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Spatial concentration of manufacturing firms in China^{*}

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Abstract. Applying the methodology developed by Duranton and Overman, we analyse localization and dispersion of firms in China. Using a unique and detailed dataset on manufacturing firms in China, we are able to follow the changes in location patterns of firms between 2002 and 2008. Our analysis shows that firms in China are more localized than in the UK or Japan. Localization is comparable to that in the US, and takes place at relatively small scales that are consistent with the size of Chinese cities. Localization increases rapidly, even in the relative short period between 2002 and 2008, especially new entrants localize. Private firms, firms from Hong-Kong, Macao and Taiwan, and foreign firms are more localized than state-owned firms. Our findings are consistent with the notion that China is increasingly liberalizing its economy, enabling (profit seeking) manufacturing firms to benefit from agglomeration economies.

JEL classification: F23, R12, L70

Key words: Spatial concentration, China, manufacturing firms, localization

1 Introduction

Economic activity is unevenly distributed across space. The reason for this is the subject of a large and growing body of literature (see e.g., the surveys of Rosenthal and Strange 2004; Brakman et al. 2009). But before answering the question why this is the case, it is important to know how economic activity is distributed across space and how strong industries tend to cluster, if at all. Furthermore, if industry tends to cluster it is important to know at what spatial scale this happens. The answers to these questions are important for a number of reasons. Holmes and Stevens (2004) list three problems that are ‘at stake’ and that require answers to the questions stated above: what is the importance of geography to determine the economic success or failure of a location, can government policy influence location choices, and can regions lose or gain from relocations of core industries? The first step in dealing with these types of problems is to find out where economic activity is

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located, and that is what we do in this paper. Location studies have by-and-large concentrated on the US, countries of the European Union (EU), and Japan (see surveys by Combes and Overman 2004; Fujita et al. 2004; Holmes and Stevens 2004). In general, the conclusion is that economic activity is unevenly spread across space, but also that many differences between regions and countries exist, that ask for possible explanations.

In this paper we concentrate on location patterns in China. China is an interesting case. Historically, concentration of economic activity seems low compared to other countries (for a long-term historical perspective, see Brandt et al. 2013; and for an account on more recent periods, Au and Henderson 2006a, 2006b). Fujita et al. (2004, p. 2955) note that the Chinese Gini-coefficient (in population terms) in 2000 is 0.43 which is 'way below the world average ... Only former Soviet bloc countries have similarly low Gini's'. Limited concentration of economic activity is worrying, because it may indicate efficiency losses or the loss of potential agglomeration rents. To a large extent the Chinese *hukou* system is held responsible. The *hukou* system is a system that limits migration between rural and urban areas and between urban areas. This system is gradually becoming more liberal, but its effects are still visible. The *hukou* system is an example that illustrates that China is becoming more liberalized; other institutional changes have similar effects (Brandt et al. 2013). A more liberal system most likely results in more concentration, along the Chinese coast but also more in inland China (see Bosker et al. 2012).

Most of the studies dealing with China use regional population/employment data or regional GDP statistics (Bosker et al. 2012). In this paper we employ a detailed dataset on individual manufacturing firms, differentiating between privately owned firms, state and collectively owned firms, firms from Hong Kong, Macao, and Taiwan (HMT), and finally foreign firms. Furthermore, we have sectoral information for these groups of firms. The data allow us to address the question whether there is a ranking of concentration associated with ownership or state control. In the remainder of this paper we will first in Section 2 motivate the choice for our measure of spatial concentration. Section 3 then introduces the data set, and Section 4 provides the stylized facts on spatial concentration in China. In the remaining sections we differentiate between various types of firms by ownership (Section 5), firm size (Section 6), and new firms (Section 7). Section 8 concludes. In general, we find that localization is present in China, and seems comparable to that of the US. Evidence that China is in transition is clearly visible from the localization analysis, which indicates that increasingly firms try (and succeed) to benefit from agglomeration economies that go along with increased spatial concentration.

2 Measuring spatial concentration

Measuring spatial concentration remains a challenge despite considerable recent progress (see Combes and Overman 2004 for an in depth discussion). Measures should ideally be comparable across industries (some industries have many firms, some only a few), across spatial scales (changing spatial scale should not affect conclusions with respect to concentration), have a well-defined null-hypothesis (have a bench-mark), indicate whether findings are significant (confidence intervals), and unbiased with respect to changes in spatial scales (changes in borders of spatial units) or industrial classification (changes in 'borders' of industrial classifications; for a detailed discussion of these criteria see Combes and Overman 2004; Combes et al. 2008). The ideal index still has to be found but good ones exist. Most notably the Ellison and Glaeser (1997) index and the Duranton and Overman (2005, 2008) index (DO index hereafter). The Ellison and Glaeser (1997) index explicitly deals with the problem of comparing between industries that consist of different number of firms (the Ellison and Glaeser index corrects for the fact

that some industries consist of just a few firms, while others consist of many firms). Furthermore it defines a clear benchmark (the dartboard). The index that satisfies most requirements, however, is the DO index.¹ Results using different indices can be very different. Duranton and Overman (2005) find that the Ellison and Glaeser index indicates that 94 per cent of the UK four digit industries are localized, whereas the DO index shows that only 52 per cent are localized. A disadvantage of both measures is that they require relative detailed location information of (individual) firms.

In this paper we analyse manufacturing concentration in China with the DO index. The main reason is that the DO index is unbiased for changes in spatial scales because it circumvents the use of exogenous spatial units altogether.² This is an important advantage of this index. If an industry is concentrated at a specific location it should not matter if an administrative spatial boundary cuts through this agglomeration. Most measures, however, treat neighbouring spatial units exactly the same as far away spatial units and dividing an agglomeration over more spatial units affects results. For a large country like China, we especially aim to avoid this potential bias especially because administrative borders in China change over time (for policy reasons).³ The DO index calculates the bilateral Euclidian distance between all pairs of firms. Counting the number of firms at a given distance gives the frequency of firms at that distance and allows us to calculate the density of firms at that distance (Duranton and Overman 2005). If the distribution of densities has a maximum at a certain distance, this particular distance separates firms the most. Euclidian distance is only a proxy for true distance which can be expected to differ between low-density areas and high-density areas. Kernel-smoothing deals with this problem. Furthermore, Monte Carlo simulations provides confidence intervals.

The empirical analysis proceeds in three steps. We first calculate the pairwise distances between firms. Next, we estimate the kernel density function of the distribution of pairwise distances. Third, we construct (global) confidence interval bands and calculate the index of localization or dispersion of firms in order to assess the spatial pattern of a manufacturing industry.

The density estimation involves the density of pairwise distances between firms. For each industry A , with n firms, there are $\frac{n(n-1)}{2}$ bilateral distances between firms. The estimator of the density of bilateral distances at distance d is given by (Duranton and Overman 2005, see Silverman 1986 for a discussion on choosing h , and DiNardo and Tobias 2001 for a discussion of kernel estimates):

$$\widehat{K}_A(d) = \frac{1}{n(n-1)h} \sum_{i=1}^{n-1} \sum_{j=i+1}^n f\left(\frac{d - d_{ij}}{h}\right), \quad (1)$$

where d_{ij} is the Euclidean distance between firm i and j , h is the bandwidth, and f is the kernel function (we use GIS, to deal with the curvature of the earth which is important for a large country like China).

¹ Although, as is the case with all indices, this index might be susceptible for changes in industrial classification which are carried out by statistical agencies.

² Note, that our use of this measure does not fully use the advantage of the DO index, as we allocate firms to the smallest spatial unit that we have, see below.

³ Baum-Snow et al. (2013) analyse changes in spatial definitions over the 1990–2010 period in detail and observe changes in the definitions over time (e.g. some cities did not exist as a city in 1990, but were defined as such for planning reasons). To deal with this they introduce a ‘constant boundary central city’ for consistency purposes. The conclusion they draw, is that one should not use the ‘Prefecture’ city definition over long periods of time. The potential bias in our results is limited, because: changes in spatial definitions between 2000–2008 (our sample) are less pronounced than in the 1990–2010 period (Baum-Snow et al. 2013); we do not compare changes of individual counties over time on a one-to-one basis (but compare agglomeration patterns). Furthermore, a sensitivity analysis suggests that potential biases are limited.

The counterfactual is a hypothetical industry for which firms are randomly reallocated to possible sites. Assume there are n_M manufacturing firms that define n_M possible sites. Industry A has n_A firms. Following Duranton and Overman (2005, 2008), we randomly select n_A sites from all possible sites n_M and do this 1,000 times. This results in 1,000 density estimates for each distance as defined in Equation 1. Using these estimates we can construct a 90 per cent confidence interval that contains 90 per cent of all values at a particular distance, with the upper bound the 95 per cent percentile, and the lower bound the 5 per cent percentile. If a density exceeds the upper boundary there is local concentration at that distance, and if the density is smaller than the lower bound there is local dispersion at that distance.

Duranton and Overman (2005) also define global concentration and dispersion. Global concentration is the upper limit for which 95 per cent of all draws (over the whole range of distances) is below that upper bound, and vice versa for the lower bound. As Duranton and Overman (2005, 2008) we define a distance threshold, in our case 900km.⁴ A sector is defined to be globally concentrated if its density hit the upper limit at least once (over the whole range of distances), and similarly for dispersion (with the added condition that the upper limit is never touched).⁵

3 Data set and empirical approach

We use a dataset that is collected via the Annual Survey of Industrial Firms (ASIF). The survey is conducted by the National Bureau of Statistics of China (<http://www.stats.gov.cn/tjsj/ndsj/>); our dataset consists of the years 2002 and 2008 of the ASIF. The micro firm-level data of ASIF are aggregated and published in the China National Statistical Yearbook (CNSY). For our purposes, the disaggregated data of ASIF are essential and enable us to analyse location patterns of various types of firms and also to analyse changes of location patterns over time, that is to say, changes between 2002 and 2008. The published and aggregated data of the CNSY correspond by-and-large to the ASIF. A simple check on consistency between the two sources is to aggregate the micro-level ASIF data and compare the aggregation with the officially published aggregates in the CNSY. This comparison is done in Table A1 in Appendix 1. Both sources seem consistent, with one exception; smelting and pressing of non-ferrous metals (sector 33). In 2002, the firm coverage of Sector 33 in ASIF is only 34 per cent compared to the number of firms in the yearbook (that also has access to other sources). While in 2008, the information for sector 33 is no longer available in the ASIF. We therefore decided to exclude sector 33 from the analysis. Although we have no presumption on what time scale the interaction between relocation decisions and agglomeration should be visible in the data, trends in relocation patterns take time, and we assume that they become visible in the data over the period 2002–2008. A year-to-year comparison is most likely to be less telling in this respect.

⁴ Duranton and Overman (2005) chose the range based on the median value of all pairwise distances which is 180 kilometres for UK. In China, the median value of all pairwise distances between manufacturing firms is 952 kilometres in 2002 and 884 kilometres in 2008. Thus, we chose 900 kilometres as the threshold to calculate the confidence intervals.

⁵ In principle there are many ways to construct confidence bands such that, say, 5 per cent is globally above or below a band. We follow Duranton and Overman (2005), by using the local confidence bands to search for a global band. The procedure is as follows. We start by constructing an initial global band by connecting all local 1 per cent confidence intervals (over all distances) and draw the band. Next, we count how many simulations go beyond this band. If this is more than 5 per cent we take something smaller for the local confidence interval, for instance 0.5 per cent, and repeat this until we find a confidence interval that corresponds to 5 per cent of deviations over the entire set of distances that we consider. This is the global 5 per cent confidence interval.

The ASIF covers all Chinese industrial state-owned enterprises and non-state-owned enterprises with annual sales above RMB five million.⁶ The total number of firms was 176,514 in 2002, and 411,809 in 2008. We exclude the primary sector and the services sector because location decisions are very different from the manufacturing sector. This reduced the number of firms to 157,759 in 2002 and 376,935, in 2008. For the firms in the sample, ASIF gives detailed location information at the county level, industry information at two, three and four-digit levels, ownership information (state-owned and collectively-owned, private and foreign owned), firm size, the number of employees and other (financial) firm specific indicators.

The precise location of the manufacturing firms is essential in our distance-based analysis. However, restricted by the data, the location information is at the county level. Therefore, bilateral distances between firm pairs are unavailable. Instead, we use the location of counties and assign this location to all firms in that county. The county-level is at a fine geographical scale, compared to China as a whole, and we assume that the aggregation error is small (see below for some sensitivity analysis).⁷ We use the county-level administrative divisions map (ADM) in 1999 provided by National Geomatics Center of China to construct the geographical information of counties (using the GIS software).⁸

ADM at county level in 1999 has spatial information for 2,367 county spatial units. However, 2,860 county level administrative units are recorded in the Chinese Administrative Divisions System (CADS). The reason that the number of county level units in ADM is less than that in the CADS is that ADM does not have sub-divisions of municipal districts of prefecture-level cities. The CADS, for example, sub-divides the municipal district of Beijing into six sub-municipal districts (comparable to counties), that are aggregated in our analysis (reducing the number of counties). To make the analysis comparable between 2002 and 2008, we match the location information of the ASIF to the administrative coding system of ADM.⁹ The matching process leaves us 2,360 counties which are consistent for both 2002 and 2008 ASIF and ADM. We then allocate the geo-information on a county to all firms in that county, which might bias results as the size of counties differs (ideally we would like to have individual location information for all firms which would be consistent with our methodology of the Duranton-Overman index). An indication of the importance of this bias is to assume that counties are circular (as the actual shape differs) and that firms are spread evenly within this circle. The average distance between two points in a circular county equals $D_{ii} = 0.66 \times \sqrt{\text{area}_i / \pi}$. Such intra-county distances are then used as the distances between firms locating in the same county. County size variation is small, the mean value of the intra-county distances is 19 kilometres, compared to the median value of all pairwise distances between manufacturing firms in China, which is around 900 kilometres. Figure 1 shows in ascending order intra-county distances: D_{ii} . The largest intra-county

⁶ The threshold implies that small firms are not covered by the survey or that firms enter or exit the survey if the threshold is reached. Note, that we find that small firms are the most active in the dynamics of localization which might imply that we underestimate actual localization (see below). This is also noted by Lu and Tao (2009). The survey covers enterprises that conduct only one economic activity (or at least one economic activity which is predominate) at one location. Firms with more establishments in one single location (city) are recorded as a single firm. Firms with more plants at different locations are differentiated in the survey.

⁷ County level is the third level of administrative divisions in Chinese administrative division system which is under the provincial (including municipalities) level and prefecture city level and above township level. County level administrative units include the municipal districts of prefecture-level city, county-level cities, deputy-level cities, forests, etc. In 2002 China had 2,860 and in 2008 2,859 county level administrative units.

⁸ See for National Geomatics Center of China: <http://ngcc.sbsm.gov.cn/>. ADM at county level definition in 1999 is the closest ADM available for 2002.

⁹ In ASIF, location of manufacturing firms includes 2,678 counties and 2,797 counties respectively in 2002 and 2008.

Fig. 1. Ascending order of intra-county distances

Source: Authors.

distance is around 170 km while the smallest is less than 10 km. Intra-county distances for most counties (around 2,000 counties) are within 0–20 km range while for the other 300 counties, the intra-county distances range from 20 km to 170 km.

As a sensitivity exercise for the k-densities, which is a crucial measure in our exercise, we include sub-samples that exclude the largest and smallest counties. Table 1 shows that excluding the 5 per cent or 10 per cent largest counties, reduces the number of firms by less than 1 per cent. Excluding the smallest counties, however, does affect firm numbers significantly. The largest counties in China are in the western part of China with very low population and firm densities.

Figure 2 shows the k-densities for the various sub-samples; in general the biases are small and only occur when the smallest counties are excluded. The conclusion based on the sensitivity analysis is that, although we would rather have location information on each firm separately, the bias of using county data is relatively small, and that our results are close to an optimal application of the DO-index.

To illustrate the DO index method, we select three two-digit industries in 2002 (only for illustration purposes): communication, electronic and computer producing (sector 40), Beverage manufacturing (sector 15), and Chemical raw materials and chemical products (sector 26). A look at Figure 3 indicates that firms in sector 40 appear to be geographically concentrated, those in sector 15 dispersed, and those in sector 26 have a similar pattern as manufacturing as a whole.

Table 1. Excluding the largest and smallest counties

Sensitivity analysis	No. manufacturing firms	Firm number decreases by (%):	Bandwidth in calculating K-density	Std. intra-county distances
Full sample with all 2,360 counties	157,759		5.03	13.4 km
Excluding: 5% largest counties	157,189	0.4	4.99	7.1 km
5% largest and smallest counties	140,841	10.7	5.21	6.7 km
10% largest counties	156,386	0.9	4.96	5.6 km
10% largest and smallest counties	120,664	23.5	5.54	4.8 km

Fig. 2. K-densities for sub-samples: excluding largest and smallest counties

Source: Authors.

Fig. 3. The spatial distribution of selected sectors and total manufacturing in 2002

Source: Authors.

Fig. 4. K-density and 5 per cent global confidence bands for sectors: 40, 15, 26

Source: Authors.

Figure 4 provides the results of K-densities for these 3 illustrative sample sectors (solid lines). The dashed lines indicate the global upper, and lower 5 per cent confidence bands. Firms in sector 40 seem to concentrate in three dense clusters: one at the Yangtze River Delta, one at the Pearl River Delta and one in the Beijing-Tianjin-Hebei area (see Figure 3). This spatial pattern is translated into a very high peak around 80 kilometres in Figure 4(a).¹⁰ Between distances of 200–900 km firms in sector 40 are dispersed.

Figure 4(b) shows that firms within the beverages sector (15) are evenly distributed and show no tendency to cluster as all observations are below the lower global confidence band. The chemical raw materials and chemical products sector (26) has a similar geographical pattern as manufacturing as a whole (not shown separately). Neither strong clustering or spreading is observed in Figure 4(c). Such a pattern is then correctly translated from Figure 3(c) into Figure 4(c). At some distances, the k-density of sector 26 deviates to some extent from randomness, however, over the entire range between 0–900 km it (almost) makes no difference with the distribution of firms in general.

¹⁰ Note, that the clusters are far apart (more than 900 km). If the clusters had been closer to each other they would show up as multiple peaks in graphs like Figure 4. Extending the horizontal axis to 1,100 km would reveal a second peak. A similar observation holds for the UK, see Duranton and Overman (2005).

4 Spatial concentration analysis

We are interested in the spatial dynamics of manufacturing firms in China. We analyse this by using the DO method described in Section 3. Since 1990, China has increasingly participated in the global supply chain and increases in productivity of the manufacturing sector might have been stimulated by agglomeration economies, which could be reflected by increased concentration of manufacturing in clusters, stimulated by the Chinese government. We first look at manufacturing industries in general. Next we differentiate between ownership. Finally, we look at firm size differences.

4.1 Localization and Dispersion

We first sub-divide 2-digit industries into 4-digit industries. We select 381 4-digit code manufacturing industries that have 10 or more firms in both 2002 and 2008.¹¹ Taking the global 5 per cent-global confidence bands as criteria to determine localization or dispersion, we find in 2002 that 73 per cent of the industries are localized (277 industries), and 13 per cent are dispersed (50 industries). The remaining share does not deviate significantly from randomness (54 industries). In 2008, the shares (numbers) change to 81 per cent (309), 14 per cent (52) and 5 per cent (20), respectively.

Figure 5 illustrates the share of localized (panel a) and dispersed (panel b) industries across all distances. Panel 5(a), indicates a steep distance-decline between 0–250 km in the number of industries that are localized. This holds for 2002 as well as for 2008. Comparing 2002 and 2008 more localization takes place at all distances, but more pronounced at smaller distances. Figure 5(b) gives the share of dispersed industries. About 10 per cent industries are dispersed within 50–250 km range, and close to 5 per cent at larger distances. This holds for 2002 as well as for 2008. Note, that the 0–250 km range is at the scale of Chinese (prefecture) cities. Note, that Lu and Tao (2009) also using a very detailed firm dataset for China find, using the Ellison and Glaeser index, that only 24 per cent of all industries are somewhat to very concentrated, which is in contrast to our findings.¹²

Figure 5 shows deviations of randomness, but not the extent of these deviations. Duranton and Overman (2005) define indices that allow us to calculate the extent of the deviations (see Appendix 2 for the definitions). Summation over industries gives a measure of the extent of deviations at any given distance: for localization we have $\Gamma(d) = \sum_A \Gamma_A(d)$ and similarly for dispersion $\Psi(d) = \sum_A \Psi_A(d)$. Figure 6 reports both measures for 381 industries in 2002 and 2008. In a qualitative sense the conclusions with respect to Figures 5 and 6 are the same; the extent of localization and dispersion is greater at smaller distances. However, localization has increased markedly between 2002 and 2008 between distances 0–250 km.

Comparing our results to those of Duranton and Overman (2005) for the UK or Nakajima et al. (2012) for Japan we find more localization for China than these studies find for the UK or Japan (around 50% of UK or Japanese industries are localized). Our results for China are more in line with those of Ellison and Glaeser (1997) and Holmes and Stevens (2004) for the USA, or Maurel and Sédillot (1999) for France who find

¹¹ The sample contains of 399 4-digit industries in 2002, and 392 in 2008. Selecting only those industries that have at least 10 firms in both years results in 381 4-digit industries.

¹² This comparison shows the advantages of using the DO index instead of an Ellison and Glaeser (1997) index; border effects tend to bias localization measures downward, see Duranton and Overman (2005, pp 23–24, for a discussion).

Fig. 5. Share of localized or dispersed industries – 2002 and 2008

Source: Authors.

between 75 and 95 per cent of industries to be localized (note, however, that they use employment data).

A common finding in all studies is that localization is more likely to occur at smaller distances. For China this holds for 2002 and for 2008. However, even in this relative short period localization within China has increased markedly. This change could imply some firm relocation that is related to agglomeration economies.

4.2 Spatial structure of 4-digit industries

Instead of summing the localization and dispersion indices over industries, we can sum over distances to give a sector index of both measures: that is, for localization $\Gamma_A = \sum_d \Gamma_A(d)$ and similarly for dispersion $\Psi_A = \sum_d \Psi_A(d)$. Figure 7 shows the result when we rank the sectors in descending order of the indices. As clearly visible in Figure 7, the distribution is skewed; around 20 industries (comprising about 5% of all 4-digit industries in our sample) are highly localized compared with other industries. Furthermore, the distribution for 2008 is always above that of 2002, indicating increased localization (*mutatis mutandis* for

Fig. 6. Extent of Localization and dispersion – 2002 and 2008

Source: Authors.

Fig. 7. Rank-order distributions of localization indices for four-digit industry

Source: Authors.

dispersion; only a few industries are highly dispersed). Table 2 lists the 30 most localized and dispersed 2-digit industries in 2002 and 2008.

Table 2 is based on the 30 most localized or dispersed 4-digit industries. In order to avoid too much detail, Table 2 lists the names and the codes of the 2-digit industry branches that have the largest number of 4-digit industries (among the 4-digit top 30) in 2002 and 2008. The upper part of Table 2 gives the results of localized industries. More than half of the 30 most localized 4-digit industries belong to only three 2-digit industries which are textiles (S17), electrical machinery and equipment manufacturing (S39) and special equipment manufacturing (S36). The lower part of Table 2 gives the results of dispersed industries. Food manufacturing (S14), beverage manufacturing (S15), pharmaceutical manufacturing (S27), wood processing and products (S20) and ferrous metal smelting and rolling processing (S32) contain most of the 4-digit dispersed industries.

The results for China are quite similar to those for the UK, the US and Japan, using the same DO index. For example, the textile sector, is highly localized in all these countries and wood processing is not. These facts hint at common characteristics of these industries that stimulate localization or dispersion in all countries. Textile is an interesting example. China is the world's largest producer and exporter of textile products. Both the historical origin of the sector, along the Yangtze River Delta, and the export-orientated sector strategy contribute to the highly localized pattern of textiles in China at the Yangtze River Delta. The textile sector is also found among the most localized industries in the UK, US and Japan, most likely for the same (hysteresis related) reasons. Furthermore, even though textiles is among the most localized industry in 2002, the extent of localization still increased; six 4-digit industries in the textile industry became more localized in 2008. Such change is probably driven by labour market pooling in the coastal areas, because of an increased export orientation of the textile industry (see for an historical analysis of location factors that are important for the textile industry Crafts and Wolf 2013; note that according to the WTO 2014; China is the world's largest textile exporter and textile export growth is four times larger than world trade in general).

5 Ownership and spatial concentration

Ownership might affect the spatial pattern of firms. Governments, for example, might like to stimulate firm spreading instead of clustering to stimulate economic growth in

Table 2. Number of most localized/dispersed industries in two-digit branches (selection out of top-30)

Localized			
2002		2008	
Industry Branch	No. of industries among the most localized 30 industries (No. of total industries in this industry branch)	Industry Branch	No. of industries among the most localized 30 industries (No. of total industries in this industry branch)
S17 Textile	7 (20)	S17 Textile	9 (20)
S39 Electrical machinery and equipment manufacturing	5 (24)	S39 Electrical machinery and equipment manufacturing	5 (24)
S36 Special equipment manufacturing	3 (41)	S36 Special equipment manufacturing	4 (41)
Dispersed			
2002		2008	
Industry Branch	No. of industries among the most dispersed 30 industries (No. of total industries in this industry branch)	Industry Branch	No. of industries among the most dispersed 30 industries (No. of total industries in this industry branch)
S14 Food manufacturing	5 (9)	S14 Food manufacturing	7 (9)
S15 Beverage manufacturing	5 (12)	S15 Beverage manufacturing	7 (12)
S26 Chemical materials and chemical products manufacturing	3 (31)	S13 Agro-food processing industry	3 (15)
S27 Pharmaceutical manufacturing	3 (6)	S20 Timber processing, bamboo, cane, palm fiber and straw products	3 (8)
		S32 Ferrous metal smelt ing and rolling processing industry	3 (4)

Source: Authors.

peripheral regions. In China publicly owned firms are still very important and location decisions by these firms might follow government policies. Private firms on the other hand could have different (spatial) objectives. It is well-known that Foreign-owned firms tend to cluster, and this is also the case for China, see for example, Head and Ries (1996), Fujita et al. (2004), Yeaple (2013) for a general survey. Explicit spatial comparison between firms with different ownership has received considerably less attention. For China especially, these differences are potentially important as firms with different owners are operated in different institutional environments and could have dissimilar spatial patterns (He and Wang 2010).

We divide our data into four ownership groups: (i) privately owned firms; (ii) firms originating from Hong Kong, Macau and Taiwan (HTM) firms (these are special administrative regions with a more market oriented history); (iii) other foreign firms; and (iv) state and collectively-owned firms (S&C owned) that are controlled and owned by the

government or by a (local) community. Appendix 3 gives more detailed information on these ownership groups. We use essentially the same methodology as in Section 4. Excluding industries with less than 10 firms results in 377 industries in which S&C-owned firms are active in 2002, and 368 in 2008; for privately owned firms these numbers are 330 and 380; for HTM firms, 248 and 305; and for foreign firms 249 and 327. Note, that government policies might affect location patterns, for example, by giving foreign firms tax exemptions at specific economic zones. Groups (i)–(iii) are firms that have a more market-oriented history than group (iv). A priori, one expects groups (i)–(iii) to differ from (iv).

In 2002 31 per cent of S&C-owned firms are localized while 28 per cent are dispersed; 66 per cent of private firms are localized and 5 per cent are dispersed; 55 per cent of HMT firms are localized and 14 per cent dispersed; finally 45 per cent of foreign firms are localized and 6 per cent are dispersed. Two observations stand out. First, S&C firms are the least localized and most dispersed. Second, although foreign-owned firms are more localized and less dispersed than S&C owned firms they are not the most localized firms in China; private firms and firms from HTM show a larger tendency of localization. From 2002 to 2008, the share of dispersed industries in S&C-owned firms increases; in the other three groups the number of localized industries increases considerably. This suggests that two main groups can be distinguished from each other; a controlled group, and a group that is susceptible to market forces (which might involve special treatment in, for example, economic-zones).

Fig. 8. Shares of localized industries by ownership groups

Source: Authors.

Figures 8 and figure 9 summarize the findings. The four panels in both figures distinguish between ownership and show the changes that took place between 2002 and 2008. Figure 8 shows that S&C owned firms stand out by hardly showing localization at any distance. The other three ownership groups do localize. HMT firms and foreign firms localize at smaller spatial scales, smaller than 200 km, than privately owned firms that localize between roughly 200–400 km.

Figure 9 shows the extent of localization, using the localization index. S&C owned firms do not show a tendency to localize, whereas HMT firms form the most localized group at smaller scales, followed by foreign firms. Privately-owned firms do not have peak value and the localization tendency is relatively small, compared to HTM firms and foreign firms, over the 0–400 km range (Figure 9).

Both Figures 8 and 9 show interesting changes between 2002 and 2008. In Figure 8(b), we see that the numbers of localized private industries decrease noticeably at small scales. At larger scales some increase is visible. In contrast, localization for HMT and foreign owned firms increased remarkably at smaller scales. One can speculate about the causes. Private firms were originally often S&C owned firms and located in cities where congestion rapidly increases, creating an incentive to spread. However, adverse initial conditions and some hysteresis is probably active for this group of firms. HTM and foreign firms do not have this unfavourable ‘initial condition’ effect.

Figure 10 shows results for dispersion for only S&C-owned and HMT firms (as privately-owned and foreign firms do not show a clear dispersion pattern). For HMT firms, dispersion is more important for medium and larger spatial scales whereas for S&C-owned firms, around

Fig. 9. Localization indices by ownership groups

Source: Authors.

Fig. 10. Shares of dispersed industries for S&C-owned and HMT firms

Source: Authors.

20 per cent of industries are dispersed in 0-200 km in 2002 and dispersion increases to 30 per cent in 2008.

The suggestion of the analysis so far is that S&C owned firms are, from a location perspective, different from firms whose location decision is determined by market forces. Firms that can choose locations without government interference are affected by the same market forces. This could imply that localization clusters for HTM, foreign, and privately owned firms are found at the same places. In order to find out if co-location patterns exist we consider six ownership pairs: S&C owned and private; S&C owned and HMT; S&C owned and Foreign; private and HMT; private and foreign; and the last one is HMT and foreign. We apply the methodology of the previous sections to these ownership pairs (comparing localization patterns of 4 digit industries within an ownership pair).

Figure 11 gives the results for co-location and co-dispersion patterns of the six ownership pairs in 2002 and 2008. In 2002, three group pairs are significantly co-localized: private-foreign; HMT-foreign; and private-HMT. Location decisions for these groups are affected by market forces, and localization is similar. In 2008, HMT-foreign and private-foreign still show co-localization, while private-HMT become less co-localized (which is consistent with the development represented in Figure 9(b)). Noticeable is the change for HMT – foreign firms between 2002 and 2008. The tendency to co-localize increases remarkably. Turning to co-dispersion; the most noticeable changes are related to S&C owned firms, especially the combination with HTM firms in 2008. S&C owned firms become more co-dispersed. Local protectionism could favour especially the S&C-owned enterprises. The other three ownership groups are more profit oriented, and potentially are interested in benefiting from agglomeration economies.

6 Firm size and spatial concentration

In this section, we want to compare the location patterns of small and large firms. Holmes and Stevens (2002, 2004) suggest that clustering in the United States is driven to a large extent by large establishments. Duranton and Overman (2008) revisit this issue and find that large firms affect industry clustering in different ways and they suggest that the role of large establishments are less important than suggested by Holmes and Stevens. In this section we examine the spatial patterns of firms of different sizes.

Fig. 11. Co-localization and co-dispersion for ownership pairs

Source: Authors.

Fig. 12. Share of industries localized by size

Source: Authors.

First, we select the smallest firms in the bottom decile and largest firms in the top quartile with respect to employment in the industry.¹³ This gives 118 industries for large firms in 2002 and 212 industries in 2008, and 377 industries for small firms in 2002 and 380 industries in 2008. All industries have at least 10 firms.

For China we find similar results as Duranton and Overman (2008) for the UK; large firms are less important for localization. The share of localized industries for small firms increases from 30 per cent (113 industries) in 2002 to 56 per cent (213 industries) in 2008. Only 14 per cent (51 industries) are dispersed in 2002 and 8 per cent (29 industries) in 2008. For large firms these numbers are: 14 per cent (17 industries) are localized in 2002 and 20 per cent (42 industries) are localized in 2008 19 per cent (23 industries) are dispersed in 2002 and 23 per cent (48 industries) are dispersed in 2008. Figure 12 gives the detailed information of localization industries at every distance. The share of localized industries is limited for large firms. However, this share has increased in 2008. However, for both large and small firms, localization is less pronounced compared with the baseline estimation of all 4-digit industries (see Section 3).

One possible explanation for the findings in Figure 12 is that S&C-owned are relatively large and we already established in the previous section that S&C-owned firms are less localized compared to other firm types. Excluding S&C-owned firms changes the conclusion only marginally.

Figure 13 shows that excluding S&C firms increase the shares of localized industries for both small and large firms, however small firms are still more localized.¹⁴ So, firm size matters and does not, in a qualitative sense, change our conclusion.

7 New entrants

If some sort of hysteresis is present in location decisions, new entrants might be more dynamic in finding optimal locations than existing firms. Duranton and Overman (2008) analyse the entry and exit behavior of UK firms and find, that in approximately two thirds of industries,

¹³ The top decile contains too little firms. Following Duranton and Overman (2008) we choose the top quartile.

¹⁴ Looking at co-location between large and small firms does not change this conclusion.

Fig. 13. Share of localized industries by size, excluding S&C owned firms 2008

Source: Authors.

firm entry and exit is not different from permanent establishments. Similarly, Nakajima et al. (2012) find for Japan that the location pattern of firm entry and exit is analogous to permanent firms. China, however, might be different as it more recently liberalized location decisions and became more open to FDI.

In our sample entrants are those firms that start to operate after 2002. Firms that are operating before 2002 are existing firms. To introduce some dynamics we define two sub-periods: 2003–2005 and 2006–2008 and sum the entrants over the (sub-) periods.

Dropping industries with less than 10 entrants, we are left with entrants in 290 industries in 2003–2005 and 318 industries in 2006–2008. In 80 per cent of the industries entrants are more localized than the existing firms if we compare the entrants in the period 2003–2005 to existing firms in 2002. This number decreases to 74 per cent if we compare entrants in the period 2006–2008 to existing firms before 2002.

Figure 14 shows the share of industries in which entrant firms are localized and dispersed at every distance. Striking is the difference between the two periods. In 2003–2005, entrants are more localized at small scales. While in 2006–2008, the share at medium and large scales increase. A cause might be that formation of new clusters increasingly takes place outside the

Fig. 14. Share of localized and dispersed entrants

Source: Authors.

most agglomerated coastal areas. This was the simulation outcome of Bosker et al. (2012) where the agglomeration results of relaxing the Hukou system were analysed; inland China becomes more important.

Table 3 indicates in what 2-digit sectors we find the most localized or dispersed 4-digit industries for entrants. Some sectors appear both in the localized and the dispersed group, such as: chemical materials and chemical products (S26), special equipment manufacturing (S36) and instrumentation and culture, office machinery manufacturing (S41). The reason is that 2-digit industries contain 4-digit industries with different location characteristics. An example is S26, that contains for example a basic agriculture inputs industry such as potash producing (S2623) and a more technological advanced industry S2662 which refers to special chemicals manufacturing.

Investigating the co-location pattern of entrants with existing firms is again interesting in order to follow the evolution of industrial spatial structures. We use the same co-location methodology as in section 5. Figure 15 gives the co-location results. The number of industries in which the entrants show co-dispersion with existing firms is small. At the range between 0–100 km less than 10 per cent of entrants co-disperse with existing firms. Co-localization is

Table 3. Number of the most localized/dispersed industries (for entrants) in two-digit branches

Localized			
2003–2005		2006–2008	
Industry Branch	No. of industries highly localized (for entrants)	Industry Branch	No. of industries highly localized (for entrants)
S31 Non-metallic mineral products industry	5	S17 Textile	3
S17 Textile	4	S26 Chemical materials and chemical products	3
S24 Educational and Sports Goods	3	S31 Non-metallic mineral products	3
S26 Chemical materials and chemical products	3	S39 Electrical machinery and equipment	5
S36 Special equipment manufacturing	3	S41 Instrumentation and culture, office machinery manufacturing	3
Dispersed			
2003–2005		2006–2008	
Industry Branch	No. of industries highly dispersed (for entrants)	Industry Branch	No. of industries highly dispersed (for entrants)
S26 Chemical materials and chemical products	5	S36 Special equipment manufacturing	7
S34 Fabricated Metal Products	3	S13 Agro-food processing industry	6
S36 Special equipment manufacturing	3	S19 Leather, fur, feathers and its products	3
S41 Instrumentation and culture, office machinery manufacturing	3	S41 Instrumentation and culture, office machinery manufacturing	3

Fig. 15. Share of industries which the entrants and the existing firms are co-localized or co-dispersion

Source: Authors.

clearly visible. It more likely happens at the medium ranges and is more pronounced in the 2006–2008 period than in the 2003–2005 period.

8 Conclusions

The unprecedented growth experience of China is changing location patterns of economic activity. The liberalization of the Chinese Economy allows firms and workers to find more optimal locations. The *hukou* system, that restricts internal migration, is increasingly liberalized and China is attracting more and more foreign investors. The question as to which forces drive these location decisions is the subject of a large and growing body of literature, but before one can answer the question what explains location decisions, it is important to know how economic activity is distributed over space and how strong industries tend to cluster, if at all. Location studies have by-and-large concentrated on the US, countries of the European Union, and Japan (see the surveys by Combes and Overman 2004; Fujita et al. 2004; Holmes and Stevens 2004). In this paper we concentrate on location patterns of manufacturing firms in China using a very detailed dataset on firm locations. This allows us to use the Duranton and Overman (2005) location index that does not suffer from the disadvantages of other location indices (Combes et al. 2008). Also the dataset allows us to follow location patterns changes between 2002 and 2008. In general we find:

- strong localization of manufacturing firms in China. The localization pattern in China is stronger than is found for the UK or Japan, and comparable to that of the US;
- localization is strong at relative small scales with a strong distance decay. The scale is comparable to that of Chinese cities;
- localization has increased markedly over the period 2002–2008. Dispersion has changed less dramatically;
- localization tendencies are stronger for private firms, ‘foreign’ firms from Hong Kong-Macao-Taiwan (HTM), and foreign owned firms. State & collectively owned manufacturing firms are more dispersed. Private firms are less-localized than HTM and foreign firms, possibly because of an adverse initial condition effect. The more profit oriented firms are found to co-localize;

- large firms are relatively less important for localization than smaller firms. Most location dynamics take place among smaller firms; and
- new firms, that is to say firms that entered our data set between 2002 and 2008, are more localized than incumbents.

In this paper we illustrate patterns in the data and do not explicitly analyse the characteristics of the locations that attract firms and workers. In Hu et al. (2014) this topic is addressed in detail for China. It is shown that especially large locations are attractive for firms and workers in China because these locations offer better opportunities for high-skilled workers and high-skill intensive firms; high-skilled workers and firms sort into larger locations. Our findings are consistent with this literature on sorting in general and findings of Hu et al. (2014) for China in particular.¹⁵

¹⁵ See especially the section on ownership in which we show that the conclusions are particularly strong for foreign owned (high skill intensive) firms, although specific policies (tax exemptions might also be responsible).

Appendix 1: Comparison between National Statistical Yearbook (CNSY) and ASIF

Table A1. Comparison between China National Statistical Yearbook (CNSY) and ASIF

	2002			2008		
	Number of firms reported in the CNSY	ASIF	Coverage ASIF (%)	Number of firms reported in the CNSY	ASIF	Coverage ASIF (%)
Logging and transport of timber and bamboo	383	383	100			
Mining and washing of coal	2,812	2,812	100	9,212	9,212	100
Extraction of petroleum and natural gas	84	84	100	299	299	100
Mining and processing of ferrous metal ores	696	696	100	3,984	3,984	100
Mining and processing of nonmetal ores	1,711	1,711	100	3,953	3,947	100
Processing of food from agricultural products	10,413	10,695	103	22,800	22,800	100
Manufacture of foods	4,615	4,571	99	8,108	8,108	100
Manufacture of beverages	3,287	3,287	100	5,411	5,411	100
Manufacture of tobacco	287	287	100	156	156	100
Manufacture of textile	13,248	12,697	96	33,133	33,133	100
Manufacture of textile wearing	9,061	8,711	96	18,237	18,236	100
Apparel, footwear and caps						
Manufacture of leather, fur, feather and related products	3,932	3,932	100	8,622	8,622	100
Processing of timber, manufacture of wood, bamboo, rattan, palm and straw products	3,033	3,033	100	10,314	10,314	100
Manufacture of furniture	1,767	1,767	100	5,386	5,386	100
Manufacture of paper and paper products	5,285	5,285	100	10,011	10,011	100
Printing, reproduction of recording media	3,806	3,932	103	6,481	6,481	100
Manufacture of articles for culture, education and sport activities	2,327	2,251	97	4,797	4,864	101
Processing of petroleum, coking, processing of nuclear fuel	1,144	1,144	100	2,416	2,411	100
Manufacture of raw chemical materials and chemical products	12,637	12,139	96	28,224	26,744	95
Manufacture of medicines	3,681	3,962	108	6,524	6,524	100
Manufacture of chemical fibres	909	773	85	2,029	2,029	100
Manufacture of rubber	1,822	1,822	100	4,649	4,649	100
Manufacture of plastics	7,665	7,665	100	19,484	19,484	100
Manufacture of non-metallic mineral products	15,305	15,305	100	30,524	30,524	100
Smelting and pressing of ferrous metals	3,333	3,642	109	8,012	8,012	100
Smelting and pressing of non-ferrous metals	2,942	991	34	8,200		
Manufacture of metal products	10,039	8,888	89	24,547	24,547	100
Manufacture of general purpose machinery	10,767	11,074	103	36,919	36,919	100
Manufacture of special purpose machinery	6,546	6,479	99	18,685	18,563	99
Manufacture of transport equipment	7,470	7,063	95	18,808	18,468	98
Manufacture of electrical machinery and equipment	9,385	9,433	101	25,727	25,727	100
Manufacture of communication equipment, computers and other electronic equipment	5,320	4,701	88	14,347	13,212	92
Manufacture of measuring instruments and machinery for cultural activity and office work	2,146	2,230	104	5,620	5,600	100
Manufacture of artwork and other manufacturing		4,353		7,692	7,169	93
Recycling and disposal of waste				1,087	1,087	100
Production and supply of electric power and heat power	4,946	4,943	100	6,242	6,242	100
Production and supply of gas	329	329	100	856	856	100
Production and supply of water	2,420	2,420	100	2,052	2,052	100

Appendix 2: Localization and dispersion indices

The upper and lower global confidence bands of industry A at the 5% level are denoted by $\overline{K_A}(d)$ and $\underline{K_A}(d)$ respectively. For industry A, if $\widehat{K_A}(d) > \overline{K_A}(d)$ for at least one d between 0–900 km, industry is said to exhibit global localization at the 5% confidence level. If $\widehat{K_A}(d) < \underline{K_A}(d)$ for at least one d between 0–900 km and industry A never lie above the upper confidence band, this industry is said to exhibit global dispersion at the 5% confidence level. An index of localization is defined as:

$$\Gamma_A(d) \equiv \max\left(\widehat{K_A}(d) - \overline{K_A}(d), 0\right). \quad (\text{A1})$$

And an index of dispersion is defined as:

$$\Psi_A(d) \equiv \begin{cases} \max\left(\underline{K_A}(d) - \widehat{K_A}(d), 0\right) & \text{if } \sum_{d=0}^{d=900} \Gamma_A(d) = 0 \\ 0 & \text{otherwise} \end{cases}. \quad (\text{A2})$$

Appendix 3: Ownership

Table A2. Statistics of the firm number by 2-digit sectors and by ownership in 2002

Sector	Ownership	No. firms	Sector	Ownership	No. firms	Sector	Ownership	No. firms	
13	Agro-food processing industry	6109	22	State-owned	2848	31	Non-metallic mineral products industry	State-owned	9409
		3146		Private	1677			Private	4244
		601		HMT	492			HMT	942
14	Food manufacturing	839	23	Foreign	268	32	Ferrous metal smelting and rolling processing industry	Foreign	710
		2482		State-owned	2698			State-owned	2053
		1077		Private	670			Private	1338
15	Beverage manufacturing	485	24	HMT	412	34	Fabricated metal products	HMT	139
		527		Foreign	152			Foreign	112
		2077		State-owned	548			State-owned	3940
16	Tobacco industry	747	25	Private	631	35	General equipment manufacturing	Private	3144
		210		HMT	687			HMT	1057
		253		Foreign	385			Foreign	747
17	Textile industry	280	26	State-owned	688	36	Special equipment manufacturing industry	State-owned	6317
		2		Private	348			Private	3361
		3		HMT	39			HMT	574
18	Textile and garment, shoes, hat manufacturing	2	27	Foreign	69	37	Transportation equipment manufacturing	Foreign	822
		5206		State-owned	7199			State-owned	3994
		4778		Private	3152			Private	1583
19	Leather, fur, feathers (down) and its products	1810	28	HMT	930	39	Electrical machinery and equipment manufacturing	HMT	457
		903		Foreign	858			Foreign	445
		2270		State-owned	2560			State-owned	4236
20	Leather, fur, feathers (down) and its products	2906	29	Private	729	40	Transportation equipment manufacturing	Private	1721
		2087		HMT	311			HMT	527
		1448		Foreign	362			Foreign	579
21	Leather, fur, feathers (down) and its products	1115	30	State-owned	378	41	Electrical machinery and equipment manufacturing	State-owned	4665
		1220		Private	215			Private	2710
		1009		HMT	117			HMT	1173
22	Leather, fur, feathers (down) and its products	588	31	Foreign	63	42	Electrical machinery and equipment manufacturing	Foreign	885

(Continues)

Table A2. (Continued)

Sector	Ownership	No. firms	Sector	Ownership	No. firms	Sector	Ownership	No. firms
20 Timber processing, bamboo, cane, palm fibre and straw products	State-owned	1100	29 Rubber	State-owned	938	40 Communications equipment, computers and other electronic equipment manufacturing	State-owned	1603
	Private	1302		Private	511		Private	784
	HMT	358		HMT	208		HMT	1240
	Foreign	273		Foreign	165		Foreign	1074
21 Furniture manufacturing	State-owned	568	30 Plastic products industry	State-owned	3033	41 Instrumentation and culture, office machinery manufacturing	State-owned	1080
	Private	666		Private	2387		Private	408
	HMT	326		HMT	1503		HMT	386
	Foreign	207		Foreign	742		Foreign	356

Table A3. Ownership classification

Ownership type in ASIF	Classification
State-owned enterprises	State-owned and Collectively-owned
Collective enterprises	
Stock cooperative enterprises	
State-owned joint venture	
Collective joint venture Enterprises	
State-owned collective Associates	
Other associates	
State-owned sole proprietorship company	
Other limited liability company	
Inc.	Private
Private enterprise	
Private partnership	
Private limited liability company	
Private Limited	
Other domestic enterprises	HMT
Joint ventures (Hong Kong, Macao and Taiwan)	
Cooperative Enterprises (Hong Kong, Macao and Taiwan)	
Hong Kong, Macao and Taiwan-owned enterprise	
Hong Kong, Macao and Taiwan-invested shares in the company	
China-foreign joint ventures	Foreign
CJV	
Foreign (owned) enterprises	
Foreign Investment Co., Ltd.	

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Resumen. Mediante la aplicación de la metodología desarrollada por Duranton y Overman, se analizó la localización y dispersión de empresas en China. Haciendo uso de un conjunto de datos único y detallado sobre empresas manufactureras en China, el artículo ha logrado dar seguimiento a los cambios en los patrones de localización de las empresas entre 2002 y 2008. El análisis muestra que las empresas de China están más localizadas que en el Reino Unido o en Japón. La localización es comparable a la de los EE.UU., y se lleva a cabo a una escala relativamente pequeña, consistente con el tamaño de las ciudades chinas. La localización aumenta rápidamente, incluso en un período relativamente corto como 2002 a 2008, sobre todo para la localización de nuevas empresas. Las empresas privadas, las empresas de Hong Kong, Macao y Taiwán, y las empresas extranjeras están más localizadas que las empresas de propiedad estatal. Nuestros resultados están en consonancia con la idea de que China está liberalizando cada vez más su economía, lo que permite que las empresas manufactureras centradas en lograr beneficios se beneficien de las economías de aglomeración.

要約: 本稿では、Duranton と Overmanが開発した方法論を採用し、中口の企業の局在化と分散化を分析する。中国の製造業者に関する独自かつ詳細なデータセットを使用することにより、2002年から2008年の企業の立地パターンの変遷を追跡する。分析の結果によると、中国の企業は英国や日本の企業に比べ局在する傾向にある。中国における局在化は、米国での局在化に類似しており、その規模は相対的に小さく、中国の各都市に見合う規模である。2002年から2008年という相対的に短い期間で、局在化は急速に増えており、特に新参の企業では顕著である。民間の企業、香港、マカオ、台湾に本拠地を置く企業、その他の外国籍の企業は、国営企業よりも局在的である。本研究の知見は、中国はさらに経済の自由化を進めており、(営利目的の)製造業者が集積の経済の恩恵を受けるという認識に一致するものである。