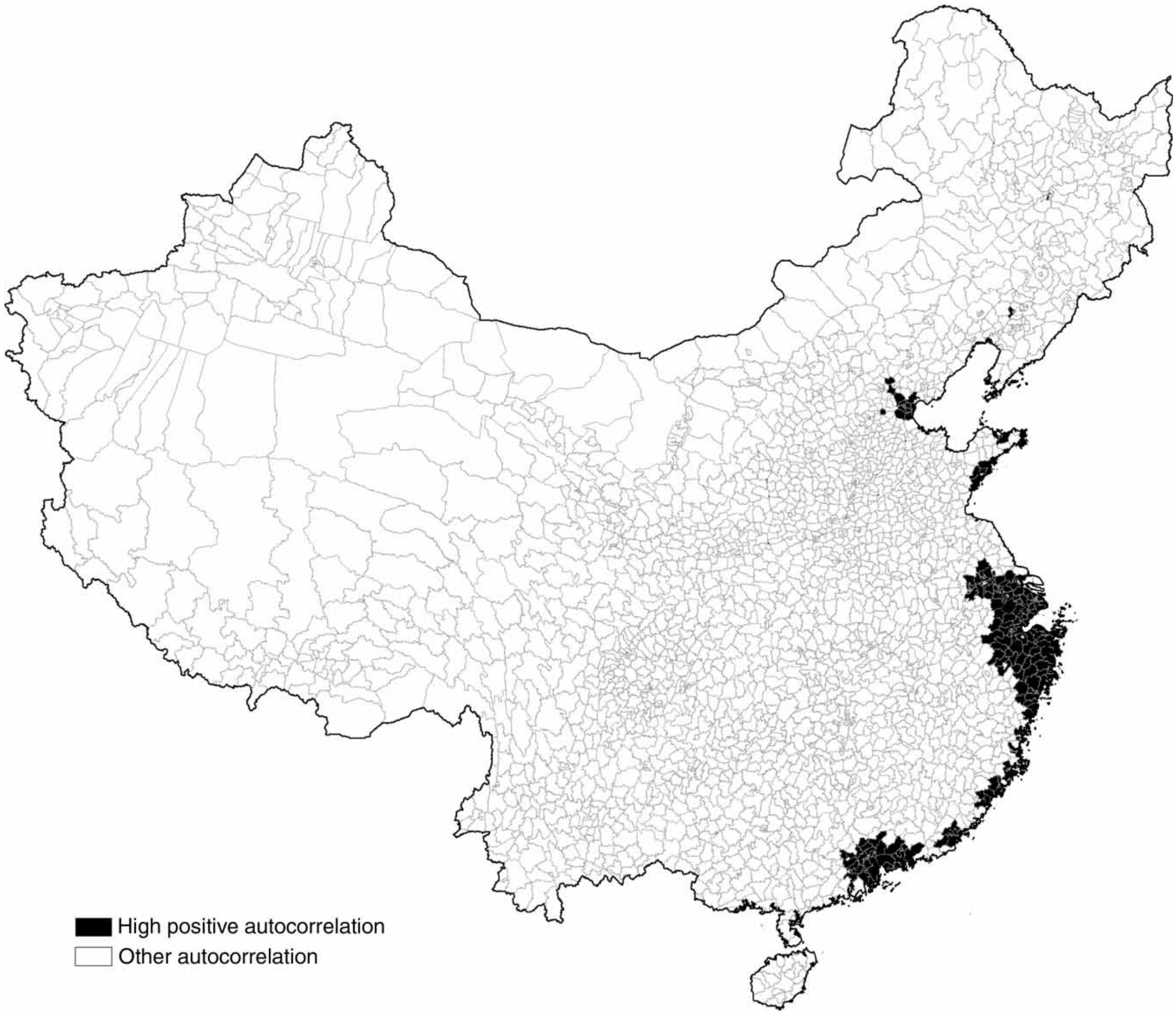

Fig. 8. Spatial clusters of 2000 employment encompassed in specialization factor 2 scores

There is some evidence that, policy-induced or otherwise, inequality is declining in China (WANG and GE, 2004; FAN and SUN, 2008). It is unlikely, however, that the spatial concentrations in the Chinese economy along its coast will decline, and it is likely that their continuation as a result of agglomeration efficiencies is a vital component of aggregate growth in the country's economy. Policy initiatives are probably best comprised of actions that are not spatially directed in such a way as to limit coastal growth purposefully and perhaps interfere with an ongoing spatial spread of income that is, in fact, sourced in the coastal centres (GROENEWOLD *et al.*, 2007). They should rather be aspatial in their targets, such as those geared toward improving agricultural productivity and continued financial reform (DÉMURGER *et al.*, 2002; PICARD and ZENG, 2005). Such policies certainly have spatial effects – much of the coastal labour force can be traced to agricultural reforms – but they can also contribute to an environment that is conducive to growth in many parts of China.

APPENDIX

Fig. A1. *Reference map*

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