A study of industrial agglomeration and co-location in China

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目录

Chapter 1. Introduction

In the three decades since 1978, China has experienced an average growth rate of around 10%. In particular, the performance of manufacturing industries has been remarkable with becoming China known as the "World Factory". Between 1949 and1978, however, China's GDP growth rate was fairly unstable with fluctuations due to political instability. During this early period, the central government played a very important role in maintaining and boosting China's economic growth. The collapse of the planned economy system in Russia, whose lead the Chinese government had followed, revealed the inefficiency and lag of macroeconomic adjustment caused by administrative orders to control the economy. Therefore, part of the economic liberalisationin China and the introduction of the market-economy system were to increase the previously low productivity, which had been caused by local protectionism and national monopolies. The series of policies for foreign direct investment (FDI) attracted investment from many developed countries, in particular countries close to China such as the Four Asian Tigers (Hong Kong, Singapore, South Korea, and Taiwan) and Japan. The demographic dividends have turned 1 billion USD of inward FDI in 1979 into 327 billion USD at the end of 2007(Fetscherin, Voss and Gugler, 2010; UNCTAD, 2009a; UNCTAD, 2009b). Meanwhile, another 83 billion USD of FDI still entered China in 2007. With an annual growth rate of 23.6%, FDI is one of the most important contributions to China's trade engine and its economic growth. Local governments in China are able to attract FDI to help boost their local economy by offering various benefits to investors such as tax cuts. These policies have led to rapid urbanisation and industrialisation of coastal regions in China.

Exports have also boosted China's economic growth. Over the last decades, the growth rate of exports in China has been even higher than the GDP growth rate. By offering natural resources and low-cost labour, China became part of the world manufacturing industry chain. The "open door" policy that was effected in 1978 released the production activity constraints on the private sector. Until then, only state-owned enterprises (SOEs) had been allowed to export their products to foreign countries, with private firms not able to export their products directly regardless of their high quality. The SOEs either played a role as the trading agent, buying products from private enterprises or produced the products themselves and exported them to foreign markets. With the removal of the restrictions on private sector exports, more competitive heterogeneous firms entered the foreign markets. Through competition with other East Asia countries, China has gained a greater share of the foreign markets in low-technology products and has kept climbing up the value-added chain (Lall *et al.*, 2004). Amiti and Freund (2008), however, in their examination of the structure of exports in China between 1997 and 2005, find that, although the export products have shifted from agriculture and apparel to electronics and machinery, the skill content of manufacturing such export products remains at a relatively low level, excluding the processing trade. Berger *et al.* (2011) analyses the determinants of the rapid growth of China's exports from 2000 to 2007. They found that the effective policy applications and fortuitous timing led to higher growth in exports in China. Some high-tech industries are critical in these export growth processes. By looking at the products imported into the US from China, Berger *et al.* (2011) conclude that Chinese products are more competitive in the US and the domestic market. The job losses in the manufacturing industries in the US are due to the lack of competition, lack of investment and slow GDP growth rate in the country. Regardless if China upgraded their level of technology, export-led growth has also been the determinant of economic growth in China in the last decades. Therefore, exports could be a vital factor affecting industrial location choice.

On the other hand, the Chinese central government also attracts FDI to the Special Economic Zones and other coastal regions. Free Trade Zones and Technological Development Areas are two types of special zones, which enjoy tax-free and preferential policies from the government to encourage trade activity in the coastal regions. The motivation for the establishment of Free Trade Zones and Economic and Technological Development Areas is to attract foreign investment by having a cheaper labour force, lower corporation taxes and easier access to consumer markets in Mainland China. The idea was that knowledge spillovers from foreign firms would then help domestic firms to increase productivity. This is the so-called "Market for Technology" strategy put forward by the Chinese central government in the 1980s. The establishment of Shenzhen's Special Economic Zone, for example, has turned the area from a small village into one of the top cities in China within 30 years[1]. Furthermore, the entry of FDI in the coastal regions and their advantage of being close to the export destinations has boosted the development of labour-intensive industries. TEDA (Tianjin Economic and Technological Development Area) is another good example of such a trade zone where 76 Fortune 500 companies are located, including Motorola and Samsung.

These changes have led to regional development and the re-location of manufacturing, resulting in industrial clusters in China. Studies of industrial clusters in China after 1978 interested researchers using data from the National Bureau of Statistics of China (NBS). China experienced 30 years of a planned economy from 1949 to 1978. The location of the manufacturing industry and the products it produced were planned by the central government. Due to the Cold War and the insecure international environment facing the People's Republic of China, the heavy industry established during that period tended to be located in the inner provinces for national security reasons. Firms located in the traditional manufacturing industry provinces tended to be located in the eastern coastal regions but were also relocated to provinces with less manufacturing to protect the industry from military attacks by the US or USSR. Skilled workers were also moved to less developed provinces together with the firms they worked for. Therefore, the geographic distribution of the manufacturing industries in China was greatly affected by national policies and the political environment.

After the "Open Door" economic reform in 1978, China moved from being a planned economy to a market economy, characterised by FDI inflows and export-oriented

[1] Shenzhen was the combination of five county areas in 1979 to establish the first Special Economic Zones (SEZs) in China. The population of Shenzhen has grown from 0.314 million to 10.467 million people between 1979 and 2011. Real GDP value has increased from 0.196 billion RMB to 129.5 billion RMB in 2012. The establishment of the Shenzhen Stock Exchange and Shenzhen Port has made Shenzhen one of the largest financial and trade centres in China.

development of light industries in the coastal regions. As the early overseas investors were countries and regions nearby (Japan, Taiwan, Hong Kong, Macao and Singapore), it was convenient for Chinese manufacturing companies to be based in coastal regions, even if the composition of these coastal province clusters differed. For example, Shandong is where heavy industry is clustered while Guangdong became the centre for labour-intensive industriesin China. Wen (2004) and Fan (2003) first studied the industrial localisation of China and conclude that industrial localisations are mainly found in the coastal regions and were established between 1980 and 1995. The extent of China's liberalisation affected industrial agglomeration. Wen (2004) notes that heavy industries, such as vehicle and machinery, are highly localised in the northeast of China, whereas Shanghai, Wuxi, Tianjin and Qingdao, as the traditional port cities, were the centres of the textile industry before 1978. To balance the regional economic development, two-thirds of the all new agglomerated industrial projects are located in inland China in provinces such as Shanxi, Sichuan and Hubei. The duplication of production among provinces also leads to industrial dispersion. The geographic concentration of manufacturing industries shifted from the northeast and centre of China to the coastal regions. For example, Jiangsu, Zhejiang and Fujian became the new agglomerated regions for the textile industry. The large amount of investment in southeast China is mainly from the Chinese businesses who relocated to Southeast Asia (Thailand, Malaysia, Indonesia and Singapore) and aimed to trade goods with the Chinese mainland or escape from the war at the end of the Qing Dynasty. These investors mostly share the same surnames or are still connected to their extended family in southeast China. Therefore, such investment is actually motivated by the willingness of such businesses to support their hometown. FDI from HTM (Hong Kong, Taiwan and Macau) is also a capital source, encouraging the growth of manufacturing industries in southeast China. As a member of the Four Asia Tigers, Hong Kong and Taiwan are also the main source of the FDI to the coastal regions; such investment was initially motivated by the low labour costs and attractive taxation policies in the target areas. The end of the Cold War also helped China to develop closer relationships with other developed countries as part of economic corporation. FDI investment in the Chinese mainland from western countries was mainly under the guidance of the Chinese central government and foreign governments. Foreign capital was initially allowed to foster cooperation with domestic firms to establish joint-venture enterprises. The Chinese government restricted the location of these joint-venture enterprises to the Free Trade Zones or Economic Technology and Development Areas, separating them from other domestic firms. FDI and outsourcing from the US, Japan and EU countries encouraged the growth of production of this type. The Chinese central government also implemented the Catalogue for the Guidance of Foreign Investment Industries to restrict the foreign investment category in China in 1995. As more employees were required by these exporting foreign enterprises, millions of workers living in the county areas in the inner provinces moved to the coastal regions to work for toys, clothes and food companies.

Mainland China is large in terms of both its geography and its population. Preferential policy bias, productivity variation and other natural advantages led to unbalanced regional development in China, leading to a step-wise direction of population migration from the western regions to the middle regions and on to the coastal regions (Fan, 2005). The population, especially young workers, who were immigrants from inner provinces moving to the coastal regions, is also the consequence of the implementation of these strategies (Liang, 2001; Taylor, 2010). With a large population, such demographic dividend in production was shared by enterprises, including those exporting-oriented foreign firms. However, after 20 years of rapid growth in the manufacturing industries in the coastal regions, the Chinese government considered developing manufacturing industries in the inner provinces. The gradual implementation of FDI location restrictions after China joined the WTO, and other preferential policies and funding strategies were designed to support the inner provinces[2].

It is clear that preferential policies, foreign investment and exporting activities have a significant impact on regional development in China. The geographic concentrations of

2 More special economic zones were established in smaller cities in the coastal regions or inner provinces after 2000.

manufacturing industries in the coastal regions are the phenomenal result of such impacts. Motivated by related theories on the reasons and benefits of regional clusters, we carry out an empirical study on the pattern of industrial agglomeration in mainland China, tracking changes between 1998 and 2007. Since the development of manufacturing industries may have different characteristics in different regions in China, we also make a case study on industrial agglomeration in Tianjin, which is the centre of the manufacturing industry in north China to allow for comparisons with the whole of mainland China. We also compare their agglomeration pattern with other developed countries from previous research. We study the determinants of agglomeration by ownership in mainland China and Tianjin. Our results show that the characteristics of the pattern of industrial agglomeration in China and in its metropolitan areas are different and we discuss the mechanisms behind this. Comparing the determinants of agglomeration in China and Tianjin specifically also reveals the reasons for the regional unbalance in China.

After examining the benefits of increasing productivity by applying agglomeration economy, we also examine the negative impacts from exogenous shocks to manufacturing production activities. By employing the wind-field model, we estimate the strength of typhoon that made damage to the manufacturing production activities in the coastal regions. Our results showed that typhoon has a negative and significant impact on TFP, production sales value and export. In order to quickly recover from such damage, more workers would be needed while wage level turned down. Stronger typhoon would have last longer period for the economy recovery.

Chapter 2. The pattern of industrial agglomeration and changes Evidence from China

Abstract

In this chapter, we investigate the pattern of geographic concentration of production activities in China and trace the changes on the pattern of industrial agglomeration in a decade by using results from selected target years (1998-2007). We also compare the pattern of industrial agglomeration in China with US, France and the UK. In order to find out if there is geographic concentration across related industries in China, we study industrial co-agglomeration at the aggregate industry level and based on the input-output (I-O) table. The Ellison-Glaser index (γ_{EG}), Maurel-Se'dillot index (γ_{MS}) and Herfindahl index are used to estimate and compare with other results from previous studies.

We find the geographic concentration increases steadily at province level but show a U shape trend at smaller region level such as county or postcode area level within this decade. In general, most of the industries are tended to be agglomerated at both 2-digit and 4-digit industry level. The manufacturing industries are most likely to be agglomerated in the coastal regions and most of the highly agglomerated industries are labour-intensive industries. The two core manufacturing centre pattern: Shandong and Guangdong has been replaced agglomeration pattern along the four coastal region provinces until 2007. The most agglomerated industries in the two centres are also varied according to our top twenty most agglomerated industries tables. The county area with largest share of employment for the most twenty agglomerated industries are generally having much higher share of employment than the second. There are more and more high-tech industries become highly agglomerated and are listed in the top agglomerated industries table. In the international comparisons, we find China has high degree of

industrial agglomeration: it is equal to the US and France but is more agglomerated than the UK, which is less agglomerated on manufacturing geographic distribution. Ultimately, as we found many textile industries at the 4-digit industry level in the top twenty most agglomerated industries in all four target years, our estimate shows that the textile industry has the highest co-agglomeration in China.

Key Words: Industrial agglomeration, Regional inequality, International comparisons,

1. Introduction

The regional development bias can be traced back to the orientation of human culture. The traditional Von Thunen model explains this by emphasising the benefits of proximity to customers and suppliers. The desire to lower transport costs led to the early establishment of cities, all close to ports or waterways. Studies on the economic performance of cities and the scale economy answer the question why such geographic concentration exists. There are two kinds of industrial geographic concentration: urbanisation, where a firm benefits from other firms located within the same city (Hoover 1937; Chinitz 1961); or localisation, where a firm benefits from other firms in the same industry. Alfred Marshall (1890) summarises the benefits of industrial localisation into three externalities: lower costs by proximity to suppliers and customers; advantages from a flexible and specialised labour market; and knowledge spillovers through communications. Following this idea, Jaffe *et al.* (1993) find that the knowledge spillovers in US cities are localised using patent citations as the estimator. In the dynamic study of industrial externalities, Henderson *et al.* (1995) find that those mature industries are likely to become more localised together with an increasing number of employees and prove the Marshall-Arrow-Romer's externalities by knowledge spillovers within the same industry but not Jacob's externalities where spillover effects happen across industries in the same city. For those new industries (high-tech industries), the location of prosperity is large metropolitan areas that are highly diversified. However, when the industry becomes mature, firms re-locate to more specialised smaller cities. Ciccone *et al.* (1996) and Combes *et al.* (2012) developed a model to estimate the productivity advantages of large cities compared to small towns. Ciccone *et al.* (1996) find that both the localisation and the urbanisation models show that productivity is positively correlated with production density. Average labour productivity increases by around 6 percent if employment doubles in the US cities. Over 50% of the variance of output per worker can be explained by production density across the US cities. Combes *et al.* (2012) examine two sources of productivity advantages – firm selection and industrial externalities in larger cities – and conclude that firm selection cannot explain the variation of productivity in different regions. Therefore, externalities promote higher productivity through localised natural advantages. Considering the importance of externalities in increasing productivity, it is necessary to examine the extent of industrial agglomeration in developing countries. Au and Henderson(2006) examine city size in China and find that real income per worker shows a U-shape against employment for the city. The correlation between agglomeration and real income per worker shows an inverted U-shape on the other hand. In addition, the sizes of the cities in China are generally undersized due to restrictions on migration.

In this chapter, we study the pattern and characteristics of industrial agglomeration in China at a very detailed industry level. We use data for two five-year periods to examine the pattern of productive activity in China before and after China joined the WTO and before the financial crisis (1998-2002 and 2003-2007)[3]. Our empirical study examines the pattern of industrial agglomeration in China at the 2-digit industry level and the 4-digit SIC level and presents the most and least agglomerated industries at the 4-digit SIC level. The change in industrial agglomeration is also analysed within each five-year period. Examining agglomeration at the 4-digit industry level represents the most detailed study for China so far and makes comparisons between China and other developed countries possible. We compare patterns of industrial agglomeration between China and the US, France and the UK. We finally investigate the role of co-agglomeration among related industries at the 4-digit industry level.

2. Literature Review

The history of industry location studies is one of the oldest in economics. It can be traced back to the orientation of human culture and productive activity. The location of

[3] There are two reasons to separate the research period into two five-year period: The restructuring of the Standard Industry Code (SIC) in 2002 in China led to mismatching of 4-digit industries between 2002 and 2003 together with the years that followed. Moreover, in our dataset there is a big jump in the number of observations for 2003 compared with 2002. The firm number is even larger in 2004 because it is the year of the economic census in China and the annual firm number remains steady at a higher level in the following years. To match our data at 4-digit industry level in the whole time period will lead to big drops in the number of observations. It may also lead to ignorance of new trends in the second time period.

economic activity even determines the success of economic development policies. The central theme of spatial economics is the relationship between industrial geographic distribution and economic growth. Fujita *et al.* (2001) review the history of humans' economic activities and provide a comprehensive summary of the economic models and new tools of the spatial economy. Marshall (1890) indicated that industrial localisation has three advantages: lower costs by proximity to suppliers and customers; benefits from flexible and specialised local labour markets; and gains from knowledge spillovers from nearby firms. There are many traditional manufacturing industries in the UK. Hoover (1937) discussed the origins of localisation and the development of industries in these regions. Examples are cutlery (Sheffield), shoes (Northampton), lace (Nottingham) and fish processing (Doncaster and Aberdeen). There are many studies on the pattern of industrial distribution in different countries and regions. Holmes (2004) examined the spatial economy activity in North America. Combes and Overman (2003) showed the pattern of industrial geographic distribution in the EU, comparing their results with those of the US. Fujita *et al.* (2004) provide a general description of the industrial distribution in East Asia including Japan and China. Among these empirical studies, the Ellison-Glaeser index is widely applied and developed. The advantage of the EG index and MS index compared with the Gini coefficients and Herfindahl index is that it combines the geographic concentration and industrial concentration effect in a single index. It eliminates the biased estimation in two extreme cases: that industrial concentration is caused by a limited number of big firms, and that geographic concentration is caused by a large number of small firms. Cassey *et al.* (2014) examined the statistical significance of the EG index value at the 4-digit industry level based on Ellison and Glaeser (1997) and shows that some industries' EG index value is significant above the *ad hoc* threshold and that many values below this *ad hoc* level are significant.

Ellison and Glaeser (1997) develop an index to measure the geographic concentration and industrial concentration of production activities in the US. They find that industries are most agglomerated at the region level and least agglomerated at the county level. The 4-digit industry has the highest degree of agglomeration than at the 3-digit and 2-digit industry level. The degree of industry agglomeration at the state level is between the region and county-level results. They also find that the textile and leather industries are most agglomerated in the US. Some high-tech industries such as aerospace are also one of the top agglomerated industries in US. The value of the EG index and MS index is between -1 and 1 – an industry with a value greater than 0 implies that that industry is somewhat agglomerated. The closer the value is to 1, the greater the degree of agglomeration. On the other hand, an industry with a value less than 0 means that the industry is dispersed. The closer the value is to -1, the greater the degree of dispersion. The EG index and MS index can also be used to make comparisons of the level of industrial agglomeration across countries. Another strand of the literature examines the correlation between industry development and industrial localisation. Ellison and Glaeser (1997) also examine the co-agglomeration effect between upstream-downstream industries and find that most of the upstream-downstream industry chains are geographically concentrated.

Using a similar index, Maurel and Se'dillot study industrial agglomeration and co-agglomeration in France at different local authority region levels and various levels of industrial classification. Their results show that the most and least agglomerated industries show similar patterns to the US. High-tech industries, along with raw material extraction and traditional industries, are found to be the most agglomerated industries in both countries. Paris and Leon are two main areas where manufacturing companies prefer to locate themselves. One question that arises is whether the industry distribution follows the same pattern in all developed countries and whether high-tech industries are more likely to be localised. Devereux *et al.* (2004) found the opposite results using various indices to study the distribution of productivity in the UK. There are some other low-tech industries, excluding the textile industry, which appear to be highly agglomerated while many high-tech industries are the least agglomerated industries in the UK. Moreover, the overall degree of agglomeration in the UK is less than in the US and France. The results from Spain, which take into account minimum transportation costs, show that industrial concentration takes advantage of being located close to suppliers and customers (Alonso-Villar *et al.*, 2004). The textile industry and some high-tech industries are also found to be the top agglomerated industries in Spain between 1993 and 1999. Finally, high-tech industries are not only more agglomerated than low-tech industries; rather, the higher the level of technology that an industry has within the high-tech industry group, the greater agglomeration it experiences compared to other industries. A strong requirement of highly skilled and mobile labour, rapid information spillovers and good service for high-tech industries examined Marshall's theory. Barrios *et al.* (2004) also trace the trends of industrial agglomeration in Ireland and Portugal. They mainly focused on the phenomenon of old firms dying and new firms being born, together with large numbers of employee movement. Although the net agglomeration rarely changes in both countries between 1985 and 1994, the geographic concentration was strongly mobile due to structural changes to catch-up with the rest of the EU. Such large geographical mobility of industries, together with the stability in the aggregated agglomeration levels, suggests that agglomeration is an equilibrium phenomenon without any dominant role reserved for historical accidents, as often proposed by the renewed economic geography literature. Betinelli *et al.* (2005) provide a comprehensive study on industrial agglomeration in Belgium using micro-level data from 1997 to 2000. They draw the employment density map of Belgium to describe the geographic distribution of manufacturing industries and compare their most and least agglomerated industries, comparing the results with those in the US and the UK.

The pattern of industrial agglomeration varied in different regions in mainland China. Wen (2004) investigates the geographic concentration in 1980, 1985 and 1995 in China using the Gini coefficient at the 3-digit industry level. He concluded that a large number of manufacturing industries have re-located from the inner provinces to the coastal regions since 1978. He notes that heavy industries, such as vehicles and machinery, are highly localised in the northeast of China, whereas Shanghai, Wuxi, Tianjin and Qingdao, as the traditional port cities, were the centres of textile industry before 1978. To balance the regional economic development, two-thirds of all new agglomerated industrial projects are located in the inland of China in provinces such as Shanxi, Sichuan and

Hubei. The duplication of production among provinces also leads to industrial dispersion. But, in general, the geographic concentration shows manufacturing industries having relocated from the northeast and central China to the coastal regions. Wen (2004) also conclude that industrial localisations are mainly found in the coastal regions from 1980 to 1995. Long and Zhang (2012) study the changes of industrial agglomeration between 1995 and 2004. The number of increasing enterprises in cluster regions increases faster than non-clustered regions. Moreover, they find that firms, which are highly interconnected, are also agglomerated within certain regions such as SEZs. Lu and Tao (2009) utilise firm-level manufacturing industry data from the National Bureau of Statistics in China (NBS) to estimate the degree of industrial agglomeration at the 3-digit industry level and at the county level. They conclude that most industries' degree of agglomeration increased between 1998 and2005. However, industrial agglomeration is still lower than in the US, France and the UK. They also give evidence that the SOEs had had a negative impact on agglomeration.

In view of the size of China, industrial agglomeration shows different regional characteristics. Highly clustered light industries are located in the south coastal areas of China at the district, city or even province level. The textile, accessories, toys, footwear, household appliances and decorations industries are considered to be the main clustered industries in those regions. Barbieri *et al.* (2012) introduce the guidance effect of government policy on the trends of industrial geographic concentration, such as the "specialised towns" in Guangdong province. Another study on the specialised markets in Zhejiang province gives an introduction on how specialised local markets connected with clustered local manufacturing industries (Bellandi *et al.*, 2012). Ding (2006) selects one of those specialised markets, Yiwu in Zhejiang, to introduce the distribution system of industry clusters in China. Lin *et al.* (2011) focus on the textile industry at the 2-digit industry level, using the firm-level dataset from NBS and the EG index at the city level and found a decreasing trend of EG index values on garments and other fibre products but an increasing trend in the textile industries from 2000 to 2005. Huang *et al.* (2008) study how Wenzhou overcame the constraints from low-level capital and technology by industry clustering and became a specialised town (shoes) in China.

The role of technology is mentioned often in these studies. However, the pattern of industrial agglomeration in China is rarely mentioned. China, as a large developing country, is mainly focusing on labour-intensive or medium-low tech industries. However, with the rapid growth rate in the economy and sufficient funding support from central government, some of the country's high-tech industries are catching up or have already reached world-leading positions. Another reason to look at the industry upgrading process is due to the rise in labour costs and the difficulty of skill spillovers in China.

We attempt to fill in these gaps in the empirical studies of China by looking at the trends of the degree of agglomeration within each period and over two periods. The degree of agglomeration for high-tech industries is also examined. At last, we investigate if there is inter-connection across industries by looking at the location of agglomeration and estimating the co-agglomeration.

3. Measurement of agglomeration

There are a number of measures of the geographic concentration employed in previous works. The Gini coefficient, used by Krugman (1991) and Amiti (1998), is applied to measure the geographic concentration within an industry. However, it ignores the biased effect caused by different sizes of firms. To improve upon the Gini coefficient, Ellison and Glaeser (1997) proposed a new index to measure agglomeration by estimating the geographic concentration in excess of the industrial concentration, which eliminates the impact of large firmson the measurement of agglomeration. Maurel and Se'dillot(1999) derived MS and provided a modified index based on the EG index. Alonso-Villar *et al.* (2004) express Ellison and Glaeser's co-agglomeration index as the combination of intra-industry and inter-industry spillovers. Another measure, applied by Duranton and Overman(2002) and Marcon and Puech (2003), uses the distance between plants to estimate the industry geographical density represented by K-density. In order to make comparisons with previous results from other countries and trace the regional development over the period, we follow Devereux (2004) and use the EG and MS index together with the Locational Gini coefficient and the concentration index to measure the pattern of industrial agglomeration in China. Mareul and Se'dillot (1999) develop a sequential model of location choice to compare the differences between one-stage location choice compared to location choice at a region level and then at a sub-region level. In this section, we first give a brief introduction of the Ellison-Glaeser index and compare it with the Maurel-Se'dillot index. In order to make international comparisons based on a different number of regions and industries, Mareul and Se'dillot (1999) give a sequential model of location choice to prove the un-limitation of the number of regions in the index estimation, which is detailed later in this section. Finally, we also introduce the co-agglomeration measurements applied in previous studies.

3.1 A model of location choice

Following Ellison and Glaeser's research, there are mainly two types of concerns considered by industrial companies when deciding on the preferred location for their plants: natural advantages and spillovers. In Ellison and Glaeser's location choice model, plants choose to locate independently to benefit from natural resource advantages and spillovers generated by proximity to other business units. They first consider plant-only benefits from natural advantages and then focus on the benefits from spillovers. The profitability function is therefore written as:

$$log\pi_{ki} = log\bar{\pi}_i + g_i(v_1, \dots v_{k-1}) + \epsilon_{ki} \quad (1)$$

where *k* th business unit prefer to locates in v_k to maximum their profits π_{ki} from locating in *i*. $\overline{\pi}$ represents a random variable that explains the profitability of locating in region *i* for a typical firm (considering environmental characteristic of the region). g_i

captures the spillover effects caused by location choice of business units that made the location choice previously. ϵ_{ki} is the additional random term, describing the hetergenous of business units. Since the benefits of natural advantages have been decided by business units at the beginning, the function becomes a logit model if spillover effects are zero ($g_i \equiv 0$ for all *i*). We specify that the $\{\epsilon_{ki}\}$ are independent Weibull random variables independent of the$\{\pi_i\}$, and the firms' location choices are conditional independent random variables with:

$prob\{v_k = i|\bar{\pi}_1, \dots \bar{\pi}_M\} = \frac{\bar{\pi}_i}{\sum_j \bar{\pi}_j}$(2)

We would like to have the distribution of manufacturing activities on average across all industries, which are assumed as:

$$E_{\bar{\pi}_1,\dots\bar{\pi}_M} \frac{\bar{\pi}_i}{\sum_j \bar{\pi}_j} = x_i \quad (3)$$

where x_i represents the share of overall manufacturing in different estimators, we followed previous work and use employment as the valuable measuring the size of the firm. We then construct the joint distribution of natural advantages as:

$$var\left(\frac{\bar{\pi}_i}{\sum_j \bar{\pi}_j}\right) = \gamma_{na} x_i (1 - x_i) (4)$$

where γ_{na} captures the importance of natural advantages to that industry. The natural advantage of the location will have no impact if $\gamma_{na} = 0$. On the other hand, the natural advantages areextremely important for this industry if $\gamma_{na} = 1$. Another assumption made on the distribution of the $\{\pi_i\}$ is that it is scaled. For example, $2[1 - \gamma^{na})/\gamma^{na}]\{\pi_i\}$ has a x^2 distribution with $2[(1 - \gamma^{na})/\gamma^{na}]x_i$ degree of freedom. $E\left(\overline{\pi}_i\right) = x_i$ and $\text{var}\left(\overline{\pi}_i\right) = [(1 - \gamma^{na})/\gamma^{na}]x_i$ shows a negligible impact on the profit level if $\gamma^{na} = 0$ but shows a great impact on profit level if $\gamma^{na} = 1$

The second factor of the agglomeration estimator – spillovers – is in the second part of the profitability function. It combines gains from knowledge spillovers, benefits from a flexible and specialised labour market, gains from trade and industrial specialisation and any other impacts that could increase profits to firms locating close to others within the same industry. This implies that if a firm locates itself near another specific firm, its close proximity may potentially providehigher profits than if it was located near a different firm. Therefore, for each pair of firms, the profitability gains caused by localisation are fully received by both firms if they are located in the same place; there is a gain in profit if they are not located in the same place. By assuming a probability parameter of locating in the same place that $\gamma^s \in [0,1]$, we have a spillover function written as:

$$log\pi_{ki} = log(\bar{\pi}_i) + \sum_{l \neq k} e_{kl} (1 - u_{li})(-\infty) + \epsilon_{ki} \quad (5)$$

$\{e_{kl}\}$ are Bernoulli random variables equal to one with probability γ^s that indicate a potential spillover effect within each pair of firms. u_{li} indicates firm *l*being located in region *i*. The spillovers can transmit from a pair of firms into a third firm or more located in the same region. For example, $e_{kl} = e_{lk} = e_{lml} = e_{km} = 1$.

We set s_i as the share of industry employment in region *i* which is endogenous and x_i as the share of overall manufacturing industries' employment in region *i* which is exogenous. So the industrial geographic concentration is written as: $G \equiv \sum_i (s_i - x_i)^2$. s_i is described by $s_i = \sum_k z_k u_{ki}$ where endogenous z_k is the share of employment of firm *k*,and$u_{ki}$is the indicator variable equal to 1 if firm *k* chooses to locate in region *i*. The location choice model has been found to satisfy equations (3), (4) and (5) to maximise their profits through taking advantage of spillovers:

$$E(G) = (1 - \sum x_i^2)[\gamma + (1 - \gamma)H]^4 \quad (6)$$

[4] See equation proof in Ellison *et al.* (1997)

where *H* represent the Herfindahl index of the plant size distribution of industry and $\gamma = \gamma^{na} + \gamma^{s}$-$\gamma^{na}\gamma^{s}$.

3.2 A sequential model of location choice

Maurel and Se'dillot(1999) provide a proof on the spillovers at a higher region level that is weighted by the share of sub-region. In general, the model of location choice applied by previous works are the same. The difference in the definition between the EG index and the MS index will also be present in this section. We first consider two levels of geographic units:

1. The region level (*i=1,2,...M*), that will be composed of regions. We take provinces of Mainland China as an example.
2. The sub-region level m(*i*)=1,2,...r_i, that will be composed of cities or counties in China.

The manufacturing units' location choice follows two steps: In the first step, manufacturing units consider the natural advantages of geographic areas and the intra-industry spillovers to choose the region in which to locate. γ_0 represents intra-region spillovers. In the second step, manufacturing units prefer to locate in a more specific part of the region. Within each region *i*, we denote the intra-industry spillovers in region *i* according to the spillover model.

We define x_i as the share of region *i*'s employment in total employment, x_{im} as the share of sub-region *m* (*i*)'s employment in total employment and y_{im} as the share of sub-region *m* (*i*)'s employment in region *i*'s total employment.

We also define $x_{im} = x_i y_{im}$ and $\sum_{i,m} x_{im}^2 = \sum_{im} x_i^2\, y_{im}^2 = \sum_i x_i^2 \sum_m y_{im}^2 = \sum_i x_i^2\, \Omega_i$ where $\Omega_i = \sum_{m=1}^{r_i} y_{im}^2$. The probability model follows the Bernoulli distribution. In the first stage, if n_j is defined as a random variable describing the location of business unit *j*, for example n_j=*1,2,...M* if *j* is located in region *i*, 0 otherwise. If u_{ji}=0 is the associated Bernoulli variable (0,1), it follows from the spillovers model that:

$E(U_{ji}) = x_i,\ V(U_{ji}) = x_i(1-x_i)$and $Corr(u_{ji}, u_{ki}) = \gamma_0$ for$j \neq k$.(9)

Then the spillover model for the sub-region level is under condition of the first-stage model and describes as:

$E(w_{jim}/u_{ji} = 1) = y_{im}$, $V(w_{jim}/u_{ji} = 1) = y_{im}(1 - y_{im})$ (10)

and $\text{Corr} = \left(w_{jim}, {}^{w_{kim}}/_{u_{ji,u_{ki}=1}}\right) = \gamma_i$ for $j \neq k$(11)

Therefore, the probability of two manufacturing units (*j* and *k*) locating in the same sub-region *m* of region *i* is the probability that the manufacturing units locate in *m (i)*, knowing that they previously chose to locate in region *i*, by the probability that they simultaneously decided in the first step to locate in region *i*. For $j \neq k$, it becomes:

$$P(j \in m(i), k \in m(i)) = P\left({}^{j,k \in m(i)}/_{j,k \in i} \right).P(j, k \in i)(12)$$

The probability that two manufacturing units (*j* and *k*) locate in the same area *i* is independent from *j* and *k*, andis written as:

$$P(i,i) = E(u_{ji}, u_{ki}) = cov(u_{ji}u_{ki}) + E(u_{ji})E(u_{ki}) = \gamma x_i(1 - x_i) + x_i^2(13)$$

The probability (independent on *j* and *k*) that pairs of manufacturing units locate in the same sub-region is:

$$p = \sum_{i,m} p(m(i), m(i)) = \sum_{i,m}(\gamma_o x_i(1 - x_i) + x_i^2)(\gamma_i y_{im}(1 - y_{im}) + y_{im}^2)(14)$$

4. Measurement of agglomeration

In this section, we briefly introduce the indices employed by Ellison *et al.* (1997) and Maurel *et al.* (1999). These indices emphasise the correlation between each pair of firms, which represents the decision of a pair of firms to locate close to each other being interdependent. We also compare the results using the Herfindahl index (industrial concentration), G (geographic concentration), EG index and MS index using different SIC industry levels.

Assume the variable $u_{ji} = 1$ if plant *j* locates in region *i*, $u_{ji} = 0$ if not. The correlation between any pair of plants within the industry is therefore:

$$\gamma = corr\left(u_{ji}, u_{ki}\right) \, for \, j \neq k \quad (15)$$

The comparison of γ between industries reflects the relative strength of spillovers across the industry. Relatively strong correlations may reflect localisation due to Marshall's externalities and other natural advantages.

On the other hand, if the location decision of any pair of plants is independent, the probability that both plant *j* and plant *k* locate in the same region *i* is written as:

$$P(i,i) = E\left(u_{ji}, u_{ki}\right) = cov\left(u_{ji}u_{ki}\right) + E\left(u_{ji}\right)E(u_{ki}) = \gamma x_i(1 - x_i) + x_i^2 \quad (16)$$

Let *M* denote the number of geographic regions, the probability function can be aggregated to:

$$p = P(i,i) = \gamma\left(1 - \sum_{1=i}^{M} x_i^2\right) + \sum_{1=i}^{M} x_i^2 \quad (17)$$

Let *N* denote the number of industry plants and $z_1 \ldots \ldots z_N$ the share of each plant in industry employment. The fraction of industry employment located in region *i* is written as:

$$s_i = \sum_{j=1}^{N} z_j \, u_{ji} \quad (18)$$

Maurel and Se'dillot (1999) demonstrate the linear linkage between p and γ and the simplified frequency estimator of p written as:

$$\hat{p} = \frac{\sum_{1=i}^{M} s_i^2 - H}{1-H} \quad (19)$$

where H denotes the industry Herfindahl index:

$$H = \sum_{j=1}^{N} z_j^2 \quad (20)$$

The Herfindahl index is applied to estimate the share of plants in employment at the industry level. By substituting equation (5) into equation (3), the linear function for the index is given by:

$$\hat{\gamma} = \frac{G-H}{1-H} \quad (21)$$

where the estimator of geographic concentration represents:

$$G = \frac{\sum_{i=1}^{M} s_i^2 - \sum_{i=1}^{M} x_i^2}{1-\sum_{i=1}^{M} x_i^2} \quad (22)$$

The geographic concentration estimator from Ellison and Glaeser (1997) is slightly different:

$$G_{EG} = \frac{\sum_i (s_i - x_i)^2}{1-\sum_i x_i^2} \quad (23)$$

Both estimators are unbiased, the G_{EG} weights each plant by its share of employment. The G_{MS} index distinguishes the situation where two employees belong to plants located in the same geographic region with two plants located in the same geographic region. The definition of G_{MS} is consistent with the weighted Herfindahl index H that gives the higher weight to plants with a larger number of employees.

Both γ_{EG} and γ_{MS} represent the strength of industrial agglomeration. Industries with a greater value than 0 are to some extent agglomerated and the higher value represents the higher extent of agglomeration. Conversely, the value of γ closer to -1 implies that an industry ismore dispersed.

The co-agglomeration index aims to calculate the spillovers across related industries. Ellison *et al.* (1997) provide the upstream-downstream agglomeration across pairs of 4-digit industries. Maurel *et al.* (1999) and Devereux *et al.* (2004) examine the spillovers within 4-digit industries within the same 2-digit industry. Ellison *et al.* (1997) generate the calculation of co-agglomeration as:

$$\gamma^C \equiv \frac{[\frac{G}{(1-\sum_i x_i^2]} - H - \sum_{j=1}^{r} \hat{\gamma} w_{j\ j}^2 (1-H_j)}{1-\sum_{j=1}^{r} w_j^2} \quad (24)$$

where *H*is calculated as $H = \sum_j w_j^2 H_j$, meaning the sum of weighted Herfindahl index value at 4-digit industry level for an industry group. w_j denotes the share of employment in an industry over employment in a group industry. *G* is the geographic concentration index defined previously at the 4-digit industry level. The degree of such spillover effects γ caused by agglomeration is written as:

$$\lambda = \frac{\gamma^C}{\sum_i w_j \hat{\gamma}_j} (25)$$

Maruel *et al.* (1999) and Devereux *et al.* (2004) use the same method to calculate the co-agglomeration index but make slight changes on the spillovers measurement; they demonstrate the relationship between the agglomeration index values at a 2-digit industry level above. We also follow Devereux *et al.* (2004) to estimate spillovers using a percentage value which is the second part of the equation:

$$\gamma_2 = \frac{\sum_{j=1}^{r} r_j w_j^2 (1-H_j)}{1-\sum_{j=1}^{r} w_j^2 H_j} + \frac{C(1-\sum_{j=1}^{r} w_j^2)}{1-\sum_{j=1}^{r} w_j^2 H_j} \quad (26)$$

The Ellison and Glaeser (1997) index is similar with the MS agglomeration index. The EG's index is based on the comparison between the fraction of employment located in region *i* for one industry and in aggregate. It is therefore calculated as:

$$\widehat{\gamma_{EG}} = \left\{\frac{\sum_{i=1}^{M}(s_i^2 - x_i^2)}{1-\sum_{i=1}^{M} x_i^2} - H\right\} \Big/ 1 - H \quad (27)$$

We also use the concentration index and a local Gini coefficient together with γ and γ_{EG} to perform comparisons on agglomeration. We describe the methods to estimate the indices above: the concentration index is defined as the proportion of plants in an industry in the top three regions to measure geographic concentration denoted as CI:

$$\mathrm{CI} = \sum_{\mathrm{k}=1}^{3} s_k \quad (28)$$

where s_k is the *k*th region's share of employment, *k=1…3* give the top three most with largest share of employment.

A locational Gini coefficient is denoted as:

$$L_A = \frac{2}{K^2 \bar{s}} \left[\sum_{k=1}^{K} \lambda_k (s_k - \bar{s})\right] \quad (29)$$

where s_k is as the same definition, λ_k denotes the position of the region in the ranking of s_k and $\bar{s}$ represents the mean value across the regions (Krugman, 1991).
In general, *0n ge*, but if the industry is not located in any one of the regions in our geographic map, this may cause a problem. When *N<K*, then *1-N/K≤L≤1*. For example, if industry *L* does not exist in region *k*, then we still include this region as one of the total number of regions in calculating the Gini coefficient. We assigned regions where one industry does not appear as zero when doing the calculations.

5. Data Description

In this chapter, we utilise the Industrial Enterprises Dataset collected by the National Bureau of Statistics of China (NBS dataset) which has been widely applied by other researchers. It includes all of the state-owned enterprises (SOEs) and non-state-owned enterprises (groups, limited companies, joint stock enterprises, Hong Kong, Taiwan and Macau-investment enterprises (HTM) and FDI enterprises(overseas)) with a turnover larger than 5 million RMB. The dataset covers over 40 2-digit, 90 3-digit and 600 4-digit industries. The total GDP of the enterprises in the dataset accounts for over 90% of the whole GDP of the manufacturing industries in China. It is the most comprehensive annual data at the firm level in China. Two variables are required to calculate the MS index – the number of industries and the number of regions. We clean the data and aim to maximise the number of observations. Previous studies on the patterns of industrial agglomeration are generally based on the rankings of EG index values at the 4-digit and 2-digit industry level. We too have followed this approach in our study so we can make easy international comparisons with previous works. GB/T 4754_1994 and improved GB/T 4754_2002 (also called SIC) are the official industry classifications set up by the National Bureau of Statistics of China in 1994 and 2002, providing the coding system of ISIC (International Standard Industrial Classification). These coding systems were officially applied in 1995 and 2003. China, as a very dynamic economy, adjusts its industry classification over time. The adjustment is consistent with the development of economic growth in China. Some emerging and new established industries in China have also been included on the SIC (Standard Industry Classification). The most recent version of SIC GB/T 4754-2011 was applied in 2011. Since the restructuring of the industry coding system by NBS in China in 2002, it is difficult to compare value changes of the MS index from 1998 to 2007. In the previous study, most of the studies focused at the 3-digit industry level, which is the most detailed level to overcome the recoding issue. Lin *et al.* (2011) discussed agglomeration at the 4-digit industry only focusing on the textile industry. Although Brandt *et al.*(2014) give the concordance tables for China, it does not include natural resources and energy and water supply industries. Therefore, we prefer to look at changes of the MS index of each 4-digit industry within the time period of the same coding system. That gives us two time periods: from 1998 to 2002 and from 2003 to 2007. Doing so offers detailed information on the changes of industrial agglomeration in this emerging economy, ruling out changes in coding. In general, most of the 4-digit, 3-digit and 2-digit industries are identical over all time periods. However, some merge and recoding creates differences for some industries at various industry levels.

We first target our time period of analysis. The number of 4-digit industries before 1998 varied significantly year by year in this dataset. It is therefore difficult to include earlier years at the 4-digit industry level. Since we aim to calculate the value of the MS index at the most detailed industry level – the 4-digit industry level – our starting year is 1998. On the other hand, although we also have data for 2008 and 2009, the missing 4-digit industries make datasets incomplete for both years. Hence the ending year of our analysis is 2007. After that, as the dataset includes inactive enterprises, we need to exclude those enterprises not still in operation. There are seven types of enterprises business status defined by NBS[5]. The definition of business status "Open" relates to enterprises that have been in production for over three months in the year of the survey. "Close down" designates those enterprises that have been in production for less than three months or were completely out of business in the survey year but still retain their business license[6]. "Preparation" refers to an enterprise that is still in the starting process or in trial operations; we also treat enterprises with business status "Preparation" that have positive turnover as enterprises in business and include them in the dataset. This judgement is important when we examine the dynamic of agglomeration using survival analysis. We only keep those enterprises that are in business activity. Finally, we keep

5 According to the type of enterprise status defined by NBS, enterprises can be classified as “Open”, “Close down”, “Preparation”, “Cancel”, “Close down in the statistic year”, “Bankruptcy in the statistic year”, and “Others”.

6 The Business license is applied by the Chinese government to register different type of business units in China. The license is free for any person or legal person. The type of business needs to satisfy the amount of capital investment and related law. In the situation of business "Close down", the business unit must either have suffered financial crisis or legal violation. The business unit is allowed to keep its license while solving its financial or legal issues. Therefore, the "Close down" firms can be reopened in the next year although the business status shows "Close down" in the previous year.

4-digit industries with over six enterprises in each year and the duration is five years.

In the judgement of plants status, we treat plants with business status "Open" and "Preparation" together with turnover greater than zero as inactive and keep them in the dataset while the rest are excluded. We assume "*t*" as the survey year, then the "Entrance" category means that the enterprise did not appear in *t-1* but appears in *t*; the "Exitor" category means that enterprises appear in year *t* but not in *t+1*; the "One-year" category represents enterprises appearing in *t* but not in *t-1* nor *t+1*; the "Survivor" category represents enterprises that appear in both *t* and *t+1*. Note that if a plant had a turnover greater than zero and its business status was "Preparation" in *t-1*, we do not treat it as "New entry" if its status is "Open" in *t*. We also follow Devereux *et al.*'s (2004) definite "job creation" and "job destruction" factors. The total number of new employment positions is defined as the number of workers employed by new entrants together with the additional number of workers for plants that increased employment compared with the previous year. Job creation is defined as the total new employment over total employment. Job destruction is also estimated as the total reduction in employment over total employment where total reduction in employment is defined as the total number of employees of the "Exitors" together with the total reduction of employment for those plants who reduce their workforce.

Some cleaning of the geographical data was also required. There are two regional code systems in China: the administration division code and postcode. The administrative division code is officially called the ISO-3166-2: CN. It uses a 12-digit code to include all urban and rural regions in China. The NBS update the code of several regions every year. The first two digits represent the province, municipalities, autonomous region (Xinjiang, Tibet etc.) and Special Administrative Regions (Hong Kong and Macau). The third and fourth digits of the code represent the associated city, prefecture, autonomous prefecture, Mongolian league, municipal city and county regions. The fifth and sixth code represents city districts, county-level cities and the banner areas of the Inner Mongolia region level. The seventh to ninth digit is the township in the rural area or street in the city. The last three digits give the village in a rural area or community area in a city. We aggregate the urban and rural areas of the four municipalities and treat them as one city (equal to 4-digit administration division). Note that the administrative division is based on political enquiries; therefore, the area across divisions may vary due to historical, cultural background and other reasons. We also applied postcode regions for the general industrial agglomeration in China to compare the results with those based on administrative division classifications. These comparisons are also applied at postcode level in international comparisons.

In a previous study, Lu and Tao (2009) merged the regions based on the administration division codes from 1998 to 2005. Although there were some code changes for certain county areas during the period, they still merged the county areas and used those areas each year from 1998 to 2005. However, it may still lead to recent developed county areas being missed where they were recorded into administration divisions. China has set up additional county areas since 1998 and the newly developed regions may be important to trace. We would like to analyse the changes for the whole of China on the pattern of industrial agglomeration, not just those regions recorded for many years. We, therefore, keep all the enterprises located in 31 provinces in mainland China to maximise our dataset, which also helps us to trace the industrial agglomeration changes in China. Since the MS index gives smaller weight to regions with fewer production activities, the newly established regions will have a limited impact on the value of the MS index. Rapid growth in China has resulted in a dynamic map of industrial geographic distribution. There have been newly established manufacturing industry zones and large-scale entry in the traditional industry cluster regions every year. Hence our analysis would be biased if we only keep traditional industry clustered regions, dropping the new regions that appear in the dataset. Bai *et al.* (2004) investigate the local protectionism within administration divisions in China. Therefore, we calculate the MS index at different administration division codes to capture if local protectionism also affects the degree of changes in the MS index over time.

Finally, following Devereux *et al.* (2004) with the assumption that the plant location decision is independent, enterprises owned by the same owners, located in the same place and producing the same products cannot be treated as different enterprises. Hence, we combine two or more enterprises into one "firm" by aggregating their number of employees and other main indicators in the descriptive part.

In summary, our data cleaning process enabled us to achieve our three main aims: to study the trends of industrial agglomeration at a very detailed industry level; to make international comparisons at the same industry level and various region levels; and to study the regional development of the manufacturing industries over time.

5. Patterns of industrial agglomeration in China

In this section, we present our results using both the EG and MS indices to examine the pattern of industrial agglomeration at various region and industry levels. We calculate our EG indices at the 4-digit industry together with 6-digit (county), 2-digit (province) administrative divisions and for postcode regions. We also compare the results on EG index and MS index and examine the characteristics of those index in China case. We use the un-weighted MS index at the 2-digit industry level (the average value at the 4-digit industry level) to study the pattern of industry agglomeration in our target analysis years in general. Then, the results for the 4-digit industry and 6-digit administrative divisions give the most and least agglomerated industries and we use the rankings and indices to compare the most agglomerated industries with other developed countries. As Ellison *et al.* (1997) note, the EG index value varies by regional level, so we also compare the pattern of industrial agglomeration at a similar region level with the US, France and the UK. Co-agglomeration at the 2-digit SIC industry level is also considered.

5.1 Statistical analysis

In the second column of table 1.1, we give the total number of enterprises in each year before cleaning the data. We have cleaned the data after merging 4-digit industry data, keeping enterprises that are in operation and dropping enterprises with abnormal values for number of employees. We dropped the enterprises and 4-digit industries that are too small; the total remains are given in column 3. The last column gives the share of cleaned data over raw data. We can see that over 90% of the raw data are retained. From 1998 to 2002, there is a 10% increase in the number of enterprises. In the second period, the total number of enterprises increased by 40% between 2003 and 2007. Although the number of enterprises increased steadily in general, there is a jump in the number of enterprises in 2004 due to using the NBS and the inclusion in the dataset of more private enterprises with over 5 million RMB.

[Table 1.1 about here]

Table 1.2 provide basic statistics for the year 1998，2002，2003 and 2007, which are the selected years of our data periods. We have 576 4-digit industries in the first period (1998 to 2002) and 513 4-digit industries in the second period (2003-2007) that appears in all years during each period. The change on the industry classification is due to rapid growth on recent established industries and reclassification of industries by the Natioal Bureau of Statistics of China[7]. In the results, the share of non-state-owned enterprises increases from 70% to 10% between 1998 and 2007 suggesting that the share of private sectors grow fast. The total number of firms shows that there are more enterprises has more than one plants and the number of multi-plants grow steadily during the overall time period. However, the average firm size falls from 397 to 239 from 1998 to 2007.

7 Some of the 4-digit industries in the first period are aggregated into one more general 4-digit industry in the second period due to the vanishing of some industries or the previous 4-digit industries being too detailed. For example, the industry of other condiments and fermentation products (SIC-1469) in the second period is a combination of eight 4-digit industries in the first period. Amino acid (SIC- 1441) and citric acid (SIC-1443) are two of the combinations which are quite small industries with limited products.

[Table 1.2 about here]

Tables 1.3 and 1.4 show the structure of firm size in 1998 and 2007[8]. The second and third column show the firm size distribution based on total number of firms and its share. The fourth and fifth column introduce the similar distribution pattern based on number of employment and its share. In general, most of the firms are with employees between 20 to 200. However, the large firms with employees over 500 still own over 50% total number of employees although its share has significantly decreased during these ten years. This result is consistent with table 1.2 and fewer SOEs, which were very big firms, over the time period can be the reason to explain such firm size falling. Therefore, medium-large firms and giant firms are the two portions with large influence on the manufacturing economy in China.

[Table 1.3 about here]

[Table 1.4 about here]

5.2 The concentration of production activities

5.2.1. The regional inequality on manufacturing regional distribution

Figures 1.1, 1.2 also show the production employment distribution at the province level in 1998 and 2007[9]. In general, we can see a clear trends of industrial concentration in the coastal regions. We can see Guangdong province as the economy advanced province in China have the largest share of employment although its number of firms is smaller than Zhejiang province. In general, the top four provinces with the largest manufacturing industry share are all located in the coastal regions while the least advanced provinces in manufacturing industries are all from inner-land. Besides, the coastal regions not only maintained their position as the manufacturing centre in China but also keep increasing

8 See the firm size distribution in 2002 and 2003 in the appendix in table A.1 and A.2.

9 See the employment distribution for 2002 and 2003 in the appendix in table A.1 and A.2.

their shares of employment and number of firms during the decade. Four provinces in the coastal regions with the top four largest share of employment and number of firms owns over 45% share of total manufacturing employment and number of firms in 2007[10]. There is also an over 10% increase on shares of total employment and number of firms in these provinces over China mainland from 1998 to 2007 while other provinces close to these coastal regions in the northern China shrink their share of manufacturing industries. The share of inner-land remains steadily with less than 1% employment overall except Sichuan province.

[Figure 1.1 about here]

[Figure 1.2 about here]

5.2.2. The regional cluster of manufacturing industries in China

Figure 1.3 and table 1.5 further show a more detailed manufacturing employment distribution map at city level. It appears that the manufacturing industries employment is even more concentrated in one or two cities within those provinces having high proportion of employment at province level. About 20% of the total employment clustered in the top seven cities, where locates in Yangtze river delta and Pearl river delta areas, with share of employment larger than 2%. The second-class fourteen cities with between 1% and 2% share of employment also locate in Bonhai Gulf area, Shandong Peninsula and areas around the Yangtze river delta and Pearl river delta areas. Other regional centre such as Shenyang in northeast of China appears to be the third class of manufacturing centre while the rest regions have less share of manufacturing employment. We can find out the significance of cities on promoting manufacturing clustering process in China. The large cities own a large share of manufacturing employment within the province suggesting manufacturing clusters in cities.

[10] See table A.3 in the appendix for manufacturing employment distribution at province level in 2007.

[Figure 1.3 about here]

[Table 1.5 about here]

5.3 The magnitude of industrial agglomeration and its trends

We study the magnitude of industrial agglomeration at different region level in the same year and compare values between 1998 and 2007. Tables 1.6 show the industrial agglomeration level at different regional levels in 2007. The dataset includes 31 provinces in mainland China. After merging the 4-digit industries that appear during each five-year period, we have a different number of counties and postcode areas in our dataset, enabling comparisons over different years. The county and postcode coding system has changed significantly over the last three decades with some counties being merged while some other new counties have been established. Furthermore some regions do not have manufacturing industries, especially those with natural resource extraction operations. On the other hand, new postcode areas located within existing county regions have also been included in the dataset. Hence, the number of county regions decreased while the number of postcode areas increased between the two periods[11]. Our motivation is not only to track the changes of industrial agglomeration in the existing regions but also to look at the impact of those diminishing or emerging regions' impact on industrial agglomeration in China. Therefore, we only drop those observations with errors in county codes or postcode codes from our data. The number of province is consistent for a comparison in general.

[Table 1.6 about here]

It can be found that the degree of agglomeration at province level is the strongest among

[11] The number of counties and postcodes is cleaned based on our dataset. We have corrected some information offering fewer details but there might still be some errors. For example, 316,000 is also a 6-digit region code but only has useful 3-digit information – the last three digits do not tell us which county it locates.

the three region levels in 2007. However, the very high locational Gini index value which found highest at postcode area level suggesting that manufacturing industries is highly agglomerated in small regions in China. This is consistence with finding in figure 1.3. A higher value on G than H shows the geographic concentration is higher than industrial concentration.

As the overall EG and MS index treat all manufacturing industries as one industry and the share of each geographical regions is the same, according to our index equation, both index values are identical based on the same G value and H value. However, in concern the slightly different nature and value for EG and MS index from previous studies (Ellison *et al*, 1997; Maruel *et al.*; Alonso-Villar *et al.*, 2004 and Simpson, 2007), the values of disaggregated industry can be different. Figure 1.4 show the industrial γ value correlations between the EG index and MS index at 4-digit industry and province level in 1998 and 2007. The fitted line is also provide for both years respectively. The value variation in 1998 is larger than in 2007. There are more 4-digit industries with stronger geographic concentration than industrial concentration or industrial concentration than geographic concentration in 1998 leads to larger variation on the value of correlations between two indices. It is potentially due the difference of industry agglomeration patterns. On the other hand, the value of correlations in 2007 is more fitted and is more skewed than in 1998 suggest that industrial agglomeration is more emphasize on the geographic concentration over time. It is consistent with stronger manufacturing geographic concentration map in figure 1.1 to 1.3.

[Figure 1.4 about here]

[Figure 1.5 about here]

In the comparison study on the magnitude of agglomeration over time period, we compare values of MS index at matched 2-digit industry and province level. Apart from Mining industry, nothing else specified (SIC-11), the Gamma value in 2007 is larger than in previous years. The Gamma value is constantly increase during the time period. The degree of increase from 1998 to 2002 is mostly larger than the degree of changes on agglomeration during the second time period suggesting the degree of agglomeration from 2003 to 2007 become more stable than the first time period.

5.4. Patterns of industrial agglomeration

In order to introduce the pattern of industrial agglomeration at a more detailed industry and region level, we now use the un-weighted mean value of the MS index to study industrial agglomeration at the 2-digit industry level. Tables 1.7 exhibit the pattern of industrial agglomeration at the 2-digit industry level in 2007, calculated using an un-weighted 4-digit industry mean value of the MS index. In column 2, we aggregate the γ value at the 4-digit industry level to un-weighted mean values at the 2-digit industry level. We follow the example of Devereux *et al.* (2004) and Maurel and Se'dillot (1999) and classify the 4-digit γ values into quartiles (the last quarter on the right representing the most agglomerated industries). The share of each class reflects the degree of agglomeration of each 2-digit industry. The MS index is represented by the value of γ here. We calculate the MS index at the 4-digit industry level and county level.

In 2007, it is clear to find that natural resources extractions and labour intensive industries are most agglomerated while energy, some high-tech industries, and raw material oriented industries are least agglomerated[12][13]. At least 40% of the 4-digit industries belong to the top four most agglomerated 2-digit industries have γ value between 0.019 and 0.478. On the other hand, energy supply and water supply industries with over 80% of the 4-digit industries within the least agglomerated 4-digit industries have γ value smaller than 0.003.

[Table 1.7 about here]

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[12] See table A.4, A.5 and A.6 for the un-weighted 2-digit industrial agglomeration patterns in 1998, 2002 and 2003.

[13] We treat Communications equipment, computers and other electronic equipment (SIC-41) here as the assembling of high-tech products and therefore as labour-intensive industries in China.

Figures 1.6, 1.7 and 1.8 show the overall pattern of industrial agglomeration at the 4-digit industry and county level in 2007[14]. The agglomeration measures are highly skewed. The degree of geographic concentration is much higher than industrial concentration support the idea that industrial agglomeration is driven by geographic concentration in China.

[Figure 1.6 about here]

[Figure 1.7 about here]

[Figure 1.8 about here]

In tables 1.8, we show the top twenty most agglomerated industries at the 4-digit industry level. We match the 4-digit industries' name and code with industries before the restructuring of SIC in 2002 in column 2 for 2007 results. The star sign behind some 4-digit industry represent that industry has also been included in the top twenty most agglomerated industries table in 1998 or 2003[15]. We first study the pattern of the most agglomerated industries. Then, the changes and trends of the most agglomerated industries from 1998 to 2007 are also discussed.

[Table 1.8 about here]

In 2007, Small electricity appliances, small tools making and textile industries which are export-oriented and labour-intensive industries in China are included in the top agglomerated industry table. Some other natural resource related industries are also found in the table. The reason of these high agglomeration level is due to their much higher geographic concentration value compared with their industrial concentration value.

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14 See figure A.3 to figure A.11 for the value distributions of agglomeration in 1998, 2002 and 2003 in the appendix.

15 See table A.7, A.8 and A.9 in the appendix for the top twenty most agglomerated industries in 1998, 2002 and 2003.

There two silk-related industries are positioned 6th and 14th in the table. and the number of firms for these two industries is much larger than for those other industries. In general, the motivations of agglomeration given by Marshall is partially proved in the China case.

In figure 1.9 we give the Gamma value of top most agglomerated industries in four selected years. We can see industries' degree of agglomeration in 2007 is larger than in previous years between γ value 0 to 0.2. However, the values in 1998 is significantly greater than in 2007 after that suggesting more extreme values on the top agglomerated industry estimation in 1998 than in 2007. Consider the large amount of natural resource extractions industries and natural advantage based industries in the top agglomerated industry table, those extreme values come from those industries and leads to big difference between the result of two years.

[Table 1.9 about here]

[Figure 1.9 about here]

Table 1.9 and figure 1.9 further provide a comparison between the top twenty most agglomerated industries across the time. We track the value changes of those key indicators for those top twenty agglomerated industries in the selected years. There is a big change on the top agglomerated industry table from 1998 to 2007 although the top five agglomerated industries in 2007 remains to be the top agglomerated industries since 2003. Only two industries are found to be still highly agglomerated from 1998 to 2007. It also implies the pattern of industrial agglomeration become relatively stable in the second five years.

In general, the top twenty most agglomerated industries in 2007 has more number of firms than matched industries in previous years. However, their trends of industrial agglomeration is quite mixed while industries with a higher geographic concentration would also have a higher industrial agglomeration extent (SIC-3424 and SIC-1743). On the other hand, a quicker decrease on industrial concentration than on geographic concentration may have mixed impact on industrial agglomeration (SIC-2623 and SIC-3316). In combination of findings from table 1.8, the top twenty agglomerated industries mostly come from those 2-digit industries also highly agglomerated except Potassium fertilizer (SIC-2623) in 2007.

5.5 The location of agglomeration

In previous studies in developed countries, most of the top agglomerated industries may geographically concentrated in big cities such as London. In concern of the relatively high geographical concentration of manufacturing industries in coastal regions in China, we now focus on the geographic distribution of the most agglomerated industries and investigate the related industries located in close geographic areas. Tables 1.10 show the regions with the first and second largest share of employees for the most agglomerated industries in 2007. The average firm size of the industry and the share of large firms among the total number of firms is also provided.

[Table 1.10 about here]

The first observation is that natural resource extraction industries have much higher geographic concentration than other industries. Gaizhou as a region with very rich natural resources have about 60% of total employment and 40% of number of firms in Magnesium Mining and Dressing. Xiuyan Manchu Autonomous County is also renowned as the origin of precious stones in China and magnesium ore in the world. A similar example of geographic agglomeration of natural resources is the tin smelting industry. Gejiu City in Yunnan Province is the place of origin for tin, with over 60 % share of total employment in the tin smelting industry in 2002 and 2007[16].

[16] See the location of top twenty most agglomerated industries result in table A.10.,A.11. and A.12 for 1998，2002 and 2003 in the appendix.

The textile industry especially silk industry is a traditional manufacturing industry as the part of Chinese culture orientation and have been well developed since Han dynasty (BC-202). Shaoxing County, as the traditional silk processing region, appears as the top agglomerated regions for two silk industries in 2007 – silk spinning and silk processing (SIC-1742), and silk dyeing and finishing (SIC-1743). Wujiang District in Suzhou, another region in Jiangsu province is another silk processing centre with over 15% of employment concentrated within the region for both Silk dyeing and finishing industry and Silk spinning and silk processing industry. With 33.42% share of employment, the top agglomerated region for silk products (SIC-1754) which is the downstream of silk industry is in Shengzhou, where is close to Shaoxing and other silk industry concentrated counties. It implies an upstream-downstream chain in Zhejinag and Jiangsu Province in the south coast region of China.

Small tools and electronics are the third top agglomerated industry group including Knives, scissors and similar household metal tool (SIC-3424), Calculator and money and special equipment (SIC-4155), Home electronic ventilation appliances (SIC-3953), Other household electrical appliance (SIC-3959), Household kitchen appliances (SIC-3954) and Teaching equipment (SIC-4126). The top region of share of employment and number of firms are found in Zhongshan, Shunde District and Bao'an District in Guangdong Province. The share of total employment and number of firms for these industries is the lowest among the natural resource extractions and traditional industries, about 40% and 30% share of total employment and number of firms concentrated in the first and second agglomerated regions. Calculator and money and special equipment (SIC-4155) is the only industry agglomerated due to limited number of large firms according to its high share of employment ratio and low number of firms ratio. The agglomeration type of other industries in this group is due to large number of employment and firms. We find no evidence that high-tech industries are highly agglomerated at county level in China.

Finally, there are five industries with average firm size at top agglomerated region is larger than the other regions 2007. Those industries usually have much smaller share of firm numbers in the second agglomerated region compare with the top region. It leads to the pattern that firms are highly geographically dispersed and with larger firm size in those other regions. The limited number of larger firms is therefore give us a higher average firm size number.

As we mentioned in previous, some highly agglomerated 4-digit industries belong to the same 2-digit industry or have a close value-chain relations may geographical concentrated close to each other. We further apply the map of share of employment distribution to examine such minimizing of transportation costs phenomenon. Figure 1.10 to 1.13 give selected examples of the top and second industrial agglomerated region of top twenty most agglomerated industries[17].

[Figure 1.10 about here]

[Figure 1.11 about here]

[Figure 1.12 about here]

[Figure 1.13 about here]

Shandong province as the centre of machines and equipment manufacturing has a large supply on metal and has large share of employment on precious metal rolling (SIC-3352). In figure 1.10, the reason that top and second agglomerated regions are both located in the coastal region is attempting to take advantage of lower transport costs of importing raw metals from overseas. On the other hand, some light industries are agglomerated with the top and second most agglomerated regions in southern China. Guangdong province as the centre of small electronics and tools manufacturing industries show a clear regional industrial agglomeration bias. Both household kitchen appliances

[17] See other samples of top agglomerated regions in figure A.12 to A. 15 in the appendix.

(SIC-3954) and home electronic ventilation appliances (SIC-3953) are found to be highly localized in the Pearl River Delta where are close to ports in Hong Kong for exports to the north America market. Industrial agglomeration in inner land are different from previous two coastal regions. The more resource based silver smelting are geographically concentrated in two countries in Hunan province close to each other in 2007. It is clear to show a regional variation on the type of top agglomerated industry across regions.

5.6 The least agglomerated industries

The least agglomerated industries in China for 2007 are presented in tables 1.11[18]. The least agglomerated industry cover many field including energy and water supply, beverage, some natural extractions related industries and high-tech industries. The patterns of the least agglomerated industry in China is more stable than the top agglomerated industry. Those industries with highly natural advantage bias remains in the table from 1998. The key reason for the less agglomerated is their production scale. Apart from those energy and water supply industries, most of other less agglomerated industries have very small number of firms in 2007. The same value of G and H for those industries suggest that the limited number of firms in each region locate within the same region or it is more likely that there is only one firm in each region. It explains why industries with relative higher geographic concentration compared with those industries in the top twenty most agglomerated industries are still classified as least agglomerated industries.

[Table 1.11 about here]

On the other hand, Film Machinery (SIC-4151) defined as high-tech industries also appears in the both tables. Although there is a significant development on high-tech industries in China during this time period, the number of firms and industry scale of

[18] See the twenty least agglomerated industry on table A.13, A.14 and A.15. in 1998, 2002 and 2003 in the appendix.

high-tech industries in China is still small compared with developed countries[19].

6. International comparisons

A comparison of the degree of industrial agglomeration across countries is of most important on examining the previous work and looking for new findings. We aim to compare the pattern of industrial agglomeration with results of previous studies in developed countries. The big challenge of making international comparison based on EG or MS index is their different country and region size. The index value calculated at different region level can be very different (Ellison and Glaeser, 1997). The mechanism of the estimation of γ values is by using the share of employment within a geographic area and the share of employment within each industry. Firstly, the number of regions in the estimation is crucial to determine the γ values. In general, the larger the variation of the industry across different regions, the larger the geographic concentration value. Likewise, the larger share variation we have across different regions, the larger the industrial concentration value we have. Moreover, the geographic area is also crucial when comparing the results across countries. Ellison and Glaeser (1997) calculated the EG index value at state level and classified a γ value greater than 0.05 as being a highly agglomerated industry; a γ value between 0.02 and 0.05 as a somewhat agglomerated industry; and a γ value less than 0.02 as a less agglomerated industry. This classification has been widely used on international comparisons. In concern of the similar administration region level in the US, France and the UK applied in estimating and comparing the degree of agglomeration, province region as the second administration region level is the best option for China to match the state level, department level and postcode area which are also the second largest administration region level in those countries. We also provide the distribution of MS index values at other region level in our selected years to study the changes on the degree of agglomeration in China in the past decade.

[19] See table A.16. of high-tech industries in China in the appendix.

6.1 The comparison at the 2-digit industry level

Table 1.12 summarises the previous analysis on the pattern of industrial agglomeration among the US, France and the UK. France has the highest percentage of highly agglomerated industry classifications with 27% of 4-digit industries being highly agglomerated; the US follows and the UK is the least. Our results give agglomeration results for China at the province level, the district/county level and the postcode level in 1998, 2002, 2003 and 2007.

[Table 1.12 about here]

In table 1.12, the percentage of 4-digit industries that falls into the very concentrated industry class goes up from 42% in 1998 to 51% in 2007 based on the province level results. The percentage of somewhat concentrated industries steadily increase from 16% to 19% from 2003 to 2007. However, there is a slightly overall value downward trends from 2002 to 2003. It implies that industries have become more agglomerated in general while the trend in the percentage of somewhat agglomerated and not very agglomerated industries is mixed due to the alternation of 4-digit industry code after 2002. It is clear to find that the degree of agglomeration in China has experienced a stable increase at all region levels in the last decade.

Most importantly, the percentage of highly agglomerated industries is much higher than the US and other countries and its percentage has been increased steadily over the whole period. In general, the percentage of highly agglomerated industries and somewhat agglomerated industries rises continuously in China. Our comparisons aim to consider the results of industrial agglomeration across different countries based on a similar geographic area. Some 42%-51% of 4-digit industries defined as very concentrated in China were the largest share of the very concentrated classification among all countries. If the US state is the closest geographic area in size to the province area in China, there are actually more very concentrated industries in China than in the US since 1998. The greater number of raw materials extraction industries in China than in the US can partially explain these results. Furthermore, the share of somewhat agglomerated industries in the US is higher than in China and the share of less agglomerated industries in the US is smaller than in China. It suggests that the γ value distribution in China is a "dumbbell" pattern while it shows a "spindle" in the US. In general, the level of industrial agglomeration is obviously underestimated as China has more very concentrated industries than the US. The degree of agglomeration in China is also much larger than France and the UK.

6.2 Comparison among the top agglomerated industry

It is also important to study the pattern of industrial agglomeration by looking at the types of most agglomerated industries in different countries. The previous comparison show that the most agglomerated industries in France is close to the US that high-tech industries are found to be highly agglomerated. However, the pattern and degree of agglomeration in the UK is different and lower than two other countries. We introduce the results of China at province level into the comparisons in following tables.

[Table 1.13 about here]

In tables 1.13, we match the top agglomerated industries in 2002 and 2007 with the top agglomerated industries in the US, France and the UK. There are fewer 4-digit industries that can be matched in 2007 than in 2002. The MS index value for those top agglomerated industries in China is still higher than other countries. However, the products can be different according to different definition of 4-digit industry in each country. Knives and scissors (SIC-3484 or SIC-3424) is the only 4-digit industry can be matched with France and the UK in both years. In general, we find similarity on the type of most agglomerated industries in China and other countries. Traditional industries including textiles and cutlery together with some natural resource extractions are most likely to be matched. High-tech industries is still rare in the top agglomerated industry table at province level and therefore lead to difficulty to matched with highly agglomerated high-tech industries in the US and France.

Since the difference on the pattern of industrial agglomeration between China and other developed countries, we also attempt to match the top agglomerated industries in the US, France and the UK with similar industries in China. We apply the MS index value and the ranking of agglomeration to investigate the difference in table 1.14, 1.15 and 1.16[20]. The last column also give the changed value and rankings of each industry between 2002 and 2007[21]. The negative value mean industry become less agglomerated while a positive changed ranking number represent industry become more agglomerated compare with other industries in China over time. In general, a positive changed value on MS index also matched with an increasing on rankings and vice versa.

Table 1.14 first show the matching between China and the US. The trends of degree of agglomeration for those matched Chinese industries is mixed. Seven industries with an increasing value and higher ranking on both value of MS index and ranking number. On the other hand, another seven industries show an downward trends on both degree of agglomeration and rankings. Leather Luggage, packages (bags) (SIC-1923) is the only industry having lower agglomeration degree but a higher ranking overall the industry. It might be explained as less 4-digit industry after 2002 in the dataset. Spacecraft (SIC-3762) has experienced a great increasing on the degree of agglomeration and ranking which is consistent with good performance of China space exploration progress since 2000. Its degree of agglomeration is also higher than the US.

[Table 1.14 about here]

[Table 1.15 about here]

[20] The same comparisons made based on results in 2002 is also applied on table A.17, A.18 and A.19 in the appendix.
[21] We use the average value of MS index and rankings to generate the changed values in the last column if one foreign industry matched with several industries in China.

In table 1.15, matched industries between France and China are mostly increased. Watches and timekeeping instrument (SIC-4130) and home audio equipment (SIC-4072) as high-tech industries are industries has very close agglomeration degree in China and France. Other textile industries and coal mining industries also have close MS index value in both countries' results.

[Table 1.16 about here]

In table 1.16, matched industries with similar degree of agglomeration in the UK and China mainly include ceramic, textile and leather industries, cutlery and hand tools. Some of the matched industries also have high rankings in overall degree of agglomeration in China. Therefore, the similarity of industrial agglomeration is only found on traditional industries that can be classified into several types while the degree of agglomeration in other aspect of comparisons show a big variation between China and other developed countries. Such as characteristics would be interesting for the future study on the determinants of industrial agglomeration across countries.

7. The dynamics of agglomeration

7.1. Changes in the pattern of industrial agglomeration

It is important to note that the maturity of each industry varies according to their different stages of development. The growth of the number of firms and their location choice in an industry affects the degree of agglomeration. On the other hand, industries that experienced contractions would also become dispersed or localised due to firms closing down. Dumais *et al.* (2002) indicates that the degree of industrial agglomeration rarely changes from 1972 to 1992 in the US. The influence of historical background on agglomeration is also found in France and the UK. Moreover, Dumais *et al.* (2002) also show empirical findings that the birth of new firms in an industry is likely to weaken agglomeration while the closure of old firms enhances it. However, as a developing country, the structure change of industrial agglomeration in China has experienced a tremendous change in the last decade. There are only two 4-digit industry can be matched remain as the top twenty most agglomerated industries from 1998 to 2007 in table 1.9. The reason of such big change is quite mixed by only looking at the impacts of geographic concentration over time.

In this section, we examine the dynamic for each industry in two ways: running an OLS regression between several estimators and tracing the location changes of the twenty most agglomerated industries in China. The "New entrants", "Exitors", "One-year", "Survivors" are the percentage of those new entries firms, exit firms, only one-year stay in the dataset firms and surviving firms as we defined in the data description. The job creation and destruction ratio is also applied to investigate if the business cycle of an industry has an impact on the agglomeration at the industry level. The 2-digit industry level data are also used as controlled variables. In section 7.2, we further investigate trends of top twenty most agglomerated industries by examining changes on industrial top clustering location in each five-years time period. The comparison between industrial top agglomerated regions and other regions is also applied. we trace the location changes of the top twenty most agglomerated industries in the first and second time period.

We follow Devereux *et al.* (2004) and define the "New Entrance" ratio as employment by "New entrance" firms divided by the total number of firms. The "Exitors" ratio is defined as the total number of workers from "Exitor" firms over total employment. The "One-year" ratio is defined as the total number employed by "One-year" firms over the total number of employment in the year. We also define the “Survivors” ratio as employment by survivor firms over total employment. To calculate the job creation and destruction rate, we define the job creation rate as the total number of workers employed in new entrants plus the increase in employment in existing enterprises divided by total employment. The job reduction rate is defined as the number of workers employed in "Exitors" plus the reduction in employment in enterprises decreasing their workforce divided by the total employment. Since we have two time periods, we look at the impact of these ratioson industrial agglomeration for all 4-digit industries using two three-year time-period panel regressions.

$$\gamma_i = a + \beta Entrants_i + \epsilon_i \tag{30}$$

$$\gamma_i = a + \beta Exitors_i + \epsilon_i \tag{31}$$

$$\gamma_{it} = a + \beta Survivors_{it} + \epsilon_{it} \tag{32}$$

$$\gamma_{it} = a + \beta Oneyear_{it} + \epsilon_{it} \tag{33}$$

$$\gamma_{it} = a + \beta Jobcreation_{it} + \epsilon_{it} \tag{34}$$

$$\gamma_{it} = a + \beta Jobdestruction_{it} + \epsilon_{it} \tag{35}$$

Equations (30) to (35) provide the OLS regressions which help us to investigate the dynamics of agglomeration in China. As a developing country, the equation will have a different meaning compared with developing countries. The early industrial geographic concentration is mainly characterised as geographical concentration within a certain region by many industries and the location of each industries are also random. After the policy is applied and productivity competition between enterprise and industries, the location is gradually formed as an industrial agglomeration. Taking the TEDA (Tianjin Economic and development area) as an example, the early entrants combined many un-related industries with different characteristics such as instant noodles, food and beverages, piano manufacture etc. After raising the capital investment limits to the entrant and the costs control by the multinational entrances (multinational enterprises), the low-tech industries gradually moved to other small Economic Technological Development areas or other regions. TEDA has now become a real high-tech industry economic zone. Pharmaceutical products, exchange equipment (Motorola), and aircraft

(Airbus) are the main industries geographically concentrated in the region.

[Table 1.17 about here]

[Table 1.18 about here]

Tables 1.17 and 1.18 give the coefficient values between the MS index at 4-digit industry and county level and various measures of the dynamic characteristics of firms. Table 1.17 shows that only the survival rate has a negative impact on the MS index while other variables show a positive impact on the agglomeration. The positive impacts from one-year firms and the MS index represent the one-year firms also enhancing their agglomeration in a short time period but which could not survive or perform due to strong competition between firms within the same industry over longer time period. The job creation and destruction rate also reflects the localisation phenomenon in manufacturing industries over the time period. Combine with previous results, the positive impacts from the rate of new entrants, exitors and the MS index implies that the industries in China become more agglomerated through rapid restructuring of industry's patterns. The industry development and changes bolster the process of industrial agglomeration from 1998 to 2002.

Results for the second five-years time period is completely opposite, all of the regressions in table 1.18 show a negative correlation between the MS index and other estimators, excluding the survivor rate. It implies the firms and employment become more geographical stable and still maintain the increase of industrial agglomeration. Firms locate in the industrial agglomerated regions are more competitive than others and keep taking advantage from Marshall's externalities during the process of firm growth and development.

The different coefficient in the first and second time period help to describe the dynamics of industrial agglomeration in China in this decade. In the first time period, the explosive growth on manufacturing industries in the coastal regions attract employee from the whole country. The degree of agglomeration has reached its peak during this time period. However, once all firms have decided their geographic locations in the coastal regions, they compete each other on productivity, profits, exporting orders and high-skilled or low cost employees. These competition or even excessive competition lead to death and move out of firms in the industrial agglomerated regions and therefore decrease the magnitude of industrial agglomeration. The low proportion of new entrants in the top agglomerated regions also partially implies the excessive industrial cluster and limited resources including labour, natural advantage and production costs in those existing agglomerated regions. Firms need to seek for other regions where have lower costs, less competition and sufficient resources and that may have negative impacts on the degree of agglomeration. Moreover, the increasing number of firms together with a shrinking on average firm size suggest that smaller firms may cluster within the agglomerated regions. Smaller firm size may potentially given a smaller Herfindahl index. Therefore, the magnitude of industrial agglomeration may still rise up with a smaller industrial concentration value and a remained geographic concentration value.

7.2. The location changes of the top most agglomerated industries

In tables 1.19 and 1.20, we examine the impact of new entry firms on the extension of the agglomeration of the twenty most agglomerated industries by tracing the location of new entry firms during two time periods. Tables 1.19 and 1.20 show the percentage of new entry firms located in the top agglomerated regions in the first year of each time period, the number of new entry firms, geographic concentration (G) and γ value for the new entry.

[Table 1.19 about here]

[Table 1.20 about here]

From 1998 to 2002, the number of new entry firms for each industry goes from 5 to 643;

ten industries have new entry firms located in the top agglomerated region in 1998. The percentage of new entry firms located in the top agglomerated region rises from 11% to 48%. Knives and scissors (SIC-3484), with 48% of new entry firms located in the top agglomerated region, exhibits strong localisation, which is similar to the finding in the UK. It also reflect the enquire of skills and the nature of knowledge spillovers effects' impact industrial agglomeration of o cutlery production. About 40% of new entry firms in the precious stones and jade mining industry (SIC-1095) – the top most agglomerated industry – are located in the top agglomerated region. Moreover, the γ value for the new entrant is also the largest among the twenty most agglomerated industries. On the other hand, exchange equipment (SIC-4112), with only 11% new entries located in the top region, has the smallest γ value, although its geographic concentration value G is not low in the table. The top two industries with the most number of new entries are the silk industry and paper industry. However, the proportion of new entries located in the top regions for the two industries are relatively low. Hence, the new entrants would have a great impact on agglomeration and our new finding of the industry becoming more agglomerated can be explained as the prosperity of new agglomerated regions rather than the increase of new entries in the old agglomerated region.

In 2007, sixteen industries were among the top twenty agglomerated industries, with new entries preferring to locate in the top region. However, the share of new entries located in the top region is relatively small in general. The silk industry experienced a huge increase in the number of new entries but very few of these were located in the traditional top agglomerated region. Moreover, although two of the natural resources extraction industries have very few new entry firms, these often prefer to locate in the traditional cluster region, showing that the extent of agglomeration for those industries is still high. This implies that the geographic exploration of natural resources and extraction is localised in the new region.

Home electronic ventilation appliances (SIC-3953), household kitchen appliances (SIC-3954) and other household electrical appliances (SIC-3959) have small γ values in table 1.13 and their share of new entry firms locating in the top agglomerated region is quite small as well. This shows that the location of new entries into these household electronic appliances manufacturing industries goes against agglomeration.

We find that the characteristics of each industry determine the impact that the new entries have on the extent of agglomeration in the dynamic trends. The region of agglomeration for natural resources extraction industries is highly determined by the location of the raw material and a new cluster region may be formed if a new mining region is explored. Some labour-intense industries, such as the silk industry and household electronic appliances with a significant number of new entries, are located in different regions to extent the scale of the industry.

8. Conclusions

In this chapter, we examine the patterns of industrial agglomeration in China by mainly use the MS index. We study the patterns of industrial agglomeration and its trends from 1998 to 2007 at 2-digit and 4-digit industry level. We also investigate the top agglomerated industries' location of cluster and compare the most agglomerated industries in China with other developed countries. In order to study the impacts of business cycle on industrial agglomeration, we applied the firm birth, death, job creation and destruction ratio to estimate their impacts on the degree of agglomeration.

In general, manufacturing industries in China has become more and more agglomerated during the decade. The increase on the degree of industrial agglomeration from 1998 to 2002 is stronger than from 2003 to 2007. The highly regional localisation in the coastal regions is mainly lead to higher agglomeration. The industrial agglomeration appears to be the strongest at province compare with estimations at other region levels. However, the type of highly agglomerated industries across regions is quite different. Meta product and machines manufacturing would more likely to locate in the north coastal regions while light industries especially those export-oriented light industries are localized in southern coastal regions. The natural resource extractions, the textiles and labour-intensive industry are three types of industry with highest degree of agglomeration in China while energy and water supply, some highly natural advantage biased industries together with several high-tech industry are the least agglomerated industries.

In the international comparisons, the degree of industrial agglomeration in China is much higher than other developed countries in general since 1998 due to much higher geographic concentration. There are very rare top agglomerated industries in China are found could be matched with the top agglomerated industries in other developed countries suggesting the very difference between the pattern of top agglomerated industries between China and other selected countries.

In the dynamics studies, the structure changes of firms including firms' birth and death together with location changes of manufacturing employment may have positive impacts on agglomeration while firms prefer to stay have a negative impacts on agglomeration from 1998 to 2007. From 2003 to 2007, we have a completely opposite results that firms' survive and location stability would bolster the industrial agglomeration. The location choice of top agglomerated industries in 2002 show that new firms and employment would prefer to localized in the top industrial agglomerated region from 1998 to 2002. However, new firms and employment in top agglomerated industries would prefer to located in new industrial agglomerated regions rather than old regions to prevent excessive competitions within the region.

Future analysis could be extend in the following aspect: the reasons behind the pattern of industrial agglomeration in China; the economic performance of those highly agglomerated industries in China; comparisons between top agglomerated industries across different regions and their reasons in China is also interesting; finally, in concern of different characteristics for those top agglomerated industries, the determinants of dynamics of the industrial agglomeration is also essential to investigate in further analysis.

Chapter 3. The Dynamics and determinants of industrial agglomeration in China

Abstract

Using a strong panel data from 1998 to 2007 on industrial agglomeration estimation, we examine the dynamics and the determinants of agglomeration in China. We find the trends of industrial agglomeration at more detailed region level is more complex than simply constant upward trends at 2-digit industry and province level. The tremendous changes on firm size distribution and ownership have a significant impacts on industrial agglomeration in China. With the decreasing of SOEs, the SOEs have a negative impacts on agglomeration. On the other hand, the steadily growth on domestic private firms together with their export-oriented growth pattern significantly promote the degree of agglomeration over time. The foreign firms show a positive coefficient with industrial agglomeration in China. Besides, we also include other control variables in the pooled OLS and industry fixed effects regression. The impacts of ownership remains and processing industry together with export show a positive coefficients on industrial agglomeration while other indicators have less significant evidence in China case.

Key words: Ownership, trade, industrial agglomeration, trends

1. Introduction

Urbanisation and industrialisation are twofold that a history of being and regarding analyse geographical concentrations in the economy. A large number of empirical studies exist in the literature, which examine the impact of manufacturing industries' spatial concentration on productivity and economic growth. Highly concentrated regions, such as cities, have played a very important role in boosting product and production competition. A larger metropolitan area and population could promote higher productivity within the same industry and area. Sveikauskas (1975) estimated the Hicks-neutral productivity and found an increase of 6 percent when the population of the metropolitan area doubled. Segal (1976) finds that the Hicks-neutral productivity is 8 percent higher in Standard Metropolitan Statistical Areas (SMSAs) and the same or greater in SMSAs with a population ranging from 0.25 million to 2 million. Nakamura (1985) also studied manufacturing industry productivity and spatial economy. The results in Japan show that light industries gain a greater productive advantage from urbanisation than from localisation economies. However, heavy industries receive more productive benefits from localisation economies rather than urbanisation economies. Henderson (1974) developed Edwin Mills' argument on the restrictions of city size. The higher productivity in those highly industrially concentrated regions is due to Marshall's externalities: lower costs by being located close to suppliers and customers; benefitting from a flexible and specialised labour market, and knowledge spillovers.

Since so many benefits come from spillover effects from industrial agglomeration, developing countries are seeking to establish similar clusters to help increase their productivity and encourage such knowledge spillovers. The imbalanced development policy in China has successfully promoted regional growth in the coastal region and increased the value of total factor production (TFP) from 1952 to 2005 (Ozyurt, 2009). However, such a remarkable increase also comes with regional imbalance on productivity, income and technology levels (Chen *et al.*, 1996; Shiu *et al.*, 2006). Skewed productivity levels are more obvious at the city levels across China's eastern, middle and western regions (Xu *et al.*, 2012). However, this inequality is not completely negative – Deng *et al.* (2011) estimate a productivity growth–technology gap reaction function and find that the coastal regions have closed their technology gap with their international frontiers. The growth of labour productivity, on the other hand, has become slow compared with the inner provinces. Moreover, some other studies have also suggested that this imbalance in regional development is being reversed (Andersson *et al.*, 2013; Lemoine *et al.*, 2014). Meanwhile, the China Western Development programme gives an opportunity for regional development rebalancing in China. It is, therefore, worthwhile studying the trends of such regional industry concentration across China and finding the factors that influence industrial agglomeration, which can change such regional imbalances and promote economic development in less developed regions.

2. Literature review

There are many theoretical works on the causes of industrial agglomeration, including Smith (1776) on comparative advantages of trade, Ohlin (1935) on resource endowments, Marshall (1920) on externalities, and Krugman (1991) on scale economy and "iceberg effects". Marshall's externalities, as one of the most famous studies, has developed three main causes for industrial agglomeration: the pooling of a larger labour market; lower inputs share; and knowledge spillovers including technological innovations. Some empirical studies also examine the impact of these factors (Helsley and Strange, 1990; Goldstein and Gronberg, 1984; Ellison, 1999; and Audretsch and Feldman, 1996). Rosenthal and Strange (2001) use comprehensive establishment-level data to estimate the correlation between industrial agglomeration calculated by the Ellison and Glaeser index and the education level of workers, resources and production inputs share as the determinants of the previous three externalities, categorised by firm age, industry and geographic scope levels. The results show that labour market pooling benefits and input share cuts have a positive effect on agglomeration in the US but that technology innovation has a negative influence. On the other hand, Kim (1995) studied the trends of industrial location and regional specialisation in the long run and found evidence of regional specialisation arising in the US from 1860 until World War II then steadily falling. Studies into regional specialisation examine the theory of scale economies and the Heckscher-Ohlin model but not Marshall's externalities. There are still some other factors that may have a potential impact on industrial agglomeration. Harris (1954) mentioned the importance of the market on the localisation of industries in the US. Holmes *et al.* (1999) calculated the value of purchased input as a share of output to measure vertical disintegration and found a positive impact of vertical disintegration on agglomeration, which examines the theory of industrial specialisation. However, there are still some obstacles blocking certain agglomerative advantages. Zheng (2001) studies agglomeration in the Tokyo metropolitan area and finds that agglomeration is caused by corporate headquarters, financial industries and governmental organisations; the negative effects of such agglomeration are shown to be high house prices, long commuting times and bad environmental quality of life. Ellison and Glaeser (1997) also demonstrate the importance of the impact of natural advantages on industrial agglomeration.

In studies on China, most of the empirical literature focused on the impact of agglomeration on the economy. In recent papers, Li and Lu (2009) examine the positive impact of agglomeration on vertical disintegration in China. Using a two-year dataset, Li, Lu and Wu (2012) examine the positive impact of agglomeration on firm size and find that firms tend to become larger by locating close to other large firms rather than close to a number of small firms in China. However, research on agglomeration and trade remains limited in China. Indeed, Smith's (1776) theory on trade is another fundamental factor that has initially caused agglomeration and has a great impact on agglomeration. While the impact of trade on China has been significant in recent decades (Ge, 2009; Sun, 2010; Berger, 2011), the country's economic reform, transferring China from a planned economy to a market-based economy, has left some friction regarding economic liberalisation, which could promote industrial agglomeration. Bai *et al.* (2004) demonstrate the production activity of a planned economy and its obstruction of economic liberalisation and agglomeration through local protection policies. On the other hand, FDI also plays a very important role in encouraging growth and regional development in China (Liu, 2002). In addition, the technology spillovers from FDI have also been found to have a significant effect (Cheung *et al.*, 2004; Liu *et al.*, 2008). Kamal studied the influence of ownership on industrial agglomeration in China and found that spillovers are more likely with firms that have the same ownership. Therefore, it is necessary to further study the impact of ownership on industrial agglomeration. The National Bureau of Statistics of China (NBS) has categorised enterprise ownership in more detail since 1998.We mainly focus on three general types of ownership and estimate the impact that each has had on agglomeration in China.

In this chapter, we focus on the indicators that affect the patterns and trends of industrial agglomeration from 1998 to 2007 at the 4-digit and 2-digit industry level. To examine the impacts of economic liberalization on the degree of industrial agglomeration in China, we use shares of ownership to study the impacts of ownership on agglomeration. Other key economic indicators may also applied as the controlled variables in the regressions.

2. Indices of agglomeration

We followed Ellison and Glaeser (1997) and Maurel and Se'dillot (1999) and use the EG index to calculate industrial agglomeration as follows[22]:

$$\mathrm{EG}_{\mathrm{it}} = \frac{\mathrm{G}_{\mathrm{it}}/(1-\sum_{\mathrm{s}} \mathrm{s}_{\mathrm{st}}^{2}) - \mathrm{H}_{\mathrm{it}}}{1-\mathrm{H}_{\mathrm{it}}} \quad (1)$$

[22]Maurel and Se'dillot (1999) made a small change to the EG index and rewrote $G_{it} \equiv \sum_s (s_{it} - x_i)^2$ instead. x_i is the share of aggregate employment in region *i*, For more details, see chapter 2.

where s_{ist} is the share of employment of industry *i* located in region *s* at time *t*. $G_{it} \equiv \sum_s (s_{it}^2 - x_i^2)$ measures the deviation of squared value between the share of total industry employment located in region s and the share of overall industry employment in region s. $\mathrm{H_t} = \sum_{j=1}^{N} z_{jt}^2$ is the Herfindahl index where z_{jt}^2 is the share of employment for firm *j* in industry *i* given *N* firms in this industry in each year.

3. Data Description

We utilise the micro-foundational plant level cross-section dataset from 1998 to 2007 in China, collected and issued by the National Bureau of Statistics of China (NBS)[23]. The dataset includes plant location, economic performance and finance situation information from all 31 provinces in mainland China. The first six digits of the administration code (ISO-3166-2: CN) and postcode provide the location of those plants. Total output, turnover, export ratio and new product value are included and partially applied in our study. Wage and intermediate inputs, together with different types of capital by ownership are also listed in the financial information section. The NBS has classified the type of capital investment into domestic investment and joint ventures with foreign enterprises initially before 1998. The classification by ownership was extend to SOEs' capital; group, limited company and joint stock capital; private capital; foreign capital and HTM capital (Hong Kong, Taiwan and Macao)[24]. The amounts of capital by different types of ownership, together with the total amount of capital of each enterprise, are provided in the dataset. We define the type of enterprise by ownership using the amount

23 We define a "plant" as an enterprises with separate financial and economic performance information in the dataset. Those enterprises that share the same legal person and work in the same industry are still separate firms if they have different and separated information.

24 Group, Limited and joint stock capital enterprises are mainly established in county areas in China. It is a kind of socialist enterprise type. The capital of enterprise is owned by a group of people who work together and own the enterprise equally. Limited and joint stock enterprises are invested and owned by shareholders with limited responsibility, which is the same as joint-stock enterprises. Private capital enterprises represent individual invested limited liability corporate enterprises in China. Foreign capital represents capital invested by other countries. HTM capital is defined as the amount of capital owned by Hong Kong, Taiwan and Macao within the enterprise.

of each type of capital divided by total capital. For example, a SOEs must have at least a 50% share of capital owned by the state. All workers in a SOEs are, hence, included into SOE employment when we calculate the share of workers by type of ownership. In our studies, we classified the type of firms by ownership into three groups: National owned, domestic private and foreign firms[25]. Our investigation on the determinants of agglomeration would be

The regional administration code have experienced a tremendous change during the urbanisation process by combing or changing former county's 6-digit regional code into a new one to include them as the sub-urban areas of the city nearby. We therefore use the 6-digit administration code in 2007 as the benchmark to match the region code in previous years. We only include those 6-digit county regions appears in all sample years. with at least one firms. We also aim to track the changes of industrial agglomeration at a detailed industry level. As the NBS restructured the SIC (Standard Industry Classifications) at the end of 2002, the 4-digit industry codes need to be adjusted for consistency over the whole time period. We follow Brandt *et al.* (2012) to give a new coordinated 4-digit industry code. Our target 4-digit industries include all 2-digit manufacturing industries from agriculture product processing (SIC-13) to handicrafts and other products (SIC-42). In order to trace the dynamics of industrial agglomeration at detailed industry level, we only include 4-digit industries have no less than ten firms in each year to ensure the significance of industrial agglomeration index to ensure the industry scale. There are also some error region code has been corrected for our dataset to ensure a reasonable changes on number of firms within each region over time. To examine the determinants of industrial agglomeration, we include several key indicators and keep those values normal after cleaning. We drop those plants with abnormal values (less than 0) on total capital (values are not positive), different types of capital by ownership (less than 0), wage (values are not positive), intermediate inputs value (less than 0), new product value (less than 0) and export values (less than 0).

[25] There are very limited number of firms belongs to none of these classification due to their equalled share from two ownership types, we would just drop those observations from the regression part.

[Table 2.1 about here]

In general, we have less regions in 2007 than 1998 due to region combination and disappearance of production activity in less developed regions in the inner land. Table 2.1 introduce the number of observations as raw data and after cleaned. There are over 80% firms kept after cleaning during the whole time period. However, the average number of employment showed in the last column is gradually decreasing. The slightly disturbs on trends of the data in 2004 is due to the statistical year that more firms would be included into the database.

3. Statistical Analysis

The degree of industrial agglomeration has been examined with steadily increase in China and characterized with industrial geographic concentration at province level in the coastal regions[26]. However, the degree of industrial agglomeration and its trends at smaller region levels is still unclear. The consistence finding at province level and county level may due to the significant agglomeration in some 4-digit industries. We therefore examine the overall changes of industrial agglomeration at various region level by using a yearly plot on value of G, H and Gamma from 1998 to 2007 in figure 2.1 to 2.3.

Figure 2.1 shows the trends of MS index value over time. We can see the Gamma value has experienced an significant increase from 1998 to 2007. However, the industrial agglomeration at city and county level shows a much smooth trends without much increases suggesting little change on the degree of industrial agglomeration at smaller region level. The geographic concentration also show a similar trends with the industrial agglomeration distribution over time in figure 2.2. However, the overall Herfindahl index value trends exhibits a much different from MS index value and G value. The value

[26] See Chapter 2.

dropped from a relative high value down to the bottom in 2004 and then slightly increased until 2007.However, its limited impacts on industrial agglomeration is due to the very small value on Herfindahl index value and its changes over time. Therefore, in general the upward trends for industrial agglomeration remains at various region level while changes on industrial concentration level may also affect the industrial agglomeration.

The other variables with constant changes is average firm size. The average firm size has been decreased for 38.5% since 1998. It is clear to find the reason of such decreasing by looking at changes on share of firms in different ownerships. From figure 2.4, we can see there is a steadily increase on total number of domestic firms together with foreign firms. The number of SOEs show a significant decrease in the decade. On the other hand, the average firm size for SOEs and foreign firms is relatively stable and larger compare domestic firms. The average firm size on domestic show a constant decrease.

Therefore, we can conclude that the tremendous drop on Herfindahl index which is highly related to firm size could be explained by decrease of domestic firm size during the time period. In the next section, we examine the impacts of ownership on Herfidahl index value and therefore on MS index value. We aim to explain reasons behind the stable degree of industrial agglomeration at county level.

4. The impact of ownership on agglomeration

In this section, we estimate the impact of different types of enterprise at the industry level on agglomeration and compare the results. We examine the share of plants according to different types of ownership in agglomeration from 1998 to 2007 (see equation (1) as an example). The value difference regression represents the degree of impact from changed share of capital by ownership to the changed degree of agglomeration (see equation (2) as an example). Other control variables are also applied to explore the determinants of industrial agglomeration in China (see equation (4) as an example[27]). The growth pattern of the manufacturing industry is partly explained by these determinant factors. We used county (6-digit), city (4-digit) and province (2-digit) as our different regional levels in the regressions. The four municipalities (Beijing, Shanghai, Tianjin, and Chongqing) are aggregated into a single region at city level regressions.

$$\gamma_{it} = \beta_0 + \beta_1 \frac{SOEsEMP_{it}}{TotalEMP_{it}} + \varepsilon_{it} \quad (1)$$

$$\Delta\gamma_{it} = \beta_0 + \beta_1 \Delta \frac{SOEsEMP_{it}}{TotalEMP_{it}} + \varepsilon_{it} \quad (2)$$

$$\gamma_{it} = \beta_0 + \beta_1 \frac{SOEsEMP_{it}}{TotalEMP_{it}} + \beta_2 numberplants\_S + \varepsilon_{it} \quad (3)$$

$$\gamma_{it} = \beta_0 + \beta_1 \frac{SOEsEMP_{it}}{TotalEMP_{it}} + \beta_2 \mathrm{export_{it}} + \beta_3 newproductratio + \beta_4 averagefirmsize + \beta_5 wagepremium + \beta_6 intermediateinputs + \varepsilon_{it} \quad (4)$$

4.1 The impact of ownership type on agglomeration

We examine the impacts of ownership by using pooled OLS together with year and 2-digit industry dummy. The long-period changed value is also applied in the value difference regressions. Table 2.2 nd 2.5 show an significant negative impacts from SOEs on industrial agglomeration. It suggest the lower share of SOEs within the industry, the more likely that industry become highly agglomerated. In the long-period difference regressions, the value difference of Gamma and share of SOEs from 1998 to 2007 also show a strong negative coefficient at all region level. In both tables, the regression R-square value also become larger at larger region level.

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[27] Since the share of foreign enterprises has a very strong correlation with export ratio, we therefore only include export ratio in the final regressions with other control variables to investigate the importance of exports to industrial agglomeration in China.

[Table 2.2 and 2.3 about here]

The coefficients between share of domestic private firms and value changes of domestic private firms have a very significant impacts on agglomeration ay county and city level in table 2.2 and 2.3. The significant and positive coefficients are more likely to be found at county and city level. The changed value regression between domestic private firms and agglomeration is particularly positively correlated with 2-digit industry dummy control. It is consistent with extremely agglomeration manufacturing industries such as "Shoe town" or "Button town" which are mostly with domestic private small firms.

[Table 2.2 and 2.3 about here]

In table 2.4 and 2.5, the foreign firms show a positive impacts on industrial agglomeration which is varied from previous domestic firms. Due to the limited number of firms and its lower share of employment compare with previous two types of ownership, we could only find significant coefficients at county level. In the value difference regressions, the drawback of low share of employment lead us a significant value at province level mostly.

[Table 2.4 and 2.5 about here]

From previous tables, we find a consistent results with previous statistics analysis. The rapidly grown domestic private firms have become the impassive factor on industrial agglomeration over time. On the other hand, the SOEs has gradually fall as the manufacturing industry centre. On the other hand, due to the government policy restrictions, most of the foreign firms are only allow to locate in certain special economic zone for FDI. The government lead policy would allow foreign firms within a industry to localized in the region and therefore lead to industrial agglomeration.

[Table 2.6 and 2.7 about here]

4.2 Controls for omitted variables

In this section, we also apply more variables related to dynamics impacts on industrial agglomeration. We include firm size and firm age together with new product ratio, export ratio and wage premium to estimate their impacts on industrial agglomeration. Table 2.8 and 2.9 exhibit definitions of these indicators and the statistic summary. We can see that correlation Figures 2.6 and 2.7 show us the distribution of the share of domestic and foreign investment by ownership and export ratio in plots at the 4-digit industry level. We can see from figure 2.7 that the more foreign enterprises a 4-digit industry has, the higher its export ratio. However, in figure 2.6, an industry with a higher share of SOEs may have a lower export ratio, excluding the limited number of exceptions. It shows clearly that the export-oriented growth pattern has still mainly been contributed to by foreign enterprises since 1990s (Buckley *et al.*, 2002; Hu *et al.*, 2002; Graham *et al.*, 1995). Therefore, export ratio may have a collinearity problem with the share of foreign enterprises in employment.

[Table 2.8 and 2.9 about here]

[Figure 2.10 and 2.11 about here]

After the reform of the planned economic policy in 1978 in China, the wage level has changed from equalised wage payments into being strongly industry- and region-specific. The fast growth in the coastal regions has attracted immigrants from the inner land since the 1990s. However, the Hukou system restricts such immigration behaviour[28]. Besides,

[28] The Hukou system is a Chinese characteristic household registration system based on the place of birth of citizens. There are two types of registration named as agriculture and City/County Hukou. Citizens who were born and live in an agricultural area find immigrating to large cities such as Beijing or Shanghai very difficult – this is to protect the social welfare and population of the urban areas. The labourers from the inner land can apply for a temporary residence permit to stay in the big cities and find work. The Hukou system is also activated when a citizen moves their residence from one city to another in the coastal regions.

labourers from the inner land can only work on labour-intensive enterprises due to their lack of skills and lower levels of education. Their wage level is therefore below the average. Moreover, the high-tech or capital-intensive industries are the main targets that the local government aims to persuade to stay as they can be the economic pillars of a local economy. On the other hand, foreign enterprises would prefer to stay if they gain profits and attract other foreign investment to locate within an authority region. In order to estimate the labour market pooling at the 4-digit industry level, we apply the wage premium, which is defined as the average wage for an industry within a region over the average wage in that region, aggregating into overall regions and also weighted by the share of employment in those regions[29]. It implies the wage level of an industry in a region in excess of the average wage level within that region. Moreover, the high wage in an industry implies that the industry has high value-added or is a high-tech industry. The correlation between wage premium and agglomeration also indicates the impact of high-skilled labour force on agglomeration. We can use the wage premium to check if high-tech industries are likely to be agglomerated in China indirectly.

The localisation of industries has a positive impact on vertical disintegration (Holmes, 1999), which implies an industry-specialised region. The pattern of specialised markets and industry clusters has also been illustrated by many academics in case studies of south China (Barbieri *et al.*, 2012). This variable has another meaning in China. The emergence of the processing industry in China attempts to take advantage of the large number of unskilled and low-wage labourers in China, and the positive impact from the intermediate inputs ratio on agglomeration, suggesting the importance of the processing industry to agglomeration in China. Considering that most of the industries are clustered in the coastal region, the high share of inputs in the processing industries primarily could be raw materials from the inner land or primary materials that need to be obtained from overseas. Therefore, it can also be explained as a measurement of economic liberalisation or degree of easy access. We construct the purchased-inputs ratio as the share of

[29] We only use wages from non-SOEs to estimate the wage in an industry and in a region as SOEs' wage level is not driven by market forces (Gordon *et al.*, 1999).

purchased inputs (including raw material, operation and other costs) over the total output in current price.

Knowledge spillovers are also examined using the new product ratio. The application of the ratio of R&D expenditure to total sales, which is generally applied, has been said to ignore the accumulation of technology over the time and the impact of R&D on output performance (Feldman *et al.*, 2002). We therefore conduct a new product ratio and define it as the amount of new products over the total output to estimate knowledge spillovers. The positive R&D ratio impact on agglomeration implies that innovations bolster agglomeration while the negative impact implies that certain innovations work against agglomeration.

Another advantage of industrial clusters is the gain from scale economies. From our previous results, the geographic concentration is in general more skewed than the industrial concentration. Alecke *et al.* (2006) argue that the value of the EG index is still influenced by industry size and is non-linear through the Herfindahl index. They find a significant effect of scale economics on agglomeration using the EG index as the measurement of agglomeration. We construct the average firm size to examine their findings. The average firm size is defined as the total output over the number of enterprises within the industry.

The export value and total sales output in the dataset enables us to estimate the export ratio, which is defined as the export value over the total sales output in the industry. It tells us how important the overseas market is to Chinese manufacturing firms. All input and output values are deflated using an input or output deflator[30].

[Table 2.10 about here]

[Table 2.11 about here]

[30]We use 2000 as the benchmark and deflated input/output variables in other years.

[Table 2.12 about here]

[Table 2.13 about here]

Our results with other controlled variables also show the similar sign in the regression for SOEs and domestic private firms. Besides, the export ratio together with wage premium have a significant positive impacts on agglomeration over time. There are also some evidence to show firm age have positive impacts on agglomeration while firm size have negative impacts. The reason that wage premium promote the agglomeration is the typical cluster of labour-intensive industry in China, firms offer higher wage would attract many employees within the region. The firm age finding is consistent with decreasing of SOEs and increasing of Domestic firms during the decade. Recent established firms are more likely to prefer locations with good externalities.

4.4 The role of technology

On the other hand, there are also many high-tech industries developing quickly in China, supported by foreign investment under commercial agreements at country level or by the central government itself. Figure 3.4 shows that the capital-labour ratio increases quickly over time in China. However, most of it either appears in the top agglomerated 4-digit industry table, like France and the US, or in the least agglomerated industry table like the UK. Therefore, the pattern of industrial agglomeration for the high-tech industries are still mixed based on previous analysis. Rosenthal and Strange (2001) initially applied the innovation from firms of different sizes to examine the impact from knowledge spillovers. Another factor that they applied is the education level of employment. Devereux (2004) uses the capital-labour ratio and the proportion of skilled labours to examine the correlation between technology and agglomeration. The NBS data only included the employees' education level in 2004. It is therefore difficult to identify the change in education level and the impact that this may have had on agglomeration.

Moreover, industrial development in China is not innovation-motivated like in the US. Therefore, we applied two estimators to examine the correlation between the EG index and technology: the capital to labour ratio and R&D intensity. The amount of R&D expenditure has recently received attention from the NBS, which they started to collect in 2005. Year dummies and 2-digit industry dummies are also applied as the control variables. The *G*, *H* and EG index are all incorporated in measuring agglomeration.

[Figure 2.8 about here]

[Table 3.30 about here]

In table 3.29, we find positive and significant correlations between the capital-labour ratio and geographic concentration, and an even stronger correlation with the Herfindahl index. Industrial concentration has a stronger correlation with the capital-labour ratio than with geographic concentration. It is therefore a negative and significant correlation between the *EG* index and capital to labour, implying that high capital-intensive firms are more likely to be less agglomerated. This is due to H having a stronger correlation than *G* with the capital-labour ratio, which leads to negative value on the Molecular of the *EG* index measurement.

In the second section of table 3.30, we examine the correlation between the agglomeration measurements and R&D intensity at the 4-digit industry level. The correlation between *G* and R&D intensity is negative and significant with both year dummies and industry dummies controlled. We also show that the industries with high R&D intensity would prefer to be geographically dispersed. Although the correlation between the Herfindahl index and R&D intensity is positive, it may imply that high-tech industries are industrially concentrated and that the correlation value with or without dummy controls are not significant. The EG index is negative and significantly correlated with R&D in the last two rows of the table. We can conclude that R&D intensity has a negative impact on agglomeration in China, although there are also some high-tech industry zones similar to Silicon Valley. The emergence of high-tech industries is highly dependent upon the environment of the economy and education level of the population. It is hard to imagine that high-tech industries will emerge on the northwest of China or Siberia where there is a lack of productive activities. For example, silk production emerged in the richest place in China; textile industry clusters tended to be in places where machinery and textile spinning were widely available in England; Silicon Valley in California is where there are many of the world's top universities. The silk industry development is based on warm weather in southern China and the experience with sericulture and silk reeling technology over time. The machinery spinning is also based on technological innovation and "learning by doing". The large amount of investment by the University of Stanford into circuit-integrated production and related PC products led to the emergence of the internet and information globalisation. Therefore, China is still the recipient of technology spillovers rather than an initiator – investment in R&D is still quite limited although there are high-tech clusters in China such as Z-park[31]. Although we found some agglomerated high-tech industries, such as spacecraft (SIC-3762), supported by the central government in China, the technology itself is not innovative. However, the constant capital and R&D accumulation can potentially bolster the technology innovations in the future.

5. Conclusions

In this chapter, we track the trends of industrial agglomeration from 1998 to 2007. In general, we find the degree of industrial agglomeration at smaller region level is different from the results at province level. The geographic concentration drive the changes of industrial agglomeration although industrial concentration also experienced a tremendous

[31] Z-park is the short-name of Zhongguancun Park in Beijing. It is the first high-tech market for PC, cell phone and related products in China. The employees are mostly graduates from the universities in Beijing. The business areas of firms located here are mainly PC assembly, repairs, and software development in Chinese. However, it has gradually become a market for selling high-tech products rather than the location of high-tech innovations.

change over time.

The increasing on number of domestic private firms together withdecreasing of SOEs has changed the determinants of industrial agglomeration. SOEs has a negative impacts on industrial agglomeration while domestic private together with foreign firms bolster the degree of agglomeration. High wage and short firm age would encourage the productivity by promote industrial agglomeration and externalities.

Chapter 4. Patterns of industrial agglomeration: Evidence from Tianjin

Abstract

In this chapter, we study the pattern of industrial agglomeration in Tianjin which has different pattern of industrial geographic distribution from China mainland. By using year 2004 and 2008 micro-level data, we investigate the pattern of industrial agglomeration and its trends in Tianjin. The impacts of firm ownership, education level and other indicators are also considered. In general, we find the degree of agglomeration in Tianjin is much higher than overall China. The firm size distribution and top agglomerated industries are also varied. The geo-coding map show that most of the firms in Tianjin are tend to be located close to highways, national road and manufacturing centres. As time goes, there are more and more high-tech industries are found to be highly agglomerated in Tianjin. The highly geographic concentrated FDI within industry park and the Economic and Technology Development Areas (ETDAs) strongly promote the degree of agglomeration on those top agglomerated high-tech industries. The investigation of the determinants of agglomeration show that foreign firms have positive impacts on agglomeration while domestic private firms negatively affect the degree of agglomeration. SOEs in Tianjin have no significant impacts on industrial agglomeration. The positive coefficients between firms size and Gamma suggesting that the larger average firm size one industry is, the higher degree of agglomeration it has. The impacts of education show that industries have more educated

employees are more likely to be agglomerated than industries with more high-educated employees in Tianjin. The potential explanation could be the mixed effect of both domestic private and foreign dominated high-tech industries on the degree of agglomeration.

Key words: ETDAs, high-tech industries, industrial agglomeration,

1. Introduction

China has become "the factory of the world" following over 20 years of growth since the implementation of the "open door policy" in 1978, which reformed the Chinese economy. The policy abandoned the goal of "common prosperity" based on socialist theory and allowed some individuals to become rich through hard work in legal economic activities. In 1984, China opened 14 port cities in coastal regions to attract FDI and enable exporting. The restructuring of SOE enterprises, the privatisation of group capital and the establishment of ETDAs all took place at almost the same time. These restructuring therefore had a great promotion on economic growth in China in the two decades that followed. As these restructuring deeply change the industry geographic distribution map since 1990s and the positive impact of agglomeration on economic growth, it is interesting to study the pattern and dynamics of industrial agglomeration in China. However, the level of economic growth is highly imbalanced in China and it leads to very different type of most agglomerated industries in different regions. It leaves a potential blind spot on investigating the pattern of industrial agglomeration in economic advanced regions which could be different from China mainland.

There are also some case studies focusing on one region and showing their unique characteristics of industrial geographic distribution. Zhang *et al.* (2004) give a case study on the textile and apparel industry clustered at Wujiang in Jiangsu province. Ding (2006) studies the distribution system of industrial clusters by taking Yiwu commodity city as an example. He finds that both the powerful distribution channel and large domestic market make industrial clusters more likely to happen in China. Huang *et al.* (2008) study the advantage of geographic concentration in overcoming capital and technology constraints on footwear in Wenzhou in Zhejiang province. Lin *et al.* (2011) examine the influence of industry clustering on the performance of production in the textile industry. They use firm-level datasets to calculate the EG index at the 3-digit industry level to investigate the dynamic of industrial agglomeration from 2000 to 2005 and find a U-shaped pattern of the value of the EG index over time. Bellandi *et al.* (2012) examine industrial clusters in Zhejiang province and demonstrate the close linkage between industrial agglomeration and specialised markets, including Yiwu Commodity Market.

However, there are a number of important aspects that have been overlooked: first of all, researchers mostly targeted the south coastal regions at the province level. The Yangzte River Delta Economic Zone and the Bohai Economic Rim are the other main manufacturing-concentrated areas in China – it is also important to examine the existence and patterns of agglomeration in those areas. The development of urbanisation has followed a similar model in China, including attracting FDI and establishing high-tech industry zones. Tianjin, as one of the most successful cities in attracting FDI and developing high-tech industries, together with a good performance of SOE enterprises, provides a good case study of the pattern of urban development in China and in developing countries more widely.

Secondly, the analyses are mainly focused on light industries such as the textile industries and footwear. Although there are historical and policy reasons to examine industry clusters in southern China, which are mainly characterised as labour intensive and low-tech after 1978, it should be noted that the heavy industries and high-tech industries tend to be located in Shanghai and some other economically advanced cities in northern coastal provinces such as Tianjin.

Thirdly, China, as an export-oriented economy, has two channels to link production activity with exports: its processing trade and FDI. The industry clusters found in the previous analyses are processing trades based on geographic concentration. There are fewer studies that touch on FDI-oriented industry clusters in China.

Fourthly, previous research has tended to estimate industrial agglomeration using the EG index at the 2-digit and the 3-digit industry level. This is relatively broad, certainly compared with the similar studies for developed countries.

Additional motivation comes from China seeking to upgrade its manufacturing in the world value-added chains from light industries to heavy industries or high-tech industries, such as automobiles, aircraft and machinery (Nolan, 2014). However, whether FDI results in advanced technologies from foreign countries coming to China remains to be seen. The local government intends to achieve industry upgrading through attracting FDI, especially high-tech industries. Tianjin, as a traditional manufacturing-concentrated city, is an ideal example to study. The role of this policy-orientation on the performance of high-tech industries located in the economic and technology development area is an interesting area of study. We also aim to find if spillovers also appear in the development of high-tech industries in this leading city in terms of the total amount of R&D investment in China.

Finally, we include a policy discussion of how to encourage the economic growth in the integration of Beijing-Tianjin-Hebei. The motivation of constructing a metropolitan area in the Bohai Gulf Rim aims to develop the third pillar of economic growth besides the Yangzte River Delta Economic Zone and the Pearl River Economic Zone in the middle and southern coastal regions. There are several reasons why we choose Tianjin as our target city. Tianjin is located by the Bohai Gulf in the northern coastal region in China, in the coastal region of the Bohai Bay. Several rivers run through the city and finally run into the sea. Such geographic characteristics are also found in London, Paris and New York. The capital of China, Beijing, is also located close to the north-west of Tianjin. Those characteristics offer geographical advantages in developing manufacturing industries, especially processing and logistics. This city links East Asia and other countries in the world with other large cities in China. Tianjin was a nineteenth-century traditional industrial city (both light and heavy industry) and is the fifth largest city in China in terms of GDP and first in terms of GDP per capita at province/municipality level in 2013. The growth of GDP is increasing and Tianjin has risen from sixth to fourth according to a report in the first half of 2014.[32] Moreover, Tianjin, as the port city in Bohai Gulf, also gains support from the central government for SOE investment and preferential policies, and is expected to become the economic centre city in the third pillar of economic growth after Shanghai in the Yangtze River area and Shenzhen and Guangdong in the Pearl River area in the coastal regions. This implies great potential for Tianjin's urban development and bright prospects for the city, becoming the economic centre of the Bohai Economic Rim in the near future. The TEDA[33] is also important being the top economic and technology development area (ETDAs) in China; it has attracted investment from more than 60 enterprises from the Fortune 500 such as Motorola and Airbus. It is therefore important to understand the pattern of industrial agglomeration in this city and investigate the influence of FDI and trade sectors on agglomeration. The results will help us to analyse the economic development of Tianjin and the north part of China in the near future.

Beijing, as the capital of China, is China's national economic and financial and has enjoyed tremendous economic growth for decades. Based on these advantages and preferential policy support from the central government, Beijing has become the second largest city after Shanghai in China. Such gravity effects have also had a negative impact on the development of Tianjin since 1949. However, land restrictions and air pollution problems have hindered further development of the city. Recent regional economic development restructuring lead by preferential policies for Tianjin and the rapid growth of TEDA provide a good opportunity for Tianjin to become the top-class city in China again since 1949.

[32] See statistics from official website of National Bureau of Statistics of China.

[33] TEDA is the Tianjin Economic-Technology Development Area and was established in 1984 in the first group of National Economic and Technological Development Zones. In the evaluations of the investment environment of the 54 national Economic and Technology Development Areas, TEDA was ranked first for 14 years until 2008.

Using two years firm level data, we exhibit the MS index results at county level together with geo-coding information to describe the pattern of manufacturing industrial agglomeration in Tianjin. A comparison on the pattern of agglomeration also applies among Tianjin, China mainland and other developed countries. We also compare the pattern of agglomeration in the Binhai New Area and around city centre area is also introduced. To study the trends of agglomeration, we examine the degree of agglomeration in both years and the impacts of new entrants and exitors on the degree of agglomeration changes over time. We also examine the impacts of education level, technology and ownership on agglomeration by using OLS, fixed effects and changed value regressions from 2004 to 2008.

This chapter is organised as follows: we first review the main theories on localisation and agglomeration. Then we introduce the model and explain our measures of agglomeration, geographic concentration and industrial concentration. In the next section, we present statistical analysis of firm size and distribution within our target area. We also examine the patterns of geographic concentration and agglomeration at the 4-digit industry level and across the 2-digit industry levels. We present the most agglomerated industries together with their location and its change over time and examine the possible emergence of new agglomerated industries after 2008. Section 4 compares the most agglomerated industries in Tianjin with previous results for the US, France, the UK and the Chinese mainland. Section 6 discusses the determinants of agglomeration in Tianjin. Section 7 summarises the chapter and presents our conclusions.

2. Theoretical review

The study of a city is motivated by its high productivity and discussed both theoretically and empirically (Smith, 1776; Alfred Marshall, 1890; Ciccone et al., 1996). The additional production is explained by Marshall's externalities, increasing return to scale (Krugman, 1979; 1991) and firm selection (Melitz, 2003; Beheren *et al.* 2012). However, the productivity between cities and between different areas of a city also varies. Krugman

(1991) and Bladwin *et al.* (2006) develop the core-periphery model to demonstrate the spatial distribution of industry in cities. It shows that big cities attract the most productive firms, with the most productive firms moving to the core of a city while less productive firms tend to move outward to the edge in a dynamic process. Combes *et al.* (2012) found that large cities are more productive than small towns in France and that there is no impact from the firm selection effect.

On the other hand, economic openness also has an impact on agglomeration through FDI and export activities. Openness to trade could have a significant impact on the welfare sector, the pattern of agglomeration, urban costs and firms' marginal costs (Ottaviano, 2002; Del gatto, 2006). Based on the processing trade characteristics of China's manufacturing industry, Hsu *et al.* (2012) develop a firm selection model of trade and agglomeration. When the share of unskilled labour is small, trade liberalisation leads towards industrial dispersion and the impact of firm selection is small while the selection effect becomes stronger as the increase of unskilled labour influences trade liberalisation. Ottaviano (2012) also develops a model to demonstrate how heterogeneous firms impact agglomeration in terms of productivity. The heterogeneous firms shift the extent of industrial concentration (estimated by market size and costs-of-living effects) and dispersion (competition effect) depends on the firms' productivity distribution.

There are a number of previous empirical studies relevant to this topic. Marsal (2002) discussed the influence of agglomeration on cities' growth capacity in Spain. She found that cities that start from higher levels of population, general economic activity, industrial activity and higher unemployment and lower levels of technology and surface area present lower rates of economic and demographic growth. Empirical studies also examine the positive relationship between urbanisation and agglomeration at the geographic level and industry-specify level in the metropolitan area of Istanbul (Elif *et al.*, 2012). However, there is little evidence that knowledge spillovers affect agglomeration. McCann *et al.* (2002) introduce transaction costs into the pattern of agglomeration study. We focus on three sectors when examining the pattern of industrial agglomeration in

Tianjin and compare our results with China and other developed countries. We study the most agglomerated industries in Tianjin to examine the pattern of agglomeration in a high-productivity city. We also study the spatial distribution of manufacturing industries to examine the core-periphery model and other spatial distribution patterns. Finally, we aim to find if FDI promotes agglomeration of high-tech industries in Tianjin. We also aim to examine the technology level in Tianjin, which is close to being a world leader, and also investigate the technology gap with China, through examining the agglomeration level of high-tech industries and expecting to find evidence like Silicon Valley.

3. Measures of agglomeration

There are mainly two types of measurements on industrial agglomeration: Gini index used by Amiti (1991), EG index, MS index and Herfindahl index are widely applied in previous studies. Duranton and Overman (2002) propose another index based on a continuous measure of location – the distance between pairs of plants. Borhens et al. (2015) The agglomeration area measures are no longer based on existing administration or postcode boundaries but are purely based on the geographic concentration areas of industries. It offers the detailed distance difference between two pairs of firms located in the same administration. Table 3.1 give the list of all indices we apply in the study[34].

[Table 3.1 about here]

Two reasons explain our choice of measurement indices. Our dataset contains the basic comprehensive information of each plant which could help us to locate the plants. The different geographical scale we use is useful to examine agglomeration at the regional level in Tianjin. Secondly, at the macro-level, the land use and economic development plan in Tianjin is strictly driven by each district government. The local government of Tianjin municipality defined the functions of each district in the future development plan

34 See detailed definition of EG index and MS on Ellison and Glaeser (1997) and Maureal and Maurel, Se´dillot (1999) and Devereux (2004).

in 2008. Each district in the urban area and around each urban area has different development directions which are given a name: Jinrong-Heping (Finance), Shangwu-Hexi (Business), Keji-Nankai (Technology), Jinmao-Hedong (Finance and Trade), Chuangyi-Hebei (Entertainment and creative industry), and Shangmao-Hongqiao (Commercial)[35]. This regional division classification implies the trends of policy support from Tianjin Government and the advantages for each region. Heping district, as the core of the old urban area, aims to develop into a high-end financial, business and commercial centre. Hexi district is targeted to offer finance and insurance, business services and outsourcing services to the technology industry. Nankai district is the location of universities and colleges to offer academic and skilled labour support to high-tech and biochemical industries in Tianjin. Hedong district concentrates on logistics, commercial flows and the entertainment industry. Hebei district is the centre of electrical R&D, electronic communications, and precision instruments manufacturing industries. Hongqiao district is defined as the centre of the SMEs (small and medium enterprises) which mainly focus on wholesale and merchandise display. At the micro-level, each district issues business licences to the plants located in its own area. Plants located nearby but in different administration areas may suffer inconvenience when doing business with each other. In this chapter, we primarily use the first type of indices to measure agglomeration, geographic concentration and industrial concentration. However, a plot map draws based on firms' geo-coding information is also applied.

4. Geographic distribution and industrial concentration in Tianjin

The total area of Tianjin is 11,920 m^2 and the total population is 12.938 million. The population of Tianjin is between a fifth and a quarter of the UK. Tianjin, as one of the four municipalities, had suffered from a relatively low growth rate until the 1990s. This was mainly due to the policy support given to the neighbouring city of Beijing and the slow reconstruction of industry. After 2000, Tianjin returned to the top ranking of GDP growth rate among all the provinces in China. It benefited from TEDA status in the

[35] The first part of the name is a transcription of the Chinese characters that have the same meaning as the explanation in the brackets.

manufacturing industry and related services and policy support from the central government. In 2013, Tianjin, with total GDP value of 14.4 billion RMB, was placed in fifth place in the GDP ranking at the city level and surpassed Shenzhen in the first half of 2014, being placed fourth in terms of total GDP among all of the cities of China. In 2009, the establishment of a national development area – the Binhai New Area – combined three former coastal area districts into another economic centre to make the geographic boundaries in Tianjin much clearer. TEDA, as the core of the Binhai New Area, together with Tianjin city centre appear to be the dual cores of the economic centre linked by highways and railroads. The port of Tianjin, with total cargo throughput of over 4 hundred million in 2010, is ranked in the top 20 ports in the world. This artificial port links the Bohai Bay with South Korea, Japan, Southeast Countries (such as Singapore) and even North America[36]. FDI and exports play a crucial role in the growth of Tianjin, especially for the duty-free trade zone. At the firm level, foreign-owned firms and joint-venture firms are mostly located in the TEDA and other development areas. After the establishment of the Binhai New Area in 2009, Tianjin enjoyed many preferential policies from the central government's future economic plan. To understand the pattern of industrial distribution in Tianjin before 2009 is important and the results will help us comment on the urban development of Tianjin in the near future.

Before 1949, Tianjin was the second largest city with a comprehensive manufacturing industry base. However, Beijing, as the capital, became the priority for economic development and Tianjin, as a nearby city, gradually lost its leading position in China until recently. After 2000, Tianjin increased its rate of growth and by 2002 the GDP growth rate of Tianjin was the top of all the provinces. According to the predictions, Tianjin will surpass Guangzhou in total GDP and become the third largest city in China in three years' time. Tianjin's geographic location and large artificial port means its economic activity is linked with the world through trade and FDI. The total population of Tianjin is around a fifth of the UK or France. Although the GDP per capita for Tianjin is 13,058 RMB, which is the top ranking among all of the provinces/municipalities in China, it is

[36] See official website of Tianjin Port. http://www.ptacn.com/about.asp?id=109

about one third of the GDP per capita in France and the UK. Compared with these nations, the area of Tianjin is 11,920km^2, which is smaller than the metropolitan area of London but bigger than the metropolitan area of Paris.

Combining the geographic background with its higher GDP growth rate, Tianjin has the potential to become a world-class metropolitan area. It is, therefore, useful to look back at the performance of manufacturing industries in Tianjin in the recent decade as an indicator of future performance.

There are two main reasons that make our dataset unique: the large sample and various types of firm included. Firstly, most of the dataset sources organised by the China National Bureau of Statistics only record SOEs and non-state-owned enterprises above a certain level, with annual turnovers greater than 5 million RMB. By including all firms, the dataset is richer and the type of enterprise included is more diverse. Including plants with various sizes and different types of registration helps us consider not only large firms but also small and medium firms located in Tianjin. Private enterprises, foreign firms and the privatisation of former state-owned enterprises (SOEs) and joint-ventures enterprises have grown fast both in quantity and in quality in recent years. The analysis of these domestic private enterprises is still rare. In our dataset, 82% of employees in 2004 and 91% of employees in 2008 did not work in state-owned and joint-venture enterprises. Some 72% of firms in 2004 and 79% in 2008 are SMEs (small-medium enterprises) employing less than 50 people. The firm-level industrial data in China is collected from most provinces comprising only big enterprises. Our dataset includes all the enterprises located in Tianjin in the survey years. The total number of enterprises for our dataset is seven times larger than the number of firms included in the China Economic Survey. For example, there are 70,000 enterprises in our raw data including all sectors (natural resources, manufacturing, finance and non-profit institutes) while there are only 19,000 manufacturing enterprises in China Economic Census in 2004 for Tianjin. After cleaning the data, the dataset remains larger than the China Economic Census. Devereux *et al.* (2004) use seven times more observations to estimate the agglomeration in the UK while the total number of the population of the UK is six times greater than the population of Tianjin.

Secondly, the China Economic Census is organised every five years since 2004 due to its difficulty in organising data collection and cleaning. Our data, before reporting to the central government, included all of the enterprises registered in Tianjin in the academic year. This comprehensive characteristic not only reflects the number of enterprises but also the number of industries. There are over 300 manufacturing 4-digit industries located in Tianjin in both of our sample years. Hoover (1937) discusses the pattern of traditional industries' agglomeration such as shoe and leather industries in England. The agglomeration of labour- and skill-intensive industries is characterised as SMEs that are highly concentrated within relatively small geographic areas. In contrast, an example about agglomeration led by big enterprises given by Ellison and Glaeser (1997) is four plants in the US vacuum cleaner industry (SIC-3635) which have 75% the of employees in the entire industry. The reason behind these agglomeration types can be spillovers and labour flexibility. Therefore, clarifying the characteristics of agglomeration is crucial for us to understand the motivation and mechanism behind the phenomenon. Those existing agglomeration patterns may also be found in Tianjin through learning from developed countries or FDI from multinational enterprises.

The growth of foreign firms located in the economic and technology development area in the coastal regions and districts in the urban area in Tianjin and the increase in the number of SMEs are two interesting phenomena that we investigate. It is interesting to study if domestic SMEs locate close to foreign firms. Moreover, studying if there is co-agglomeration links between the foreign firms and the performance of private-owned enterprises helps us to estimate the impact of FDI on the local private sectors and their reactions. The evidence of policy support being successful in promoting cooperation between foreign firms and local private investment is an interesting area of study for emerging markets.

Finally and most importantly, Tianjin is an international port city and a transportation centre in northern China. Tianjin Port Free Trade Zone and Tianjin Airport Industrial Park, located near the Tianjin Binhai international airport, support manufacturing, bonded warehouse, logistics, R&D and international trade. The trade factors may also affect the location of enterprises, which take advantage of convenient transport. Studying the pattern of manufacturing distribution in Tianjin is a crucial part of manufacturing and trade research in China.

4.1 Data Description

In order to maximise the number of observations, we use the version of the China Economic Census data that is unreported to the central government in the statistical part. The difference between the reported and unreported versions is their sample size and standard collection. The data collection is organised by each local government and they collected all registration enterprises in Tianjin but only reported the SOEs, together with other types of enterprise with turnovers in excess of 5 million RMB before 2008 and 20 million after that, to the central government. The number of observations in 2004 is smaller than in 2008. The number of employees is applied to calculate our key estimator, the MS index, to study the pattern of industrial agglomeration. Therefore, we dropped observations with fewer than one employee at first as the raw data also includes observations with business status closed, bankruptcy, in trial operation and other status. We only keep those plants that are open and in trial operation together with turnover greater than 0 RMB[37].

The census offers various information about the enterprises located within Tianjin, including SMEs. It is different from other datasets for China in both the quantity and quality of the enterprises involved, regarding their basic information and economic performance. It includes large and small enterprises, privately-owned and state-owned,

[37] China Economic Census data classified business status into open (in operation more than three month per statistical year), Closed (Stopped business operations for more than three months per statistic year), in trial operation, close in the open year, went bankrupt in the open year and other status.

and domestic and foreign enterprises. There are two kinds of key information that we consider in this chapter: the geographical categorisations and the number of industries. Firstly, there are two geographic categories in China: the administrative divisions and the postcode region. The administrative division is established based on a 12-digit administrative division code (ISO 3166-2: CN[38]). The Tianjin municipality is denoted by a 2-digit division code and the division is classified at 6-digit, 9-digit and 12-digit levels. Each 6-digit code represents a district, each 9-digit code represents a township and each 12-digit represents a street. The postcode region is between street and township and is slightly inconsistent with the 6-digit district level. Basic information of enterprises includes legal representative, status, total income and total assets. We use these variables to clean the data by removing those enterprises that are not in operation or with abnormal economic estimators. We combine enterprises that are owned by the same people, located in the same area and that produce the same product as one "firm". We collate this plants' information to get the new number of workers, total assets and total income as the estimators of that "firm" in the statistical analysis. We also use very detailed 6-digit administration boundaries as our geographic area and 4-digit industry level. This is a lower level of agglomeration than has previously been considered. Based on micro-data focusing on a metropolis in China, we attempt to examine the changes on manufacturing activities and present a comparative study on the agglomeration in each region over time. A study of the recently explored regions of the manufacturing industry will also be illustrated in the changes of agglomeration section.

Before any data cleaning is carried out, the total number of plants for our raw data is 113,939 in 2004 and 145,447 in 2008. Our data cleaning involves two steps. Firstly, we concentrate on the manufacturing, natural resource extraction and energy supply sectors (SIC-610 to SIC-4690). This leaves 35,482 enterprises for 2004 and 33,804 enterprises for 2008. Since the data also include enterprises that are in trial operation, closed down, in bankruptcy in the establishment year, closed down in the establishment year and other

[38] Please see related information on the country subdivisions on UN website http://www.unece.org/fileadmin/DAM/cefact/locode/Subdivision/cnSub.htm

types of business status, we only keep plants that are in operation and in trial operation with capital and income greater than 0. We also drop plants with negative values on capital, income and number of employees. After that, the numbers of enterprises is reduced to 25,791 plants in 2004 and 33,567 plants in 2008.

Secondly, in order to track industrial agglomeration over time, we restrict the geographic regions to plants that are located in both time periods by using the 12-digit local authority code and postcode. Since some enterprises offer an incorrect 12-digit local authority code or postcode, we first correct those codes that are not very detailed and drop those enterprises with regional codes that belong to Tianjin[39]. Since we aim to study regions that have had stable manufacturing activities over these five years, we need to coordinates our two years' data considering both industry and region concerns. We coordinate regions that have data in both years based on a 12-digit region code and postcode. We also coordinate those 4-digit industries with more than five plants within those coordinated regions. The final number of plants and firms based on the previous calculation method is shown in tables 4.2. Around 5,000 plants are dropped and will generate further studies in the dynamic of agglomeration section. In other words, we focus on regions where manufacturers prefer to locate over time. These regions are mostly in the traditional manufacturing areas in Tianjin. Our aim is to investigate changes in industrial agglomeration over time in these regions. The dropped regions are where manufacturing industries disappear over time or regions where in recent have manufacturing production activities emerged in Tianjin. We demonstrate the decline of traditional industry and the rise of new industries in these regions.

[Table 3.2 about here]

After cleaning, the number of 4-digit industries for 2004 is 382, and the 2008 data contains 399 4-digit industries. There is also an increase in the number of firms during

[39] Some enterprises offer very general regional codes. For example, postcode code 30000 belongs to Tianjin but does not provide any further detailed region information. We correct this information through finding the right information from their website (if they have one).

these five years from 21,352 to 28,309. The number of plants registered as incorporated companies, sole-traders or partnerships is 17,656 in 2004 and 25,309 in 2008, giving the share of private sector companies in the manufacturing industry in Tianjin. The total number of "firms" also shows a significant increase from 20,619 to 27,567. We estimate the number of multi-plants in Tianjin and the difference between the number of plants and the number of firms is very close in 2004 and 2008, suggesting that the number of multi-plants does not change much over the time. There are two characteristics to note from our data in tables 4.2. The total number of firms increases significantly together with the significant increase in the number of four-digit industries from 2004 to 2008. However, average firm size dropped from 65 employees per firm to 51 employees per firm over the time period.

[Table 3.3 about here]

Tables 3.3 show the size distribution of firms[40]. Over 90% of the firms are SMEs with number of employees between 5 to 100. The size distribution of firm size becomes more and more like a "spindle" when graphically plotted. Although there is only 3.7% firms are defined as large firms with over 200 employees, it share of employment still weighted around 50% of total number of employment. Over 80% of the firms have between 5 and 100 employees, defined as small and medium firms in 2004. Note that the share of SMEs (small-medium enterprises) has increased over the time period to around 92% in 2008. Furthermore, firms with a number of employees between 0[41] and 1 decreased from 263 to 189. The share of employment accounted for by the largest size firms also fell during this period. Therefore,

In the investigation of ownership on industrial agglomeration. We also apply the same version data as the statistic part. We define each type of ownership with share of capital no less than 50%. In order to examine the impacts of education level to industrial

[40] See same results for year 2004 in appendix table C.1.

[41] Enterprises with zero employees represent the chief manager also worked as an employee. The enterprise hires no one.

agglomeration, we need to estimate the share of employment in each education level. However, the lack of education level information in unreported version of 2004 data force us to merge it with reported version of data. It leads to a significant decrease in the number of observations in 2008 from 19,198 in 2004 to 7,537.

4.2 The concentration of production

We now consider the distribution of employment at the district and postcode level. China applies a 6-digit regional code to represent the county area. The district in Tianjin is the same region size as counties belonging to a province (6-digit region code). The complete local authority code contains 12-digit information. The 9-digit local authority code represents the community level of the region size while the 12-digit code represents the street level geographical area. The postcode geographical areas are across 6-digit local authority and 9-digit local authority geographical areas in Tianjin. We use employment to look at the manufacturing distribution of employment to give a comparison of the two area standards.

Tianjin can be generally divided into city centre districts, districts around the city centre (suburb area) and rural areas. In concern of the rapid growth of TEDA and the Duty-Free Trade Zone, the recent established Binhai New Area by combining three counties (Tanggu district, Hangu district and Dagang district) in the coastal regions has become a new economic development centre. After giving a general administration map by using different colour and names of each 9-digit local authority region in figure 3.1 and figure 3.2. We present the distribution of manufacturing employment at 9-digit local authority region level. It is clear to see the highly concentration of employment in part of the around city area and the BinHai New Area in figure 3.3 and figure 3.4.

[Figure 3.1 about here]

[Figure 3.2 about here]

[Figure 3.3 about here]

[Figure 3.4 about here]

[Figure 3.5 about here]

Tanggu district as the main part of the Binhai New Area has the largest share of employment over 5%. Areas with between 3% to 5% employment includes two city centre areas and part of the areas in Xiqing and Dongli district close to them. Heping district has the lowest share of employment at less than 1% apart from other rural areas. In 2008, there is a significant decreasing on the share of employment in the city centre areas but a further increasing on the Binhai New Area. It gives us a first sign that manufacturing is still growing steadily, meanwhile the location of these manufacturing industries has moved from the city centre toward districts around the city and the new economy growth areas nearby. The star on the map give the location area of Economic Development Area where is the location of most FDI in Tianjin. We can see most of these areas have a relatively large share of employment. The importance of FDI on the development of manufacturing in Tianjin is significant.

[Table 3.4 about here]

Table 3.4 introduce a brief description on the main Economic Development Area in Tianjin. TEDA, XEDA and BCEDA are the largest three Economic development area which also give large number of employment on Tangu, Xiqing and Beichen district. Those three districts are also districts with large share of employment in Tianjin. TEDA has maintained its top GDP growth rate position among the fifty-seven national Economic and Technological Development Areas in China for fourteen years. TEDA also has three other semi-areas in Wuqing district, Xiqing district and Hangu district, focusing on high-tech manufacturing industries. Since the establishment of the Binhai

New Area, TEDA, as the cornerstone of the development of the manufacturing industries, has had a closer linkage with the development of the "Top Ten Campaign[42]" and economic technological development areas in Dagang district and Hangu district. The economic development area in Jinnan district also gains from spillover benefits from TEDA through convenient transportation links.

The XEDA (state-level Xiqing Economic-Technological Development Area) is another crucial area to consider. XEDA is located in the Xiqing district in the south of the city centre. Its location is the nearest Economic-Technological Development Area to the city centre. It was the state-level production base of the electronic information industry in 2007 and was upgraded to a state-level Economic-Technological Development Area in 2010. IC (integrated circuit), chip components, monitor and digital home appliance production are the main manufacturing sectors concentrated in this area.

In general, 13 districts have been formed some sort of different level of the economic-technological development area since 1984 and for most of them it is crucial for the manufacturing industry growth of each district. Figures 3.3 and 3.4 both show that the share of employment for those county areas that are Economic-Technological Development Areas tends to be higher than other county areas. Table 3.5 shows that the TEDA, XEDA and Tianjin Wuqing Economic-Technological Development Areas are larger than other areas. Moreover, districts that have a large economic-technological area also have a large share of manufacturing employment.

4.3. Agglomeration at the industry level

Tables 3.5 and 3.6 present measurements of agglomeration calculated for total production activity. We construct measurements at different levels of regional unit. We

[42]The Top Ten Campaigns are the ten big project plans that lead the development of the Binhai New Area. These project include the development of advanced manufacturing industries, Tianjin Free Trade Zone, Tianjin Harbour Economic Area, Tianjin Binhai Hi-tech Industrial Development Area, Tianjin Nangang Industrial Zone, Harbour logistics area, Tianjin Binhai New Area CBD (Central Business District), Sino-Singapore Tianjin Eco-city (SSTEC) and Binhai Tourism Area.

set our level of regional units based on two regional codes: administration code and postcode. To study the changes of degree of agglomeration in Tianjin over time, we give estimations of agglomeration at different region level. To compare the degree of agglomeration in Tianjin with China mainland, we compare results at county level and postcode area level. We provide the results of mainland China from 2003 and 2007 to compare with the results in 2004 and 2008 in Tianjin. Our results indicate that the larger the geographic unit we select, the higher the values of geographic concentration, industrial concentration and γ and γ_{EG} indices.

We find that the industrial concentration index changes from 0.0009 to 0.0014 as a result of increasing on total number of enterprises. Other concentration indices based on community regional level and block regional level increased from 2004 to 2008 in Tianjin. It suggest that growth is of most important on promoting industrial agglomeration We also estimate agglomeration at postcode and county level in China with values much smaller than Tianjin in both tables. However, the locational Gini index value in mainland China is greater than in Tianjin, suggesting that the top three industrial agglomerated regions in Tianjin are less concentrated than the top three most agglomerated regions in China.

[Table 3.5 about here]

[Table 3.6 about here]

To show the trends of agglomeration in Tianjin, we compare the γ together with *G* (geographic concentration) and *H* (Industrial concentration) in 2004 and 2008. The value trends at county and postcode area level is consistent. A rise on G, H and γ values suggest a increasing on industrial agglomeration. However, the decreasing on locational Gini and concentration index value implies the importance of regions with largest share of employment become small over the time.

We calculate our main part of agglomeration at the postcode level. Firstly, the limited number of county area would lead to a extreme large MS index value such as 1 if all firms locate within one county region. It make our study on the pattern of industrial agglomeration very difficult. Secondly, in concern of the value calculation is based on the share of employment, a similar number of regions would technically bring a close value of agglomeration measurements. Imagine Tianjin is a small country with only 6 county regions. The second region level is therefore postcode between county region and local authority region which is the best option to use on make comparisons between Tianjin and China mainland based on the MS index in the next sections. Besides, If we would like to get a close value to make comparison between Tianjin and China mainland based on the MS index. It may also prevent listing those natural advantage based industries on the top agglomerated industries such as fishing or ship building and repair which usually locate along the coastal regions.. Finally, the area of Economic Development Area is overlapped with postcode area and it offer good opportunity for us to estimate the impacts of FDI on agglomeration.

Using the postcode region as the geographic estimator unit, together with four-digit industry codes, Tianjin obtained a gamma value range from -0.016 to 0.85 in 2004 and from -0.029 to 0.84 in 2008. The mean value of γ is 0.068 and the median value is 0.029. In 2008, the mean value fell to 0.059 and a median is 0.024.

Following the classification of the degree of agglomeration (Ellison *et al.*,1997), we conclude that there are 44.09% (168 four-digit industries) industries classified as not very agglomerated, around 19.95% (76 industries) industries defined as somewhat agglomerated, and over 35.96% industries (137 industries) defined as very agglomerated in this region in 2004. After four years, 47.12% (188 four-digit industries) of industries fall into the low degree of concentration range; the moderate concentration group has 20.80% (83 industries) and the share of most agglomerated industries falls to 30.08% (128 industries). We can find that around 45% of the four-digit industries are categorised as not very agglomerated. This proportion is 10% in the US, 50% in France and 65% in the UK. For the somewhat agglomerated class, around 65% of industries for the US, 23% for France and 19% for the UK belongs to this range. Tianjin's proportion is 20%, which is a little larger than the proportion of the UK. The most agglomerated class have a 25% share in the US; 27% in France and 16% UK. Around 30% of the four-digit industries are categorised into this class, which is the region with the largest proportion among the US, the UK and France. However, a different number of industries among different countries and regions and the disaggregated region definition also need to be carefully considered when we attempt to explain these values.

[Figure 3.6 about here]

[Figure 3.7 about here]

[Figure 3.8 about here]

Figure 3.6 to 3.8 show the distribution of geographic concentration across the four-digit industries in 2008[43]. The overall distribution of industrial agglomeration is quite alike in both years. The geographic concentration is less skewed than the industrial concentration which is consistent with finds in overall China mainland and other countries.

[Figure 3.9 about here]

Tables 3.7 list all of the two-digit industries located in Tianjin (column1) in 2008[44] with their un-weighted mean value of gamma at the two-digit industry level. The quartile boundary shows the number of four-digit industries located in each gamma value boundary for each two-digit industry.

[43] The same distribution figures for 2004 is apply in the appendix in figure c.1, figure c.2 and figure c.3. The distribution of industrial concentration is also less skewed in 2004 than in 2008.

[44] See table C.2 in the appendix for 2004.

[Table 3.7 about here]

[Table 3.8 about here]

In table 3.7, most of the unadjusted average γ values have a positive value suggesting the high agglomeration economy in the city. The beverage production (SIC-15) give the highest degree of agglomeration while Natural gas production and supply (SIC-45) have the least degree of agglomeration. Table 3.8 makes a comparison of the un-weighted mean gamma over various two-digit industries during between 2004 and 2008 and shows the changes on number of 4-digit industries and firms within each 2-digit industry. In general, we find fewer than half of the mean value of gamma (13 two-digit industries) increased from 2004 to 2008. More than half the number of two-digit industries have more four-digit industries enter. Those have an decreasing trends on total number of firms are mostly natural resource related industries. Therefore, industry and firm birth phenomenon may have a mixed impacts on the degree of agglomeration.

In general, we can categorise the table into two parts: The industries ranked in the first half became more agglomerated over time. One characteristic is that most of the highly agglomerated two-digit industries are high-tech industries. Such a pattern of manufacturing distribution is different from China mainland. For the second half, those less agglomerated industries become even less agglomerated after four years but most of them have increased their total number of firms although petroleum and natural gas extraction (SIC-7) is a exception. The big change of petroleum and gas extraction is due to the disappearance of a four-digit industry in 2008 with its strong geographic advantage.

Although the highest and lowest degree of agglomeration value is quite extreme, the mean value of MS index in table 3.7 and 3.8 is relative small. The quartile Gamma value distribution of 4-digit industries at each 2-digit industry is very dispersed. Leverage as the top agglomerated industry have 33% 4-digit industry with Gamma value in the top and least agglomerated class. Other most agglomerated industries also have similar pattern on the Gamma value distribution. It is necessary to further investigate the pattern of agglomeration at more detailed industry level.

Tables 3.9 list the twenty most agglomerated four-digit industries in 2008[45]. Column 2 gives the number of firms in each industry. The agglomeration measures together with *G* and *H* reflect the agglomeration, geographic concentration and industrial concentration estimates. All the industries display higher geographic concentration relative to the distribution of employment measured by industrial concentration. Enamel products for industry production (SIC-3471) with both high geographic concentration and industrial concentration appear in the top twenty most agglomerated industries. On the other hand, flower painting handicraft manufacturing (SIC-4214) have the lowest industrial concentration measures but still have relatively high geographic concentrations (G>0.4). Home video equipment manufacturing (SIC-4070) and some other high-tech industries are also found in the table.

[Table 3.9 about here]

To summarise, the degree of agglomeration in Tianjin has experienced an increasing at aggregated level. However, the degree of agglomeration within each 2-digit industry may varied significantly. There are five four-digit industries that appear as the twenty most agglomerated industries in both years reflecting a big change on the top agglomerated industries over time. Another observable characteristic is that more high-tech industries have joined in the twenty most agglomerated industries list in 2008

To examine the impacts of FDI on agglomeration, tables 4.10 further exhibits the most agglomerated four-digit industries in 2008 by region[46]. Columns 2 and 3 give the postcode regions with the largest and second largest proportion of employees for each

[45] See table C.3. in the appendix for 2004 results.
[46] See table C.4 in the appendix for 2004 results.

industry. The percentage of employment in each postcode in columns 4 and 5 give the proportion of employment located in the top and second postcode region. Columns 6 gives the total number of firms for each industry. Column 7 and 8 calculate the proportion of firms located in the top and second postcode regions. The last two columns compare the firm size between firms located in the top postcode region and the others using the proportion of employees.

[Table 3.10 about here]

The proportion of industry employment in the top postcode area ranges from 95.5% in the most agglomerated industry –Tea and other soft drinks manufacturing – to 51.9 % in Manufacturing of household electrical appliances parts. Only a small proportion of employment locates in the second regions. It implies the strong impact of geographic concentration on industrial agglomeration in Tianjin.

On the other hand, although the range of number of firms is similar from 91% (Flower painting handicraft manufacturing) to 11.5% (Biscuits and other baked goods), the share of number of firms located in the top regions is much smaller. The average firm size in the top regions and other regions also have large gap except manufacturing of household electrical appliances parts and flower painting handicraft manufacturing. Firms locate in the top regions is much larger than the average standard of other regions. The positive impacts of firm size on agglomeration is clear.

Therefore, there are two types of industry distribution patterns for the top twenty agglomerated industries. Most industries have both a high proportion of employment and the numbers of firms in the top postcode area. The second pattern is industries with a high proportion of employment but the firm size is relatively small in the top postcode area than in the other areas. For those industries with a high proportion of employment and high proportion of firms in the top postcode area, the difference between firm size in the top postcode area and the others is not that large.

Apart from natural advantage lead industry, high-tech industries are not only in the top twenty most agglomerated industries but also appear in both 2004 and 2008. Those industries are mostly concentrated in TEDA and industry park in the around city centre areas. The example can be clocks and timekeeping instruments manufacturing (4130), as the traditional manufacturing industry in Tianjin with its famous cornerstone brand name "Sea-gull", is agglomerated in the Nankai district and has a dominant proportion of employment. Other newly joined high-tech industries includes electricity, communication parts and computer parts (SIC-4013, SIC-4052, SIC-4041). The pattern of these industries are with large firm size and highly geographical concentrated.

To summarise the distribution of the most agglomerated industries at the district level, we match the postcode areas that appear with the districts they belong to that. In 2008, there were six industries concentrated in TEDA. Another six industries were agglomerated in the districts around the city centre. Three industries concentrated in the Hexi district and Nankai district. The rest were distributed in the rural districts. More industries located in TEDA became more agglomerated industries while those industries located around the city centre became less most agglomerated in 2008[47]. In general, the TEDA and areas around the city centre are the two areas that tend to be the most agglomerated. This is consistent with the previous information in the introduction that TEDA and around city centre area have largest share of employment.

The city pattern in Tianjin is a typical example of spatial equilibrium. The manufacturing industries are clustered in and around city areas in order to minimise transport costs from city centre districts and around city districts. Glaeser and Kohlhase (2004) demonstrate that there is a 90% reduction in transport costs to move a mile by railroad. The establishment of a satellite town in the Binhai New Area has become another economic growth centre. The geographic advantage of the Binhai New Area, which has close connections with Japan, South Korea, Singapore and other countries through

[47] See table C.4 in the appendix.

waterway, also promotes its FDI activities.

Due to pollution and environment protections policy, those natural resource extractions and related industries has gradually vanished. Such a change gave the chance for Tianjin to develop high-tech industries and they have become more agglomerated in the economic development zone by introducing FDI.

5. The dynamics of agglomeration

5.1 Geographic distribution of unmatched firms

Tables B1 and B2 in the appendix provide all of the 4-digit industries that have been dropped from the previous dataset and the number of enterprises in 2004 and 2008. Two reasons explain the decline in sample size. From tables A1 and A2, we can see most of the industries have fewer than five enterprises. The disappearance and emergence of some industries over the period leads to an industry being dropped if it appears in only one year. Furthermore, we also merge the geographic area and keep those regions that have manufacturing activities in both years. We also dropped an industry with a small number of enterprises and some of them locate in geographic regions that have manufacturing activity for only one year. In this section, we give the geographic distribution of those firms by the proportion of employment. We have dropped 3911 firms in 2004 and 4571 firms in 2008.

[Figure 3.9 about here]

[Figure 3.10 about here]

From figures 3.9 and 3.10, we can see that those dropped firms appear in the city centre, districts around the city, Tanggu district and other rural regions. In general, those regions do not change much in both years. From our micro-level data, we have only 11% firms established in 2004 while 33% firms established until 2008. The recent established firms are more geographical concentrated in some regions while dropped firms in 2004 can be found in a broader areas. Table B3 in the appendix also provides the industrial agglomeration value based on estimators applied in previous. Most of them are less agglomerated or natural resource-based industries with a small number of firms. The future study can be looking at the dynamics or the birth and death effects of industrial agglomeration by using a longer panel data.

5.2 Changes in the most agglomerated industries

Every industry has a life cycle and it is important to notice which industries are expecting to grow in the future. Table 3.11 shows the top twenty most agglomerated industries which have great potential to expand and the geographic distribution of the new entries in the same ranking as table 3.9[48]. In column 2, we first list the number of entrants for each four-digit industry from 2004 to 2008. Since agglomerated industries must also be geographically concentrated, we give the proportion of new entrants located in the top most agglomerated postcode regions in column 3. We also measure the geographic concentration and agglomeration of the most agglomerated industries based on their new entrants only.

[Table 3.11 about here]

The numbers of new entries varied due to industry characteristics. For example, flower painting and handicraft manufacturing (SIC-4214) has the largest number of new entrants during these five years because the industry mainly relies on the traditional skills of handmade crafts, which tend to be highly localised. The share of new entrants located in the most agglomerated postcode areas are also significantly different when making comparison among different industries. For those industries with new entrants located in the top postcode area over 40%, communication terminal equipment (SIC-4013), as the most recent high-tech industry, was localised in the Hexi district, which is in the city centre,

[48] Figure C.4 to C.43 also provide the top and second most agglomerated location for top twenty most agglomerated industries in both years.

whilst new entrants are more likely to be located in postcode 300384 – in the XEDA.

Five years is the usual time period for the announcement of a government preferential policy and the entry of firms that wish to benefit from such policies. The growth of communication terminal equipment is an example with relatively high geographic concentration and agglomeration measures for the new entrants. Although most of the new firms in tea and other soft drinks manufacturing (SIC-1539) are located in the top postcode area and close by, the negative value of γ demonstrates that industrial concentration is the main factor in explaining the large share of employment that is located in the top postcode area rather than the number of firms located in this area. If we consider the result of those industries that have a negative value of γ in column 6 in table 3.13, we can find that those industries have a very low new entrants ratio of new entrants' locating in the top agglomerated postcode area. Semiconductor discrete device manufacturing (SIC-4052) is another interesting example that, although it has a high geographic concentration measure, has a low agglomeration value. The top postcode is 300384, which is located in XEDA. It shows that industry new entrants reinforce the geographic mobility in the city.

To summarise, the effect on industry agglomeration made by new entries is mixed. Those with a relatively high proportion of new firms prefer to locate in the top postcode and hence reinforce the existing agglomeration with high measures of geographic concentration and agglomeration. Although some new entrants locate in the top postcode area, the birth of new firms leads to the development of these industries in new areas. Tea and other soft drinks manufacturing (SIC-1539) and home audio equipment manufacturing (SIC-4072) are examples. Finally, the traditional localised postcode area is no long attractive to the new entrants and other postcode areas, becoming the agglomerated areas. Another shining example is two regions become the new agglomeration area: XEDA and postcode area 301700 (301701) in Wuqing district. High-tech industries agglomerated in XEDA while traditional handicraft, food are concentrated in 301700(301701) postcode area (Wuqing district) implying the regional different pattern of industrial agglomeration. Low-tech industries are gradually clear out from the city while some high-tech industries were born in Tianjin during our sample period[49].

6. The determinants of agglomeration

From previous study, it is clear to show that most agglomerated industries in Tianjin is usually with large firm size and close to FDI. In order to examine the impacts of ownership, firm size and firm age on the magnitude of industrial agglomeration. We provide pooled OLS and fixed-effect regressions at the 4-digit industry level and examine the coefficients between the magnitude of agglomeration and ownership in 2004 and 2008. We only keep 4-digit industries appears on both years to investigate the coefficients of value difference between two years. Other indicators are also considered in the pooled regressions. We estimate that the value of the MS index at the county (6-digit), local authority area (9-digit) and postcode region levels and classify the type of plant based on the type of registration, which in turn is based on the percentage of capital. In general, we can categories firms into SOEs, domestic private and foreign (including multinational firms from Hong Kong, Taiwan, Macau and other foreign countries).

Table 3.12 give the calculation of indicators and summary of these variables we applied in the regressions. The average firm size is given by total income over total number of firms within a industry. The average firm age is given by the difference between data collection year and the average established year of an industry. Table 3.13 provide the correlations between variables we applied in the regression. Firstly, firms in Tianjin are very large and young. Secondly, industries have a strong ownership bias.

[Table 3.12 about here]

[Table 3.13 about here]

[49] See 4-digit industries exit after 2004 in table C.5 in the appendix.

Table 3.14 to 3.16 provide the regression results by different ownership together with firm size and firm age. The robustness results show a positive impact of firm size on agglomeration in column 3 and 4. From the positive and significant coefficient on the changed value regression at 9-digit local authority and postcode area level, it also show that an increasing on firm size would bolster industrial agglomeration over time in Tianjin.

[Table 3.14 about here]

[Table 3.15 about here]

[Table 3.16 about here]

Firms ownership are usually found have a significant impacts at 9-digit local authority level for domestic and foreign firms. Industry with higher domestic firms are tend to be less agglomerated while foreign firm dominated industry have a positive impacts on agglomeration. However, SOEs have no significant impacts in all regressions in table 3.14. This is opposite with previous findings in China mainland and also maintain our previous study in statistics. The firm age is currently have no significant impacts on agglomeration. In summary, the impacts of ownership and firm size on the magnitude of agglomeration is often happens at 9-digit local authority level. The pooled OLS show a significant evidence that ownership and firm size affect the agglomeration in Tianjin. However, the results of industry fixed effect (at 2-digit industry level) and regression of value changes is much weaker. Future analysis could link the pattern of agglomeration with export information to examine the TFP of firms in different ownership and its impacts on agglomeration.

7. The role of technology

There are 31 4-digit high-tech industries in Tianjin and most of them belong to the communications equipment, computers and other electronic equipment manufacturing sector (SIC-40), with 62% and 79% share of employment belonging to foreign enterprises in 2004 and 2008 respectively, and instrumentation and culture and office machinery manufacturing (SIC-41) with 72% and 63% share of employment belonging to domestic private enterprise in 2004 and 2008. The opposite impact of domestic private and foreign enterprise on agglomeration means that such entities' impact on high-tech industries is mixed. We therefore use the proportioning of different levels of education among employees in different industries to study the impacts of technology or education level on agglomeration. Our census data classifies an employees' level of education into different strata: those having obtained an M.A. or above (postgraduate degree); those having obtained a B.A. (undergraduate degree);those having completed a three-year college education; high-school education; junior high school education; oran education year above five class. We aggregate employees who is at the M.A., B.A. and three-year college education levels into a 'high education' level employee, those who received high-school education into 'medium education' level employee, and the rest into 'low education' level employee.

[Table 3.17 about here]

Tables 3.17 give the pooled OLS and industry fixed effect regressions. Although our regressions have the same sign at different region level, there is still weak evidence to show education level's impacts on agglomeration. In general, the medium-educated group have negative impacts on agglomeration at county level in the pooled OLS and at postcode level in the industry fixed effects result. The low education group have a positive coefficient with agglomeration which is consistent with other previous works. The possible reason could be the mixed effect given by domestic and foreign dominated high-tech industries on agglomeration. Due to limited data, we didn't observe any significant impacts over time for education level. We need examine the dynamics of impacts of education on agglomeration in the future.

8. Conclusion

Our ideal core-periphery and transaction costs lead geographic distribution in Tianjin has constructed a different pattern of industrial agglomeration pattern of industrial agglomeration compared with the whole of China. In general, we find some evidence of high technology level and productivity in Tianjin through looking at the most agglomerated industries compared with the results for China. The statistical analysis on the overall distribution of employment shows that the Binhai New Area and districts around the city centre area have a larger proportion of numbers of workers. Meanwhile, a large number of employees still keeps moving from the city centre to two manufacturing centres.

The manufacturing industry becomes more agglomerated at all region levels and its constant arise of industrial agglomeration is driven by increasing on industrial geographic concentration and the birth of new firms. The degree of agglomeration for each 4-digit industries within a 2-digit industry can be quite mixed and it leads to small value on the un-weighted MS index at 2-digit industry level. Natural resource extractions is gradually diminishing in Tianjin together with decreasing of degree of agglomeration. Apart from some traditional industries and labour intensive industries, there are more and more high-tech industries appear as the top agglomerated industries in Tianjin as time goes. FDI has play an very important role on bolstering industrial agglomeration by locating concentrated in the industry park or Economic and technology development Area. The top agglomerated industries maintain their high degree of agglomeration by giving a number of new firms concentrated in new agglomerated regions.

Our regression results provide more or less evidence on the positive impacts of firm size on agglomeration and the importance of FDI on agglomeration. However, We only have a weak evidence on the negative impacts of education level on agglomeration by using share of employment having different education levels.

Our future analysis can go to several directions. Firstly, we could use distance estimation to examine our findings on the pattern of agglomeration. Secondly, in concern of the strong export motivation of highly clustered industries in southern China, the coefficients between FDI and export is vital on study the reasons behind agglomeration in China. Finally, in concern of the high-tech industry clustering in Tianjin, we need to examine the productivity of those industries and its linkage with local research institutes

Chapter 5

The location of firms and the impact of typhoons on the performance of manufacturing firms in the coastal regions of China

Abstract

We use rich firm level data to examine the impacts of typhoon on local economic activity and the process of economic recovery in China coastal regions. To capture the damages from an individual typhoon we use historical typhoon track data in conjunction with a detailed wind-field model. We then combine our damage proxy with the detailed geo-coding information of each individual firm to construct a panel data that allows us to estimate the impact of typhoons accurately. Our results show that typhoons have a negative and significant impact lagged one year time at maximum on TFP (total factor production). Such negative and significant impact has also been found on the output, intermediate inputs, revenue and value-added in the current year and one-year lagged suggesting that typhoon may badly damage the economic performance of individual firm in the year that typhoon happens and year follows. The annual damage value reduction is at ten million RMB level from our sample time period (2000-2006). The typhoon landing also leads to increase on current liabilities together with inventory, wage and employment welfare reduction in two-years time. It suggests that firms maintain their business by borrowing more funds and selling their finished products made before the typhoon landing. The stronger co-efficient value, in general, suggesting that the damage suffering typhoon at wind speed 278km/h is more severe than at wind speed 203km/h. However, the typhoon only have a negative and significant impact on import and export value in the year of occurrence.

Keyword: China coastal regions, Typhoons, wind field model, economic impact

1. Introduction

Benson *et al.* (2004) define a natural disaster as "... *the occurrence of an abnormal or infrequent hazard that affects vulnerable communities or geographical areas, causing substantial damage, disruption, and perhaps causalities and perhaps leaving the affected communities unable to function normally*".

Natural disasters have attracted the interest of researchers and policymakers for many years. More recently increasing attention is being paid to the impact of natural disasters on the natural environment, infrastructure, individual firms and the populations in affected areas (Barro, 2009 and De Melo *et al.*, 2011).[50] In a recent study that examines the predictions of climate change models it is argued that climate change will lead to more frequent and extreme weather events (Parry *et al.*, 2007). Certainly in the last 30 years the estimated physical damage from natural disasters is estimated to be US $2.7 billion annually with direct physical damage from natural disasters estimated to be US $1,527.6 billion between 1975 and 2008 according to UNISDR in 2009 (Neumeyer and Barthel, 2011). More recently, the tsunami that followed the earthquake at Fukushima in Japan in 2011 provides a good indication of the damage that can occur following a natural disaster including the environmental disaster as a result of the nuclear disaster at the Fukushima nuclear plant and the forced relocation of thousands of people.

However, research into the economic impact and consequence of natural disasters remains relatively limited and is primarily restricted to studies that examine disasters at the macro level (see e.g. Loayza *et al.*, 2009; Hochrainer, 2009; Hallegatte and Dumas, 2009; Noy, 2009; Strobl, 2011; Ahlerup, 2013 and Fomby *et al.*, 2013). The empirical results are fairly mixed with some finding positive, some negative and some finding no discernible impact on economic activity from natural disasters. One explanation for this lack of robust findings in empirical studies is how physical damage is measured. In the macro studies 12 out of14 of the main articles that examine the economic impact of natural disasters use the EM-DAT database. Of the 369 points estimates in those 14 studies, 35% show a statistically insignificance result at 10% level. Of the statistical significant results, 44% are positive (Felbermayr and Groschl, 2013).

Another difficulty with measuring natural disaster damage is that using a direct measure captures only the direct impact of the natural disasterand is not able to distinguish between damage to buildings, crops and industry (Cavallo and Noy, 2011).[51] Pelling *et al.* (2002) and ECLAC (2003) classify the potentially more important indirect damage indicators to economic activity. Cavallo *et al.* (2011) introduce indirect costs or damage

[50] Natural disasters are mainly geophysical which includes earthquakes, tsunamis and volcanic eruptions; biological including epidemics and insect infestations and hydro-meteorological which includes hurricanes and typhoons, floods, tidal waves, droughts, landslides and avalanches.
[51] Cavallo and Noy (2011) investigate the determinants of the direct effects of natural disasters and a distinction is made between short-term and longer term indirect effects.

that includes lost production due to disasters, the lost output from resources diverted from production to reconstruction and the costs of using inferior infrastructure, production techniques or distribution channels. Accordingly, although these indicators are hard to find, they may be not necessarily be linearly related to the extent of direct losses (Hallgate and Przyluski 2010). A second technical problem is due to geographical area that natural disasters affect. For example, Bouwer (2011) states that "... *scale of analysis is also an issue, because aggregating to the regional or global level may have the advantage that local variability is eliminated, but one could fail to see trends [...] that may vary per location in sign and magnitude*" (pg. 43). Strobl (2011) provides evidence on hurricane damage using US county data and finds that hurricanes have an annual negative impact at the county level but have no effect at the state or national level. This suggests that it is important to examine the impact of Hurricanes at as low a geographical level of aggregation as possible.

In this Chapter we use firm-level data for China to measure the impact of the typhoons that hit China's coastal regions between 2000 and 2006. To the best of our knowledge there have not been a similar firm level analysis undertaken of this sort. Our main contribution is to use detailed firm level geo-coded data building on the location and co-location results in the previous chapters of this thesis. Second, we use climatic data, storm surge modelling and a wind-field model to estimate the damage of each typhoon on an individual firm to estimate the impact each typhoon had on firm performance and hence economic activity more generally. Third, this is one of the first studies to examine the impact of typhoons on the Chinese economy hence contributing to the firm heterogeneity literature and urban economics literature.

China as the second largest world economy has over 80% of its manufacturing enterprises located in just 11 of the 31 provinces that are considered to be coastal regions according to statistics of CASIF data (China Annual Survey of Industry Firms). In addition, most of the export-oriented manufacturing firms, especially foreign enterprises are also located within these coastal provinces. Hence, if a natural disaster were to hit a coastal region it is not surprising that the result could be considerable damage to China's economy which in turn, given the prevalence of the global value chain, to knock on effects for the rest of the world. The specific approach in this chapter is to conduct an econometric analysis that combines historical and simulated typhoon track data with a firm level measure of total factor productivity (TFP) where each firm is accurately geographically located using the longitude and latitude of each firm to pinpoint the exact location of each firm. To our best knowledge, this is the first study to use this method and certainly the first for China.

More specifically, in this chapter we undertake the following. First, to overcome the difficulties associated with the use of aggregate data discussed above and the uncertainties involved in estimating both direct and in particular indirect costs we take an alternative approach to the existing macroeconomic literature by using time-varying estimates of TFP for each firm. We use TFP as a proxy for economic activity and is really a measure of the net effect of the damage caused by a typhoon as we are able to take into account any re-started production within the affected area.

Second, to capture the damage from an individual typhoon we employ of a wind-field model of historic typhoon tracks which enables us to calculate the severity of any single typhoon for any given region. In contrast to the previous literature that assumes all the damage from tropical storms is derived from wind speed, we also generate measures that isolate areas where storm surges are more likely to occur (McGranahan *et al.*, 2007 and Brecht *et al.*, 2012). Other indicators that we also employ include rainfall and temperature.

Third, our choice of China is motivated for a number of reasons in addition to the fact that this paper represents a natural progression from the previous chapters of this thesis. First, China has a long coast line which gives a good sample of natural disasters which is especially important given our relatively short time period. Tropical cyclones are also known to have caused considerable damage to China's economy in the past. Second, the clustering of firms and sectors in the coastal areas of China as shown in the previous chapters of this thesis and the migration patterns of rural urban migration means that the coastal provinces of China have an increase in the concentration of economic activity and hence there is an increase in the risk faced by China if a natural disaster were to strike a given region. The growing insurance market in China is also keen to understand the risk and the costs associated with typhoons (Freeman *et al.*, 2003; Ward *et al.*, 2008 and Neumayer and Barthel, 2011). Finally, although the science is currently inconclusive as to whether global warming will lead to more numerous and more intense typhoons in the future (Webster *et al.*, 2005; Landsea *et al.* 2006; Elsner *et al.* 2008 and Li *et al*. 2010) it is still important that policymakers have a better understanding on the impacts of typhoons and the associated economic costs.

The chapter is organized as followed: section 1 briefly outlines the typhoons that have main landfall in China in recent years. Section 2 provides a detailed description on our data and methodological approach. Section 3 present our econometric results and the final section discusses the implications for policymakers and concludes.

2. Typhoons in China

There are a few numbers of empirical studies of the impact of hurricanes and tornados on the American side of the Asia-pacific (Hsiang, 2010; Strobl, 2011 and Strobl, 2012). However, few studies focus on the southern hemisphere counterpart to hurricanes which are called typhoons and even fewer focus on the impact of typhoons on China. It does not imply that typhoon have less impact. Liu *et al.* (2001) and Louie and Liu (2003) summarize the typhoons that made landfall in Guangdong province using data that goes back 1000 years using early typhoon records. More recently, Zhong *et al.* (2010)note that on average 7 out of the 34 typhoons that occur make landfall in the north-western pacific area each year. Fogerty (2004) also notes that 42% of tropical cyclones become typhoon strength and make landfall in China provinces. China's official records show annual damages of 34.7 billion RMB (US $5.57 billion) in the average year between 1985 and 2007.

To illustrate the destructive power of a typhoon we provide a brief description of typhoon Soamai which hit the southern part of China in 2006. With a centre wind speed 60km/s, typhoon Soamai made landfall at Cangnan County in Zhejiang province on the10thAugust and also caused considerable damage in Zhejiang and Fujian provinces. Damage included the loss of thousands of fishing boats, large numbers killed (missing), power cuts to six cities and up to 1.7 million people displaced. According to a Munich RE estimation, the insurable losses were around 400 million RMB (US $ 64.23 million in 2014 exchange rates). The total costs reported by the Chinese government were around 11.3 billion RMB (US $1.4billion). Typhoon Soamai therefore surpassed typhoon Rananim in 2004 and typhoon Khanun (Kiko) in 2005 and was also stronger than hurricane Katrina that hit Louisiana in the US in August 2005. Typhoon Soamai was therefore the most powerful and destructive typhoon to hit China in a hundred years.

3. Data Description

After the year 2000 China suffered more typhoons than in the 1990s and these disasters lead to considerable economic costs. Our econometric analysis on the impact of typhoons on enterprise performance is only possible because we were able to merge three databases on the location of enterprises, measure of typhoon damage and firm performance measuring including productivity. We capture the economic activity of a firm using TFP, wages, the number of employees and the value of output. We measure the damage from a typhoon proxied by wind speed, annual rain fall and average temperatures between 2000 and 2006.The following sub-sections describe in detail how we constructed these indicators.

3.1. Geographic region

Given the regions we focus on are areas that are frequently exposed to typhoon hits, we focus on 60 county areas that are located within 50km of the shoreline in China. The major coastal cities within these areas include Shanghai, Tianjin, Guangzhou, Dalian City (Liaoning Province), Qingdao (Shandong Province), Ningbo City (Zhejiang Province) and Fuzhou City (Fujian Province).[52]

[Figure 4.1 about here]

The darker areas of the map are the coastal regions that are most frequently affected by typhoons and related natural disasters. Figure 4.1 show that the area of these regions is much smaller than the larger geographical area of China. However, in terms of the density of production and GDP per capita these values are much higher than the average in China. In 2006 in terms of the number of manufacturing employees, total input, total output, total assets, total income and the number of 4-digit industries, the coastal regions

[52] In 2007 China had 656 recorded urban cities. This was slightly below the 2006 number as five cities were absorbed into nearby bigger cities (Urban Development Report of China). Of these cities 45 had a population in 2007 of above one million people and 286 cities had a population below 200,000. By 2025 it is predicted that China will have 221 urban cities with populations greater than one million people compared to just 35 in Europe (McKinsey, 2009).

which have just 10% of China's physical area have around22.3% of total manufacturing employment, 29% outputs and 25% total assets, 27% total income, and 419 out of 513 4-digit manufacturing industries are located in this area (see Table 4.1). If we consider the share of GDP, coastal regions have an even larger proportion which shows the importance of the coastal regions to the Chinese economy.

[Table 4.1 about here]

The frequency of the typhoons that occur in each coastal region may also be different, hence the potential damage that could occur is a typhoon hit a coastal region. Table 4.2 presents the distribution of manufacturing enterprises in China's coastal regions. Zhejiang, Fujian, Guangdong, Shanghai and Hainan who historically have frequently been hit by typhoons and are located in the southern area of China had 62% of total manufacturing employment between 2000 and 2006.

[Table 4.2 about here]

3.2. Economic performance

In this section we describe how we merge our geo-coding information with our economic indicators based on the CASIF and CCTS data (Chinese custom trade data). The China Annual Survey of Industrial Firms (CASIF) issued by the National Bureau of Statistics of China (NBSC) is a widely used firm-level dataset which provides basic firm information including firm id (given by NBSC), firm name (in Chinese), firm's address (in Chinese), firm's contact number (telephone number) and contact person (legal person), year of establishment, a 4-digit industry classification (Standard Industry Classification-SIC) and a 6-digit administrative code and postcode. Economic indicators includes total output, wages, intermediate inputs, new product values, total capital and capital share by ownership, number of employees and export value. The Chinese custom trade statistics (CCTS) is a trade data that provides import/export records for each year. Indicators include quantity, value, number of products and shipping destination. We first aggregate each trade activity record at the firm level and then combine this customs data with the industry data. Since the CCTS data time period is from 2000 to 2006 and CASIF data has longer time period that covers the CCTS data time period, our sample period is for the years 2000 to 2006.

In the construction of our final dataset some basic data cleaning was necessary before we merged the two datasets. First, we keep those firms with total capital and output greater than zero and8or more employees. We also drop those firms with negative values for intermediate inputs, new product value, and capital by ownership and export value. Since we only focus on the manufacturing industries, we only keep industries with SIC codes between 1310 and 4229. The SIC was discontinued by the NBS at the end of 2002. Hence, we therefore follow Brandt *et al.* (2012) and concord the 4-digit industry codes prior to 2002 with the new 4-digit industry codes so they are consistent across our time period.

To measure the impact of typhoons on firm performance we need to measure TFP, output and the number of employees as our left hand side variables together with other control variables including the typhoon indicators on the right-hand side of the regressions. We merge the industry data with the custom trade data using a three stage process. The CASIF data only includes firms with over 5 million RMB in each year and all the State-owned enterprises (SOEs) while the CCTS data includes all firms have trade activities. Since firms that have trade activities are relatively small and both data use a different firm coding system to identify enterprises, it means we lose a number of observations in the merge process. In order to maximize our sample size we merge the data using three steps. First, we merge both datasets using the precise firm name given in both data. Second, we merge the rest of observations using firm's last 7-digit contact number with contact person information. The last 7-digit telephone shows the region number so that we know whether a firm moves to another region. This enables us to track firms over time that is still owned by the same boss but move location (perhaps in response to a typhoon). Finally, we merge the remaining observations using the complete telephone number with postcode. This enables us to yet again track firms that changed their contact person or boss but still stayed in the same region. After completion of this process our final merged dataset includes 35% of the CASIF data and 20% of CCTS data. Each observation then has a unique firm id across time. We deflate all input and output variables using input/output deflator for 2000.

3.3. The location of production units

Wind speed is the key indicator that determines the strength of a typhoon. The higher the speed, the closer the core of typhoon. Hence, our measure of the damage caused to a production unit when a typhoon hits is the distance between the core of typhoon and the production unit. We first locate the enterprise geographically by using longitude and latitude based on enterprises' address information from CASIF. We then a Python coded routine to conduct an automatic geo-coding search which follows the method used in traditional geo-coding search engines (e.g. google maps). The accuracy of the geo-coding exercise depends on having detailed address information which the CASIF data provide. This includes the province, city, county, street name and door number of each enterprise. However, two issues make data cleaning difficult. First, some firms may lack address information for some years but have more comprehensive data for other years. This leads to missing data in certain years even though firms still exist and are located in the same place. Second, the data for each year may vary with the degree of address information accuracy which leads to an enterprise being geo-coded in two places when it should only be one. For example, data in 2005 may give a firm's province, city and county but no street or door number. In the following year the same firm may have comprehensive address information which now provides us with precise geo-coding information. To solve this address issue we apply a geo-coding harmonization procedure to ensure that our geo-coding information is the same and consistent over our time period.

To do this we first searched for the geo-coding information of each firm using each year's address information even if it was not comprehensive. We then dropped those firms who appear only once without valid geo-coding information and/or firms that appears several time but have different region code information (6-digit county code and postcode) with other years. For enterprises with missing geo-coding information but that still have the same region code in other years we coordinate their geo-coding information if the address is in Chinese and is at the same at broad region level.

Second, the vast majority of enterprises appear to prefer to stay in coastal regions rather than re-locate in land. Less than 1% of firms moved more than once according to 6-digit region borders and at the postcode level. We therefore harmonize each firm's geo-coding based on the assumption that firms did not move if they have very similar raw geo-coding information across time. To ensure enterprises have as precise geo-coding as possible, we use the year data with the best address information as the benchmark to harmonize each firm's geo-coded position for the other years. In general, the later years' data quality is better than in the earlier years and 2004 has the highest quality address information as it is reported for information at the region level is provided in a separate column in the raw data.[53] Therefore, we replace other years' geo-coded location with the 2004 information if the distance between benchmark location and current year's location is less than 1km according to geo-coding distance calculation. The benchmark years are as follows, 2004-2006, 2000 and finally 2003-2001.

However, following this process there remains a further difficulty. This is when a firm's final geo-coded location fluctuates between several locations. For example, according to our harmonized geo-coding a firm may move to another location in 2002 and move back in 2004 but the region code and other broad address information remains the same during the time period. In these cases we harmonize the firms' geo-coded location by replacing the raw geo-coding into the benchmark year's geo-coding if the share of harmonized geo-coding is over 50% and region code is consistence for all years that a firm appears in the data.[54] After this second cleaning process, 92% observations have less than two geo-coded locations (one explanation might be that some firms share the same firm ID but might have different locations). In these cases we keep the original geo-coded location as the final location for the other observations.

3.4. Typhoon track data

Typhoons are defined as tropical cyclones in the western North Pacific (NWP) that maintain a maximum wind speed for one minute of 33 ms^{-1}or over. At lower speeds a typhoon is more accurately called a tropical cyclone (where the wind circulates counter-clockwise in direction). Tropical cyclones tend to from over warm oceans when the surface temperature exceeds 26.5 degrees C. This is the reason why El Nino events

[53] We examine data quality by looking at the geo-coding information to obtain the ratio and length of the address. We find 2004 has the highest quality address information and 45% of total observations can be harmonized using 2004 as the benchmark. Overall, 92% of observations that have geo-coding information have been harmonized by using the higher quality years (2004-2006 and 2000).

[54] Such fluctuations may also due to errors in the region code information in the raw data.

tend to be associated with greater typhoon activity.[55]

The source of our typhoon track data is the Regional Specialized Meteorological Centre (RSMC) Best Track Data. Since 1951 the RSMC has provided six hourly data on all tropical cyclones in the West Pacific that have a maximum sustained wind speed of 28 knots (near gale) or higher. Other information provided in the RMSC data includes the position of the eye of the storm, the central pressure and the maximum wind speed. We linearly interpolate these to three hourly positions. Importantly for this chapter we restrict the number of storms in our data to those storms that achieved at least typhoon strength at some stage and came within 500km of the coast of China. One reason for the distance rule is that tropical cyclones rarely exceed 1000km in diameter. Figure 4.2 and Table 4.3 presents the tracks of all the qualifying tropical storms in our sample period 2000 to 2006 where the red portion of the tracks refers to that part of the storm that reached typhoon strength and Table 4.3 lists the main typhoons to make landfall, the year and the main province impacted. Our data reveal that a total of 27 typhoon strength storms traversed the area during the time period 2000-2006. The strongest, measured in terms of maximum wind speed was the previously mentioned typhoon Saomai that main landfall in 2006 and reached a maximum wind speed of 216km/hr. As shown in figure 4.2 it is mostly the southern coastal areas that are affected by typhoons, at least over our sample period. In figure 4.3 we show all the storms even if they did not reach typhoon strength.

[Figure 4.2 and Figure 4.3 about here]

[Table 4.3 about here]

4. Wind Field Modelling

4.1. Wind Speed Function

When we try to measure the impact of a typhoon on a firm the level of wind a particular location or firm experiences during a passing typhoon depends crucially on that firm's

[55] See Emanuel (2005) for an explanation of the history and science behind hurricanes and typhoons.

position relative to the storm as well as the movement of the storm and other salient features. Thus, to properly assess the damage to a firm due to typhoon means that we need explicit wind field modelling. To calculate the wind speed experienced by a firm due to the impact of a given typhoon we take the Holland (1980) wind field model and then use a version of this given in Boose *et al.* (2004).This model is also used in Strobl (2012) and this explanation and use of subscripts follows the exposition given in that paper. Specifically, the wind experienced at time *t* due to typhoon *j* at any point$P = i$, i.e.,V_{ijt}, is given by:

$$V_{ijt} = GF\left[V_{m,jt} - S\left(1 - SIN\left(T_{ijt}\right)\right)\frac{V_{h,jt}}{2}\right]\left[\left(\frac{R_{m,j,t}}{R_{it}}\right)^{B_{jt}} exp\left(1 - \left[\frac{R_{m,j,t}}{R_{it}}\right]^{B_{jt}}\right)\right]^{\frac{1}{2}} (1)$$

In equation (1) V_m is the maximum sustained wind velocity anywhere in the typhoon. *T* is the clockwise angle between the forward path of the typhoon and a radial line from the centre to the point of interest (firm location in this case),$P = i$, V_b is the forward velocity of the hurricane, R_m is the radius of maximum winds, R is the radial distance from the centre of the hurricane to point P. The relationship between these parameters and point P=*i* is presented in Figure 4.4 which as an example is Typhoon Saomai discussed earlier. The remaining parameters are the gust factor G and three scaling parameters F (surface friction), S (asymmetry as a result of the forward motion of the storm), and B (the shape of the wind profile curve).

[Figure 4.4 about here]

To implement equation (1) we need to observe that $V_m$is given by the storm track data, $V_h$which can be calculated directly by following the movement of the storm between locations. Hence, R and T can then be calculated relative to the point of interest P=*i*. In the case of the other parameters in equation (1) we need to rely on estimates or the values are assumed. For example, there is no information on the gust wind factor G. Hence, we need to take examine previous estimates of G such as that given by Paulsen and Schroeder, 2005 who measured it explicitly and came to a value that was around 1.5 which is subsequently the value that we assume in this chapter. Likewise, we have no information on the value of surface friction which would allow us to obtain a value for F. Similarly, we refer to the existing literature and look at a review of tropical storm hazard modelling written by Vickery *et al.* (2009) who suggest the reduction factor in open water was around 0.7. This translates into a reduction of about 14% on the coast and 28% 50km inland. We follow the literature and assume a reduction factor that linearly decreases within this range as the points *i* move further into inland China. To find a value of S we follow Boose *et al.* (2004) who calculated S to be around 1.

Finally, Vickery and Wadhera (2008) argue that the radial pressure profile parameter B and the radius maximum winds R_{max} play an important role when estimating local wind speed. This means we need to estimate these parameters rather than taking values from elsewhere. To obtain B we employ an approximation method suggested by Holland (2008);

$$B = b_s(\frac{v_{mg}}{v_m}) \approx 1.5b_s \quad (2)$$

Where

$$b_s = -4.4x10^{-5}\Delta p^2 + 0.01\Delta p + 0.03\frac{\partial p_c}{\partial t} - 0.014\psi + 0.15V_T^x + 1.0 \quad (3)$$

and where Δp is the pressure drop due to the cyclone centre, $\delta p_c/\delta t$ is the intensity change, ψ is the absolute value of latitude, V_t is the conversion factor from gradient to surface wind.[56]

In derive R_{max} value we employ the parametric model of Xiao *et al.* (2009) who estimated the following for Hong Kong;

$$lnR_{max} = 5.3259 \pm 0.0249\Delta p - 0.0161\psi \quad (4)$$

where R_{max} is constrained to be above 8km and below 150km. Taking the typhoon track data and the assumed parameters outlined above and estimating equations (1), (2), (3) and (4) means we can now estimate the wind speed that a firm experience at any given point *i*. In our case we examine the firm location for each point in time and for each

[56]It should be noted that Holland (1980) used a value of 1.6 for his conversion factor. In this chapter we use instead the value of 1.5. This is then consistent with the value we use for F in equation (1). We also re-estimated the model using 1.6 instead of 1.5 and it made no significant qualitative or quantitative difference to the results.

typhoon.

Now we have described our data generating process we present a summary of the deflated wage and production sales (output) data in table 4.4.

[Table 4.4 about here]

5. Econometric Analysis

The damage as a result of a tropical storm can be classified into three section: (a) wind destruction, (b) flooding/excess rainfall, and (3) storm surge. It should be noted that all three are closely related to wind speed and hence the wind speeds experienced at a given point can be considered as a general proxy for the potential damage due to a tropical storm. To examine more closely the correlation between typhoons and economic performance, we use the typhoon impact in terms of wind speed associated with the Saffir-Simpson Scale 1 and 3 together with aggregated annual rainfall and annual temperature in mean values to estimate the correlation between the power of the tropical storm and productivity, employment and productivity in terms of TFP and deflated total production sales, number of workers and the deflated wages over the time.[57] As wind speeds according to the Saffir-Simpson Scale 1 and 3 is 119km/hr and 178km/hr, we expect a higher correlation between economic performance and typhoons at level 3 rather than level 1 suggesting larger damages should be observed for typhoon at higher wind speeds. This means we estimate our regressions for both wind speeds which also acts as a form of robustness check.

5.1. Basic Regression

The primary aim of this paper is to measure how the potential damage induced by typhoons affects local economic activity as measured by TFP following the approach to the measurement of TFP by De Loecker (2007). Our key estimation equation is

[57] According to the NOAA scale, 1 corresponds to "No real damage to building structure. Damage primarily to unanchored mobile homes, shrubbery, and trees. Also, some coastal road flooding and minor pier damage", scale 3 refers to "Some structural damage to small residences and utility buildings with a minor amount of curtain wall failures. Mobile homes are destroyed. Flooding near the coast destroys smaller structures larger structure damaged by floating debris. Terrain continuously lower than 5 feet ASL may be flooded inland 8 miles or more."

therefore given by:

$$TFP_{it} = a + \beta vg_{it} + \pi_t + \mu_i + \epsilon_{it} \tag{5}$$

$$Wage_{it} = a + \beta vg_{it} + \pi_t + \mu_i + \epsilon_{it} \tag{6}$$

$$Labor_{it} = a + \beta vg_{it} + \pi_t + \mu_i + \epsilon_{it} \tag{7}$$

$$Output_{it} = a + \beta vg_{it} + \pi_t + \mu_i + \epsilon_{it} \tag{8}$$

$$Export_{it} = a + \beta vg_{it} + \pi_t + \mu_i + \epsilon_{it} \tag{9}$$

where *TFP* is the *TFP* calculated based on the full sample of CASIF data including the firms located in the whole of China and then merged for each observations using each unique firm ID andϵ is the error term.[58] Wage is the deflated wage value, labour is number of employees for each observations and output is represented by production sales.[59] The variable μ_i allows for unobserved individual observation time invariant effects that might be correlated with both typhoon destruction and economic activity. More precisely, whilst actual typhoon incidence can be considered to be an exogenous shock it can be shown that some areas of China are more prone to typhoons than others (southern coastal China is more prone that northern coastal China) and hence economic agents will know this in turn may invest move heavily in typhoon damage prevention or choose to locate elsewhere which will lead to less economic activity being recorded in those areas. To control for this possibility we use a fixed effects estimator. We also include time dummies π_t that will take account of anytime varying common changes in economic factors (such as aggregate disaster mitigation investment set at the central government level). Finally, vg_{it} captures the wind speed and implies the potential power and destruction of typhoons once a typhoon that makes landfall and is either 119 km/hr or 178km/hr. Table 4.4 provides a summary of our key estimators in the regressions which in this case are *V_178* and *V_119* and represent the wind speeds at Saffir-Simpson scale 1 and 3 respectively. The annual average temperature is between $-6°C$ and $29°C$ while total annual rain fall is between 26mm to 3,858mm. The number of observations with wages less than 1 thousand RMB (deflated) less than 10 employees or with less than 100,000 RMB production sales (deflated) is only 3, 118 and 120

[58] The TFP value cannot be calculated by using only sample of enterprises located in the coastal regions due to collinearity and therefore we use the cleaned full sample of CASIF to estimate TFP of each observation and merge the TFP values for each of the firms for each year in our coastal region sample.
[59] All deflated values are in 2000 prices.

respectively.

Tables 4.5. 4.6, 4.7, 4.8, 4.9 and 4.10 present our regression results using wind speeds (below 119km/hr and below 178km/hr) to examine the impact of typhoon damage on our main economic indicators based on equations (5) to (9). We also include the lagged value of wind speed to estimate if a typhoon that damaged a firm still impacts the economy in the following one or two years' time.

[Table 4.5 about here]

[Table 4.6 about here]

[Table 4.7 about here]

[Table 4.8 about here]

[Table 4.9 about here]

[Table 4.10 about here]

The results in table 4.5 show that typhoons have a negative and significant impact on TFP. However, there is no evidence to show that typhoons also significantly negatively impact TFP in the following two years. Typhoons at scale 1 also show a significant and negative impact on the deflated export value in the current year and export quickly recovers in the following year. In Table 4.8 we find similar results for the correlation between output value and typhoon strikes although we also find a positive impact on output in the following year (column 9) suggesting that production activity recovers quickly. The impact on wages is similar with a current year negative effect but positive one year later but negative again two years later. The negative and significant impact of typhoon on wage in the current year implies the typhoon damage lead social welfare losses. When we look at employment we found an insignificant effect for the current year. In general, we find that typhoons at scale 1 wind speed have a negative impact on economic activity. In order to recover quickly from the disaster, employers may hire more labour in the year the typhoon hits to help with reconstruction of buildings to fulfil delayed orders. But as production recovers to pre-typhoon standard, the excess labour would no longer need. Finally, the typhoon damages appear to lead to a reduction in wages in the year of the typhoon and recover in the following year. The correlation again turns significantly negative which is consistence with the correlation between typhoon and number of workers. The reduction in wages may result is workers resigning. In Tables 4.8, 4.9 and 4.10 we repeat the regressions for the higher scale 3 typhoons. Reassuringly we find generally higher coefficients although the general level of significance is broadly similar. Typhoons at scale 3 have less strong but significant impacts on export as its less happened frequency and shorter time. However, it has longer impacts until the third year that typhoons occurred and a positive and significant impact reflect the exporting has to take longer to repair international trade relations. Other main difference is that employment is consistently positive in the year of the typhoon. In summary, the weaker typhoon still has a significant impact in the current year but stronger typhoons appear to demonstrate a longer and stronger negative impact on economic activity and fluctuations in wage and employee numbers.

5.2. The impacts of other weather variables

In the next stage of the paper we also put the average annual temperature and the amount of rainfall into our estimating equation to investigate whether these additional factors associated with typhoons also had a significant impact on economic activity in the affected areas. The regression equation can be written as:

$$TFP_{it} = a + \beta_1 vg_{it} + \beta_2 rain + \beta_3 tmp + \pi_t + \mu_i + \epsilon_{it} \quad (10)$$

$$Wage_{it} = a + \beta vg_{it} + \beta_2 rain + \beta_3 tmp + \pi_t + \mu_i + \epsilon_{it} \quad (11)$$

$$Labor_{it} = a + \beta vg_{it} + \beta_2 rain + \beta_3 tmp + \pi_t + \mu_i + \epsilon_{it} \quad (12)$$

$$Output_{it} = a + \beta vg_{it} + \beta_2 rain + \beta_3 tmp + \pi_t + \mu_i + \epsilon_{it} \quad (13)$$

$$Export_{it} = a + \beta vg_{it} + \beta_2 rain + \beta_3 tmp + \pi_t + \mu_i + \epsilon_{it} \quad (14)$$

The results are shown in Tables 4.11 to 4.13 for typhoons below 119km and Tables 4.14 to 4.16 for the stronger typhoons.

[Table 4.11 about here]

[Table 4.12 about here]

[Table 4.13 about here]

[Table 4.14 about here]

[Table 4.15 about here]

[Table 4.16 about here]

Tables 4.11 to 4.16 show the impact of typhoons and other indirect factors on the affected area's economy. At wind speeds below 119 km/hr level, we still find a negative and significant impact of wind speed on TFP. In addition we find a strong negative and significant impact from high average annual temperatures on TFP in column (2) to (4) of Table 4.11. There is less evidence of a negative impact of typhoons on the number of employees in Table 4.12 but we still find consistent evidence that the higher annual average temperatures have a negative and significant impact on the number of workers in column (4) and output in Column (10). Rainfall does not appear to have any significant effect on any of our key performance variables. The typhoon and related weather estimator only have significant and negative impact on wages in the year the typhoon makes landfall. Finally, wind speed, rainfall and temperature all have a significant impact on production sales with the same correlation sign as we find in the previous results. We find similar results from Table 4.14 to 4.16 when the wind speed is below 178km/hr level albeit with larger coefficients as expected. The significant impact of wind speed on number of workers does appear to also hold for the year following the typhoon although interesting this becomes negative after two years. Table 4.13 and 4.14 show the same significant results on the impacts of typhoons on export value as in table 4.7 and 4.10. The influence of typhoons on export still lasts for two years after typhoons hits for scale 3 in table 4.16. It suggests that manufacturing enterprises may take longer time to recover from stronger typhoon hits lead damage on both productions and consumptions.

6. Conclusions

In this chapter we build on the previous work in this thesis to combine the location and economic performance of manufacturing enterprise with historical typhoon tracks to provide highly disaggregated estimates of the impacts of typhoons on local economic activity along the east coastal of China. Using micro-level firm data allows us to overcome problems with the reliability and availability of economic activity data in China. Our results show a negative and significant impact from wind speed and annual temperature on TFP, wages, production sales and export value. The impacts of stronger typhoons could be last longer in terms of production value and export value suggesting its stronger influence on productions and consumptions. The two year lagged value of rainfall has a significant and negative impact on number of workers when the wind speed is below 119 km/hr and 178km/hr level. In the time varying study of typhoon impacts, the typhoon damage may lead owners to hire more labour to help with the recovery and production rises quickly in the year following a typhoon hit. However, the negative impacts from two year lagged wind speed on the number of workers may suggest that workers are subsequently laid off. One possible reason that we did not find that many firms moved from the coastal regions into the rest of China is due to the benefits from a labour market pool, consumer markets and easy access to foreign market by lower transportation costs. These benefits may be perceived to more than cover for any losses due to typhoons. Besides, the rapid production recover from typhoons also helps to mitigate damage persistence on local economic activity.

From a policy perspective the important issue is how to minimize future losses and where to invest in the building of flood defences and infrastructure. While typhoons can be considered exogenous shocks, disasters risk should be considered endogenous. The concern, as pointed out by Burton (2004) is that there exists an "adaption deficit" where society responds only slowly to increases in disaster exposure. With insurance increasing popular and promoted in China the country should look to reduce barriers to individual insurance to encourage greater take up. This can include, as pointed out by Kunreuther (1996), reducing financial constraints and improving education through the provision of better information.

Chapter 6. Conclusions

The conclusions are concerned with implications for government policy of the geographic distribution of manufacturing industries and discuss how the results of our empirical study enlighten on the debate. A summary of our results by chapter as well as a comparison with our objectives is also provided. Some important issues remain excluded and we make a short discussion by postulating on potential future research in this area.

In general, this thesis discusses the geographic distribution of manufacturing industries and its determinants in mainland China. The exogenous impacts on the economic performance due to such a geographic distribution pattern is also examined. Our results provide some supports for the location theory and the agglomeration economy advantages of Marshall's externalities. Using predominantly mainland China micro-level manufacturing data, we employed various indices to estimate industrial agglomeration alluded to the location theory before estimating a succession of cross-sectional regressions that demonstrate for the determinants of industrial agglomeration. This thesis builds on the suggestive evidence of the existing literatures that study on the patterns and trends of industrial agglomeration in mainland China broadly. Our empirical results examined some of the previous findings and make some more detailed and pioneer discussions between the location of industry and its economic performance. The diversity of our results is reinforced in a number of ways: firstly, we compare the results on the pattern of industrial agglomeration across time by using key year's results. Secondly, we compare our results with previous studies on some of the developed countries. Thirdly, we compare the results between the overall mainland China and an economic advanced municipality. Finally, we measure and compare our results at different region levels. In the econometric analysis, we also develop various indicators to study the impacts on the industrial geographic concentration in mainland China. In the final chapter, we link the geographic distribution of productions with natural disasters and examine the impacts of typhoon disasters to the production activity in the coastal regions of mainland China.

7.1. Summary of Results

The primary objectives of this thesis were as follows: First, to determine the strength of the industrial agglomeration underpinnings of the location choice model. Second, to provide a comprehensive analysis of the pattern of industrial agglomeration in mainland China over the last decade and Tianjin municipality between 2004 and 2008. Thirdly, we use various indicators to examine the determinants of industrial agglomeration including exporting which is the engine of growth in the last decades for China and fourthly, we aim to investigate the impacts of exogenous natural disaster shocks on the economic performance in the coastal region of mainland China that were also cluster a large proportion of manufacturing enterprises, and merge the CASIF, CCTS and NWP data to develop a micro-level dataset that was able to test for the evidence of a typhoon impact on enterprises' total factor productivity, export value and other economic indicators.

Chapter 1, after discussion the rapid growth of China economy and its export-oriented pattern in the last three decades, provided our primary motivation to the study of the geographic distribution of the manufacturing industries in mainland China. Considering all the issues and the aims of this thesis, we demonstrate that economic productivity is imbalanced geographically. This leads us, in chapter two, to consider the theoretical aspects of the location choice as applied by the regional economy literatures.

In chapter 2, the location choice model developed by Ellison and Glaeser (1997) introduced a standard logit model that show firm's location choice motivated by Marshall's externalities including natural advantages, sufficient and specialized labour force and technology and knowledge spillovers. An index of industrial agglomeration estimation is also applied in the literature and the empirical evidence of the US reaffirmed previous wisdom that almost all the industries are somewhat agglomerated. Other empirical studies of developed countries also have more or less evidences on industrial agglomeration in the following literatures. We employed the Ellison-Glaeser index and slightly altered Maurel-Se'dillot index together with other industrial agglomeration measurements to examine the pattern of industrial agglomeration in mainland China from 1998 to 2007. The challenge to estimate the MS index value over period is the fluctuation of the number of industries classified by SIC and the number of regions that is taken into account each year. We separate our sample period into two five-year period due to the alteration of SIC by the end of 2002 in China. We aim to capture the dynamic of the patterns of industrial agglomeration over sample period by keeping all valid county regions while estimating the EG and MS index. We also delve further on the patterns of industrial agglomeration at the 2-digit and the 4-digit industry level. The MS index estimation results are also applied to make international comparisons with other development countries' results from previous literatures. The intra-industry agglomeration phenomenon found in the developed countries also attract us to examine the co-agglomeration at 2-digit industry level in mainland China. Finally, we attempt to study the dynamics of industrial agglomeration by tracking firms' business status and their locations. Our findings can be summarize as follows: firstly, the degree of aggregated industrial agglomeration in China has experienced a U-shape at county level while keep being more agglomerated at province level. We found some textile industries, natural resources extractions and some other labour-intensive industry to be the top agglomerated industries in 1998, 2002, 2003 and 2007 which is our key year of analysis. The least agglomerated industries are unsurprisingly water and energy supply industries with some other natural resources based industries. Very few evidence showed that high-tech industries are highly agglomerated although some high-tech product assembling industries are also found to be highly agglomerated. The only real high-tech industries that are highly agglomerated at postcode level is state-supported spacecraft (SIC-3762). The top twenty most agglomerated industries at 4-digit industry level show some similarity on the agglomerated industry pattern between China and other developed countries although the pattern of industrial agglomeration is far more different in general. The pattern of industrial agglomeration has showed a very strong industrial specialization within a region rather than a co-agglomeration effect. In the international comparisons, mainland China has showed the strongest degree of agglomeration compared with the US, France and the UK at similar region level. Finally, for those highly agglomerated industries, to locate in the traditional industry agglomerated regions would reinforce the degree of agglomeration although the merging of new industry agglomeration region could also boost the degree of industrial agglomeration for some other industries. From 1998 to 2002, the dynamic changes of enterprises' location and number of employees would promote industrial agglomeration while the enterprises have stable location were able to bolster the industrial agglomeration from 2003 to 2007.

The factors driving Chapter 4 and our interest in the determinants of agglomeration were twofold. First, the factors that impacts the degree of industrial agglomeration including Marshall's externalities and second, the distortions and obstructions factors according to some characteristics of the developing countries and even mainland China itself. This chapter first review the agglomeration measurement and a number of previous literatures made relevance to industrial agglomeration studies on China. After demonstrate the blind spot of previous empirical studies, we followed Lu and Tao (2009) to study the determinants of agglomeration by different type of ownership. Some additional indicators on agglomeration were also applied. We find that foreign enterprises including HTM enterprises have a positive and significant impacts on agglomeration while domestic private enterprises show a mixed impacts on agglomeration while the SOEs show a negative and significant impacts on agglomeration reflecting the local protectionist policy on the SOEs enterprises and distortion of industrial geographic distribution made by such policies. The significant impacts of government preferential policy on the industrial geographic distribution by ownership were characterised by restriction on the location of foreign enterprises and the location choice of the SOEs made by the central government. However, as the processing of economic restructuring and liberalisation, these endogenous impacts on industrial agglomeration has become more and more limited. On the other hand, the export-oriented and processing-based production pattern have been the engine of economic growth in mainland China.

To make vertical analysis on the industrial agglomeration, we also made a case study on the pattern of industrial agglomeration in Tianjin which is an economic advanced municipality in China. The comparisons between the results of Tianjin, mainland China and other developed countries are also applied in chapter 4. We employed the same MS index and find the aggregate pattern of agglomeration were very similar with the results in mainland China. However, there are many highly agglomerated high-tech related industries in Tianjin although some of them are still assembling industries which is completely opposite with mainland China's results. The development of SEZs and EDAs have driven the high-tech industries' agglomeration during the process. In the urbanization analysis, we demonstrate the geographically dual-core pattern of development in Tianjin municipality and show the importance of emerging regions through the positive impacts on agglomeration. The industrial agglomeration pattern in Tianjin have offered a good example of increasing manufacturing productivity by promoting industrial agglomeration in China. The SOEs played as cornerstone of the economy in Tianjin and maintain agglomerated while foreign

In the final chapter, we also examine the exogenous impacts on manufacturing productivity due to geographic distribution. Using a micro-level data set combined with trade and natural disaster information, we employed the wind-field model which measure the impacts of typhoon at scale 1 and 3 on the manufacturing production activity in the coastal regions. Typhoon disasters may have negative impacts on TFP, production sales value and export. More workers will be necessary help to recover the production quickly although lower wages were offered. Stronger typhoon may have longer period impacts on the economy.

7.2. Future Prospective

Our conclusion would help to provide policy implications to policymaker in China in terms of manufacturing location especially during the application of China Western Development programme. Since policy is strongly affect the economic location choice by ownership, a preferential policy would be more attractive to new firms who would like to maintain the position of world factory for China by entering into the homeland regions of those unskilled works who were originally lived at. Costs on immigration would be cut through this policy. We aim to examine if there is any significant results on this field. Besides, export-oriented growth pattern for China has been challenged due to financial crisis lead reduction of foreign market. So is it still the best choice for manufacturing to locate in the coastal regions reply on foreign market rather than domestic market? The benefits party of industrial agglomeration is also in our future concerned. Since foreign enterprises has already taken advantage from An alternative method to estimate geographic distribution may also interesting by following Duraton and Overman (2001) using Kernel-density as the indicator to study industrial agglomeration in a more detailed way.

Tables

Table 1.1. Total number of enterprises (1998-2007)

Year	Raw data	Cleaned data	Cleaned dataset as a share of total(%)
1998	165,118	155,030	94
1999	162,033	150,254	93
2000	162,885	151,867	93
2001	171,256	162,239	95
2002	181,557	173,846	96
2003	196,222	190,636	97
2004	279,092	266,763	96
2005	271,835	265,082	98
2006	301,961	294,389	97
2007	336,768	331,389	98

Table 1.2.Descriptive Statistics

	1998	2002	2003	2007
Number of four-digit industries	576	576	513	513
Number of plants:				
in total population	155,030	173,846	190,636	331,389
incorporated, sole proprietors or partnerships, and actively producing	46,742	108,544	135,917	301,156
number of' firms'	153,501	172,021	188,705	327,894
Average employment per 'firm'	397	317	302	239

Table 1.3. Size distribution of firms, 1998

Number of employees in the firm	Percentage of firms	Number of firms	Percentage of employment	Number of employees
10-19	3.0	4,659	0.1	66,872
20-49	13.5	20,663	1.2	707,035
50-99	20.1	30,807	3.6	2,215,257
100-199	23.7	36,391	8.5	5,154,429
200-299	12.0	18,354	7.3	4,444,795
300-399	7.1	10,944	6.2	3,747,499
400-499	4.5	6,862	5.0	3,042,807
500+	16.2	24,821	68.2	41,528,888
Total	100.0	153,501	100.0	60,907,582

Table 1.4. Size distribution of firms, 2007

Number of employees in the firm	Percentage of firms	Number of firms	Percentage of employment	Number of employees
10-19	3.49	11,455	0.22	169,309
20-49	20.92	68,593	3.01	2,359,449
50-99	27.43	89,945	8.14	6,383,762
100-199	22.93	75,171	13.33	10,453,670
200-299	9.67	31,712	9.85	7,723,003
300-399	4.62	15,161	6.59	5,169,395
400-499	2.66	8,729	4.93	3,862,410
500+	8.27	27,128	53.93	42,282,928
Total	100.00	327,894	100.00	78,403,926

Table 1.5. Top cities by share of manufacturing employment, 2007

City	Number of Employment	Share of Employment (%)
Shenzhen	3,011,194	3.84
Shanghai	2,726,297	3.54
Suzhou	2,725,156	3.48
Dongguan	2,104,366	2.68
Ningbo	1,739,826	2.22
Foshan	1,588,593	2.03
Guangzhou	1,578,048	2.01
Quanzhou	1,293,318	1.65
Hangzhou	1,256,859	1.60
Qingdao	1,210,419	1.54
Wuxi	1,198,076	1.53
Beijing	1,128,453	1.51
Tianjin	1,072,992	1.50
Zhongshan	1,162,127	1.48
Wenzhou	1,058,989	1.35
Jiaxing	923,238	1.18
Shaoxing	836,871	1.07
Chongqing	827,620	1.06
Yantai	826,502	1.05
Weifang	807,299	1.03
Hangzhou	789,394	1.01

Table 1.6. Geographic and industrial concentration measures for total production, 2007

Number of regional units	County, 2903	Postcode Area,22714	Province, 31
G	0.0018	0.0004	0.0450
H	0.0001	0.0001	0.0001
γ	0.0017	0.0003	0.0449
γ_{EG}	0.0017	0.0003	0.0449
Locational Gini	0.672	0.784	0.537
Concentration index	0.046	0.009	0.382

Table 1.7. Summary of agglomeration in four-digit industries, by two-digit industry, 2007

Two-digit industry	Mean γ	Percentage of four-digit industries in quartile(by γ)				Number of four-digit industries
		1(least)	2	3	4(most)	
9 Non-ferrous metal extractions and processing	0.069	14	7	29	50	14
19 Leather, fur, feathers(down) and its products	0.037	0	0	36	64	11
6 Coal mining and washing	0.036	33	0	0	67	3
33 Non-ferrous metal smelting and rolling	0.036	17	17	28	39	18
42 Artwork and other manufacturing	0.035	0	14	21	64	14
11 Mining industry, nothing else specified	0.033	0	0	0	100	1
17 Textile	0.029	5	24	43	29	21
39 Electronically Machinery and equipment	0.027	0	29	32	39	28
25 Petroleum processing, coking and nuclear fuel processing	0.027	33	33	0	33	3
10 Non-metallic mining	0.026	0	56	11	33	9
31 Non-metallic mineral products	0.026	29	19	16	35	31
41 Instrument, office and culture machinery	0.024	9	30	26	35	23
24 Education and sports goods	0.023	6	18	47	29	17
37 Transportation equipment	0.022	22	26	22	30	23
40 Communications equipment, computers and other electronic equipment	0.022	5	14	33	48	21
43 Waste resources and materials recycling	0.021	0	50	0	50	2
34 Metal product	0.020	13	17	54	17	24
30 Plastic product	0.019	20	30	30	20	10

(Continued on the next page)

Two-digit industry	Mean γ	Percentage of four-digit industries in quartile(by γ)				Number of four-digit industries
		1(least)	2	3	4(most)	
21 Furniture	0.015	0	40	40	20	5
36 Special equipment manufacturing	0.014	16	31	33	20	51
8 Ferrous metal extractions and processing	0.013	0	50	50	0	2
26 Chemical material and products	0.013	51	26	11	11	35
28 Chemical Fibers	0.011	29	29	14	29	7
35 General equipment manufacturing	0.011	39	30	18	12	33
15 Beverage	0.010	62	15	8	15	13
29 Rubber product	0.010	33	33	33	0	9
14 Food	0.009	40	30	20	10	20
18 Garment, shoes and hat	0.009	0	33	67	0	3
13 Agro-food processing	0.009	47	29	18	6	17
20 Wood processing, Wood, Bamboo, rattan, palm and grass products	0.007	30	40	20	10	10
23 Printing and media record	0.006	20	80	0	0	5
32 Ferrous metal processing	0.004	75	25	0	0	4
22 Paper and paper product	0.004	50	50	0	0	6
27 Pharmaceutical manufacturing	0.003	86	14	0	0	7
7 Oil and gas exploration	0.002	100	0	0	0	2
16 Tobacco	0.001	100	0	0	0	3
44 Electricity and heat supply industry	0.001	100	0	0	0	5
45 Gas supply industry	0.000	100	0	0	0	1
46 Water Supply industry	0.000	100	0	0	0	2

Quartile boundaries are by γ.1:(-0.00178,0.004583),2:(0.004583,0.008655),3:(0.008655,0.022321),4:(0.022321,0.397326)

Table 1.8. Twenty most agglomerated industries, 2007

Four-digit industry, 2007	Four-digit industry,2002	Number of firms	Agglomeration, γ	Geographic concentration, G	Industrial concentration, H
917 Magnesium Mining and Dressing *	932 Magnesium Mining and Dressing	81	0.397	0.412	0.024
3159 Ceramic products for Garden, artistic and others *	3159 Other ceramic products	284	0.235	0.244	0.012
2623 Potassium fertilizer*	2623 Potassium fertilizer *	65	0.209	0.334	0.157
914 Tin Mining and Dressing	915 Tin Mining and Dressing	56	0.177	0.201	0.029
3352 Precious metal rolling	3385 Precious metal rolling	89	0.177	0.233	0.068
1743 Silk dyeing and finishing *	1774 Silk printing and dyeing	221	0.155	0.173	0.02
3424 Knives, scissors and similar household metal tool *	3484 Knife & Scissor 3488 Barber appliances	328	0.153	0.159	0.007
3799 Other transportation equipment	3789 Other transportation equipment repair	101	0.163	0.309	0.175
4155 Calculator and money and special equipment	4173 Electronic calculators	88	0.134	0.191	0.065
4213 Lacquer handicraft*	4313 Lacquer handicraft	147	0.125	0.14	0.016

(Continued on the next page)

Four-digit industry, 2007	Four-digit industry,2002	Number of firms	Agglomeration, γ	Geographic concentration, G	Industrial concentration, H
3322 Silver smelting	3332 Silver smelting	82	0.117	0.14	0.025
3123 Asbestos cement products	3124 Asbestos cement products	77	0.117	0.167	0.057
1754 Silk products	1775 Silk products	218	0.111	0.126	0.016
3953 Home electronic ventilation appliances	4064 Electric fans	214	0.111	0.133	0.025
3959 Other household electrical appliance	4069 Other household electrical appliances	449	0.1	0.11	0.011
3954 Household kitchen appliances*	4066 Exhaust hoods	613	0.102	0.135	0.036
4126 Teaching equipment	4227 Teaching equipment	54	0.103	0.143	0.045
1742 Silk spinning and silk processing*	1772 Silk 1773 Silk spinning 1779 Other silk textile	1489	0.085	0.088	0.004
2451 Open-air playground amusement equipment	2450 Entertainment equipment	79	0.088	0.128	0.044
3314 Tin smelting*	3316 Tin smelting ⁎	65	0.109	0.423	0.352

Measures are: γ: agglomeration index (Eq. (21)), G: geographic concentration measure (Eq. (22)); H: industrial concentration (Eq. (20)).

* in column1 indicates that the industry was also in the top 20 in 2003. ⁎ in column 2 indicates that the industry was also in the top 20 in 1998.

Table 1.9. The value change along the top twenty industries over time

	SIC,2007	SIC, 2002	Changes on number of firms	Changed Gamma value	Changed G value	Changed H value
2003-2007	3314 Tin smelting	3316 Tin smelting	40	-0.189	-0.287	-0.235
	1742 Silk spinning and silk processing*	1772 Silk 1773 Silk spinning 1779 Other silk textile	620	-0.022	-0.026	-0.004
	3424 Knives, scissors and similar household metal tool *	3484 Knife & Scissor	221	0.026	0.005	-0.024
	1743 Silk dyeing and finishing *	1774 Silk printing and dyeing	35	0.011	0.017	0.005
	2623 Potassium fertilizer*	2623 Potassium fertilizer	31	-0.012	-0.042	-0.042
1998-2007	2623 Potassium fertilizer*	2623 Potassium fertilizer	30	-0.001	-0.054	-0.068
	3316 Tin smelting	3316 Tin smelting	47	0.021	-0.023	-0.04

Note: We take mean value on Changed value for 2002 to compare with Silk spinning and silk processing (SIC-1742) in 2007.

Table 1.10. Twenty most agglomerated regions, 2007

Four-digit industry	1st County Area	2nd County Area	Percentage of employment at County Area		Total number firms	Percentage of firms in County Area		Average firm size by employment	
			1st	2nd		1st	2nd	1st	Other
917 Magnesium Mining and Dressing	Gaizhou	Xiuyan Manchu Autonomous County	59.8	22.1	81	43.2	25.9	173	88
3159 Ceramic products for Garden, artistic and others	Dehua County	Chao'an County	46.7	13.4	284	39.8	16.5	298	225
2623 Potassium fertilizer*	Golmud	Pingyuan County, Shandong	55	15.5	65	33.8	1.5	435	182
3352 Precious metal rolling	Laizhou	Zhaoyuan, Shandong	47.3	4.8	89	7.9	3.4	1124	107
914 Tin Mining and Dressing	Linwu County	Nandan County	39.4	11.8	56	46.4	3.6	169	225
3799 Other transportation equipment	Jiaonan	Dongli District	54.3	9.9	101	41.6	2	226	136
1743 Silk dyeing and finishing	Shaoxing County	Wujiang District, Suzhou	36.3	18.7	221	16.3	16.3	627	214
3424 Knives, scissors and similar household metal tool	Jiangcheng District	Yangdong County	29	26.1	328	27.4	26.2	204	189
4155 Calculator and money and special equipment	Hanjiang District, Putian	Bao'an District	41.1	7.8	88	8	5.7	2658	330
4213 Lacquer handicraft	Huangyan District	Xianyou County	33.4	12.2	147	44.9	17.7	116	190

(Continued on the next page)

Four-digit industry	1st County Area	2nd County Area	Percentage of employment at County Area		Total number firms	Percentage of firms in County Area		Average firm size by employment	
			1st	2nd		1st	2nd	1st	Other
3322 Silver smelting	Yongxing County	Beihu District	34.2	7.7	82	40.2	1.2	65	84
3123 Asbestos cement products	Xinzheng	Hengnan County	39.1	5.7	77	20.8	1.3	341	139
1754 Silk products	Shengzhou	Wuhou District	33.4	8.1	218	29.8	0.9	184	156
3953 Home electronic ventilation appliances	Zhongshan	Shunde District	30.5	14.1	214	25.2	13.6	486	374
3314 Tin smelting	Gejiu	Chengzhong District, Liuzhou	60.5	23.1	65	15.4	1.5	2988	354
4126 Teaching equipment	Zhenping County, Henan	Yongjia County	33.8	9.9	54	13	7.4	367	107
3954 Household kitchen appliances	Shunde District	Zhongshan	32.7	12.3	613	12.7	21.2	1051	315
3959 Other household electrical appliance	Cixi City	Bao'an District	27.4	16.1	449	18.3	5.6	412	244
2451 Open-air playground amusement equipments	Yongkang, Zhejiang	Wujin District	25.1	20.4	79	41.8	5.1	82	176
1742 Silk spinning and silk processing	Wujiang District, Suzhou	Shaoxing County	24	15.4	1489	33.1	8	96	150

Table 1.11. Twenty least agglomerated industries, 2007

Four-digit industry	Four-digit industry,1998	Number of firms	Agglomeration, γ	Geographic concentration, G	Industrial concentration, H
4610 Water*+	4610 Water 4620 Water supply industry	1580	-0.001779	0.001	0.003
4411 Thermal power*+	4411 Thermal power	1219	-0.001188	0.007	0.008
1522 Beer*+	1513 Beer	572	-0.000948	0.004	0.005
3491 Coinage and precious metal laboratory supplies	3499 Other metal products	11	-0.000248	0.267	0.268
3645 Lighting producing equipment	3636 Lighting equipment for industrial equipment	62	-0.000227	0.04	0.04
3694 Special equipment for commercial, catering and services	3675 Commercial, catering and services industries dedicated machinery	33	-0.000169	0.067	0.067
4151 Film Machinery*+	4251 Film Machinery	13	-0.00007	0.161	0.161
2824 Polyvinyl alcohol fiber	2824 Polyvinyl alcohol fiber	14	-0.000059	0.365	0.365
1364 Fish Oil Extraction and its products*	1359 Other aquatic products processing	8	-0.000009	0.193	0.193
3673 Forest, wood and bamboo harvesting machinery+	3643 Silviculture machinery 3626 Forest industry dedicated equipment	12	-0.000009	0.131	0.131
933 Radioactive ores Mining and Dressing*	966 Rare radioactive metal mining	9	-0.000001	0.183	0.183

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Four-digit industry	Four-digit industry,1998	Number of firms	Agglomeration, γ	Geographic concentration, G	Industrial concentration, H
4500 Gas production and supply	4510 Gas production 4520 Gas supply	581	0.000006	0.008	0.008
3111 Cement	3110 Cement	4898	0.000068	0.001	0.001
1320 Feed processing	1314 Composted and mixed feed 1315 Protein feed 1319 Other feed	2621	0.000072	0.002	0.002
1620 Cigarette	1620 Cigarette	65	0.000076	0.039	0.039
2621 Nitrogen fertilizer*+	2621 Nitrogen fertilizer	484	0.000195	0.006	0.006
2740 Traditional Chinese Medicine	2730 Chinese herbal medicines and proprietary Chinese medicine	1356	0.000259	0.004	0.004
4420 Electricity supplement*+	4420 Power supply	1614	0.000447	0.011	0.011
3519 Other prime mover	3519 Boilers and other prime mover	26	0.00066	0.084	0.083
2611 Inorganic acids	2611 Inorganic acids	536	0.000691	0.008	0.007

Measures are: γ: agglomeration index (Eq. (21)), G: geographic concentration measure (Eq. (22)); H: industrial concentration (Eq. (20)).
+ indicates that the industry was also in the least agglomerated industry table in 1998.
*Indicates that the industry was also in the least agglomerated industry table in 2003.

Table 1.12. The pattern of industrial agglomeration by share at different geographic area level

	Country	Year	Industry	Region	Percentage of industries that are		
					Not very concentrated	Somewhat concentrated	Very concentrated
Ellison and Glaeser (1997)	US	1987	459	50 State plus District of Colombia (51)	10%	65%	25%
Maurel and Sedillot (1999)	France	1993	273	95 Departments	50%	23%	27%
Devereux *et al*. (2004)	UK	1992	211	113 Postcode Area	65%	19%	16%
China(Province)	China	1998	576	31 Provinces	34%	24%	42%
China(County)	China	1998	576	2991 Counties	77%	16%	7%
China(Postcode)	China	1998	576	18494 Postcode Area	95%	4%	1%
China(Province)	China	2002	576	31 Provinces	30%	22%	48%
China(County)	China	2002	576	2991 Counties	76%	16%	8%
China(Postcode)	China	2002	576	18494 Postcode Area	92%	6%	2%
China(Province)	China	2003	513	31 Provinces	29%	21%	50%
China(County)	China	2003	513	2969 Counties	75%	18%	7%
China(Postcode)	China	2003	513	18884 Postcode Area	93%	6%	1%
China(Province)	China	2007	513	31 Provinces	30%	19%	51%
China(County)	China	2007	513	2969 Counties	73%	19%	8%
China(Postcode)	China	2007	513	18884 Postcode Area	92%	5%	3%

Table 1.13. Comparison of γ for China top 20 agglomerated industries at different geographic area

		4-digit Industry	China		US		France		UK	
			γ	Ranking	γ	Ranking	γ	Ranking	γ	Ranking
Province	2002	4172 Radios, tape recorders	0.559	4			0.24	23		
		1033 Well Salt	0.496	6					0.499	2
		4214 Timing equipment	0.485	7			0.38	11		
		3484 Knives, scissors	0.485	8			0.28	19	0.338	6
		1713 Preliminary flax fiber processing	0.479	9	0.28	13				
		1773 Silk spinning	0.422	16	0.28	13			0.112	15
	2007	4218 Jewellery and related articles	0.523	5	0.3	10				
		3424 Knives, scissors and similar household metal tool	0.506	6			0.28	19	0.338	6
		4130 Clocks and timing equipment	0.394	11			0.38	11		
		1743 Silk dyeing and finishing	0.393	12					0.112	15
		620 Lignite mining and washing	0.36	16			0.53	6		
		3424 Knives, scissors and similar household metal tool *	0.155	7			0.28	19	0.338	6

Table 1.14. Comparison of γ for US top 20 agglomerated industries, 2007

US	γ	Rank	China (Province level)	γ	Ranking	Changes (2002-2007)
2371 Fur goods	0.63	1	1923 Leather Luggage, packages (bags)	0.167	85	-0.008 (3)
			1924 Leather gloves and Decorative leather products	0.098	158	-0.184 (-121)
			1929 Other leather products	0.097	159	-0.128 (-100)
			1932 Fur garment industry	0.076	198	0.045 (143)
			1939 Other fur products industry	0.094	166	-0.012 (-5)
2084 Wines brandy spirits	0.48	2	1524 Wine industry	0.146	102	0.052 (80)
2252 Hosiery not elsewhere classified	0.44	3	1769 Other knitwear and woven goods	0.110	144	0.003 (14)
3533 Oil and gas field machinery	0.43	4	3612 Oil drilling equipment	-0.009	452	-0.045 (-130)
2251 Women's hosiery	0.4	5	※	※	※	※
2273 Carpets and rugs	0.38	6	4217 Carpet	0.110	143	0.000 (12)
2429 Special product sawmills not elsewhere classified	0.37	7	2011 Lumber processing	0.018	362	0.031 (179)
3961 Costume jewelry	0.32	8	※	※	※	※
2895 Carbon black	0.3	9	※	※	※	※
3915 Jewelers' materials lapidary	0.3	10	※	※	※	※
2874 Phosphatic fertilizers	0.29	11	2622 Phosphatic fertilizers	-0.001	437	-0.011 (14)
2061 Raw cane sugar	0.29	12	1340 Sugar	0.193	71	-0.050 (-21)
2281 Yarn mills except wool	0.28	13	1730 Linen Textile	0.006	409	-0.272 (-183)
			1742 Silk spinning and processing	0.287	36	-0.068 (-10)
2034 Dehydrated fruits vegetable soups	0.28	14	※	※	※	※
3761 Guided missiles space vehicles	0.25	15	3762 Spacecraft	0.301	30	0.222 (175)

※ Indicates that the four-digit industry didn't located in China

Table 1.15.Comparison of γ for France top 20 agglomerated industries

France	γ	Rank	China	γ (province level)	Ranking	Changes (2002-2007)
Extraction of slate	0.88	1	※	※	※	※
Extraction of iron ore	0.88	2	※	※	※	※
Made-to-measure clothing	0.8	3	※	※	※	※
Extract of minerals for chemical industry and fertilizers	0.76	4	2614 Organic chemical raw materials	0.041	289	0.007 (41)
Steel pipe and tubes	0.69	5	3452 Building and Decoration, plumbing parts	0.064	233	0.013 (40)
Extraction of coal	0.53	6	610 Anthracite and bituminous coal mining washing	0.040	295	0.022 (120)
			620 Lignite mining and washing	0.360	16	0.227 (114)
			690 Other coal mining	0.125	126	0.039 (69)
Combed wool spinning mills	0.44	7	1722 Wool Textile	0.116	133	0.030 (62)
Vehicles hauled by animals	0.42	8	※	※	※	※
Wool preparation	0.42	9	1722 Wool Textile	0.116	133	0.041 (73)
Periodicals	0.4	10	2311 Books, newspapers, periodicals	0.022	352	0.021 (-141)
Watch-making	0.38	11	4130 Watches and timekeeping instrument	0.394	11	0.054 (-12)

(Continued on the next page)

France	γ	Rank	China	γ (province level)	Ranking	Changes (2002-2007)
Flat glass	0.37	12	3141 Flat glass	0.003	420	0.005 (81)
Screw cutting	0.36	13	3421 Cutting tools	0.039	297	-0.035 (-81)
Lawn and garden equipment	0.36	14	※	※	※	※
Carded wool weaving mills	0.34	15	1722 Wool Textile	0.116	133	0.115 (360)
Essential oils	0.32	16	※	※	※	※
Book publishing	0.3	17	2311 Books, newspapers, periodicals	0.022	352	-0.017 (-40)
Extraction of uranium ore	0.29	18	※	※	※	※
Cutlery	0.28	19	3421 Cutting tools	0.039	297	0.000 (15)
Carded wool spinning mills	0.25	20	1722 Wool Textile	0.116	133	0.030 (62)
Small arms	0.25	21	3900 Weapons and Ammunition	※	※	※
War vessels	0.24	22	※	※	※	※
Sound recording	0.24	23	4072 Home audio equipment	0.620	3	0.061 (1)
Cotton spinning mills	0.24	24	1711 Cotton, chemical fiber textile processing	0.055	249	0.031 (140)

※ Indicates that the four-digit industry didn't located in China or information cannot be provided due to data confidentiality reasons

Table 1.16. Comparison of γ for UK top 20 agglomerated industries

UK	γ	Rank	China	γ (province level)	Ranking	Changes (2002-2007)
4340 Spinning and weaving of flax	0.711	1	1730 Linen textile	0.006	409	-0.272 (-371)
2330 Extraction salt	0.499	2	1030 Salt mining	0.022	349	0.203 (-239)
4350 Jute and polypropylene	0.414	3	※	※	※	※
2489 Ceramic goods	0.41	4	3151 Sanitary ceramics products	0.142	104	0.041 (67)
			3152 Industrial ceramics industry	0.041	290	0.030 (157)
			3153 Daily ceramic manufacturing	0.054	252	0.009 (33)
			3159 Other ceramic products industry	0.304	27	0.164 (88)
4395 Lace	0.402	5	※	※	※	※
3162 Cutlery	0.338	6	3424 Knives, scissors and similar household metal tool	0.506	6	0.111 (-15)
3634 Pedal cycles	0.191	7	3741 Pedal bicycles and invalid carriages	0.161	90	0.012 (-18)
4363 Hosiery	0.168	8	1761 Cotton, chemical fiber knitwear and woven goods	0.112	139	0.058 (-127)
			1762 Wool knitwear and woven goods	0.090	172	0.004 (-22)
			1763 Silk knitwear and woven goods	0.212	60	-0.093 (28)
			1769 Other knitwear and woven goods	0.110	144	0.003 (-14)

(Continued on the next page)

UK	γ	Rank	China	γ (province level)	Ranking	Changes (2002-2007)
4910 Jewellery	0.146	9	※	※	※	
3161 Hand tools	0.139	10	3422Hand tools	0.154	94	0.048 (69)
4752 Periodicals	0.135	11	2311 Books, newspapers, periodicals	0.022	352	0.021 (141)
4310 Woollen and worsted industry	0.119	12	1722 Wool Textile	0.116	133	0.029 (62)
3523 Caravans	0.118	13	※	※	※	※
4721 Wall coverings	0.118	14	※	※	※	※
4322 Weaving cotton, silk	0.112	15	1722 Wool Textile	0.116	133	0.041 (83)
			1742 Silk spinning and processing	0.287	36	-0.134 (-20)
4831 Plastic coated textile fabric	0.111	16	※	※	※	※
2235 Other steel forming	0.092	17	※	※	※	※
4240 Spirit distilling	0.091	18	1510 Alcohol manufacturing	0.021	357	0.002 (50)
4537 Hats	0.082	19	1830 Hats	0.148	101	0.008 (15)
4150 Fish processing	0.081	20	1362Marinated processing of surimi products and aquatic products dry	0.097	160	-0.016 (13)

※ Indicates that the four-digit industry didn't located in China or information cannot be provided due to data confidentiality reasons

Table 1.17. Industry dynamics and agglomeration, 1998-2002

Dependent variable	Entrants		Exitors		One-year	
Number of observations	1731	1731	1731	1731	1731	1731
Agglomeration, c	0.161	0.166	0.176	0.078	0.148	0.137
	(0.061)	0.056	(0.005)	(0.004)	(0.028)	(0.030)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Two-digit industry dummies	No	Yes	No	Yes	No	Yes
Dependent variable	Survivors		Job creation		Job destruction	
Number of observations	1731	1731	1731	1731	1731	1731
Agglomeration, c	-0.251	-0.163	0.001	0.001	0.007	0.005
	(0.072)	(0.070)	(0.007)	(0.006)	(0.043)	(0.045)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Two-digit industry dummies	No	Yes	No	Yes	No	Yes

Table 1.18. Industry dynamics and agglomeration, 2003-2007

Dependent variable	Entrants		Exitors		One-year	
Number of observations	1539	1539	1539	1539	1539	1539
Agglomeration, c	-0.027	-0.099	-0.084	-0.101	-0.029	-0.040
	(0.052)	(0.053)	(0.038)	(0.040)	(0.022)	(0.023)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Two-digit industry dummies	No	Yes	No	Yes	No	Yes
Dependent variable	Survivors		Job creation		Job destruction	
Number of observations	1539	1539	1539	1539	1539	1539
Agglomeration, c	0.072	0.141	-0.507	-0.507	-0.055	-0.069
	(0.053)	(0.053)	(0.006)	(0.006)	(0.037)	(0.039)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Two-digit industry dummies	No	Yes	No	Yes	No	Yes

Table 1.19. Twenty most agglomerated industries—geographic distribution of entry, 1998-2002

Four-digit industries	Number entrants	Percentage of entrants to the top county area*	G entrants	γ entrants
1095 Precious stones, jade mining industry	5	40	0.667	0.479
3316 Tin smelting	21	19	0.709	0.296
2623 Potassium fertilizer*	25	12	0.376	0.221
2223 Handmade paper*	10	-	0.526	0.214
4313 Lacquer handicraft	20	30	0.205	0.153
1774 Silk printing and dyeing industry	138	20	0.128	0.115
4122 The dedicated radar equipment and parts	15	33	0.203	0.140
3484 Knives, scissors	82	48	0.150	0.123
1220 Minerals Mining	7	-	0.247	0.121
3623 Chemical fiber special equipment manufacturing	24	-	0.180	0.118
1714 Ramie fiber preliminary processing	24	-	0.173	0.116
1032 Lake Salt	12	-	0.253	0.112
3322 Magnesium smelting	87	-	0.146	0.107
1773 Silk Industry	643	22	0.087	0.080
2224 Paper	233	-	0.120	0.103
4112 Exchange equipment	79	11	0.208	0.098
1024 Boron Mining*	10	-	0.223	0.104
965 Rare earth metals and Dressing	21	24	0.163	0.102
1091 Asbestos mining industry*	21	-	0.176	0.096
2510 Synthetic crude oil production	16	-	0.489	0.092

*Defined as the most agglomerated county area in 1998. This coincides with that given in Table 23
.

Table 1.20. Twenty most agglomerated industries—geographic distribution of entry, 2003-2007

Four-digit industries	Number entrants	Percentage of entrants to the top county area*	G entrants	γ entrants
914 Tin Mining and Dressing	56	-	0.201	0.177
917 Magnesium Mining and Dressing	81	5	0.412	0.397
1742 Silk spinning and silk processing	1489	8	0.069	0.066
1743 Silk dyeing and finishing	221	16	0.156	0.139
1754 Silk products	218	30	0.116	0.101
2451 Open-air playground amusement equipments	79	-	0.125	0.085
2623 Potassium fertilizer*	65	34	0.333	0.209
3123 Asbestos cement products	77	21	0.158	0.107
3159 Ceramic products for Garden, artistic and others	284	40	0.237	0.227
3314 Tin smelting	65	15	0.420	0.105
3322 Silver smelting	82	-	0.137	0.115
3352 Precious metal rolling	89	8	0.233	0.177
3424 Knives, scissors and similar household metal tool	328	27	0.155	0.148
3799 Other transportation equipment	101	42	0.301	0.153
3953 Home electronic ventilation appliances	214	-	0.120	0.097
3954 Household kitchen appliances	613	13	0.118	0.085
3959 Other household electrical appliance	449	18	0.097	0.087
4126 Teaching equipment	54	7	0.143	0.103
4155 Calculator and money and special equipment	88	1	0.187	0.130
4213 Lacquer handicraft	147	18	0.138	0.124

*Defined as the most agglomerated county area in 2003. This coincides with that given in Table 25.

Table 2.1. Statistic summary

Year	Raw data	cleaned data	Share of cleaned data to raw data	Mean value on firm size
1998	158,515	135,237	85.3%	361
1999	155,752	132,986	85.4%	345
2000	156,802	134,712	85.9%	329
2001	165,193	144,019	87.2%	302
2002	177,057	155,170	87.6%	288
2003	192,443	172,985	89.9%	276
2004	279,092	245,375	87.9%	228
2005	267,534	241,780	90.4%	238
2006	297,108	268,749	90.5%	229
2007	334,111	305,425	91.4%	222

Table 2.2. Impacts of share of SOEs in employment on industrial agglomeration, 1998-2007

1998_2007									
	Pooled OLS with dummy variables								
4-digit industry level	County	County	County	City	City	City	Province	Province	Province
Share of SOEs capital in employment	-1.852***	-3.622***	-8.872***	-1.714***	-3.307***	-6.732***	-1.310***	-2.783***	-6.103***
	(0.236)	(0.357)	(0.864)	(0.254)	(0.375)	(0.874)	(0.258)	(0.381)	(0.892)
Observations	4,099	4,099	4,099	4,099	4,099	4,099	4,099	4,099	4,099
R-squared	0.015	0.025	0.025	0.084	0.134	0.195	0.097	0.143	0.197
Year dummy	No	No	Yes	No	No	Yes	No	No	Yes
2-digit industry dummy	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05

Table 2.3. Impacts of change of SOEs capital on industrial agglomeration, 1998-2007

	1998_2007								
	Pooled OLS with dummy variables								
4-digit industry level	County	County	County	City	City	City	Province	Province	Province
Change of SOEs capital in employment (1998-2007)	-0.897***	-1.970***	-5.057***	-0.785**	-1.619***	-3.954***	-0.785**	-1.619***	-3.954***
	(0.341)	(0.547)	(1.394)	(0.371)	(0.586)	(1.446)	(0.371)	(0.586)	(1.446)
Observations	409	409	409	409	409	409	409	409	409
R-squared	0.017	0.031	0.031	0.120	0.162	0.215	0.120	0.162	0.215
Year dummy	No	No	Yes	No	No	Yes	No	No	Yes
2-digit industry dummy	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05

Table 2.4. Impacts of share of private firms in employment on industrial agglomeration, 1998-2007

1998_2007									
	Pooled OLS with dummy variables								
4-digit industry level	County	County	County	City	City	City	Province	Province	Province
Share of Private capital in employment	0.0115***	0.0147***	0.0326***	0.0143***	0.0273***	0.0429***	-0.00340	0.00792	0.0197
	(0.00275)	(0.00418)	(0.0101)	(0.00287)	(0.00424)	(0.00991)	(0.00374)	(0.00555)	(0.0130)
Observations	4,099	4,099	4,099	4,099	4,099	4,099	4,099	4,099	4,099
R-squared	0.004	0.003	0.003	0.079	0.126	0.187	0.091	0.132	0.189
Year dummy	No	No	Yes	No	No	Yes	No	No	Yes
2-digit industry dummy	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes

Standard errors in parentheses

*** p<0.01, ** p<0.05

Table 2.5. Impacts of change of Private firms on industrial agglomeration, 1998-2007

1998_2007									
Pooled OLS with dummy variables									
4-digit industry level	County	County	County	City	City	City	Province	Province	Province
Change of Private capital in employment (1998-2007)	0.00477	0.0117	0.206***	-0.000758	0.0207	0.223***	-0.000758	0.0207	0.223***
	(0.0165)	(0.0268)	(0.0675)	(0.0189)	(0.0300)	(0.0730)	(0.0189)	(0.0300)	(0.0730)
Observations	409	409	409	409	409	409	409	409	409
R-squared	0.000	0.000	0.022	0.110	0.146	0.218	0.110	0.146	0.218
Year dummy	No	No	Yes	No	No	Yes	No	No	Yes
2-digit industry dummy	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes

Standard errors in parentheses

*** p<0.01, ** p<0.05

Table 2.6. Impacts of share of foreign firms in employment on industrial agglomeration, 1998-2007

1998_2007									
	Pooled OLS with dummy variables								
4-digit industry level	County	County	County	City	City	City	Province	Province	Province
Share of Foreign capital in employment	0.775***	1.723***	12.65***	-0.0863	-0.0219	7.246***	-0.422	-0.489	6.698***
	(0.293)	(0.444)	(1.058)	(0.329)	(0.487)	(1.128)	(0.328)	(0.486)	(1.133)
Observations	4,099	4,099	4,099	4,099	4,099	4,099	4,099	4,099	4,099
R-squared	0.002	0.004	0.034	0.074	0.117	0.192	0.091	0.132	0.195
Year dummy	No	No	Yes	No	No	Yes	No	No	Yes
2-digit industry dummy	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes

Table 2.7. Impacts of change of foreign firms on industrial agglomeration, 1998-2007

1998_2007									
Pooled OLS with dummy variables									
4-digit industry level	County	County	County	City	City	City	Province	Province	Province
Change of Foreign capital in employment (1998-2007)	3.259***	3.665	22.62***	-0.344	-0.493	14.48**	-0.344	-0.493	14.48**
	(1.205)	(1.959)	(4.884)	(1.497)	(2.375)	(5.806)	(1.497)	(2.375)	(5.806)
Observations	409	409	409	409	409	409	409	409	409
R-squared	0.018	0.009	0.050	0.110	0.145	0.212	0.110	0.145	0.212
Year dummy	No	No	Yes	No	No	Yes	No	No	Yes
2-digit industry dummy	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes

Standard errors in parentheses

*** p<0.01, ** p<0.05

Table 2.8. Definitions and summary statistics of key variables

Variable name	Definition	Number of observations	Mean	Std. Dev.	Min	Max
EG index(4-digit, County)	EG index calculated at 4-digit industry level and county level	4099	0.015986	0.028695	-0.00224	0.674543
EG index(4-digit, City)	EG index calculated at 4-digit industry level and city level	4099	0.031566	0.041976	-0.00895	0.701893
EG index(4-digit, Province)	EG index calculated at 4-digit industry level and province level	4099	0.067526	0.098761	-0.08225	0.756314
Share of state-owned enterprises in employment	The total number employees of SOEs enterprises/ total number employees of overall enterprises	4099	0.250893	0.223543	0	0.991241
Wage premium(County)	$\sum_{r=1}^{i}(\frac{wage_{ir}}{wage_r})*(\frac{Emp_{ir}}{Emp_r})$	3689	0.000026	1.81E-05	1.66E-07	0.0002
Wage premium(City)		3689	0.083047	0.094687	0	0.711321
Wage premium(Province)		3689	0.217522	0.201833	0	0.935985
Average firm age	Data collected year- year of establishment	4099	0.054692	0.115271	0.000132	1.930814
New product ratio	Total new products of an industry/total output of the industry	4099	0.019264	0.05981	1.19E-05	1.15454
Average firm size	Total output of an industry/ number of firms in the industry	4099	0.114051	0.624151	2.29E-05	20.13215
Export ratio	Export value/ Total sales output	4099	1990.863	7.200946	1953.481	2003.481

Note: Industrial variables are calculated at 4-digit industry level

Table 2.9. The correlation between indicators

	Gamma~6d	Gamma~4d	Gamma~2d	priva~re	afsize	newshare	export~e	wagep~6d	wagep~4d	wagep~2d	afyear
Gamma_reg6d	1										
Gamma_reg4d	**0.8408**	1									
Gamma_reg2d	**0.5899**	**0.7013**	1								
SOEshare	**0.0594**	**0.0643**	**0.061**	1							
Average firm size	**-0.0861**	**-0.1062**	**-0.0919**	**-0.0491**	1						
New product ratio	-0.0079	**0.0656**	**-0.0523**	**-0.1726**	**-0.3349**	1					
Export ratio	**0.2906**	**0.3661**	**0.5543**	-0.0146	-0.0257	**-0.0657**	1				
Wage Premium(County)	0.0056	0.0006	-0.0624	**-0.1859**	**-0.2909**	**0.2521**	**-0.0663**	1			
Wage Premium(City)	**0.0493**	0.0066	**-0.0604**	**-0.1787**	**-0.2556**	**0.2136**	**-0.0754**	**0.8586**	1		
Wage Premium(Province)	-0.0068	**-0.0395**	**-0.0744**	**-0.0955**	**-0.1375**	**0.0684**	**-0.0846**	**0.3745**	**0.4194**	1	
Average firm age	**0.1697**	**0.1634**	**0.2018**	**0.5721**	**-0.363**	**-0.1121**	**0.2426**	**-0.1461**	**-0.1514**	**-0.0767**	1

Note: Coefficients in bold are significant at 5% level (2-tailed).

Table 2.10. The determinants of agglomeration

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	County			City			Province		
SOEshare	-0.00165	-0.00563**	0.00324	-0.00942***	-0.0187***	-0.0127***	-0.0382***	-0.0466***	-0.0604***
	-0.00238	-0.00258	-0.00306	-0.00335	-0.00359	-0.00428	-0.00711	-0.00763	-0.00908
Average firm size	-124.2***	-98.88***	-36.23	-148.0***	-110.9***	-67.34	-459.2***	-378.3***	-477.2***
	-27.62	-30.26	-32.36	-38.57	-41.99	-45.16	-80.29	-88.28	-94.98
New product ratio	-0.00443	-0.00072	-0.00103	0.0312***	0.0233***	0.0229***	-0.0345**	-0.0815***	-0.0807***
	-0.00517	-0.00636	-0.00634	-0.00723	-0.00879	-0.00879	-0.0152	-0.0184	-0.0184
Export ratio	0.0397***	0.0426***	0.0448***	0.0716***	0.0693***	0.0708***	0.249***	0.236***	0.233***
	-0.00242	-0.00302	-0.00304	-0.0034	-0.00421	-0.00425	-0.00719	-0.00892	-0.009
Wage premium	0.00144	-0.00162	-0.00243	0.00675	-0.00025	-0.00033	-0.00513**	-0.00504**	-0.00493**
	-0.00404	-0.00418	-0.00416	-0.0108	-0.011	-0.011	-0.00214	-0.00211	-0.00211
Firm age	-2.96E-05	-9.90E-06	9.22E-07	-1.97E-05	-6.89E-06	1.70E-07	-4.92E-05	-5.32E-05	-6.94E-05
	-3.58E-05	-3.55E-05	-3.55E-05	-5.02E-05	-4.95E-05	-4.96E-05	-0.00011	-0.00011	-0.00011
Observations	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689
R-squared	0.091	0.132	0.139	0.149	0.2	0.202	0.323	0.361	0.363
Year dummy	No	No	No	No	No	No	No	No	No
2-digit industry dummy	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses *** $p<0.01$, ** $p<0.05$

Table 2.11. The determinants of agglomeration

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	County			City			Province		
Domestic private	-0.000175	0.00383	-0.00140	0.00917	0.0190***	0.0176***	0.0254**	0.0389***	0.0510***
	(0.00388)	(0.00418)	(0.00452)	(0.00545)	(0.00583)	(0.00631)	(0.0116)	(0.0124)	(0.0133)
Average firm size	-58.09*	-47.78	-30.43	-93.20**	-73.22	-68.13	-483.6***	-447.1***	-503.9***
	(30.90)	(32.78)	(33.25)	(43.17)	(45.44)	(46.31)	(89.39)	(94.84)	(97.52)
New product ratio	0.000564	0.000674	-0.000150	0.0361***	0.0242***	0.0239***	-0.0372**	-0.0859***	-0.0815***
	(0.00522)	(0.00634)	(0.00634)	(0.00732)	(0.00878)	(0.00880)	(0.0155)	(0.0185)	(0.0186)
Export ratio	0.0378***	0.0427***	0.0434***	0.0735***	0.0741***	0.0743***	0.264***	0.251***	0.250***
	(0.00234)	(0.00305)	(0.00305)	(0.00330)	(0.00425)	(0.00426)	(0.00701)	(0.00904)	(0.00906)
Wage premium	0.00576	0.00287	-0.00127	0.0159	0.0117	0.00999	-0.00584***	-0.00557***	-0.00507**
	(0.00412)	(0.00427)	(0.00448)	(0.0111)	(0.0113)	(0.0116)	(0.00215)	(0.00213)	(0.00214)
Firm age	0.000371***	0.000306***	9.06e-05	0.000324**	0.000279**	0.000224	0.000139	2.40e-05	0.000496
	(9.03e-05)	(9.61e-05)	(0.000120)	(0.000127)	(0.000134)	(0.000165)	(0.000267)	(0.000282)	(0.000340)
Observations	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689	3,689
R-squared	0.097	0.137	0.139	0.152	0.202	0.203	0.319	0.357	0.358
Year dummy	No	No	No	No	No	No	No	No	No
2-digit industry dummy	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05

Table 2.12. The determinants of agglomeration

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	County			City			Province		
L9.SOEshare	0.00185	0.00334	0.00334	-0.0132	-0.0145	-0.0145	-0.0822***	-0.109***	-0.109***
	(0.00595)	(0.00739)	(0.00739)	(0.00910)	(0.0113)	(0.0113)	(0.0192)	(0.0235)	(0.0235)
L9.Average firm size	12.36	3.801	3.801	-18.85	-50.72	-50.72	-406.7***	-404.4**	-404.4**
	(48.13)	(52.39)	(52.39)	(72.03)	(78.10)	(78.10)	(153.9)	(163.5)	(163.5)
L9.New product ratio	-0.00597	-0.0163	-0.0163	0.0218	0.00237	0.00237	-0.0415	-0.0838*	-0.0838*
	(0.0123)	(0.0154)	(0.0154)	(0.0188)	(0.0233)	(0.0233)	(0.0401)	(0.0486)	(0.0486)
L9.Export ratio	0.0285***	0.0254***	0.0254***	0.0529***	0.0405***	0.0405***	0.183***	0.177***	0.177***
	(0.00578)	(0.00688)	(0.00688)	(0.00881)	(0.0105)	(0.0105)	(0.0186)	(0.0219)	(0.0219)
L9.Wage premium	0.0846***	0.0999***	0.0999***	0.0794	0.114*	0.114*	-0.0115	-0.0115	-0.0115
	(0.0255)	(0.0285)	(0.0285)	(0.0519)	(0.0593)	(0.0593)	(0.0195)	(0.0209)	(0.0209)
L9.Firm age	0.000284	0.000430	0.000430	-7.17e-05	0.000175	0.000175	-0.00104	-0.00133	-0.00133
	(0.000224)	(0.000273)	(0.000273)	(0.000342)	(0.000414)	(0.000414)	(0.000726)	(0.000871)	(0.000871)
Observations	409	409	409	409	409	409	409	409	409
R-squared	0.118	0.183	0.183	0.143	0.208	0.208	0.368	0.431	0.431
Year dummy	No	No	No	No	No	No	No	No	No
2-digit industry dummy	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes

Table 2.13. The determinants of agglomeration

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES		County			City			Province	
L9.Domestic private	-0.0164	-0.0140	-0.0140	-0.00736	0.0146	0.0146	0.117	0.175**	0.175**
	(0.0187)	(0.0211)	(0.0211)	(0.0289)	(0.0324)	(0.0324)	(0.0614)	(0.0682)	(0.0682)
L9.Average firm size	16.88	4.670	4.670	10.02	-41.33	-41.33	-307.0**	-364.8**	-364.8**
	(47.58)	(52.25)	(52.25)	(71.32)	(78.08)	(78.08)	(155.2)	(166.8)	(166.8)
L9.New product ratio	-0.00724	-0.0170	-0.0170	0.0218	0.00252	0.00252	-0.0305	-0.0783	-0.0783
	(0.0124)	(0.0155)	(0.0155)	(0.0190)	(0.0234)	(0.0234)	(0.0411)	(0.0498)	(0.0498)
L9.Export ratio	0.0279***	0.0248***	0.0248***	0.0578***	0.0429***	0.0429***	0.213***	0.195***	0.195***
	(0.00532)	(0.00677)	(0.00677)	(0.00816)	(0.0104)	(0.0104)	(0.0176)	(0.0220)	(0.0220)
L9.Wage premium	0.0834***	0.0983***	0.0983***	0.0681	0.114	0.114	-0.0174	-0.0152	-0.0152
	(0.0254)	(0.0286)	(0.0286)	(0.0522)	(0.0600)	(0.0600)	(0.0198)	(0.0213)	(0.0213)
L9.Firm age	0.000290	0.000388*	0.000388*	0.000241	0.000477	0.000477	0.000421	0.000730	0.000730
	(0.000189)	(0.000217)	(0.000217)	(0.000289)	(0.000330)	(0.000330)	(0.000629)	(0.000716)	(0.000716)
Observations	409	409	409	409	409	409	409	409	409
R-squared	0.120	0.184	0.184	0.138	0.205	0.205	0.345	0.409	0.409
Year dummy	No	No	No	No	No	No	No	No	No
2-digit industry dummy	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses

*** p<0.01, ** p<0.05

Table 3.1 Agglomeration indices applied

Indices Name	Equation	Variables explanation
Geographic Concentration	$G = \frac{(\sum_{i=1}^{M} s_i^2 - \sum_{i=1}^{M} x_i^2)}{1 - \sum_{i=1}^{M} x_i^2}$	S: share of total industry employment in region i x share of aggregate employment in region i
Herfindahl Index	$H = \sum_{j=1}^{N} z_j^2$	z: the share of plant j in total industry employment, given N plants in the industry.
EG Index	$\hat{\gamma}_{MS} = \frac{\{\frac{\sum_{i=1}^{M} s_i^2 - \sum_{i=1}^{M} x_i^2)}{1 - \sum_{i=1}^{M} x_i^2} - H\}}{(1-H)}$	
MS index	$\hat{\gamma}_{EG} = \frac{\{\frac{\sum_{i=1}^{M} (s_i^2 - x_i^2)}{1 - \sum_{i=1}^{M} x_i^2} - H\}}{(1-H)}$	
Locational Gini Coefficient	$L_A = \frac{2}{K^2 \bar{s}} [\sum_{k=1}^{K} \lambda_k (s_k - \bar{s})]$	s_k the k th region's share of industry employment
Concentration Index	$CI = \sum_{k=1}^{3} s_k$	k denotes the position of the region in the ranking of s_k, and $\bar{s}$ is its mean across regions

Table 3.2. Descriptive statistics

	2004	2008
Number of four-digit industries	382	399
Number of plants:		
in total population	21,352	28,309
incorporated, sole proprietors or partnerships, and actively producing	17,656	25,868
number of 'firms'	20,619	27,567
Average employment per 'firm'	65	51

Number of firms is below number of plants to account for multi-plant firms

Table 3.3. Size distribution of $firm^a$, 2008

Number of employees in the firm	Percentage of firms	Number of firms	Percentage of employment	Number of employees
0– 1	0.67	189	0.01	187
2	1.44	407	0.06	814
3	2.25	637	0.13	1,911
4	2.93	830	0.23	3,320
5– 9	18.92	5,356	2.57	37,102
10– 19	28.54	8,078	7.27	104,954
20– 49	27.9	7,898	16.72	241,497
50– 99	9.52	2,695	12.44	179,615
100–199	4.18	1,184	11.07	159,926
200 +	3.66	1,035	49.5	714,746
Total	100	28,309	100	1,444,072

Note: Enterprises with zero employees represent the chief manager also worked as an employee. The enterprise hires no one.
a: We treat enterprises have the same owner, locates in the same region and have the same 4-digit industry code as one firm. We aggregate their number of employees.

Table 3.4. The Economic and Technology Development Area in Tianjin

6-digit regional code	Local authority Name	Year of Establishment	Main Economic Development Area	Area of the Zones(k^2)	Postcode	Numbers of plants entered	Amount of Investment
120107	Tanggu District	1984	TEDA	33	300457	3300	15Billion Dollar
120111	Xiqing District	1992	XEDA	16.88(153k^2)	300385	830	3.9Billion Dollar
120113	Beichen District	1992	BCEDA	17	300402	400	-
120223	Jinghai County	1992	JEDA	120	301600	150	10 Billion RMB
120112	Jinnan District	1992	JNEDA	18	300350	-	-
120114	Wuqing District	1991	Tianjin Wuqing Development Area, Yat-Sen Scientific Park(part of TEDA),Tianjin Binhai Hi-tech Industrial Development Area	50(93),32,9.34	301700	1000	40 Billion RMB
120110	Dongli District	1992	DEDA	7.21	300300	150	-
120115	Baodi District	2003	Tianjin Baodi Economic Development Area	15	301800	194	1.243 Billion RMB
120109	Dagang District	1992	Tianjin Dagang Economic Development Area	10	300270	-	-
120225	Ji County	1992	Tianjin Ji County Economic Development Area	10	301914	100	2 Billion RMB
120104	Nankai District	1992	Tianjin Binhai Hi-tech Industrial Development Area	12.22	300384	-	-
120221	Ninghe County	1992	NEDA	0.28	301500		
120108	Hangu District	1996	Tianjin Hangu Modern Industrial Park(Part of TEDA)	27	300480	-	-

Table 3.5. Geographic and industrial concentration measures for total production, 2004

	Number of regional units	Local authority, 2988	Postcode area 209	Local authority, 246	County, 18
Tianjin,2004	G	0.0043	0.0199	0.0142	0.0256
	H	0.0009	0.0009	0.0009	0.0009
	γ	0.003	0.019	0.013	0.025
	γ_{EG}	0.003	0.019	0.013	0.025
	Locational Gini	0.758	0.706	0.594	0.357
	Concentration index	0.082	0.186	0.151	0.365
	Number of regional units		Postcode Area, 18884		County, 2969
China, 2003	G		0.0003		0.0014
	H		0.0001		0.0001
	γ		0.0002		0.0013
	γ_{EG}		0.0002		0.0013
	Locational Gini		0.757		0.666
	Concentration index		0.008		0.040

Measures are: G: geographic concentration (Eq. (7)), H: industrial concentration (Eq. (5)), γ: Maurel and Se´dillot (1999) agglomeration index (Eq. (6)); Ellison and Glaeser (1997) agglomeration index, locational Gini, and concentration index calculated on firms (see Table 3.1).

Table 3.6. Geographic and industrial concentration measures for total production, 2008

	Number of regional units	Local authority, 2988	Postcode area 209	Local authority, 246	County, 18
Tianjin,2008	G	0.0042	0.025	0.0177	0.0292
	H	0.0014	0.0014	0.0014	0.0014
	γ	0.003	0.024	0.016	0.028
	γ_{EG}	0.003	0.024	0.016	0.028
	Locational Gini	0.765	0.725	0.611	0.386
	Concentration index	0.075	0.202	0.167	0.376
	Number of regional units		Postcode Area, 18884		County, 2969
China, 2007	G		0.0004		0.0018
	H		0.0001		0.0001
	γ		0.0003		0.0017
	γ_{EG}		0.0003		0.0017
	Locational Gini		0.784		0.672
	Concentration index		0.009		0.046

Measures are: G: geographic concentration (Eq. (7)), H: industrial concentration (Eq. (5)), γ: Maurel and Se´dillot (1999) agglomeration index (Eq. (6)); Ellison and Glaeser (1997) agglomeration index, locational Gini, and concentration index calculated on firms (see Table 3.1).

Table 3.7. Summary of agglomeration in four-digit industries, by two-digit industry,2008

Two-digit industry	Mean γ	Percentage of four-digit industries in quartile (by)				Number of four-digit industries
		1 (least)	2	3	4 (most)	
15 Beverages	0.150	33	11	22	33	9
40 Communications equipment, computers and other electronic equipment manufacturing	0.147	37	0	11	53	19
43 Waste Resources and Materials Recycling and Processing	0.124	0	50	0	50	2
10 Non-metal Ores mining	0.123	0	0	50	50	2
46 Water production and supply	0.121	33	0	0	67	3
42 Artwork and Other Manufacturing	0.088	14	7	50	29	14
41 Instrumentation and culture, office machinery manufacturing	0.082	35	29	12	24	17
37 Transportation equipment manufacturing	0.080	21	14	29	36	14
28 Chemical Fibres	0.078	67	0	0	33	3
39 Electrical machinery and equipment manufacturing	0.072	26	19	33	22	27
14 Food	0.070	22	28	22	28	18
21 Furniture	0.069	33	0	33	33	3
29 Rubber Products	0.067	0	44	11	44	9
30 Plastic products	0.066	0	40	30	30	10
31 Non-metallic mineral products	0.054	25	29	21	25	24
19 Leather, fur, feathers (down) processing and its products	0.052	13	25	38	25	8

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Two-digit industry	Mean γ	Percentage of four-digit industries in quartile (by)				Number of four-digit industries
		1 (least)	2	3	4 (most)	
34 Metal manufacturing	0.050	18	36	23	23	22
35 General equipment manufacturing	0.047	13	29	39	19	31
17 Textiles	0.046	18	24	35	24	17
32 Ferrous metal smelting and rolling processing	0.046	50	0	25	25	4
27 Pharmaceutical products	0.044	14	29	29	29	7
13 Agro-food processing	0.041	23	38	15	23	13
24 Educational and Sports Goods	0.035	36	14	21	29	14
26 Chemicals	0.031	26	26	32	16	31
20 Wood processing and wood, bamboo, rattan, brown, grass products	0.027	22	33	22	22	9
22 Paper and paper products	0.015	33	33	33	0	6
33 Non-ferrous metal smelting and rolling processing	0.014	43	29	29	0	7
18 Manufacturing of cloth, shoes and hat	0.009	33	67	0	0	3
44 Electricity, heat producing and supply	0.005	67	0	33	0	3
23 Printing and copy of record media	-0.001	50	50	0	0	4
25 Coke making , petroleum and nuclear fuel processing	-0.008	100	0	0	0	2
7 Petroleum and natural gas extraction	-0.009	100	0	0	0	1
45 Natural gas production and supply	-0.023	100	0	0	0	1

Quartile boundaries are by γ: 1 (-0.0229, 0.0014) 2. (0.0014,0.0237) 3.(0.0237,0.0674) 4.(0.0674,0.8415)

α:Mean is un-weighted

Table 3.8. Compare two-digit industry agglomeration between 2004 and 2008

	Mean Gamma		Trend	Number of four-digit industries		Trend	Number of Firms		Trend
	2004	2008		2004	2008		2004	2008	
15 Beverages	0.137	0.15	Up	10	9	Down	36	30	Down
40 Communications equipment, computers and other electronic equipment manufacturing	0.150	0.147	Down	14	19	Up	787	956	Up
43 Waste Resources and Materials Recycling and Processing	0.073	0.124	Up	2	2	-	921	1,246	Up
10 Non-metal Ores Mining	0.418	0.123	Down	3	2	Down	26	14	Down
46 Water production and supply	0.018	0.121	Up	2	3	Up	24	32	Up
42 Artwork and Other Manufacturing	0.107	0.088	Down	12	14	Up	68	84	Up
41 Instrumentation and culture, office machinery manufacturing	0.059	0.082	Up	15	17	Up	30	58	Up
37 Transportation equipment manufacturing	0.082	0.08	Down	15	14	Down	1,061	1,643	Up
28 Chemical Fibres	0.132	0.078	Down	4	3	Down	2,465	3,448	Up
39 Electrical machinery and equipment	0.061	0.072	Up	23	27	Up	271	268	Down
14 Food	0.065	0.07	Up	15	18	Up	168	146	Down
21 Furniture	0.065	0.069	Up	3	3	-	2,709	3,900	Up
29 Rubber Products	0.051	0.067	Up	9	9	-	403	549	Up
30 Plastic products	0.050	0.066	Up	10	10	-	391	441	Up
31 Non-metallic mineral products	0.040	0.054	Up	25	24	Down	1,146	1,543	Up
19 Leather, fur, feathers (down) processing and its products	0.083	0.052	Down	8	8	-	160	194	Up
36 Special equipment manufacturing	0.037	0.052	Up	39	42	Up	930	1,153	Up

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	Mean Gamma		Trend	Number of four-digit industries		Trend	Number of Firms		Trend
	2004	2008		2004	2008		2004	2008	
34 Metal manufacturing	0.077	0.05	Down	23	22	Down	1,678	1,796	Up
35 General equipment manufacturing	0.060	0.047	Down	30	31	Up	248	289	Up
32 Ferrous metal smelting and rolling processing	0.049	0.046	Down	4	4	-	199	198	Down
17 Textiles	0.061	0.046	Down	19	17	Down	297	377	Up
27 Pharmaceutical products	0.049	0.044	Down	7	7	-	811	877	Up
13 Agro-food processing	0.068	0.041	Down	13	13	-	536	797	Up
24 Educational and Sports Goods	0.046	0.035	Down	12	14	Up	470	611	Up
26 Chemicals	0.049	0.031	Down	28	31	Up	989	1,288	Up
20 Wood processing and wood, bamboo, rattan, brown, grass products	0.108	0.027	Down	9	9	-	1,704	2,218	Up
22 Paper and paper products	0.020	0.015	Down	5	6	Up	43	173	Up
33 Non-ferrous metal smelting and rolling processing	0.037	0.014	Down	7	7	-	634	630	Down
18 Manufacturing of cloth, shoes and hat	0.013	0.009	Down	3	3	-	583	1,238	Up
44 Electricity, heat producing and supply	0.015	0.005	Down	3	3	-	113	107	Down
23 Printing and copy of record media	0.005	-0.001	Down	4	4	-	535	744	Up
25 Coke making ,petroleum and nuclear fuel processing	0.010	-0.008	Down	2	2	-	336	504	Up
7 Petroleum and natural gas extraction	0.429	-0.009	Down	2	1	Down	21	11	Down
45 Natural gas production and supply	-0.010	-0.023	Down	1	1	-	552	746	Up

Table 3.9. Twenty most agglomerated industries, 2008

Four-digit industry	Number of firms	Agglomeration, γ	Geographic concentration, G	Industrial concentration, H
1539 Tea and other soft drinks manufacturing	9	0.841	0.911	0.439
4154 Photocopying and printing equipment manufacturing nothing else specified	6	0.669	0.807	0.418
3659 Garment processing equipment manufacturing	6	0.635	0.877	0.662
4013 Communication Terminal Equipment	8	0.606	0.774	0.427
4052 Semiconductor discrete device manufacturing*	15	0.584	0.778	0.465
4214 Flower painting handicraft manufacturing	136	0.563	0.570	0.015
3911Generators and turbine manufacturing*	47	0.511	0.631	0.245
3940 Battery manufacturing	43	0.447	0.536	0.161
4130 Clocks and timekeeping instruments manufacturing*	17	0.393	0.615	0.366
3152 Special ceramic products manufacturing	7	0.373	0.673	0.478
4053 Integrated circuit manufacturing	10	0.372	0.785	0.658
1491 Dietary supplement manufacturing	26	0.342	0.461	0.181
1524 Wine manufacturing*	15	0.336	0.492	0.235
3471 Enamel Products for industry production*	9	0.310	0.705	0.573
3050 Plastic artificial leather, synthetic leather manufacturing	9	0.293	0.531	0.337
3957 Manufacturing of household electrical appliances parts	10	0.273	0.444	0.236
4072 Home audio equipment manufacturing	15	0.264	0.527	0.357
3714 Equipment and appliances, parts manufacturing for railway	18	0.260	0.457	0.266
4041 Electronic computer finishing	6	0.252	0.741	0.653
1419 Biscuits and other baked goods	26	0.248	0.550	0.401

Measures are: c: agglomeration index (Eq. (6)), G: geographic concentration measure (Eq. (7)); H: industrial concentration (Eq. (5)).

*Indicates that the industry was also in the top 20 in 2004.

Table 3.10. Most agglomerated regions, 2008

Four-digit industry	1st postcode area	2nd postcode	Percentage of employment in postcode		Total number firms	Percentage of firms in postcode		Average firm size (employment)	
			1st	2nd		1st	2nd	1st	Other
1539 Tea and other soft drinks manufacturing	300457 (TEDA)	300170 (Hedong)	95.5	1.3	9	33.3	11.1	975	23
4154 Photocopying and printing equipment manufacturing nothing else specified	300221 (Hexi)	300300 (Dongli)	89.7	3.8	6	33.3	16.7	179	10
3659 Garment processing equipment manufacturing	301800 (Baodi)	300150 (Hebei)	93.6	1.9	6	33.3	16.7	175	6
4013Communication Terminal Equipment	300211 (Hexi)	300140 (Hebei)	87.6	6.2	8	25	37.5	898	42
4052Semiconductor discrete device manufacturing	300457(TEDA)	300350 (Jinnan)	88	7.8	15	33.3	13.3	618	42
4214 Flower painting handicraft manufacturing	301700 (Wuqing)	300301 (Dongli)	74.7	8	136	91.9	2.2	12	44
3911 Generators and turbine manufacturing	300400 (Beichen)	300380 (Xiqing)	79.5	2.4	47	27.7	6.4	222	22
3940Batteries	300457 (TEDA)	300385 (XEDA)	72.6	11.7	43	18.6	4.7	443	38
4130Clocks and timekeeping instruments manufacturing	300074 (Nankai)	300220(Hexi)	77.1	16	17	29.4	5.9	453	56
3152Special ceramic products manufacturing	300350 (Jinnan)	300112 (Xiqing)	81.1	11	7	42.9	28.6	62	11

(Continued on the next page)

Four-digit industry	1st postcode area	2nd postcode	Percentage of employment in postcode		Total number firms	Percentage of firms in postcode		Average firm size (employment)	
			1st	2nd		1st	2nd	1st	Other
4053Integrated circuit manufacturing	300385 (XEDA)	300350 (Jinnan)	88.4	8.3	10	30	10	356	20
1491 Dietary supplement manufacturing	300457 (TEDA)	300400 (Beichen)	68	5.6	26	26.9	3.8	174	26
1524 Wine manufacturing	300402 (Beichen)	300480 (Hangu)	68.5	13.6	15	20	33.3	203	23
3471 Enamel Products for industry production	300350 (Jinnan)	300402 (Beichen)	83.4	7.7	9	55.6	11.1	43	11
3050Plastic artificial leather, synthetic leather manufacturing	301509 (Ninghe)	300350 (Jinnan)	70.9	18.2	9	22.2	11.1	224	26
3957 Manufacturing of household electrical appliances parts	300402 (Beichen)	300040 (Beichen)	51.9	41.7	10	60	10	103	143
4072 Home audio equipment manufacturing	300457 (TEDA)	301604 (Jinghai)	71.3	15	15	13.3	6.7	1421	88
3714 Equipment and appliances, parts manufacturing for railway	300300 (Dongli)	300232 (Tanggu)	63.9	20.5	18	44.4	11.1	125	57
4041 Electronic computer finishing	300190 (Nankai)	300457 (TEDA)	85.8	8	6	33.3	16.7	203	17
1419 Biscuits and other baked goods	300457 (TEDA)	300385 (XEDA)	74	7.1	26	11.5	3.8	631	29

Table 3.11. Twenty most agglomerated industries—geographic distribution of entry, 2008

Four-digit industry	Number entrants	Largest proportion of entrants postcode	Percentage entrants to the top postcode area*	G entrants	γ entrants
1539 Tea and other soft drinks manufacturing	10	300457*	10	0.883	-0.014
4154 Photocopying and printing equipment manufacturing n. e. s	15	300221*	20	0.400	0.273
3659 Garment processing equipment manufacturing	10	301800*	30	0.697	0.364
4013Communication Terminal Equipment	8	300384	75	0.742	0.585
4052Semiconductor discrete device manufacturing	22	300384	23	0.352	0.006
4214 Flower painting handicraft manufacturing	221	301700*	94	0.815	0.814
3911 Generators and turbine manufacturing	68	300308	1	0.151	-0.094
3940Batteries	57	300385	9	0.158	0.036
4130Clocks and timekeeping instruments manufacturing	31	300074*	13	0.297	0.162
3152Special ceramic products manufacturing	10	300350*	30	0.350	0.078
1539 Tea and other soft drinks manufacturing	19	300385*	26	0.851	0.780
4154 Photocopying and printing equipment manufacturing nothing else specified	48	301700	15	0.455	0.333
3659 Garment processing equipment manufacturing	13	300061	8	0.133	-0.035
4013Communication Terminal Equipment	9	300402	13	0.235	0.052
4052Semiconductor discrete device manufacturing	13	301701	8	0.136	-0.043
4214 Flower painting handicraft manufacturing	9	300402*	44	0.602	0.494
3911 Generators and turbine manufacturing	17	300457*	6	0.244	-0.02
3940Batteries	23	300300*	35	0.343	0.115
4130Clocks and timekeeping instruments manufacturing	13	300384	31	0.619	0.432
3152Special ceramic products manufacturing	18	301700	22	0.507	0.295

* Defined as the postcode that most numbers of new entrants firms located which is also the top postcode in Table 14 and 15

Table 3.12. Definitions and summary statistics of key variables

Variable name	Definition	Number of observations	Mean	Std. Dev.	Min	Max
EG index(County)	EG index calculated at 4-digit industry level and county level	726	0.104	0.164	-0.07	1
EG index (local authority)	EG index calculated at 4-digit industry level and city level	726	0.054	0.1	-0.016	0.842
EG index(postcode)	EG index calculated at 4-digit industry level and province level	726	0.063	0.104	-0.023	0.852
Share of SOEs	The total number employees of SOEs enterprises/ total number employees of overall enterprises	726	0.164	0.199	0	1
Share of Domestics	The total number employees of Domestics enterprises/ total number employees of overall enterprises	726	0.576	0.255	0	1
Shares of Foreign	The total number employees of Foreign enterprises/ total number employees of overall enterprises	726	0.204	0.238	0	0.989
Average firm size	$Average\ firm\ size = \frac{\sum_{i=1} totalincome_{it}}{\sum_{i=1} total\ number\ of\ firms_{it}}$	726	82,915	498,002	365	7.00E+06
Average firm age	Average firm age=T--$\frac{\sum_{i=1} establishedyear_{it}}{total\ number\ of\ firms_{it}}$	726	7	3	0	38

Note: Industrial variables are calculated at 4-digit industry level

Table 3.13. Correlation of indicators

	Gamma_reg6d	Gamma_reg9d	Gamma_postcode	Share of SOEs	Share of Domestics	Share of Foreign	Total income	Average firm size	Average Firm age
Gamma_reg6d	1								
Gamma_reg9d	**0.6585**	1							
Gamma_postcode	**0.7274**	**0.821**	1						
Share of SOEs	0.0513	-0.0054	0.0342	1					
Share of Domestics	-0.0666	**-0.1872**	**-0.127**	**-0.3831**	1				
Share of Foreign	0.0256	**0.1717**	**0.0933**	**-0.3518**	**-0.6163**	1			
Total income	0.0455	0.041	0.0032	0.0161	-0.0511	0.0603	1		
Average firm size	0.0381	**0.0884**	0.0691	**0.0836**	**-0.1876**	**0.152**	**0.3811**	1	
Average Firm age	0.0219	0.0217	0.039	0.4378	**-0.1986**	**-0.1226**	**0.1034**	**0.1238**	1

Values on bold give the significance at 1% and 5%.

Table 3.14. The determinants of agglomeration

	OLS			Fixed effect			Changes OLS			Changes Fixed effect		
	County	9-digit region	Postcode	County	9-digit region	Postcode	County	9-digit region	Postcode	County	9-digit region	Postcode
Share of SOEs	0.0414	-0.0108	0.00987	0.0346	-0.00366	0.0122						
	(0.0573)	(0.0400)	(0.0421)	(0.0368)	(0.0225)	(0.0235)						
Average firm size	1.13e-08	1.75e-08***	1.35e-08***	-5.93e-09	7.20e-09	3.58e-09						
	(6.43e-09)	(4.56e-09)	(4.93e-09)	(1.26e-08)	(7.72e-09)	(8.06e-09)						
Average firm age	-0.000217	0.000607	0.000710	-0.00212	0.00117	0.000470						
	(0.00265)	(0.00210)	(0.00214)	(0.00220)	(0.00135)	(0.00140)						
L4.Share of SOEs							0.0947	0.0254	0.0711	0.0704	-0.0103	0.0410
							(0.0866)	(0.0694)	(0.0704)	(0.0568)	(0.0340)	(0.0336)
L4.Average firm size							1.49e-08	1.83e-08**	1.63e-08**	0	1.13e-08	9.14e-09
							(9.46e-09)	(7.18e-09)	(7.17e-09)	(1.79e-08)	(1.07e-08)	(1.06e-08)
L4.Average firm age							-0.00271	-0.00197	-0.00222	-0.00300	0.000886	-0.00115
							(0.00387)	(0.00302)	(0.00309)	(0.00388)	(0.00232)	(0.00229)
Observations	726	726	726	726	726	726	363	363	363	363	363	363
R-squared	0.004	0.008	0.006	0.135	0.130	0.133	0.011	0.010	0.020	0.178	0.246	0.265

Robust standard errors in parentheses

*** p<0.01, ** p<0.05

Table 3.15.. The determinants of agglomeration

	OLS			Fixed effect			Changes OLS			Changes Fixed effect		
	County	9-digit region	Postcode	County	9-digit region	Postcode	County	9-digit region	Postcode	County	9-digit region	Postcode
Share of Domestics	-0.0387	-0.0707***	-0.0475**	0.00900	-0.0454***	-0.00897						
	(0.0347)	(0.0236)	(0.0236)	(0.0259)	(0.0157)	(0.0165)						
Average firm size	8.54e-09	1.14e-08***	9.61e-09**	-5.57e-09	4.57e-09	3.00e-09						
	(6.69e-09)	(4.09e-09)	(4.45e-09)	(1.27e-08)	(7.73e-09)	(8.11e-09)						
Average firm age	0.000328	-0.000636	0.000318	-0.00137	0.000654	0.000613						
	(0.00229)	(0.00163)	(0.00163)	(0.00211)	(0.00128)	(0.00134)						
L4.Share of Domestics							-0.0322	-0.0818**	-0.0508	0.0263	-0.0447	0.00112
							(0.0508)	(0.0353)	(0.0332)	(0.0404)	(0.0240)	(0.0238)
L4.Average firm size							1.21e-08	1.14e-08	1.19e-08	1.60e-09	8.56e-09	9.20e-09
							(1.01e-08)	(6.33e-09)	(6.49e-09)	(1.81e-08)	(1.07e-08)	(1.07e-08)
L4.Average firm age							9.15e-05	-0.00252	-0.000585	-0.000266	-0.000285	0.000173
							(0.00345)	(0.00172)	(0.00197)	(0.00352)	(0.00209)	(0.00208)
Observations	726	726	726	726	726	726	363	363	363	363	363	363
R-squared	0.005	0.038	0.018	0.134	0.141	0.133	0.004	0.042	0.019	0.175	0.254	0.262

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$

Table 3.16. The determinants of agglomeration

	OLS			Fixed effect			Changes OLS			Changes Fixed effect		
	County	9-digit region	Postcode	County	9-digit region	Postcode	County	9-digit region	Postcode	County	9-digit region	Postcode
Share of Foreigns	0.0161	0.0700**	0.0399	-0.0348	0.0417**	-0.00356						
	(0.0348)	(0.0271)	(0.0255)	(0.0290)	(0.0176)	(0.0185)						
Average firm size	1.05e-08	1.17e-08***	1.04e-08**	-3.58e-09	4.21e-09	3.78e-09						
	(6.41e-09)	(4.07e-09)	(4.46e-09)	(1.28e-08)	(7.80e-09)	(8.17e-09)						
Average firm age	0.00102	0.00104	0.00137	-0.00175	0.00145	0.000672						
	(0.00224)	(0.00152)	(0.00160)	(0.00210)	(0.00128)	(0.00134)						
L4.Share of Foreigns							-0.00757	0.0630	0.0141	-0.0468	0.0476	-0.0197
							(0.0454)	(0.0351)	(0.0288)	(0.0420)	(0.0250)	(0.0248)
L4.Average firm size							1.55e-08	1.24e-08**	1.49e-08**	3.47e-09	7.74e-09	1.06e-08
							(9.43e-09)	(6.23e-09)	(6.27e-09)	(1.82e-08)	(1.08e-08)	(1.07e-08)
L4.Average firm age							0.000550	-0.000135	0.000526	-0.00130	0.00111	-7.47e-05
							(0.00354)	(0.00156)	(0.00198)	(0.00347)	(0.00206)	(0.00205)
Observations	726	726	726	726	726	726	363	363	363	363	363	363
R-squared	0.002	0.035	0.014	0.135	0.137	0.132	0.002	0.028	0.007	0.177	0.254	0.263

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$

Table 3.17. The correlation between industrial agglomeration and education level

	OLS			Fixed effect			Changes		
	District	9-digit region	Postcode	District	9-digit region	Postcode	District	9-digit region	Postcode
Share of high education employees	-0.089	-0.037	-0.038	-0.082	-0.045	-0.014	0.140	0.029	0.038
	(0.053)	(0.043)	(0.033)	(0.070)	(0.056)	(0.047)	(0.134)	(0.103)	(0.087)
R-squared	0.003	-0.000	0.001	0.004	0.001	0.002	0.106	0.181	0.352
Share of medium education employees	-0.129**	-0.036	-0.067	-0.116	-0.025	-0.084**	-0.084	0.033	-0.080
	(0.058)	(0.047)	(0.036)	(0.063)	(0.050)	(0.042)	(0.091)	(0.070)	(0.059)
R-squared	0.006	-0.001	0.004	0.008	0.001	0.005	0.105	0.181	0.358
Share of low education employees	0.088**	0.030	0.042	0.106***	0.036	0.056	0.012	-0.030	0.039
	(0.035)	(0.029)	(0.022)	(0.048)	(0.038)	(0.032)	(0.072)	(0.055)	(0.047)
R-squared	0.008	0.000	0.004	0.010	0.002	0.006	0.101	0.182	0.354
Observations	634	634	634	634	634	634	317	317	317

Note: Standard errors are in parentheses.

* Stand for significant at 10%. ** Idem, 5%.

Table 4.1. The importance of the coastal regions to the manufacturing sector in China, 2000-2006

Estimators(deflated)	China	Coastal Regions	Share
Total number of employees	450,255,200	100,284,152	22.27%
Number of 4-digit industries	513	419	81.68%
Total output	110,320,574,464	31,964,997,632	28.97%
Total Assets	2,999,895,982,080	746,163,077,120	24.87%
Total income	566,347,694,080	153,705,283,584	27.14%

Table 4.2. Number of enterprises in each coastal region in China

Region code(Name)	Total number of Enterprises	Size Distribution (employees)		
		employment<100	100<employment<200	employment>200
12 (Tianjin)	17,376	9,303	3,696	4,377
13 (Hebei province)	5,809	2,245	1,512	2,052
21 (Liaoning province)	8,009	3,775	1,952	2,282
31 (Shanghai)	38,489	21,232	8,789	8,468
32 (Jiangsu province)	86,455	44,004	20,519	21,932
33 (Zhejiang province)	105,524	56,767	26,442	22,315
35 (Fujian province)	32,406	14,655	8,078	9,673
37 (Shandong province)	40,752	17,886	9,755	13,111
44 (Guangdong province)	83,103	33,014	20,182	29,907
45 (Guangxi province)	984	453	235	296
46 (Hainan province)	658	305	154	199

Table 4.3. Typhoons in the sample period

Name of Typhoons	Year
Bilis	2000
Jelawat	2000
Prapiroon	2000
Saomai	2000
Wukong	2000
Chebi	2001
Durian	2001
Yutu	2001
Sinlaku	2002
Dujuan	2003
Krovanh	2003
Lmbudo	2003
Maemi	2003
Nepartak	2003
Aere	2004
Rananim	2004
Damrcy	2005
Haitang	2005
Khanun	2005
Longwang	2005
Matsa	2005
Talim	2005
Chanchu	2006
Kaemi	2006
Prapiroon	2006
Saomai	2006
Shanshan	2006

Table 4.4. Summary of key variables

Variable	Observations	Mean	Std. Dev.	Min	Max
V_178	419,565	210,050.10	1,905,218.00	0	3.15E+07
V_119	419,565	1,368,549.00	4,797,186.00	0	4.50E+07
Temperature (Annual Average)	419,565	17.55	3.59	-6.025	29.20833
Rainfalls (Annual)	419,565	1,353.94	568.40	25.9	3858
TFP	419,565	6.28	1.13	-3.47605	13.57532
Production sales (deflated)	419,565	76,186.04	656,742.00	2.0004	1.67E+08
Labor (per worker)	419,565	239.02	679.72	8	1.32E+05
Wage (Thousand RMB)	419,565	3,549.66	20,415.63	0.990295	4.82E+06
Export Value	419,565	11921.36	280282.4	0	9.31E+07

Table 4.5.The impact of Typhoons on TFP (V119)

Independent Variables	TFP		
V_119	-2.56e-09***	-2.23e-09***	-2.22e-09***
	(5.45e-10)	(5.56e-10)	(5.45e-10)
Lag1_V_119		-4.31e-10	-1.00e-09
		(9.41e-10)	(5.70e-10)
Lag2_V_119			6.60E-10
			(1.39e-09)
Observations	419,565	419,565	419,565
R-square	0.061	0.061	0.061

Notes: (1) Robust standard errors in parentheses; (2) *** p<0.01, ** p<0.05, * p<0.1; (3) time dummy included but not reported

Table 4.6.The impact of Typhoons on Other Economic Performance Indicators (V119)

Independent Variables	Employment			Wage			Output		
V_119	5.91e-07*	2.68e-08	3.09e-08	-0.0000382***	-0.0000395***	-0.0000394***	-0.0014114***	-0.0014444***	-0.0014461***
	(2.59e-07)	(2.37e-07)	(2.39e-07)	(5.90e-06)	(7.63e-06)	(7.61e-06)	(0.0002209)	(0.0002888)	(0.0002872)
Lag1_V_119		7.35e-07***	4.27e-07		1.68e-06	-2.36e-06		0.0000429	0.0001741*
		(1.91e-07)	(2.99e-07)		(5.66e-06)	(0.0000107)		(0.0001529)	(0.0000802)
Lag2_V_119			3.54e-07			4.65e-06			-0.000151
			(3.55e-07)			(8.20e-06)			(0.0001427)
Observations	419,565	419,565	419,565	419,565	419,565	419,565	419,565	419,565	419,565
R-square	0.004	0.005	0.005	0.009	0.009	0.009	0.007	0.007	0.007

Notes: (1) Robust standard errors in parentheses; (2) *** p<0.01, ** p<0.05, * p<0.1; (3) time dummy included but not reported

Table 4.7. Impact of Typhoon on Export (V119)

Independent Variables	Export Value		
V_119	-0.0002536***	-0.0003818***	-0.0003815***
	(0.0000381)	(0.0000734)	(0.0000734)
Lag1_V_119		0.0001669*	0.0001491*
		(0.0000753)	(0.0000616)
Lag2_V_119			2.05E-05
			(0.0000364)
Observations	419,565	419,565	419,565
R-square	0.001	0.001	0.001

Notes: (1) Robust standard errors in parentheses; (2) *** p<0.01, ** p<0.05, * p<0.1; (3) time dummy included by not reported

Table 4.8.The impact of Typhoon on TFP (V178)

Independent Variables	TFP		
V_178	-2.48e-09**	-2.82e-09**	-2.82e-09**
	(8.19e-10)	(9.30e-10)	(9.28e-10)
Lag1_V_178		5.24e-10	-5.64e-10
		(5.96e-10)	(4.92e-10)
Lag2_V_178			1.30E-09
			(8.03e-10)
Observations	419,565	419,565	419,565
R-square	0.061	0.061	0.061

Notes: (1) Robust standard errors in parentheses; (2) *** p<0.01, ** p<0.05, * p<0.1; (3) time dummy included but not reported

Table 4.9. The impact of Typhoon on Other Economic Performance Indicators (V178)

Independent Variables	Employment			Wage			Output		
V_178	6.33e-07*	3.64e-07*	3.63e-07*	-0.0000358***	-0.0000407***	-0.0000407***	-0.0012914***	-0.0014917**	-0.0014917**
	(3.03e-07)	(1.53e-07)	(1.53e-07)	(5.99e-06)	(9.27e-06)	(9.28e-06)	(0.0003419)	(0.0004264)	(0.0004262)
Lag1_V_178		4.06e-07	9.14e-07***		7.36e-06	0.0000143**		0.0003026*	.0002606
		(2.62e-07)	(1.81e-07)		(5.43e-06)	(5.29e-06)		(0.0001349)	(0.0001056)
Lag2_V_178			-6.06e-07**			-8.27e-06***			.00005
			(2.00e-07)			(1.01e-06)			(.0000521)
Observations	419,565	419,565	419,565	419,565	419,565	419,565	419,565	419,565	419,565
R-square	0.004	0.004	0.004	0.009	0.009	0.009	0.007	0.007	0.007

Notes: (1) Robust standard errors in parentheses; (2) *** p<0.01, ** p<0.05, * p<0.1; (3) time dummy included by not reported

Table 4.10. Impact of Typhoon on Export (V178)

Independent Variables	Export Value		
V_178	-0.0002207**	-0.0003601**	-0.0003599**
	(0..0000824)	(0.0001013)	(0.000101)
Lag1_V_178		0.0002107***	0.0000931***
		(0.0000342)	(0.0000134)
Lag2_V_178			0.0001402**
			(0.0000523)
Observations	419,565	419,565	419,565
R-square	0.001	0.001	0.001

Notes: (1) Robust standard errors in parentheses; (2) *** p<0.01, ** p<0.05, * p<0.1; (3) time dummy included by not reported

Table 4.11. Impact of Typhoon on TFP including additional controls (V119)

Independent Variables		TFP	
V_119	-2.65e-09***	-2.43e-09**	-2.88e-09***
	(4.87e-10)	(9.09e-10)	(7.48e-10)
Lag1_V_119		-7.73e-10	-1.02e-09
		(1.24e-09)	(1.56e-09)
Lag2_V_119			6.00e-10
			(1.56e-09)
rain	7.85e-06	-6.14e-06	0.0000112
	(0.0000186)	(0.0000219)	(0.0000121)
lag1_rain		0.0000569	.0000478*
		(0.0000192)	(0.0000209)
lag2_rain			0.0000678
			(0.0000503)
temperature	-0.0058724***	-0.0380733	-.043624**
	(0.0011386)	(0.0220659)	(.0132876)
lag1_temporature		.0279298	0.0035925
		(0.0217743)	(0.0335893)
lag2_temporature			0.0221584
			(0.0367468)
Observations	419,565	419,565	419,565
R-square	0.061	0.061	0.062

Notes: (1) Robust standard errors in parentheses; (2) *** p<0.01, ** p<0.05, * p<0.1; (3) time dummy included but not reported.

Table 4.12. The Impact of Typhoon on Other Economic Performance Indicators (V119)

Independent Variables	Employment			Wage			Output		
V_119	4.91e-07	-1.80e-07	-1.03e-07	-0.0000425***	-0.000049***	-0.0000464***	-0.0014504***	-0.0015357***	-0.0016028***
	(3.06e-07)	(2.93e-07)	(1.98e-07)	(4.09e-06)	(5.98e-06)	(5.94e-06)	(0.000214)	(0.0002957)	(0.0003006)
Lag1_V_119		9.31e-07***	5.29e-07		5.84e-06	-4.44e-07		0.0000371	0.0001933*
		(1.60e-07)	(2.77e-07)		(6.28e-06)	(0.000011)		(0.0001812)	(0.0000814)
Lag2_V_119			4.65e-07			6.13e-06			-.0001211
			(3.45e-07)			(7.35e-06)			(0.0001592)
rain	0.0140947	0.0140308	0.0070648	0.5912104	0.5249312	0.3823751	4.963265**	3.755515	5.013903**
	(0.0128989)	(0.0142251)	(0.0116255)	(0.4864184)	(0.4309703)	(0.3626153)	(1.804531)	(2.204579)	(1.751533)
lag1_rain		-0.0050185	0.0007559		0.2942618	0.3935066		7.83504	7.779865
		(0.0074592)	(0.0095188)		(0.487137)	(0.5528048)		(4.51935)	(5.303875)
lag2_rain			-.0182144*			-0.4546977			7.637333
			(0.009133)			(0.2599084)			(4.244704)
temperature	-0.6474893	-3.397562	-15.44433**	-55.88277	-217.2478	-336.6214	-966.7658*	-3242.455*	-7657.789*
	(1.206515)	(4.837429)	(5.807329)	(29.05181)	(199.6999)	(248.3853)	(403.4648)	(1444.878)	(3925.72)
lag1_temporature		3.563562	7.755		138.2872	274.1778		1492.496	-1882.708
		(5.53796)	(7.527177)		(147.05)	(244.0749)		(1729.161)	(2845.93)
lag2_temporature			10.4023			40.75577			7052.647
			(6.813413)			(116.8781)			(5236.816)
Observations	419,565	419,565	419,565	419,565	419,565	419,565	419,565	419,565	419,565
R-square	0.005	0.005	0.005	0.009	0.011	0.009	0.007	0.007	0.007

Notes: (1) Robust standard errors in parentheses; (2) *** $p<0.01$, ** $p<0.05$, * $p<0.1$; (3) time dummy included but not reported.

Table 4.13. Impact of Typhoon on Export

Independent Variables	Export Value		
V_119	-0.0002794***	-0.0004358***	-0.0004177***
	(0.000027)	(0.0000515)	(0.0000542)
Lag1_V_119		0.000224**	0.0001785**
		(0.0000766)	(0.0000621)
Lag2_V_119			0.0000455
			(0.0000398)
rain	3.6342	3.989629	2.901795
	(2.499434)	(2.84341)	(2.523954)
lag1_rain		-2.159628	-1.376682
		(2.476822)	(2.55768)
lag2_rain			-3.356934***
			(0.8918401)
temperature	-170.1647	178.9733	-902.8118
	(252.2293)	(1206.451)	(1810.29)
lag1_temporature		-122.1852	846.8934
		(1165.435)	(939.2173)
lag2_temporature			542.5332
			(890.1153)
Observations	419,565	419,565	419,565
R-square	0.001	0.001	0.001

Notes: (1) Robust standard errors in parentheses; (2) *** p<0.01, ** p<0.05, * p<0.1; (3) time dummy included by not reported

Table 4.14. Impact of Typhoon on TFP including additional variables (V178)

Independent Variables		TFP	
V_178	-2.47e-09**	-3.61e-09**	-3.64e-09*
	(8.29e-10)	(1.16e-09)	(1.51e-09)
Lag1_V_178		4.71e-10	-6.23e-10
		(6.78e-10)	(4.39e-10)
Lag2_V_178			1.36e-09
			(8.08e-10)
rain	3.14e-06	-.0000113	4.94e-06
	(0.0000203)	(0.0000233)	(0.0000138)
lag1_rain		0.0000542**	0.0000449*
		(0.0000196)	(0.0000213)
lag2_rain			0.0000644
			(0.0000495)
temperature	-0.0052777***	-0.0380101	-.0418441**
	(0.0013061)	(0.0225556)	(0.0142032)
lag1_temporature		0.0289019	0.0060431
		(0.0222543)	(0.0344424)
lag2_temporature			0.0194028
			(0.0393873)
Observations	419,565	419,565	419,565
R-square	0.061	0.061	0.061

Notes: (1) Robust standard errors in parentheses; (2) *** $p<0.01$, ** $p<0.05$, * $p<0.1$; (3) time dummy included but not reported.

Table 4.15. Impact of Typhoon on Other Economic Performance Indicators (V178)

Independent Variables	Labor			Wage			Output		
V_178	7.30e-07**	4.81e-07**	6.90e-07***	-0.0000326**	-0.0000421***	-0.0000399***	-0.0012776***	-0.0015705***	-0.0015234**
	(2.46e-07)	(1.36e-07)	(1.26e-07)	(0.0000102)	(0.0000109)	(0.0000103)	(0.0003474)	(0.0004058)	(0.0004167)
Lag1_V_178		4.45e-07*	9.77e-07***		8.55e-06	.0000151**		0.0003047*	0.0002679*
		(2.24e-07)	(1.68e-07)		(4.40e-06)	(5.02e-06)		(0.0001397)	(0.0001116)
Lag2_V_178			-6.15e-07**			-7.92e-06***			0.000058
			(1.86e-07)			(1.17e-06)			(0.0000475)
rain	0.0150621	0.0146701	0.0078928	0.5180623	0.4475742	0.2989427	2.410124	1.139254	2.074306
	(0.0130664)	(0.0141139)	(0.0117875)	(0.4685412)	(0.4104864)	(0.336002)	(2.025875)	(2.521341)	(2.12539)
lag1_rain		-0.0043908	0.0013722		0.2484107	0.3518748		6.354291	6.292171
		(0.0076119)	(0.0098105)		(0.4601985)	(0.5344052)		(3.917742)	(4.819015)
lag2_rain			-.0178271*			-0.5017199			5.993747
			(0.0089682)			(0.2723909)			(4.243932)
temperature	-0.7628123	-3.372763	-15.74854**	-46.46584	-212.0987	-313.5207	-642.4221	-3116.722	-6833.118
	(1.207933)	(4.899669)	(5.798705)	(25.99483)	(198.87)	(260.398)	(372.0676)	(1747.241)	(4671.802)
lag1_temporature		3.373144	7.316285		149.3814	304.1215		1906.212	-815.9605
		(5.531687)	(7.576187)		(151.4361)	(246.2784)		(1942.96)	(3285.287)
lag2_temporature			10.93587			8.19447			5881.924
			(7.003095)			(110.8009)			(6251.202)
Observations	419,565	419,565	419,565	419,565	419,565	419,565	419,565	419,565	419,565
R-square	0.005	0.005	0.005	0.009	0.009	0.009	0.007	0.007	0.007

Notes: (1) Robust standard errors in parentheses; (2) *** p<0.01, ** p<0.05, * p<0.1; (3) time dummy included but not reported.

Table 4.16 Impact of Typhoon on Export

Independent Variables	Export Value		
V_178	-0.0002001*	-0.000314*	-0.0002939*
	(0.000106)	(0.0001354)	(0.0001311)
Lag1_V_178		0.0002205***	0..0001057***
		(0.0000272)	(0.0000156)
Lag2_V_178			0.0001368**
			(0.000053)
rain	3.158373	3.469697	2.339868
	(2.420822)	(2.753804)	(2.376737)
lag1_rain		-2.400408	-1.58358
		(2.414738)	(2.482457)
lag2_rain			-3.677187***
			(0.94159)
temperature	-108.5467	219.609	-760.6326
	(242.3752)	(1189.231)	(1844.043)
lag1_temporature		-62.30035	1029.858
		(1145.465)	(894.3525)
lag2_temporature			347.2304
			(947.3172)
Observations	419,565	419,565	419,565
R-square	0.001	0.001	0.001

Notes: (1) Robust standard errors in parentheses; (2) *** p<0.01, ** p<0.05, * p<0.1; (3) time dummy included by not reported

Figures

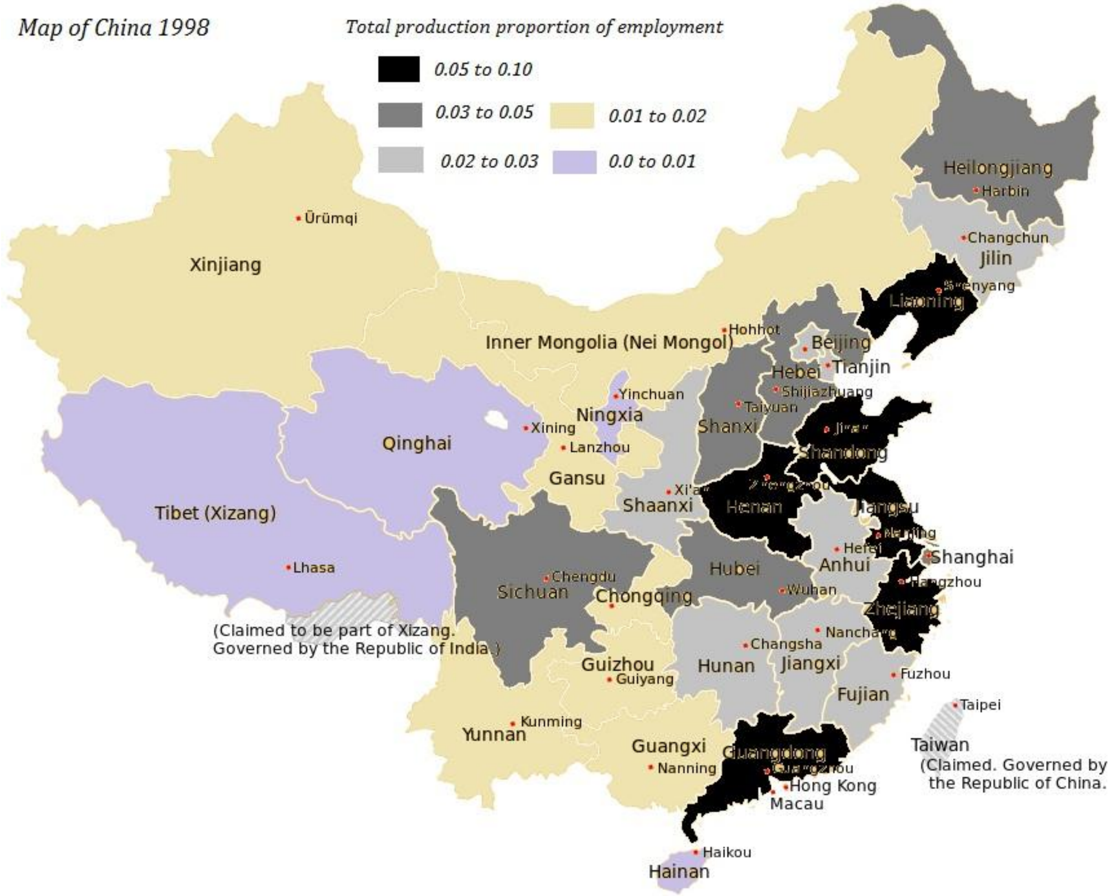

Figure 1.1.The share distribution of production employment at province level, 1998

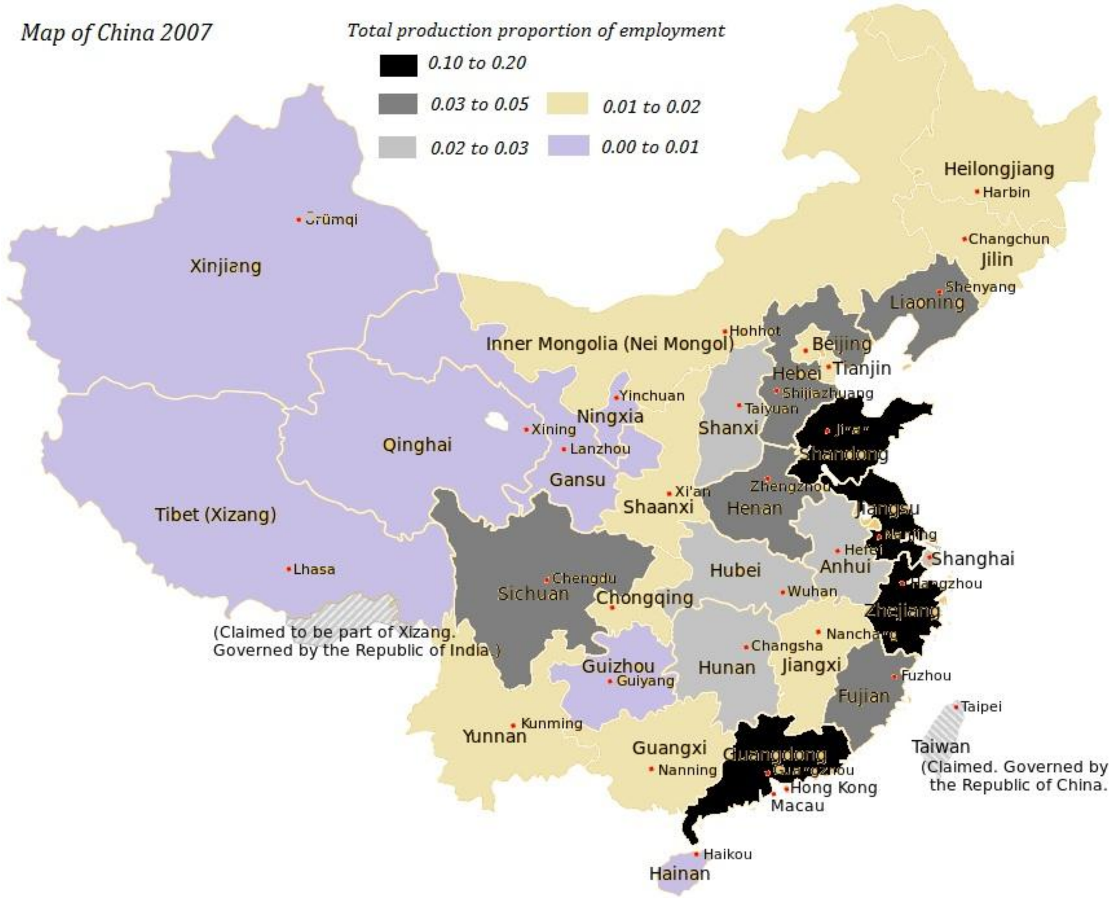

Figure 1.2. The share distribution of production employment at province level, 2007

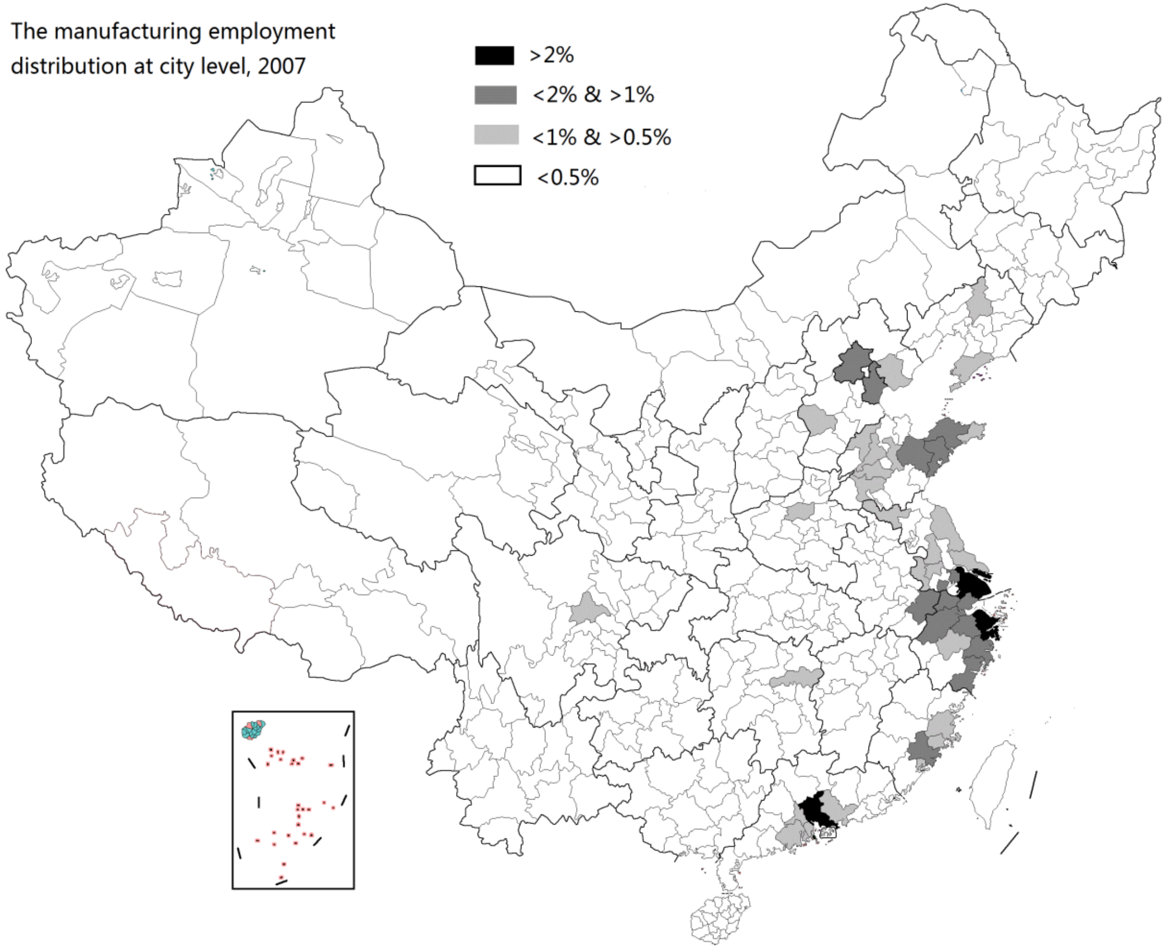

Figure 1.3 The share distribution of production employment at city level, 2007

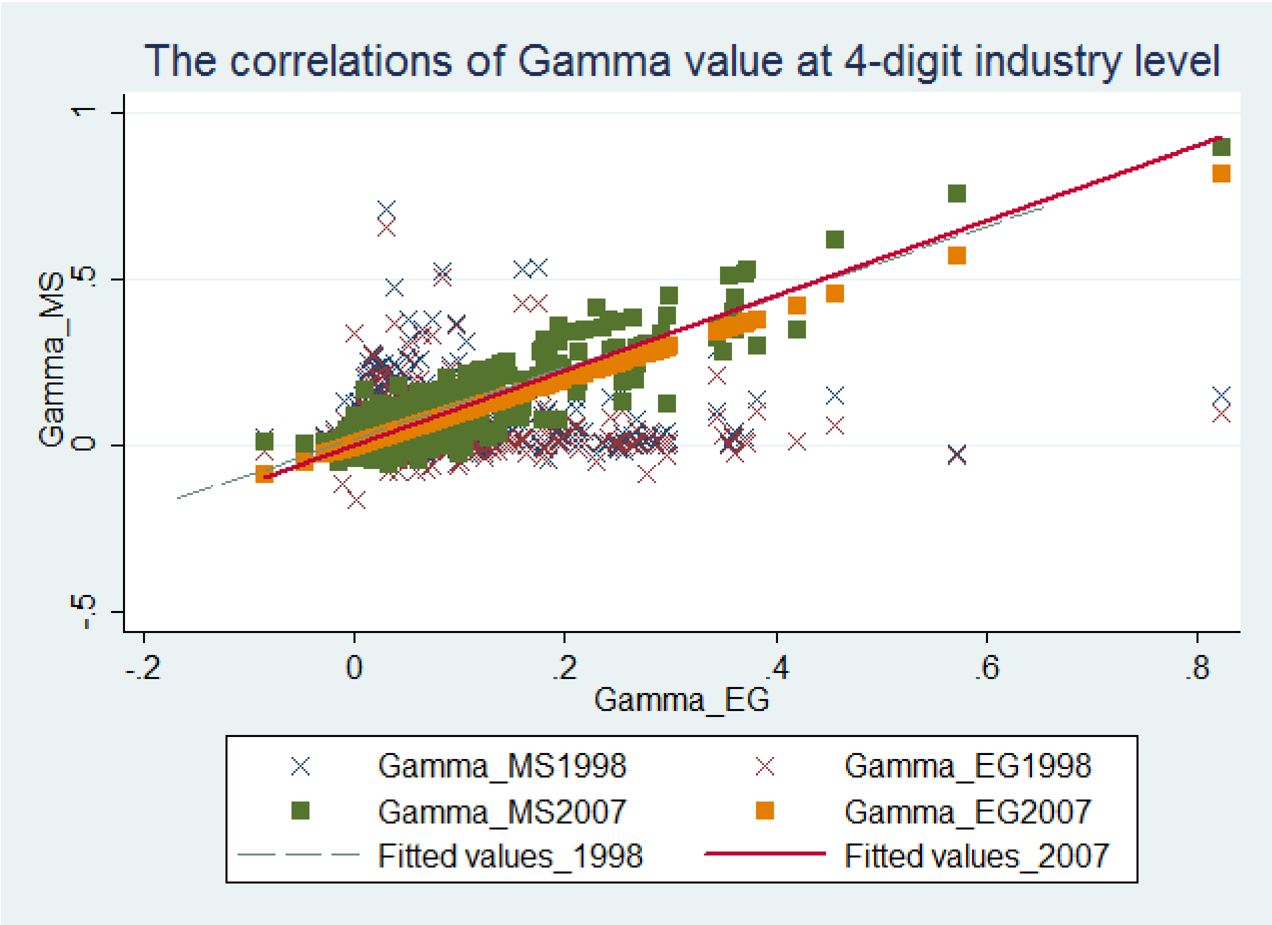

Figure 1.4. The Gamma value distribution at 4-digit industry level, 2007

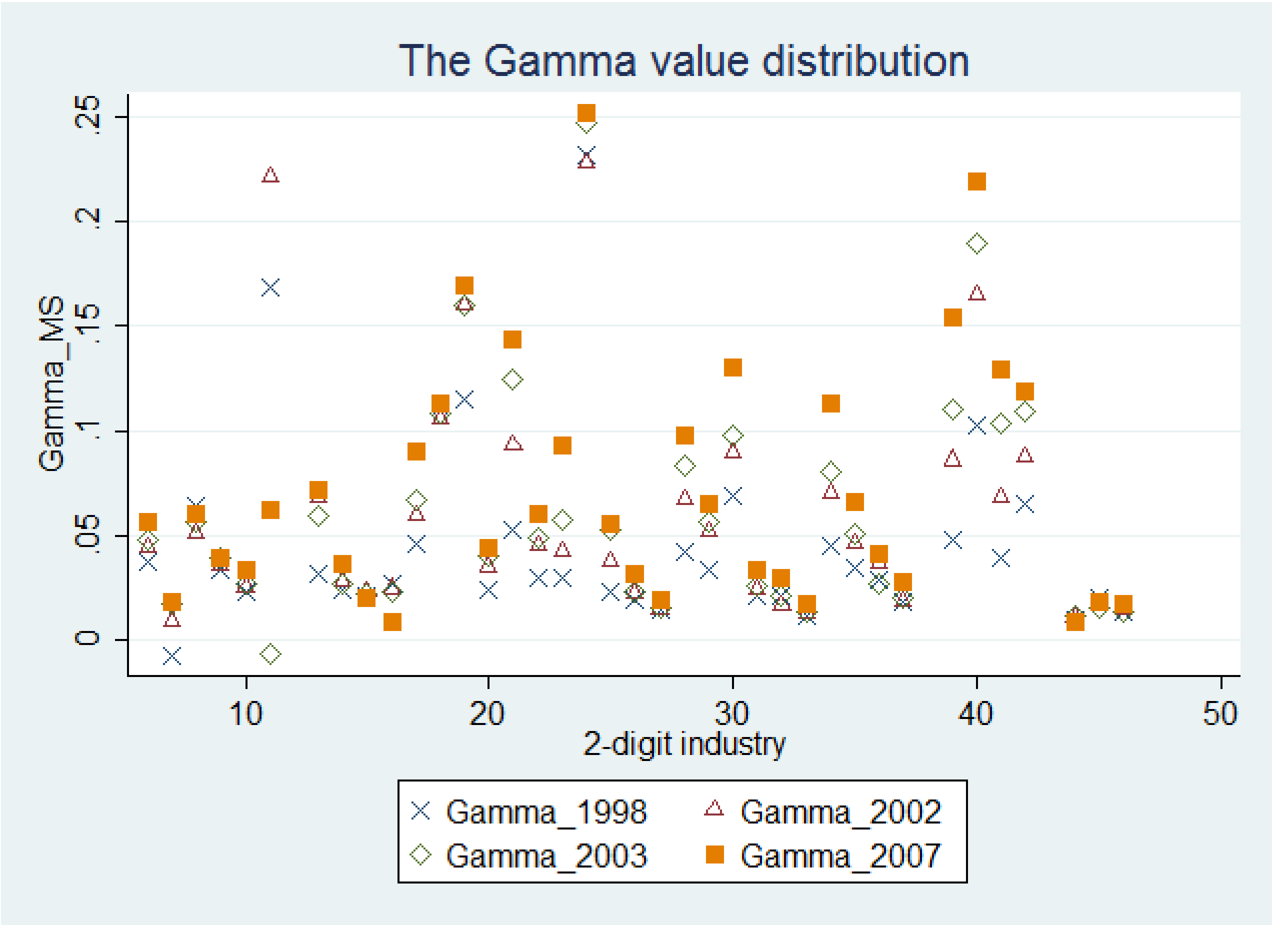

Figure 1.5. The Gamma value distribution at 4-digit industry level, 2007

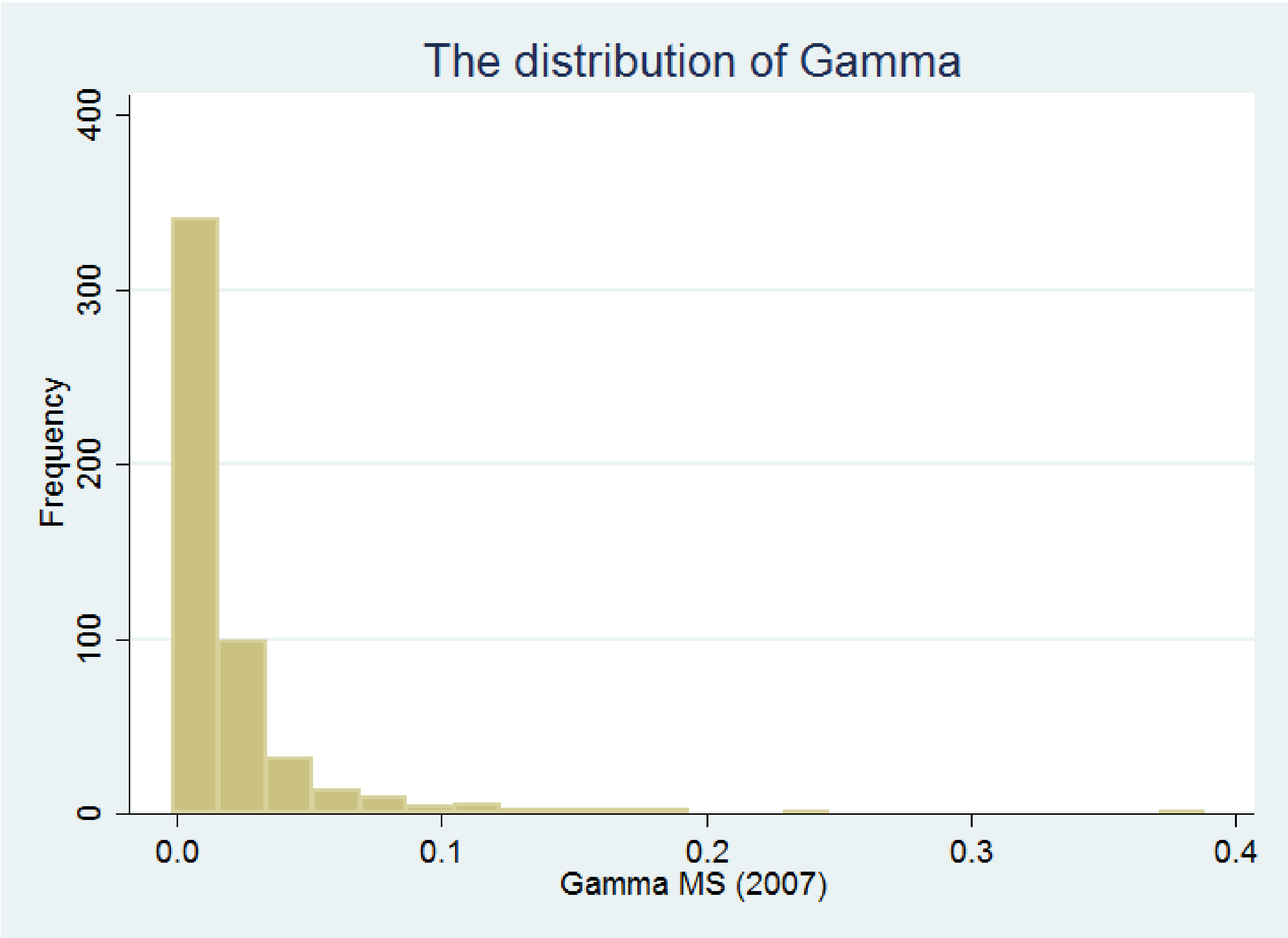

Figure 1.6. The distribution of Gamma, 2007

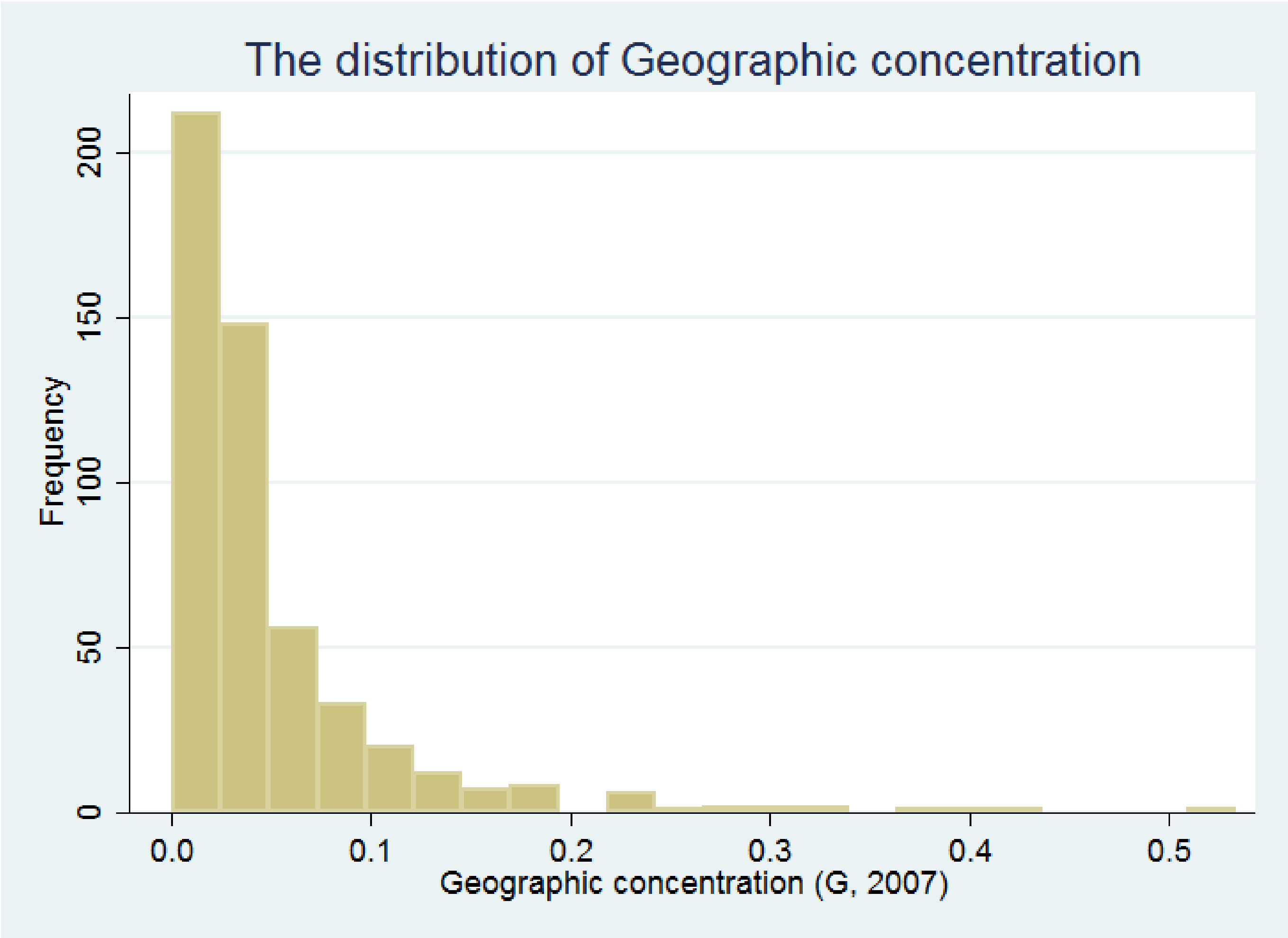

Figure 1.7. The distribution of geographic concentration, 2007

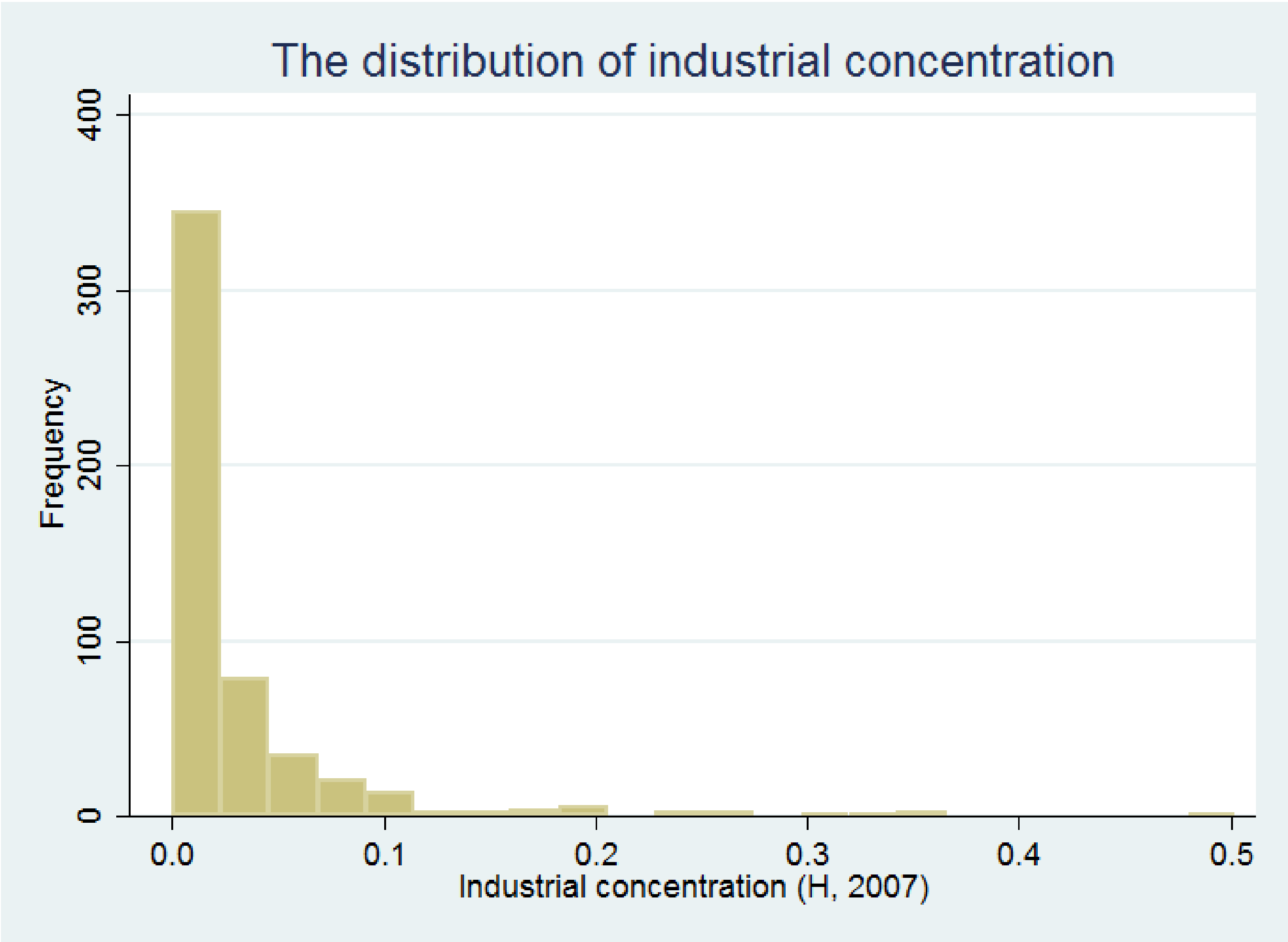

Figure 1.8. The distribution of industrial concentration, 2007

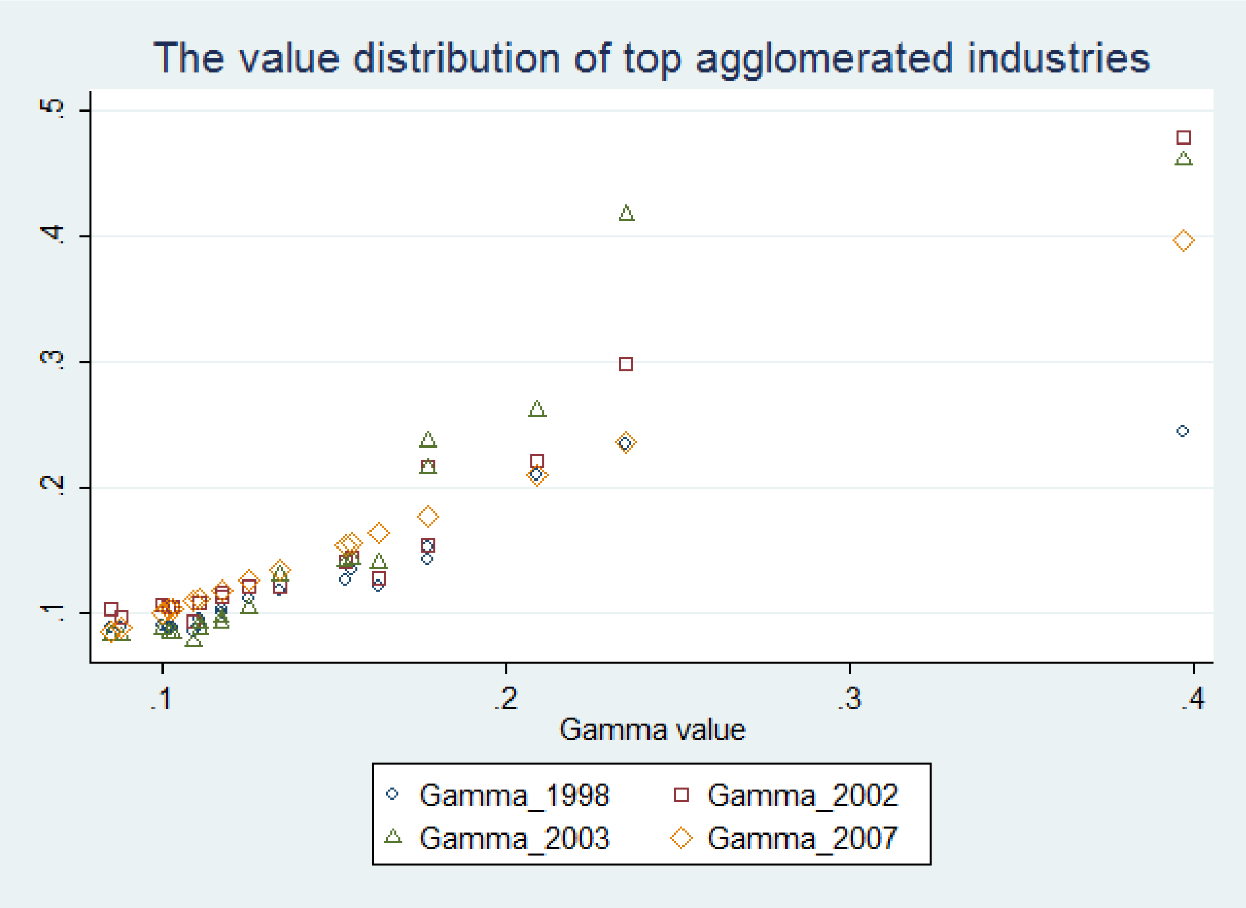

Figure 1.9. The value distribution of the top twenty most agglomerated industries.

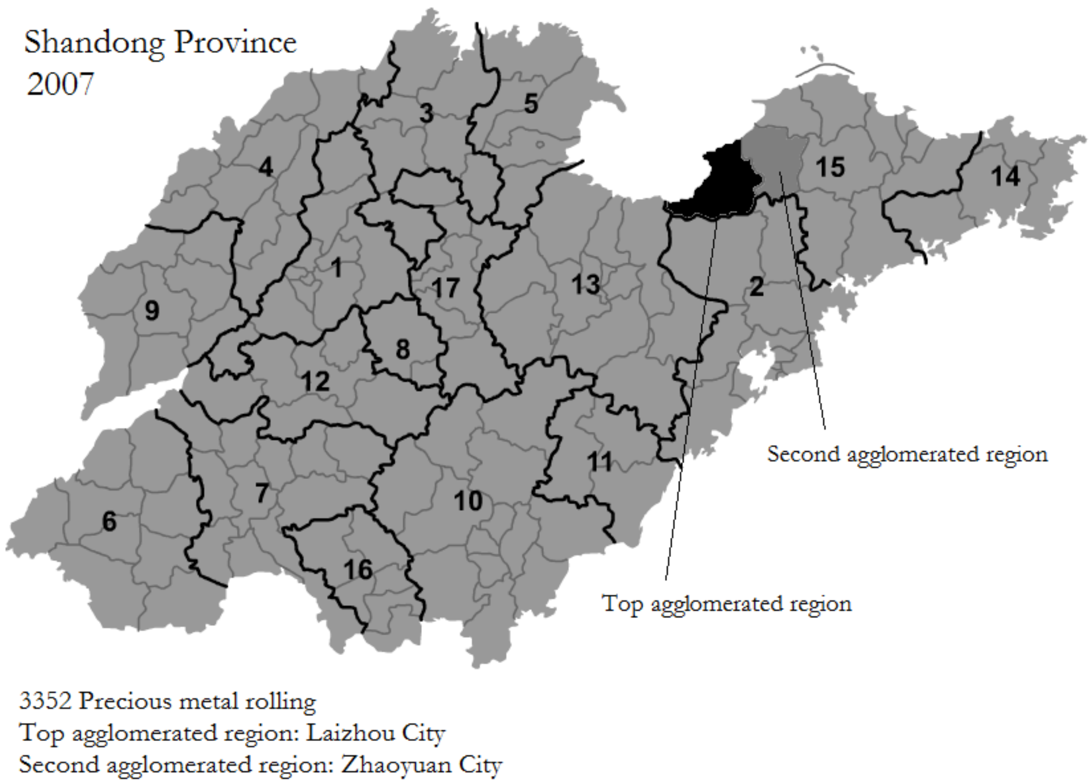

Figure 1.10. The top and second industrial agglomerated region, Precious metal rolling (SIC-3352) in 2007

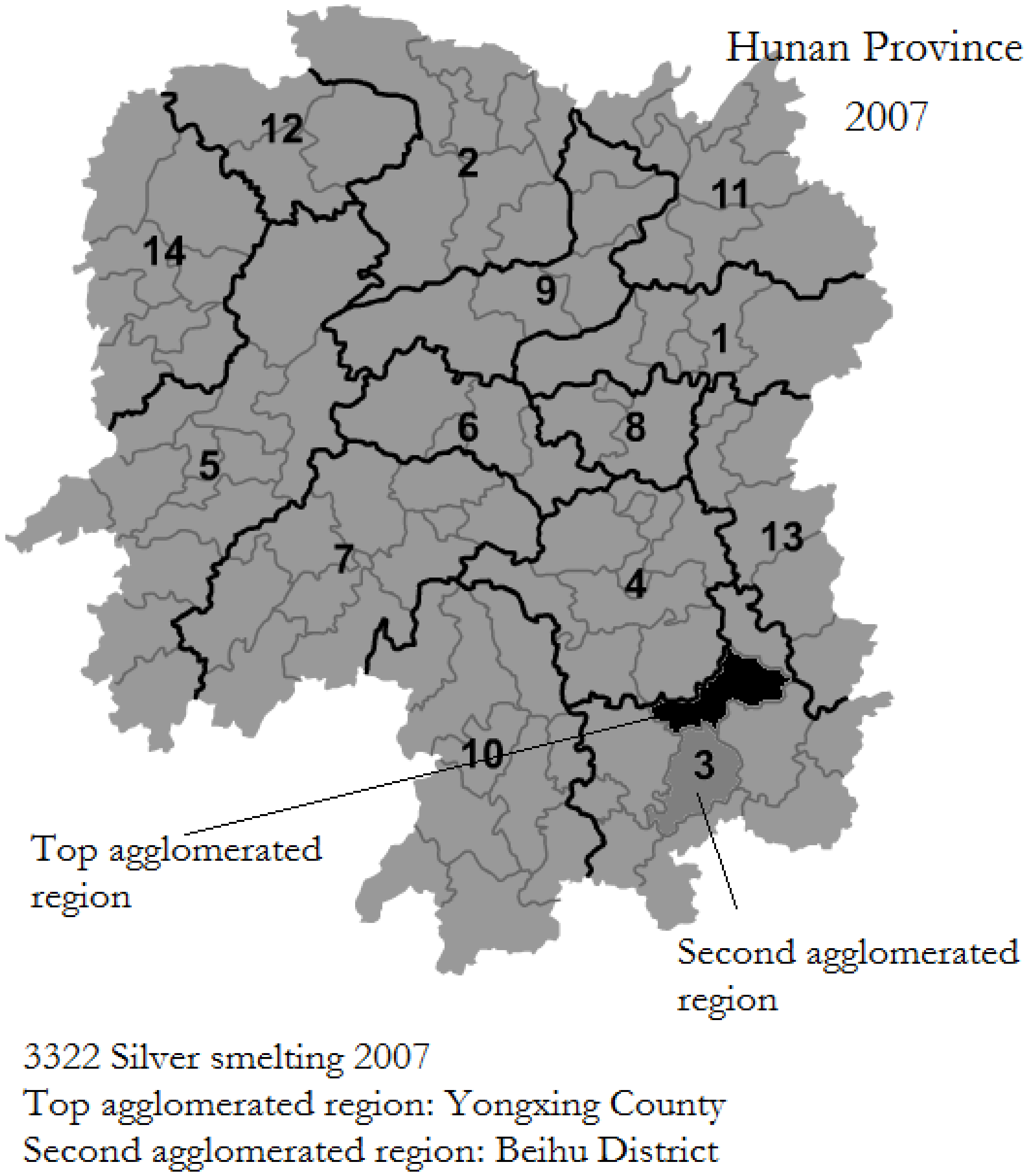

Figure 1.11. The top and second industrial agglomerated region, Silver smelting (SIC-3322) in 2007

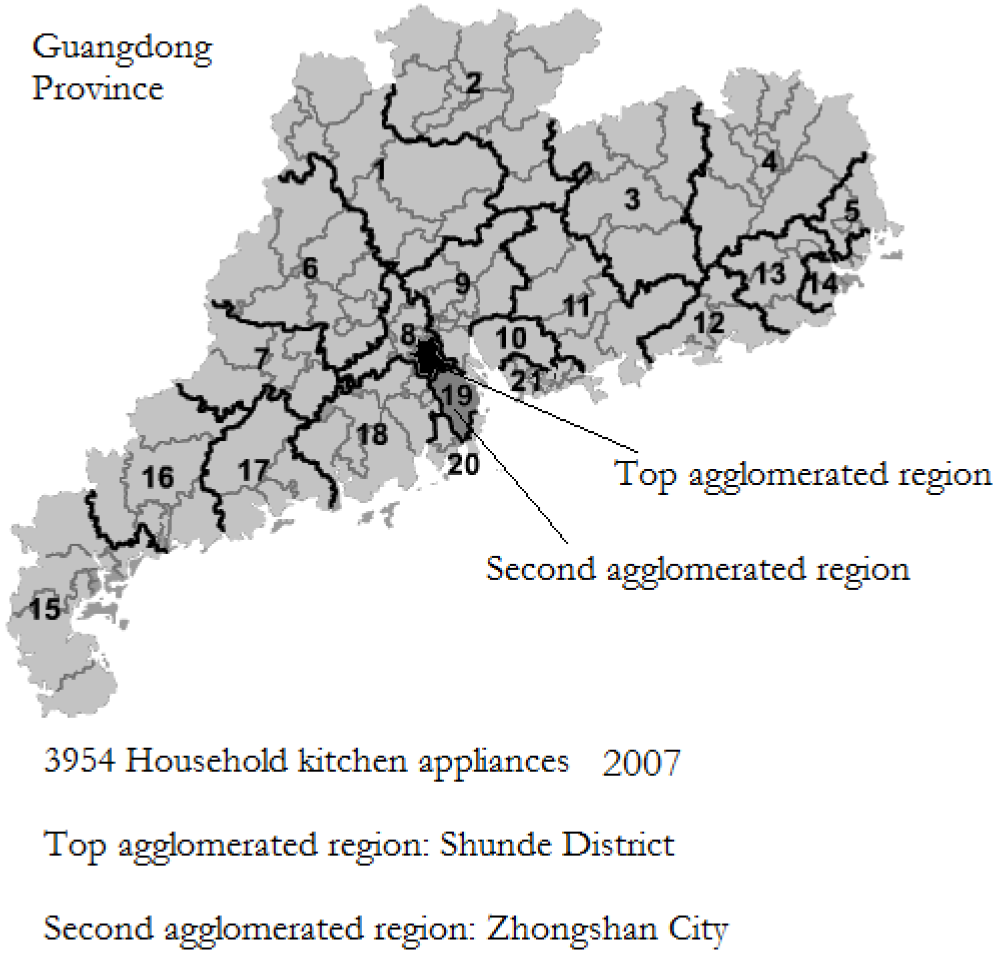

Figure 1.12. The top and second industrial agglomerated region, Household kitchen appliances (SIC-3954) in 2007

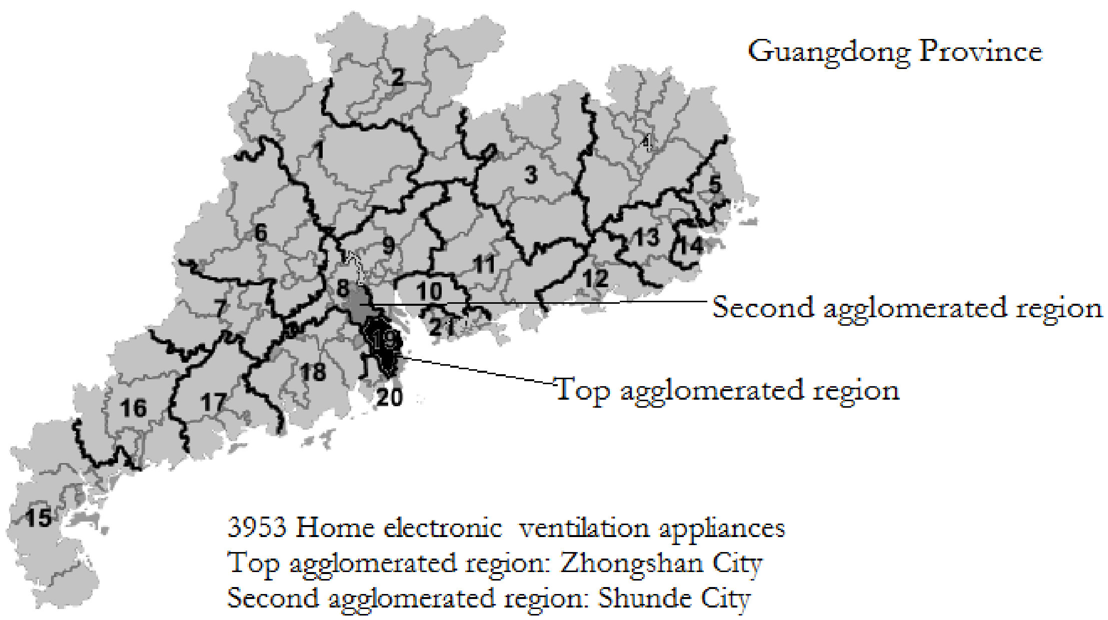

Figure 1.13. The top and second industrial agglomerated region, Home electronic ventilation appliances (SIC-3953) in 2007

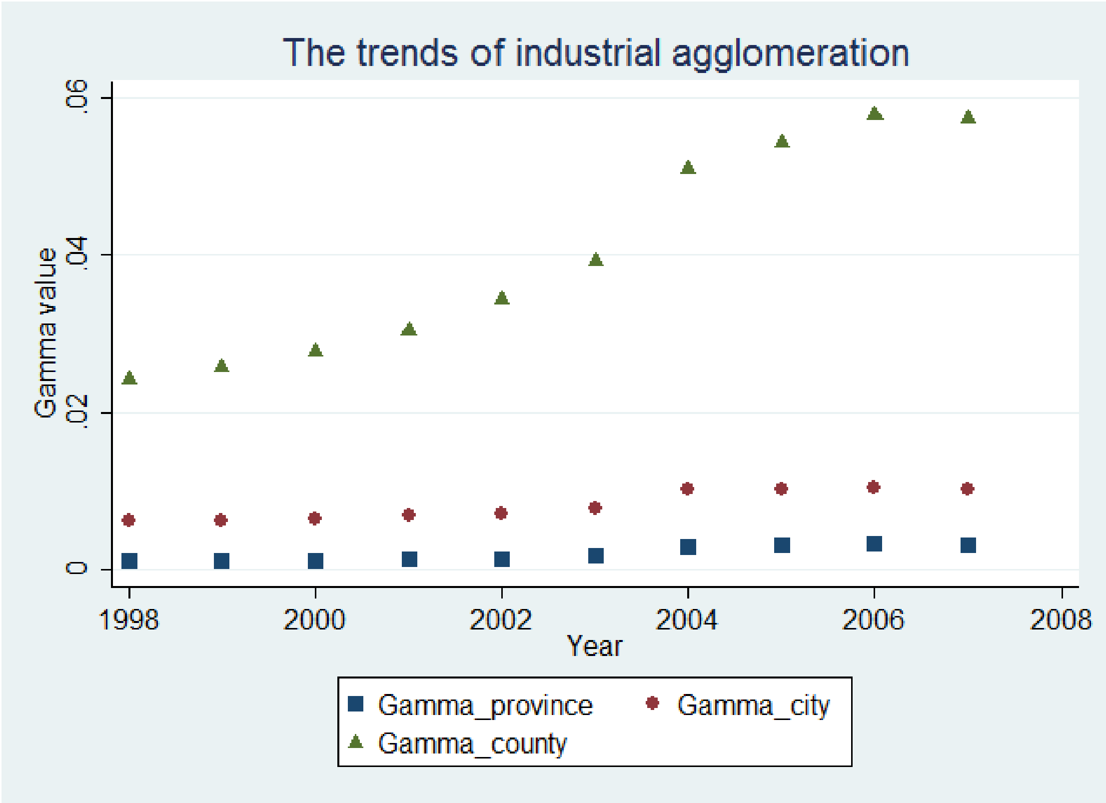

Figure 2.1 The trends of industrial agglomeration

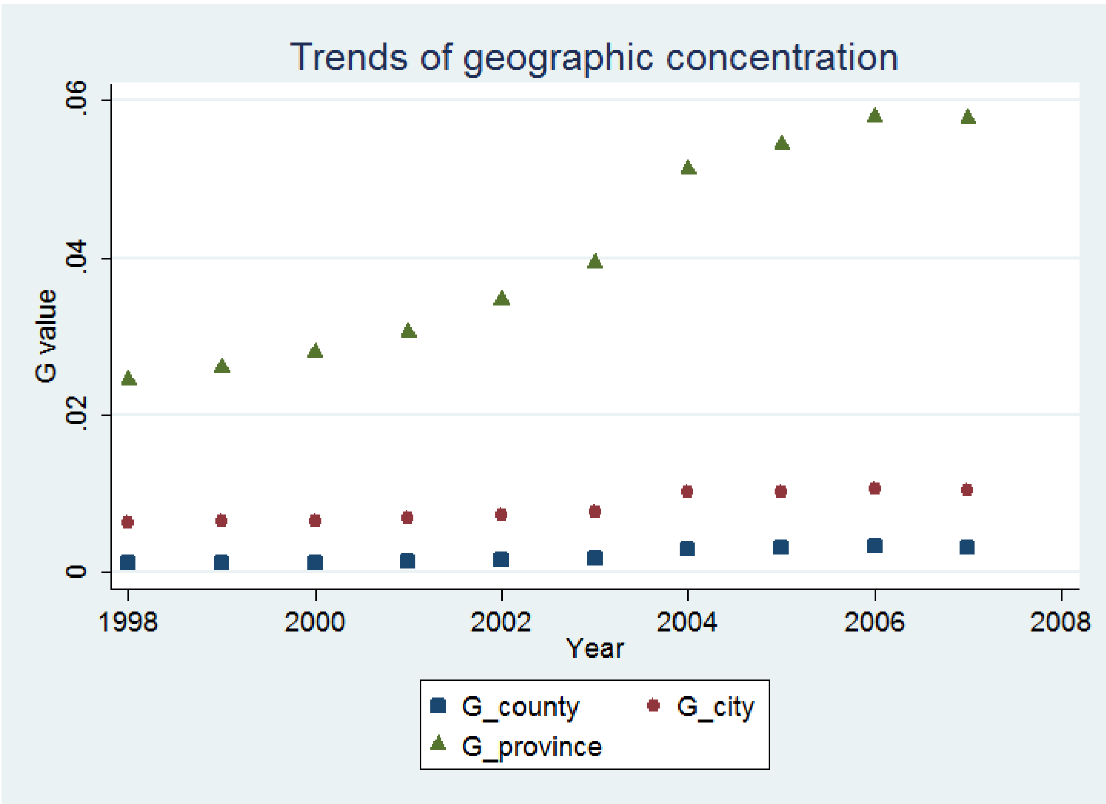

Figure 2.2 The trends of geographic concentration

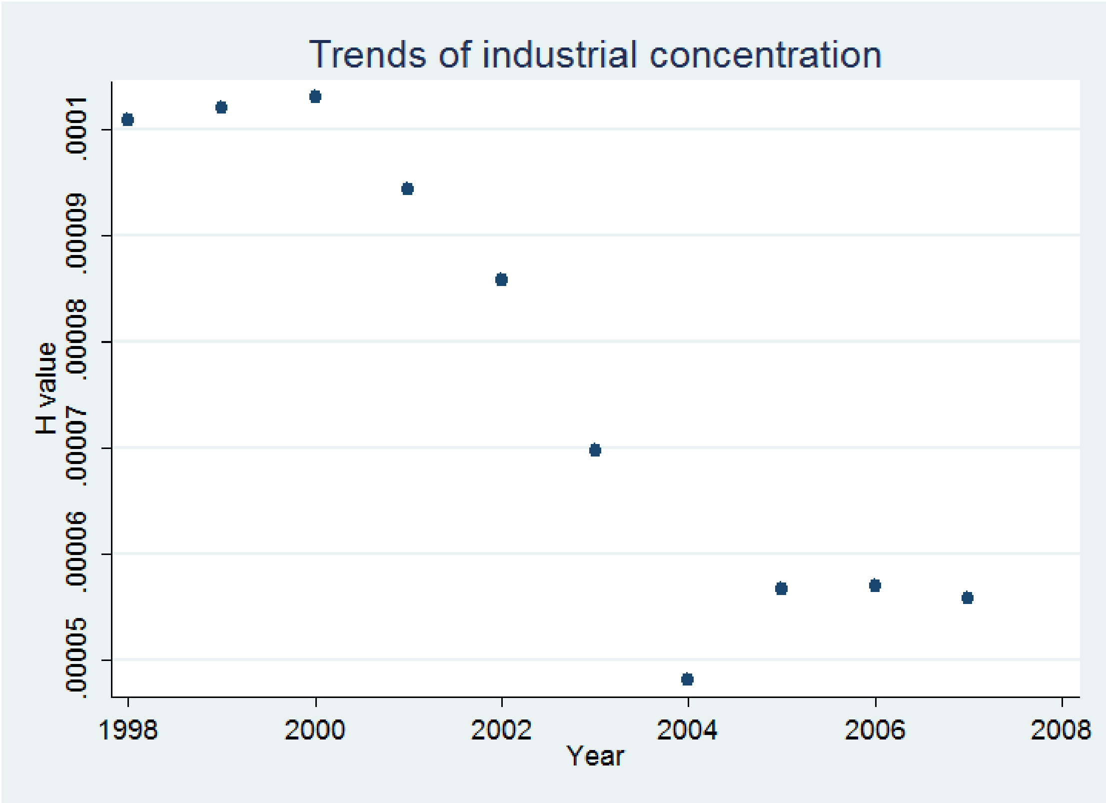

Figure 2.3 The trends of industrial concentration

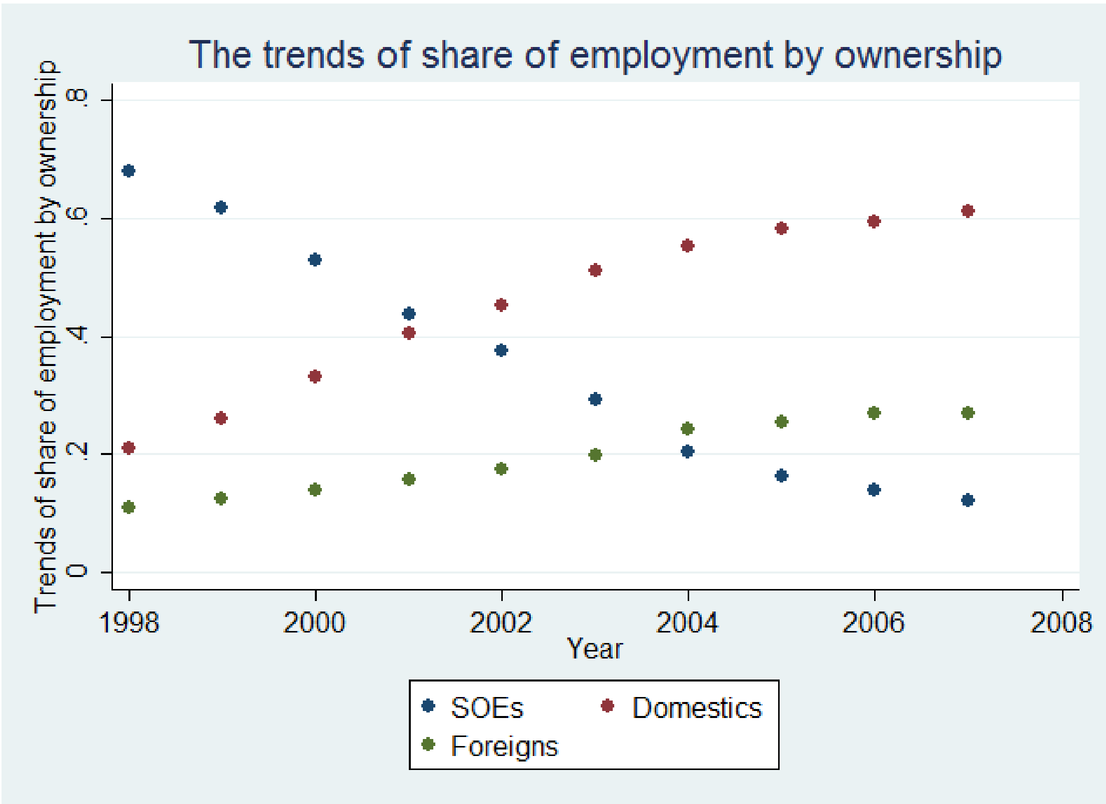

Figure 2.4. The trends of share of employment by ownership

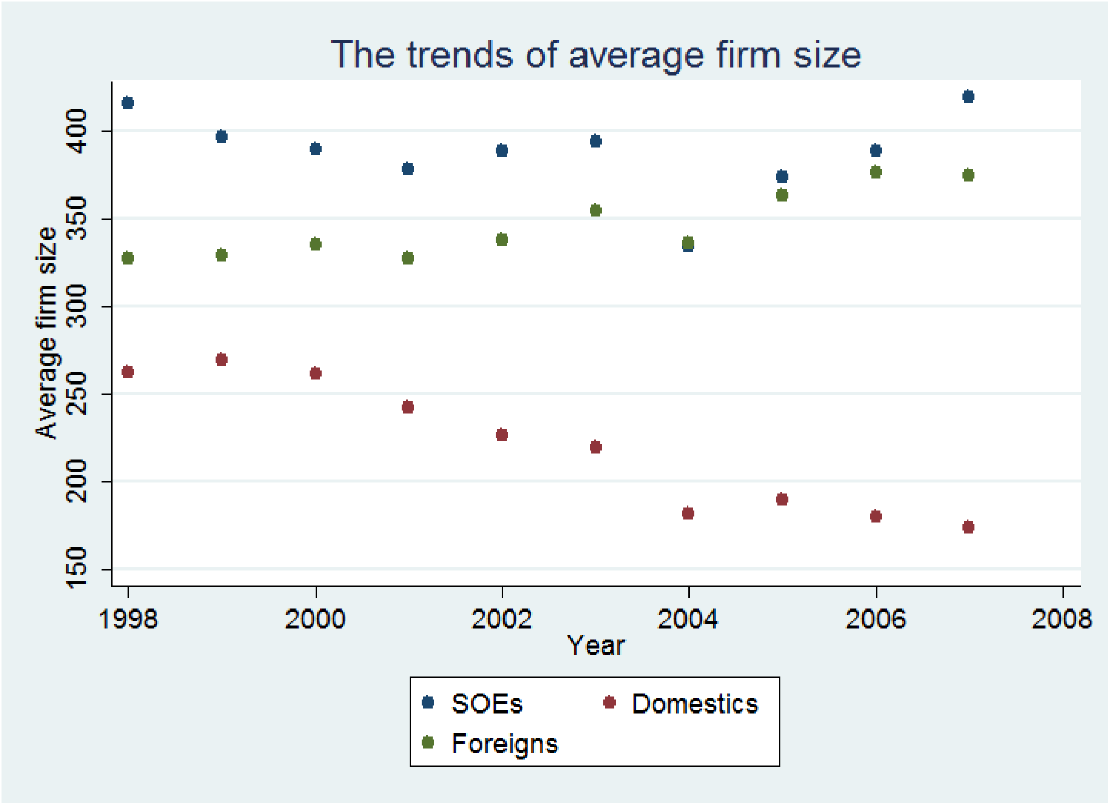

Figure 2.5. The trends of average firm size

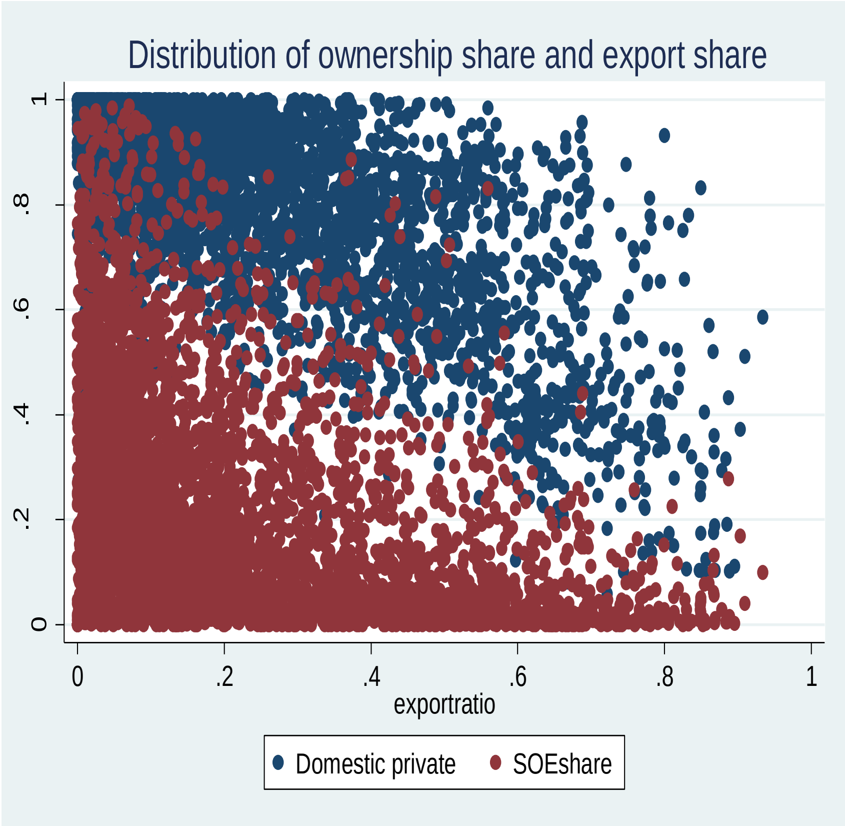

Figure 2.6. Trends of capital-labour ratio, 1998 to 2007

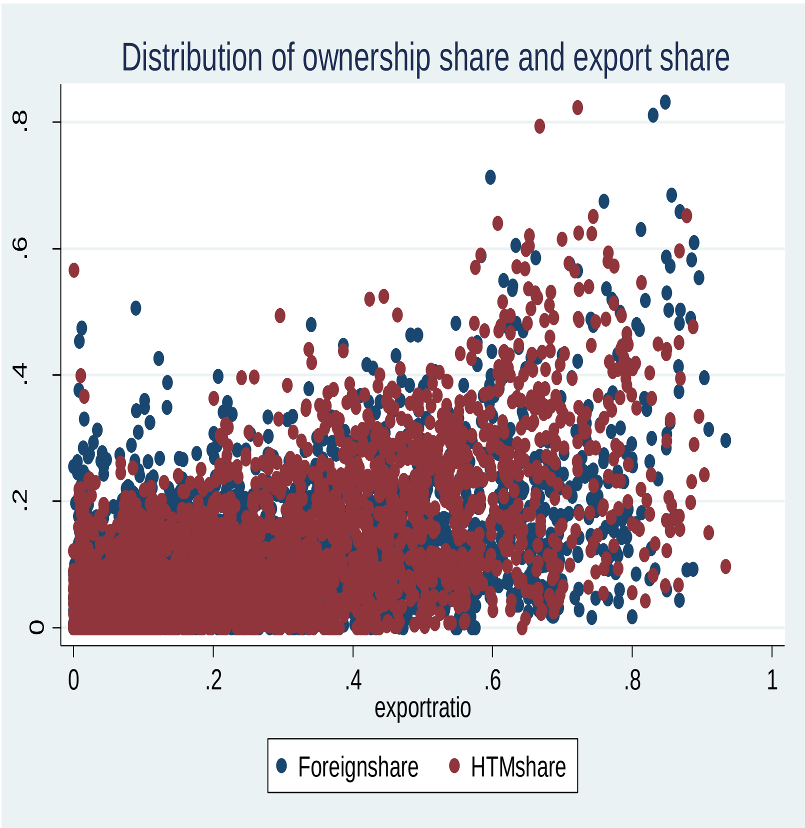

Figure 2.7. Trends of capital-labour ratio, 1998 to 2007

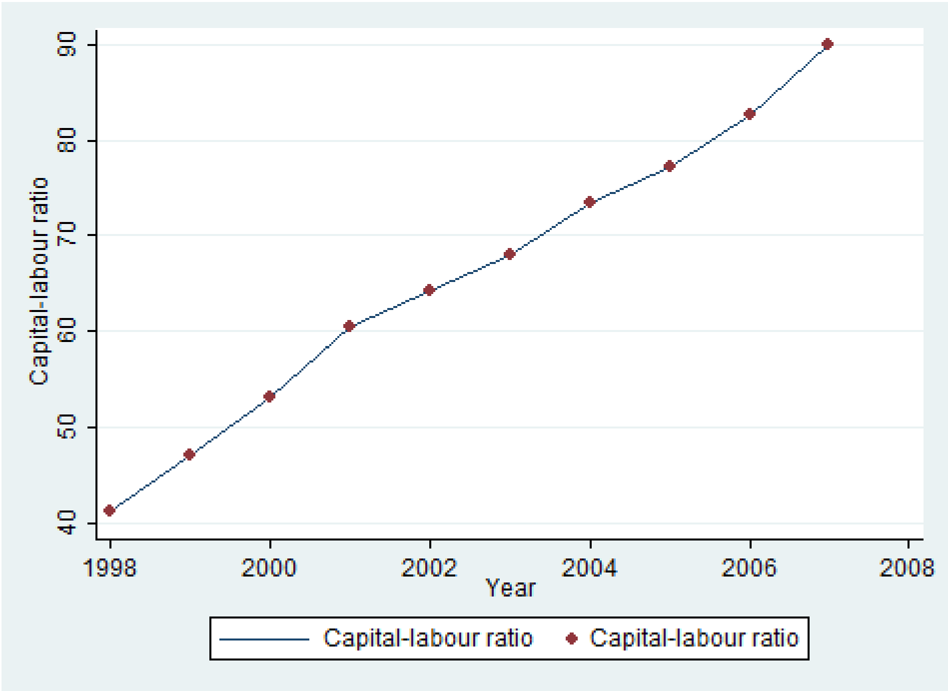

Figure 2.8. trends of capital-labour ratio, 1998 to 2007

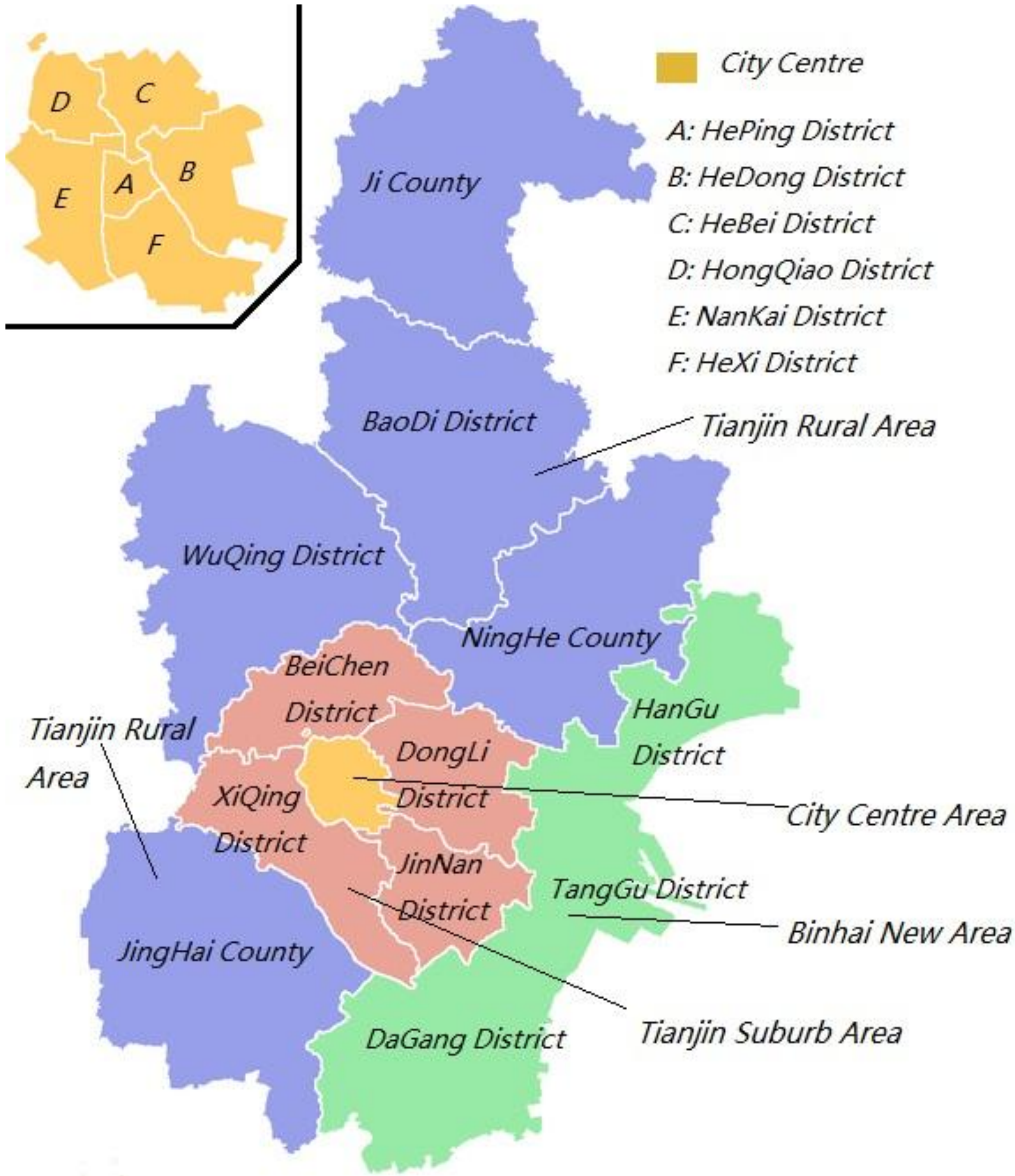

Figure 3.1 . The border of urban and rural area in Tianjin

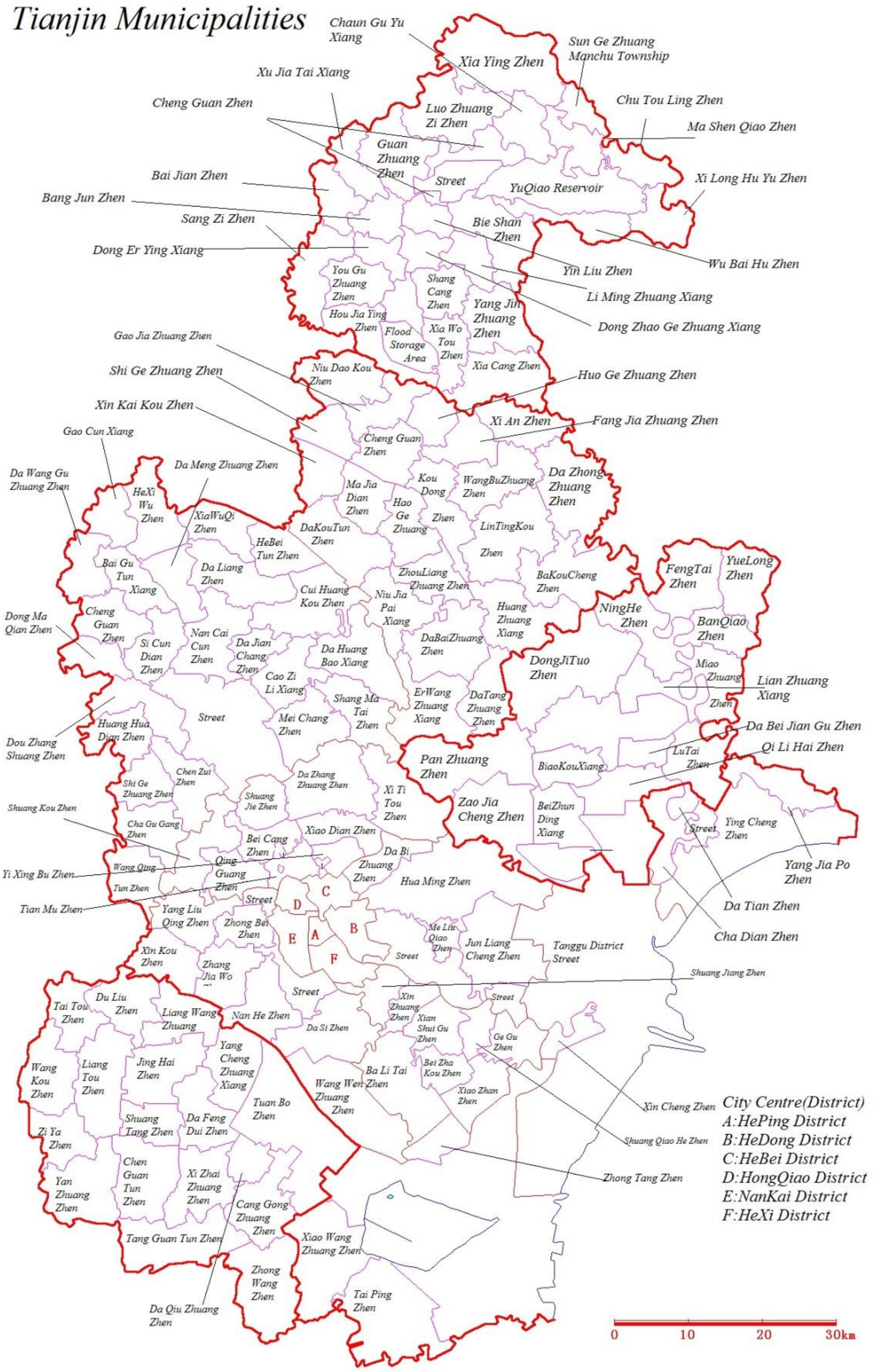

Figure 3.2. The Map of Tianjin with names of each county

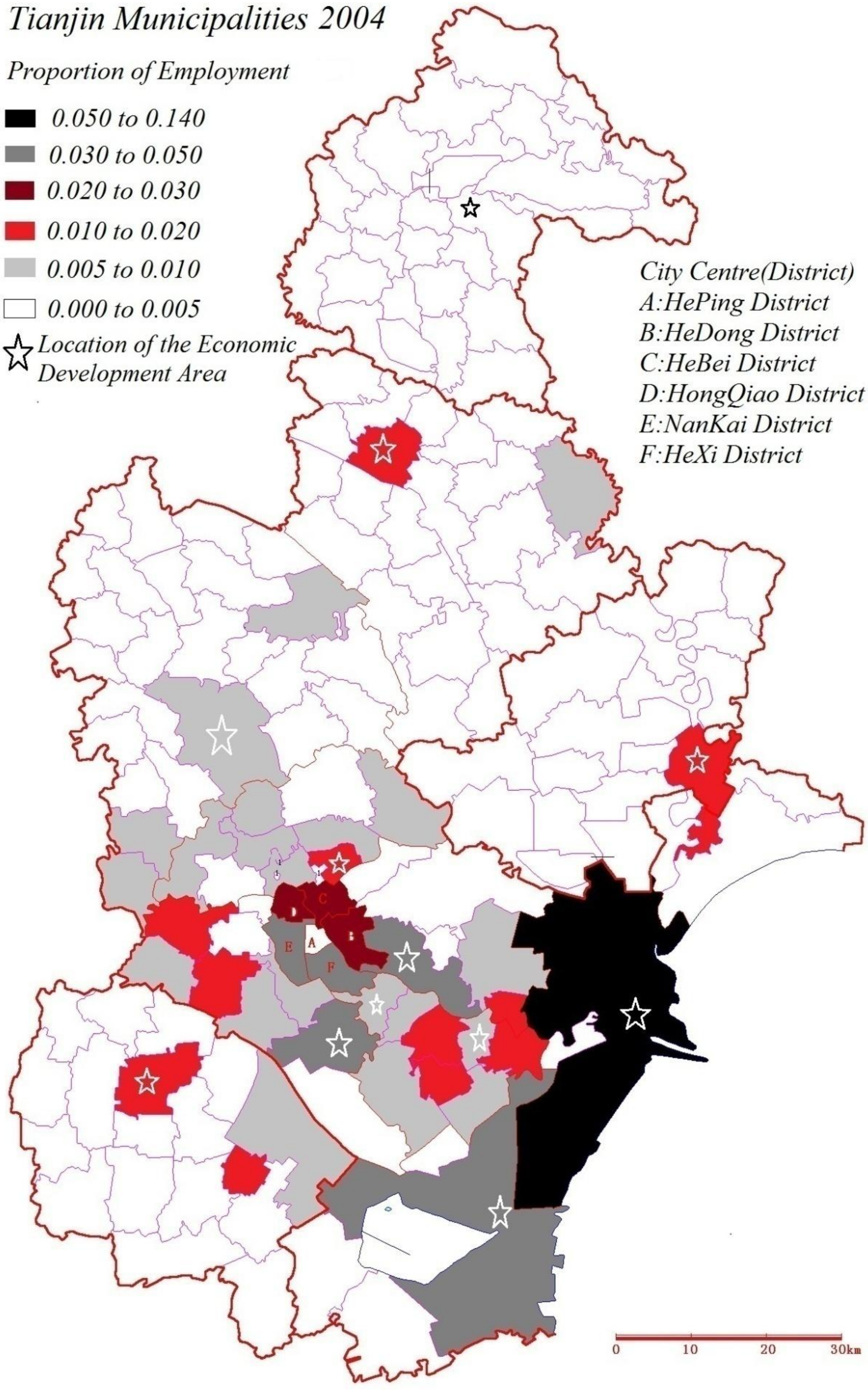

Figure 3.3. Proportion of Employment (local authority level, 2004)

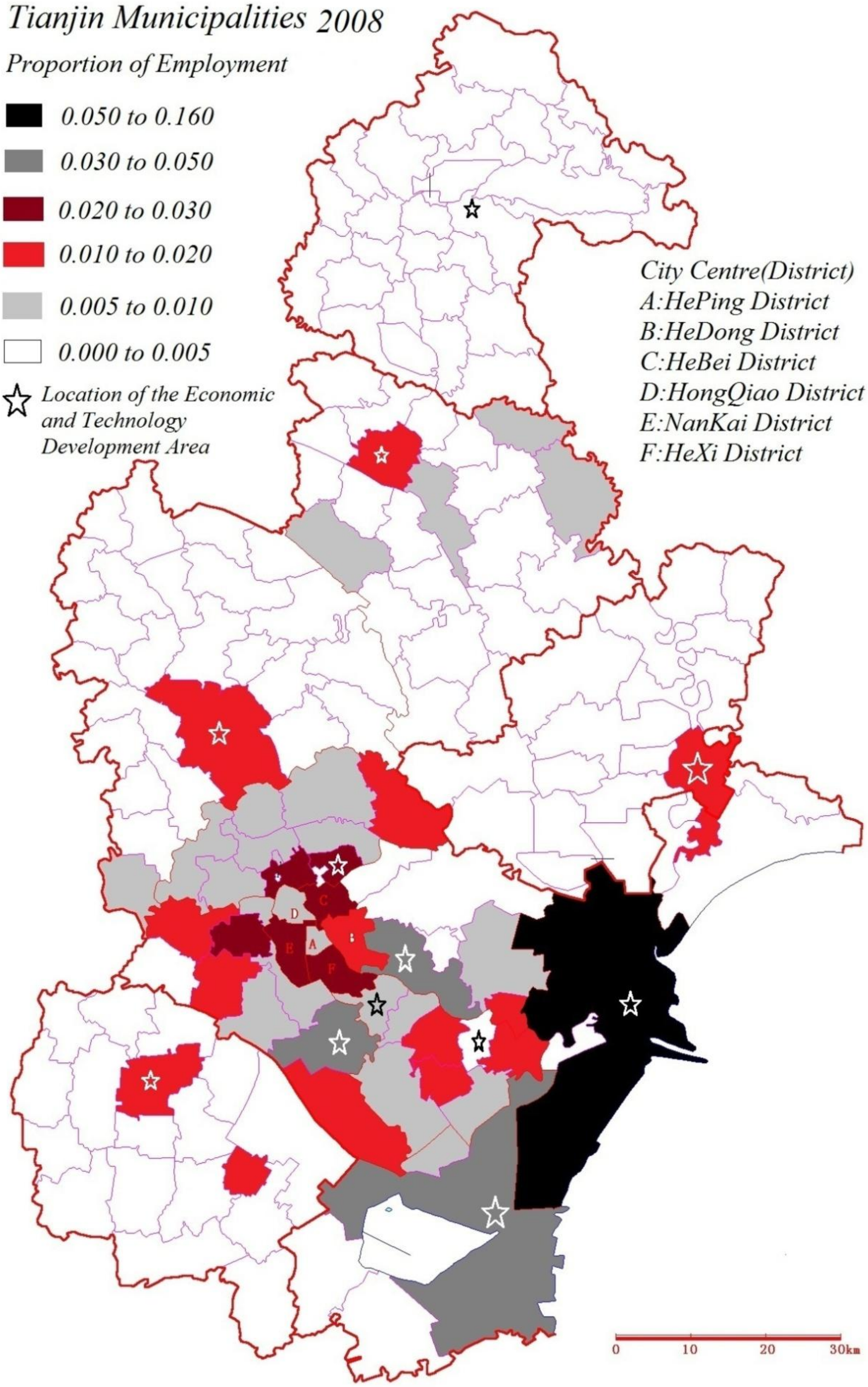

Figure 3.4. Proportion of Employment (local authority level, 2008)

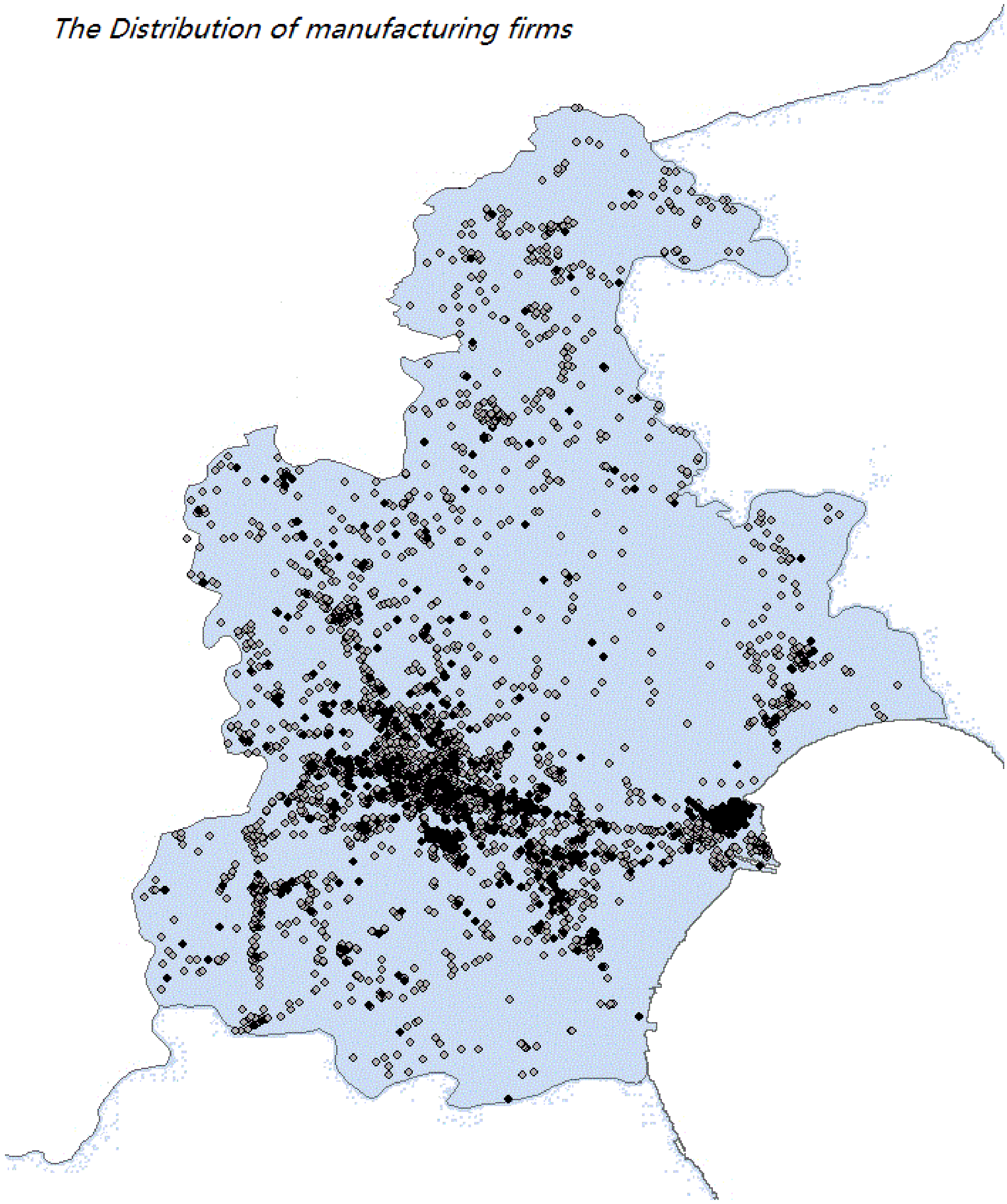

Figure 3.5. Proportion of Employment (local authority level, 2004)

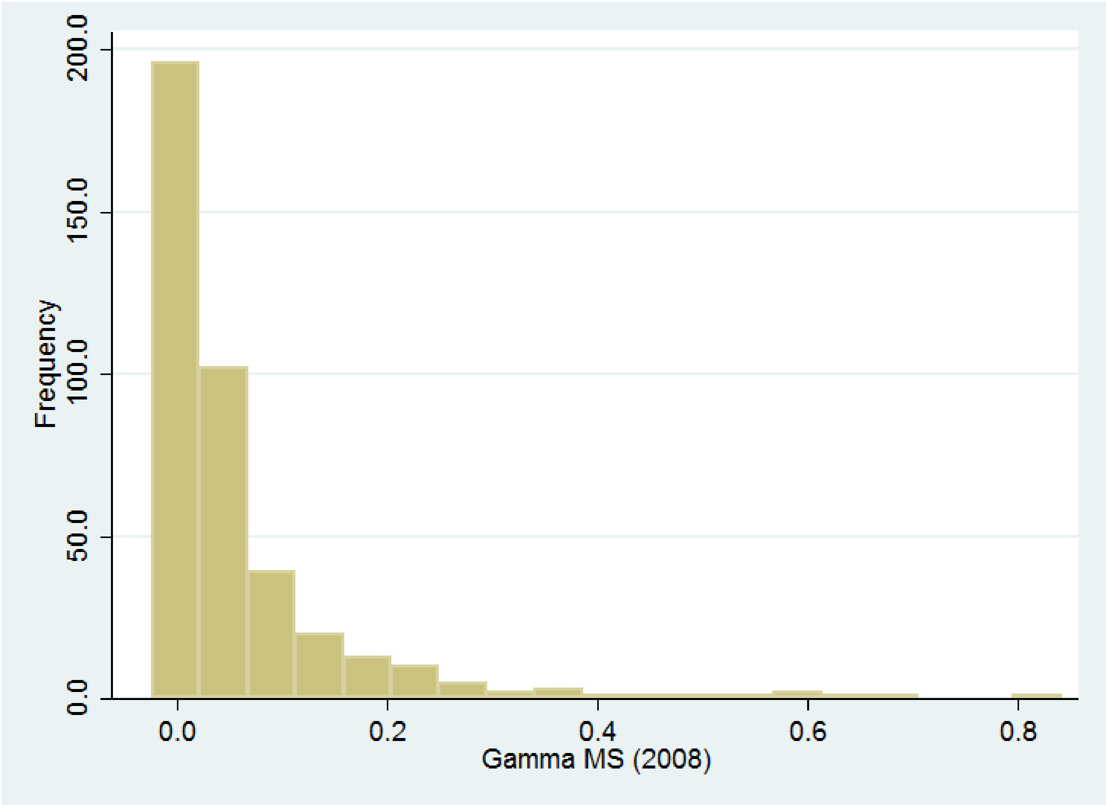

Figure 3.6. Distribution of gamma MS agglomeration index (2008)

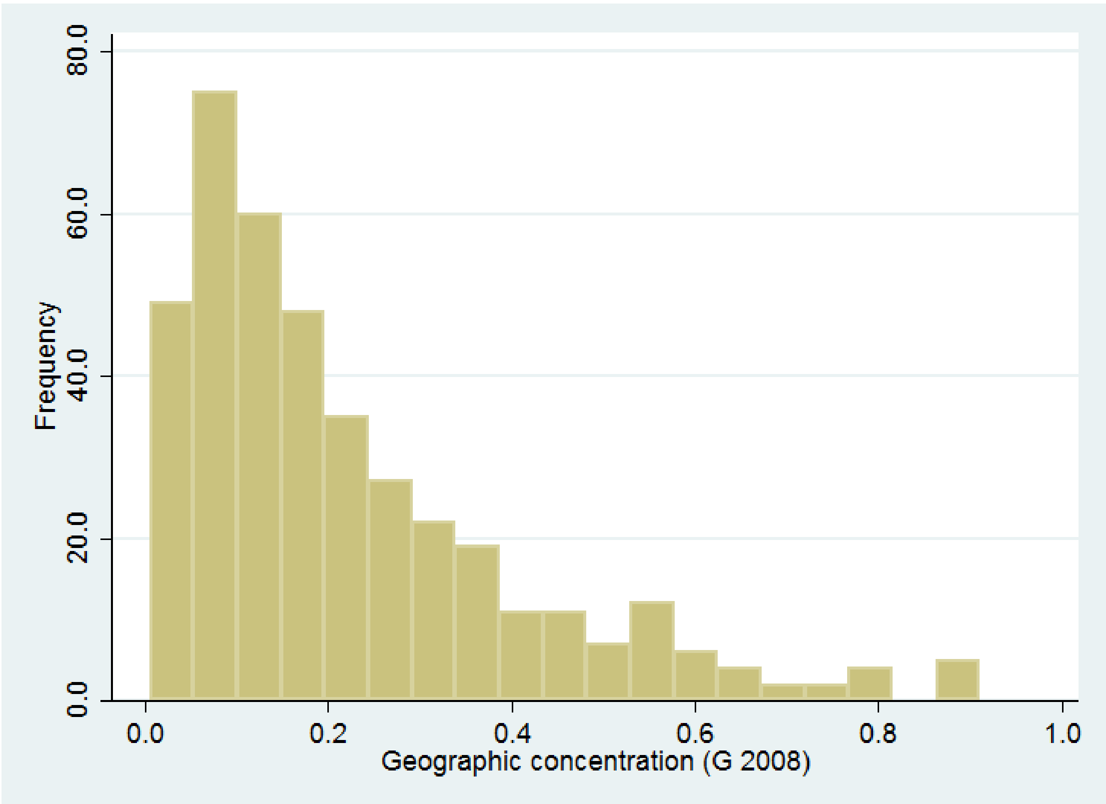

Figure. 3.7. Distribution of G adjusted geographic concentration measure (2008)

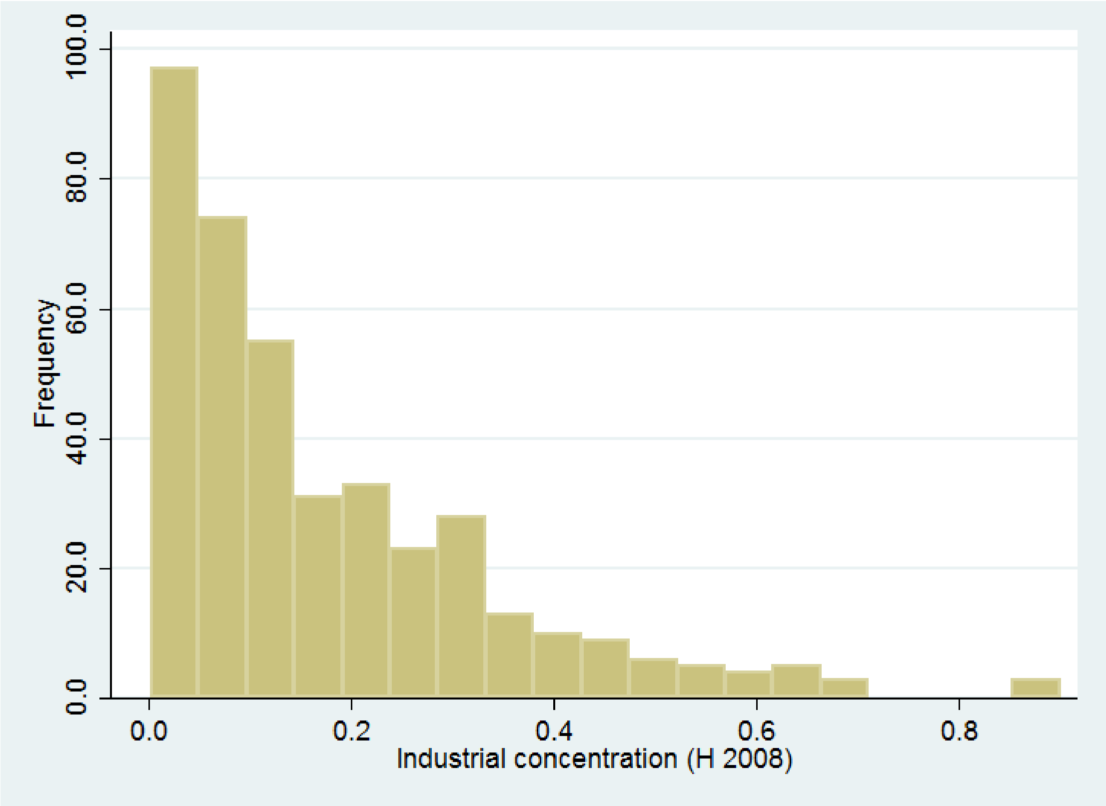

Figure. 3.8. Distribution of H industrial concentration (2008)

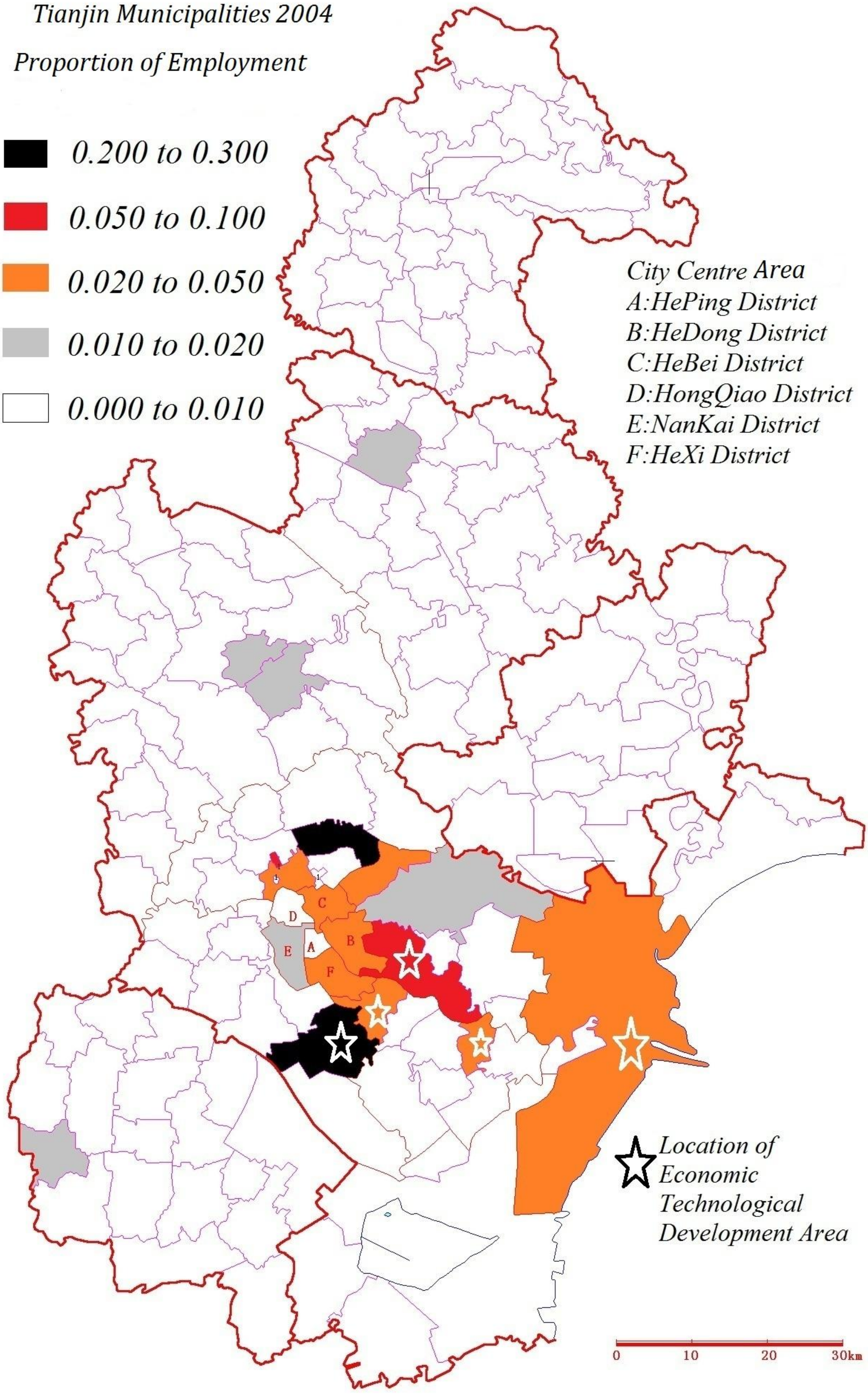

Figure 3.9. The distribution of dropped enterprises, 2004

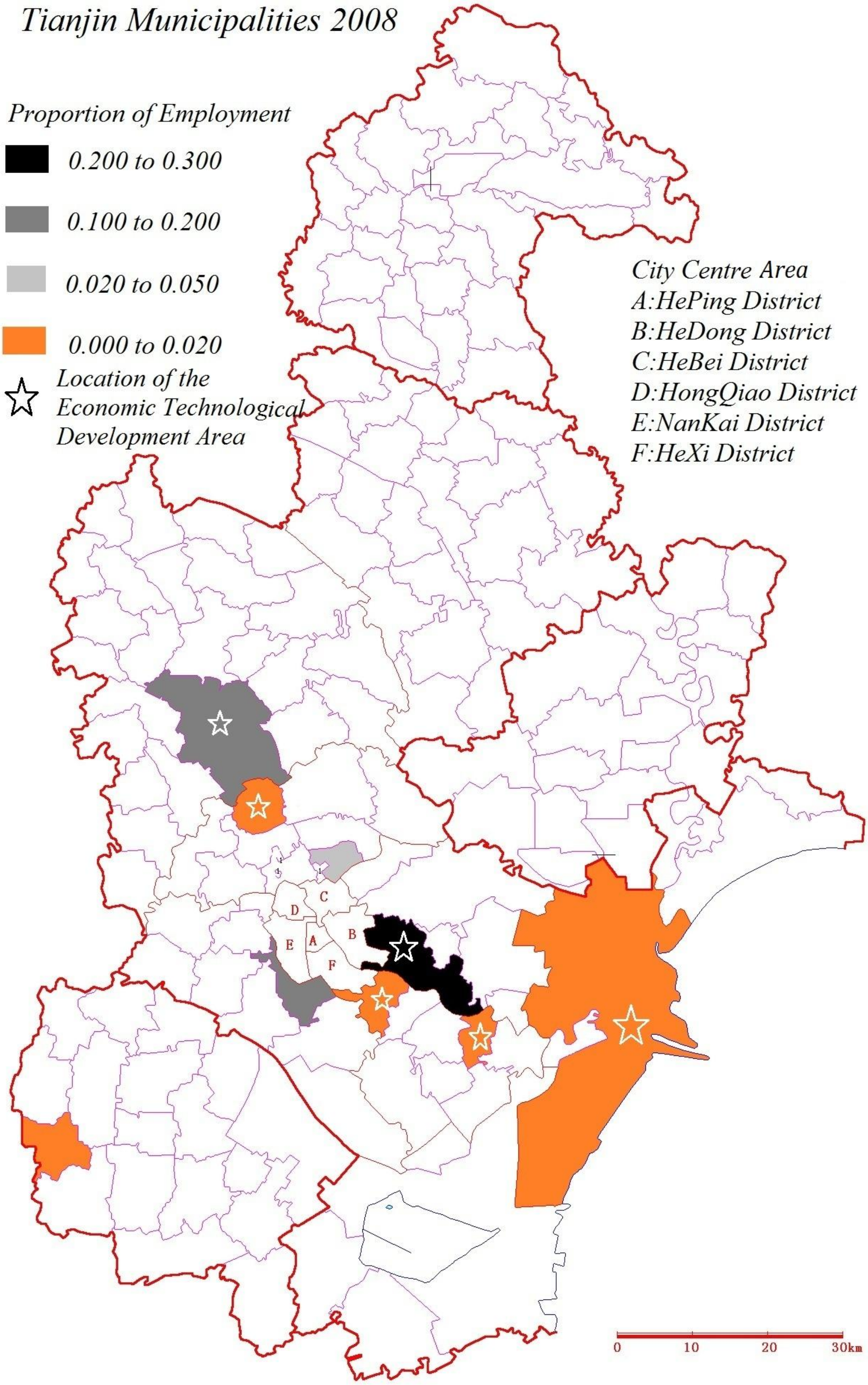

Figure 3.10. The distribution of dropped enterprises, 2008

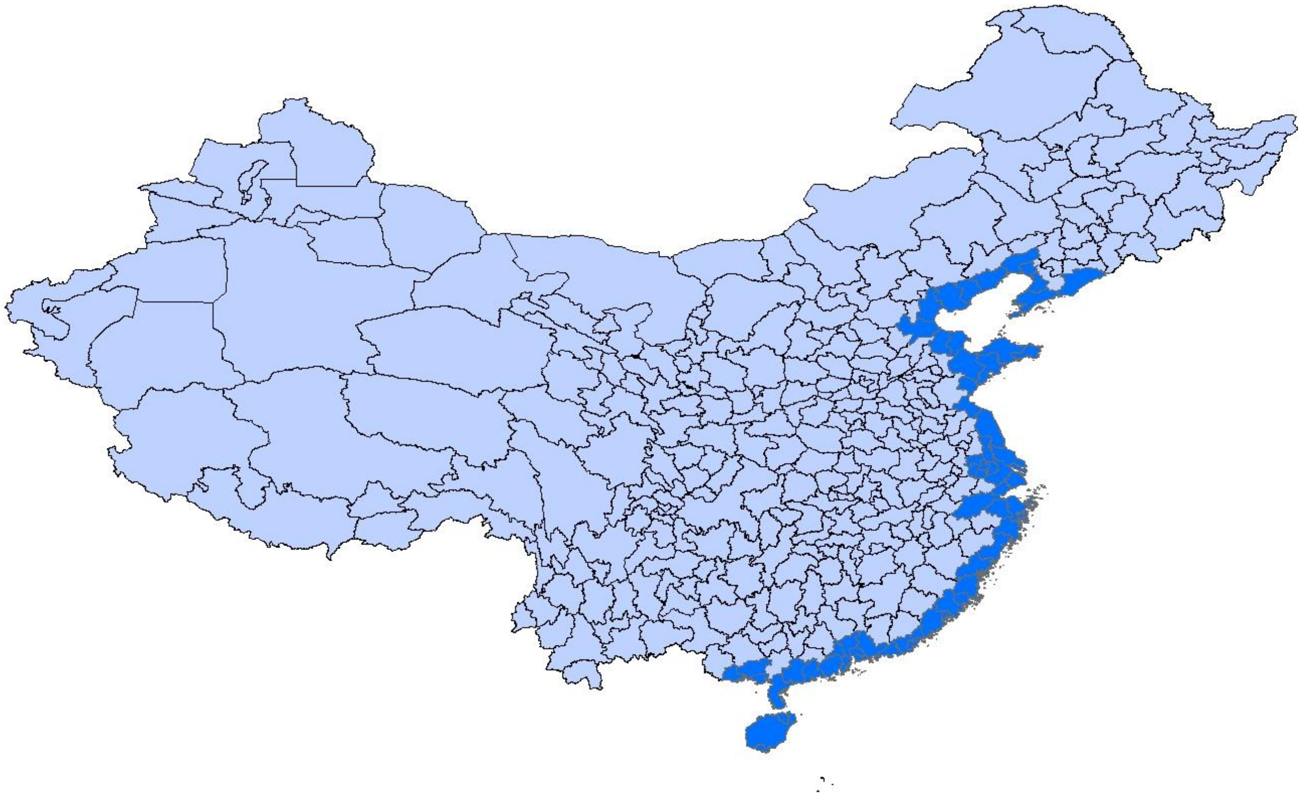

Figure 4.1. Coastal regions of China

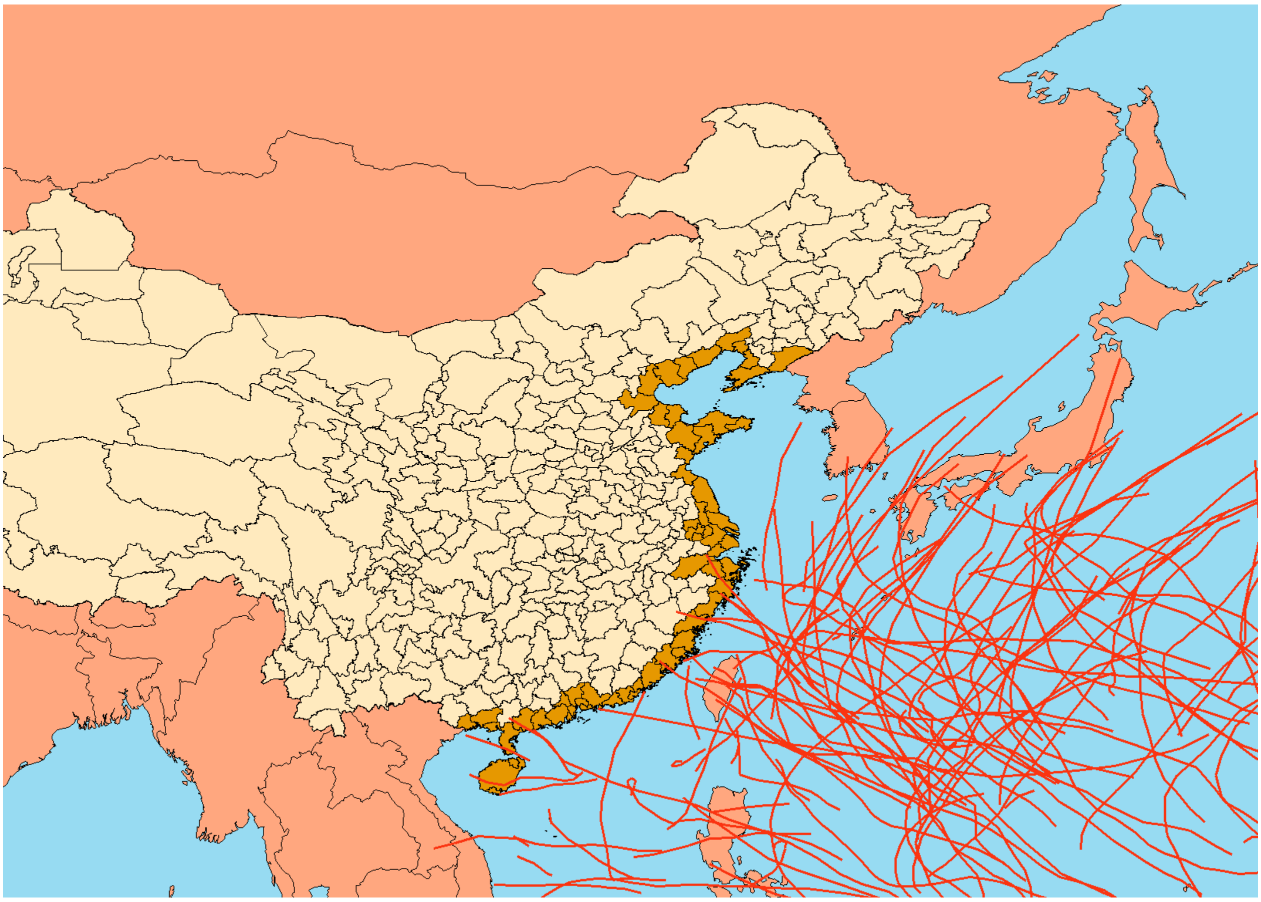

Figure 4.2. Tracks of storms only when they have at least typhoon strength: 2000-2006

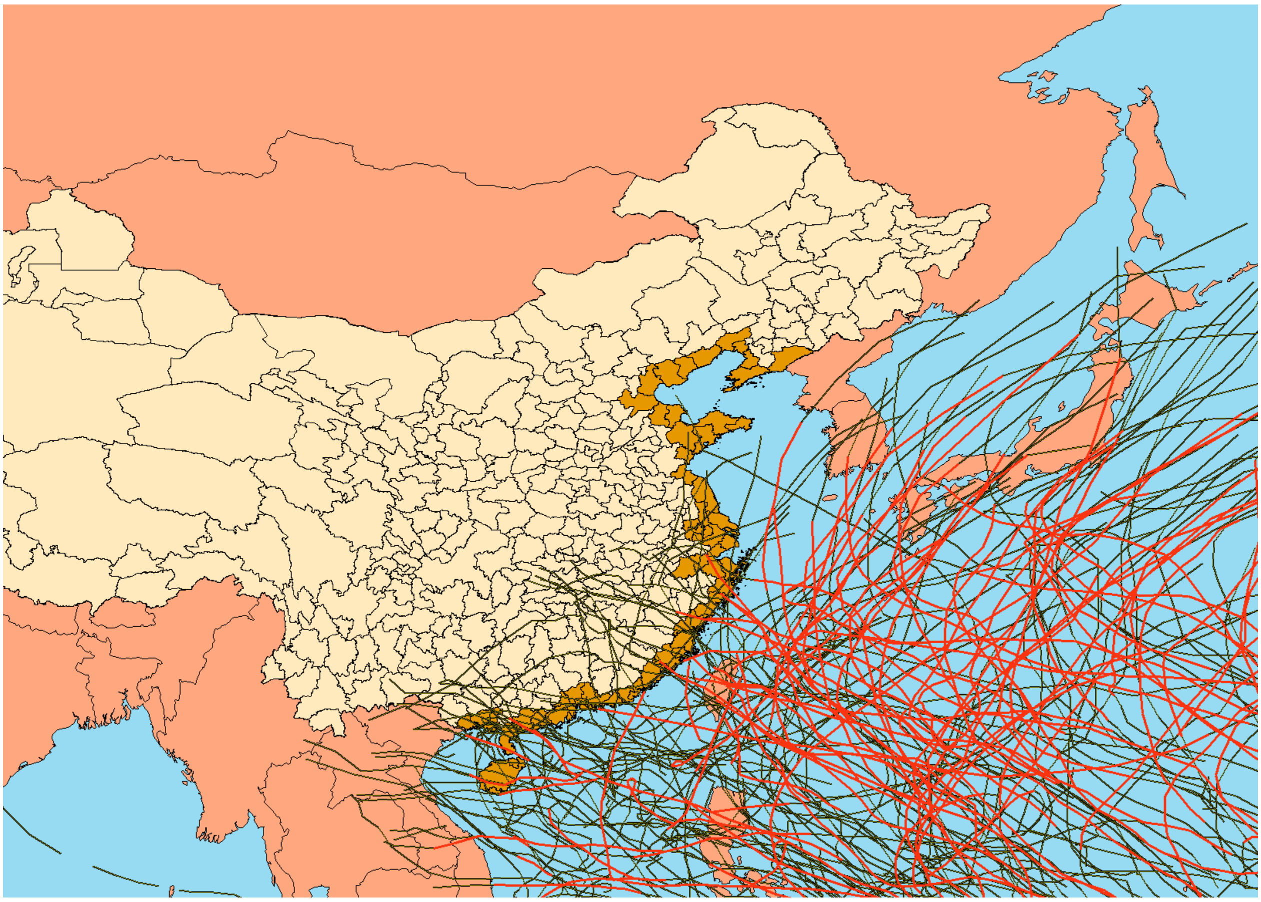

Figure 4.3. Tracks of Storms with Typhoon (red) and below strength: 2000-2006

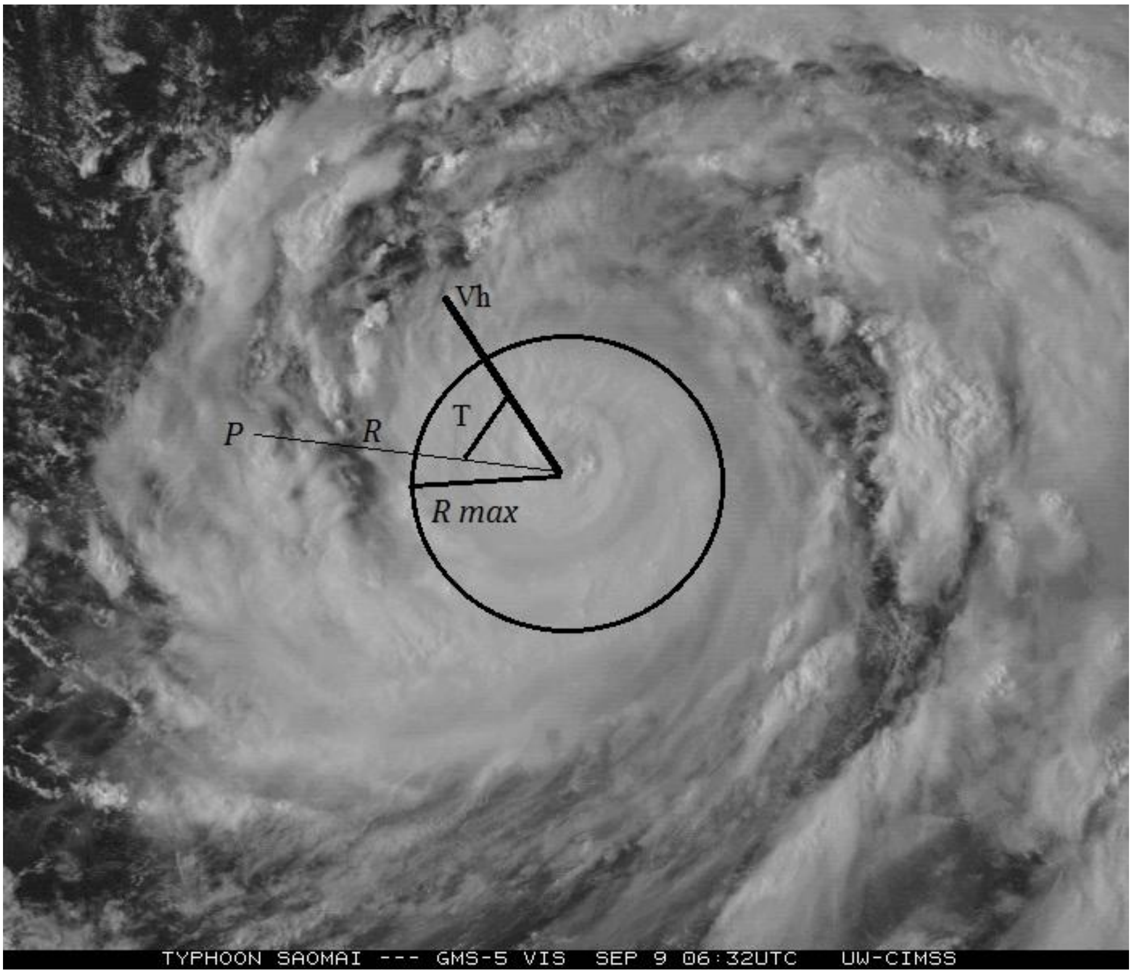

Figure 4.4. Typhoon Destruction Index

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Appendix

Table A.1. Geographic and industrial concentration measures for total production, 2002

Number of regional units	County, 2882	Postcode Area, 19268	Province, 31
G	0.0012	0.0003	0.0270
H	0.0001	0.0001	0.0001
γ	0.0011	0.0002	0.0269
γ_{EG}	0.0011	0.0002	0.0269
Locational Gini	0.656	0.756	0.458
Concentration index	0.032	0.008	0.315

Table A.2. Geographic and industrial concentration measures for total production, 2003

Number of regional units	County, 2969	Postcode Area, 18884	Province, 31
G	0.0014	0.0003	0.0313
H	0.0001	0.0001	0.0001
γ	0.0013	0.0002	0.0312
γ_{EG}	0.0013	0.0002	0.0312
Locational Gini	0.666	0.757	0.481
Concentration index	0.040	0.008	0.332

Table A.3. Employee distribution, 2007

	total number of employment	Share of employment	Number of firms	share of firm numbers
Guangdong	13,042,489	16.63	41,564	12.68
Jiangsu	8,580,962	10.94	40,910	12.48
Shandong	8,287,931	10.57	35,597	10.86
Zhejiang	7,883,614	10.06	50,576	15.42
Henan	3,817,547	4.87	13,183	4.02
Fujian	3,577,860	4.56	14,792	4.51
Liaoning	3,273,329	4.17	16,063	4.90
Hebei	3,019,180	3.85	10,608	3.24
Shanghai	2,773,126	3.54	14,321	4.37
Sichuan	2,565,257	3.27	10,436	3.18
Shanxi	2,154,381	2.75	4,382	1.34
Hubei	1,989,653	2.54	8,759	2.67
Hubei	1,944,826	2.48	10,084	3.08
Anhui	1,768,435	2.26	7,783	2.37
Heilongjiang	1,429,275	1.82	3,128	0.95
Jiangxi	1,396,796	1.78	5,894	1.80
Shananxi	1,233,691	1.57	3,287	1.00
Beijing	1,186,306	1.51	6,112	1.86
Tianjin	1,176,995	1.50	5,283	1.61
Jilin	1,084,169	1.38	3,909	1.19
Chongqing	1,080,858	1.38	3,867	1.18
Guangxi	989,772	1.26	4,295	1.31
Inner Mongolia	926,457	1.18	3,298	1.01
Yunnan	818,656	1.04	2,632	0.80
Guizhou	661,097	0.84	2,108	0.64
Gansu	660,423	0.84	1,776	0.54
Xinjiang	536,165	0.68	1,543	0.47
Ningxia	254,059	0.32	730	0.22
Qinghai	154,401	0.20	418	0.13
Hainan	116,116	0.15	479	0.15
Xizang(Tibet)	20,100	0.03	77	0.02
Total	78,361,437	100.00	327,894	100.00

Table A.4.. Summary of agglomeration in four-digit industries, by two-digit industry, 1998

Two-digit industry	Mean γ	Percentage of four-digit industries in quartile(by γ)				Number of four-digit industries
		1(least)	2	3	4(most)	
11 Mining industry, nothing else specified	0.099	0	0	0	100	1
10 Non-metallic mining	0.059	11	22	11	56	18
22 Paper and paper product	0.058	40	20	0	40	5
18 Garment, shoes and hat	0.038	0	0	75	25	4
24 Education and sports goods	0.032	0	0	33	67	15
9 Non-ferrous metal extractions and processing	0.03	20	20	7	53	15
43 Artwork and other manufacturing	0.024	7	20	47	27	15
41 Communications equipment, computers and other electronic equipment	0.021	6	22	33	39	18
42 Instrument, office and culture machinery	0.02	14	18	29	39	28
34 Metal product	0.017	4	31	23	42	26
17 Textile	0.017	18	24	27	30	33
40 Electrical machinery and equipment	0.017	7	30	30	33	30
19 Leather, fur, feathers(down) and its products	0.015	0	31	46	23	13
30 Plastic product	0.015	0	44	22	33	9
26 Chemical material and products	0.014	52	12	14	21	42
37 Transportation equipment	0.013	33	30	20	17	30
13 Agro-food processing	0.013	43	17	13	26	23
33 Non-ferrous metal smelting and rolling	0.013	25	20	35	20	20
36 Special equipment manufacturing	0.013	28	32	19	21	47
39 Weapons and Ammunition	0.012	0	0	100	0	1

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Two-digit industry	Mean γ	Percentage of four-digit industries in quartile(by γ)				Number of four-digit industries
		1(least)	2	3	4(most)	
14 Food	0.01	33	33	20	13	30
15 Beverage	0.01	46	23	8	23	13
31 Non-metallic mineral products	0.01	21	30	27	21	33
6 Coal mining and washing	0.009	0	50	50	0	2
35 General equipment manufacturing	0.009	11	46	29	14	35
23 Printing and media record	0.009	25	25	50	0	4
21 Furniture	0.008	20	20	60	0	5
8 Ferrous metal extractions and processing	0.007	33	33	33	0	3
29 Rubber product	0.007	11	33	56	0	9
20 Wood processing, Wood, Bamboo, rattan, palm and grass products	0.005	44	22	33	0	9
12 Transport of timber and bamboo	0.004	50	0	50	0	2
28 Chemical Fibers	0.004	55	9	36	0	11
25 Petroleum processing, coking and nuclear fuel processing	0.004	50	25	25	0	4
27 Pharmaceutical manufacturing	0.003	80	0	20	0	5
32 Ferrous metal processing	0.003	50	50	0	0	4
16 Tobacco	0.002	67	33	0	0	3
7 Oil and gas exploration	0	100	0	0	0	2
45 Gas supply industry	0	100	0	0	0	2
44 Electricity and heat supply industry	0	80	20	0	0	5
46 Water Supply industry	-0.001	100	0	0	0	2

Quartile boundaries are by γ.1:(-0.00204,0.002279),2:(0.002279,0.007053),3:(0.007053,0.018507),4:(0.018507,0.244456)

Table A.5. Summary of agglomeration in four-digit industries, by two-digit industry, 2002

Two-digit industry	Mean γ	Percentage of four-digit industries in quartile (by γ)				Number of four-digit industries
		1(least)	2	3	4(most)	
10 Non-metallic mining	0.066	11	11	22	56	18
22 Paper and paper product	0.066	20	40	0	40	5
12 Transport of timber and bamboo	0.066	0	0	50	50	2
43 Artwork and other manufacturing	0.034	0	0	33	67	15
41 Communications equipment, computers and other electronic equipment	0.034	6	17	44	33	18
33 Non-ferrous metal smelting and rolling	0.033	15	15	30	40	20
25 Petroleum processing, coking and nuclear fuel processing	0.031	0	25	50	25	4
9 Non-ferrous metal extractions and processing	0.03	13	7	27	53	15
8 Ferrous metal extractions and processing	0.027	0	0	67	33	3
19 Leather, fur, feathers(down) and its products	0.025	0	8	38	54	13
17 Textile	0.025	15	24	27	33	33
18 Garment, shoes and hat	0.022	0	25	0	75	4
34 Metal product	0.021	8	31	27	35	26
40 Electrical machinery and equipment	0.02	17	23	20	40	30
24 Education and sports goods	0.018	7	20	33	40	15
21 Furniture	0.017	20	20	40	20	5
39 Weapons and Ammunition	0.015	0	0	100	0	1
31 Non-metallic mineral products	0.015	12	33	27	27	33
37 Transportation equipment	0.013	33	20	27	20	30

(Continued on the next page)

Two-digit industry	Mean γ	Percentage of four-digit industries in quartile (by γ)				Number of four-digit industries
		1(least)	2	3	4(most)	
30 Plastic product	0.012	22	11	56	11	9
26 Chemical material and products	0.012	48	24	14	14	42
28 Chemical Fibers	0.012	27	18	27	27	11
36 Special equipment manufacturing	0.011	34	32	21	13	47
13 Agro-food processing	0.011	35	30	17	17	23
42 Instrument, office and culture machinery	0.009	32	36	14	18	28
11 Mining industry, nothing else specified	0.009	0	0	100	0	1
20 Wood processing, Wood, Bamboo, rattan, palm and grass products	0.009	11	44	33	11	9
14 Food	0.009	40	30	23	7	30
35 General equipment manufacturing	0.009	31	37	20	11	35
7 Oil and gas exploration	0.009	50	0	50	0	2
23 Printing and media record	0.006	25	25	50	0	4
6 Coal mining and washing	0.006	50	0	50	0	2
15 Beverage	0.006	54	31	8	8	13
16 Tobacco	0.005	33	33	33	0	3
29 Rubber product	0.005	11	67	22	0	9
32 Ferrous metal processing	0.005	25	50	25	0	4
27 Pharmaceutical manufacturing	0.004	80	0	20	0	5
45 Gas supply industry	0.002	100	0	0	0	2
44 Electricity and heat supply industry	0.001	80	20	0	0	5
46 Water Supply industry	-0.001	100	0	0	0	2

Quartile boundaries are by γ.1:(-0.00073,0.0032643),2:(0.0032643,0.00779727),3:(0.00779727,0.01945247),4:(0.01945247,0.47872075)

Table A.6. Summary of agglomeration in four-digit industries, by two-digit industry, 2003

Two-digit industry	Mean γ	Percentage of four-digit industries in quartile(by γ)				Number of four-digit industries
		1(least)	2	3	4(most)	
9 Non-ferrous metal extractions and processing	0.057	29	0	21	50	14
33 Non-ferrous metal smelting and rolling	0.032	17	28	11	44	18
31 Non-metallic mineral products	0.031	10	35	26	29	31
43 Waste resources and materials recycling	0.03	0	0	50	50	2
21 Furniture	0.03	20	0	40	40	5
40 Communications equipment, computers and other electronic equipment	0.029	0	14	43	43	21
42 Artwork and other manufacturing	0.029	0	14	29	57	14
10 Non-metallic mining	0.027	0	22	44	33	9
39 Electronically Machinery and equipment	0.027	4	21	32	43	28
19 Leather, fur, feathers(down) and its products	0.027	0	0	36	64	11
17 Textile	0.025	14	24	33	29	21
37 Transportation equipment	0.024	22	17	22	39	23
41 Instrument, office and culture machinery	0.02	30	30	13	26	23
30 Plastic product	0.02	10	30	30	30	10
24 Education and sports goods	0.019	18	12	35	35	17
18 Garment, shoes and hat	0.017	0	33	33	33	3
34 Metal product	0.017	21	25	33	21	24
8 Ferrous metal extractions and processing	0.016	0	50	0	50	2
26 Chemical material and products	0.012	37	46	9	9	35
14 Food	0.011	45	20	20	15	20

(Continued on the next page)

Two-digit industry	Mean γ	Percentage of four-digit industries in quartile(by γ)				Number of four-digit industries
		1(least)	2	3	4(most)	
22 Paper and paper product	0.011	50	0	33	17	6
13 Agro-food processing	0.011	41	18	24	18	17
20 Wood processing, Wood, Bamboo, rattan, palm and grass products	0.01	20	20	50	10	10
16 Tobacco	0.01	33	33	0	33	3
23 Printing and media record	0.009	20	20	40	20	5
36 Special equipment manufacturing	0.009	27	31	27	14	51
35 General equipment manufacturing	0.008	30	39	21	9	33
28 Chemical Fibers	0.008	43	29	14	14	7
15 Beverage	0.007	62	23	0	15	13
25 Petroleum processing, coking and nuclear fuel processing	0.007	33	33	33	0	3
29 Rubber product	0.007	0	67	33	0	9
6 Coal mining and washing	0.006	67	0	33	0	3
27 Pharmaceutical manufacturing	0.004	71	0	29	0	7
32 Ferrous metal processing	0.003	50	50	0	0	4
7 Oil and gas exploration	0.002	100	0	0	0	2
44 Electricity and heat supply industry	0.001	100	0	0	0	5
45 Gas supply industry	0	100	0	0	0	1
11 Mining industry, nothing else specified	0	100	0	0	0	1
46 Water Supply industry	0	100	0	0	0	2

Quartile boundaries are by γ.1:(-0.00141,0.003457),2:(0.003457,0.008418),3:(0.008418,0.020188),4:(0.020188,0.579516)

Table A.7. Twenty most agglomerated industries,1998

Four-digit industry	Number of firms	Agglomeration,γ	Geographic concentration,G	Industrial concentration,H
2223 Handmade paper	17	0.244	0.373	0.170
1024 Boron Mining	10	0.233	0.414	0.236
2623 Potassium fertilizer	35	0.210	0.388	0.225
1034 Halite	21	0.151	0.221	0.083
1095 Precious stones, jade mining	10	0.142	0.348	0.241
1093 Graphite mining	43	0.133	0.205	0.083
4311 Sculpture crafts industry	292	0.126	0.184	0.067
1830 Footwear	428	0.120	0.196	0.087
1353 Marinated seafood processing industry	22	0.118	0.192	0.083
1091 Asbestos mining industry	18	0.110	0.258	0.166
1433 Aquatic products canning	24	0.103	0.187	0.094
1100 Mineral mining and processing, nothing else specified	24	0.099	0.203	0.115
3761 Ocean transportation ship manufacturing	70	0.094	0.134	0.044
2415 Pen manufacturing	130	0.090	0.111	0.023
1097 Talc mining	32	0.089	0.145	0.062
3652 Medical instruments and equipment manufacturing	161	0.088	0.100	0.013
3316 Tin smelting industry	18	0.088	0.446	0.392
3674 Sewing machine manufacturing	129	0.087	0.114	0.029
3715 Railway signal equipment	19	0.087	0.308	0.242
4080 Electrical machinery repair	45	0.085	0.234	0.163

Measures are: γ: agglomeration index (Eq. (21)), G: geographic concentration measure (Eq. (22)); H:industrial concentration (Eq. (20)).

Table A.8. Twenty most agglomerated industries, 2002

Four-digit industry	Number of firms	Agglomeration, γ	Geographic concentration, G	Industrial concentration, H
1095 Precious stones, jade mining industry*	6	0.479	0.667	0.360
3316 Tin smelting *	25	0.298	0.710	0.587
2623 Potassium fertilizer *	34	0.221	0.376	0.199
2223 Handmade paper*	14	0.215	0.527	0.397
4313 Lacquer handicraft	32	0.153	0.205	0.061
1774 Silk printing and dyeing industry	186	0.144	0.156	0.015
4122 The dedicated radar equipment and parts	23	0.140	0.203	0.073
3484 Knives, scissors	107	0.127	0.154	0.031
1220 Minerals Mining	10	0.121	0.248	0.143
3623 Chemical fiber special equipment manufacturing	27	0.121	0.182	0.070
1714 Ramie fiber preliminary processing	29	0.116	0.173	0.065
1032 Lake Salt	22	0.112	0.253	0.159
3322 Magnesium smelting	112	0.107	0.146	0.044
1773 Silk spinning	869	0.107	0.114	0.008
2224 Paper processing	266	0.106	0.122	0.019
4112 Switching equipment	136	0.104	0.213	0.122
1024 Boron mining *	13	0.104	0.223	0.133
965 Rare earth mining	24	0.102	0.163	0.068
1091 Asbestos mining *	34	0.096	0.176	0.089
2510 Synthetic crude oil production	17	0.092	0.489	0.437

Measures are: γ: agglomeration index (Eq. (21)), G: geographic concentration measure (Eq. (22)); H: industrial concentration (Eq. (20)).

*Indicates that the industry was also in the top 20 in 1998.

Table A.9. Twenty most agglomerated industries, 2003

Four-digit industry,2003	Four-digit industry,2002	Number of firms	Agglomeration, γ	Geographic concentration, G	Industrial concentration, H
917 Magnesium Mining and Dressing	932 Magnesium mining	8	0.460	0.698	0.440
3159 Ceramic products for Garden,artistic and others	3159 Other ceramic products	166	0.417	0.443	0.045
3314 Tin smelting*	3316 Tin smelting	30	0.261	0.706	0.602
3753 Construction and repair of recreational boats and sporting boats	N/A	17	0.236	0.332	0.126
2623 Potassium fertilizer*	2623 Potassium fertilizer	38	0.215	0.352	0.175
1743 Silk dyeing and finishing *	1774 Silk printing and dyeing industry	192	0.142	0.153	0.014
3954 Household kitchen appliances	4066 Hoods	222	0.140	0.175	0.041
4012 Communication switching equipment*	4112 Switching equipment	143	0.139	0.241	0.118
4072 Home audio equipment*	4172 Radios, tape recorders	345	0.129	0.137	0.010
3424 Knives, scissors and similar household metal tool*	3484 Knives, scissors 3488 Barber appliances	207	0.103	0.113	0.011
4190 Other instruments manufacture and repair	4290 Other Instruments	130	0.096	0.128	0.036

(Continued on the next page)

Four-digit industry,2003	Four-digit industry,2002	Number of firms	Agglomeration, γ	Geographic concentration, G	Industrial concentration, H
1924 Decorative leather gloves and leather products	1929 Other leather products	248	0.092	0.099	0.007
2120 Bamboo, rattan furniture	2120 Bamboo, rattan furniture	27	0.091	0.159	0.075
1091 Asbestos, mica mining*	1091 Asbestos mining 1092 Mica mining	33	0.087	0.175	0.096
1742 Silk spinning and silk processing *	1772 Silk 1773 Silk spinning 1779 Other silk textile	1102	0.087	0.092	0.005
3151 Sanitary ceramics products	3151 Construction, sanitary ceramics	281	0.084	0.094	0.011
4213 Lacquer handicraft*	4313 Lacquer Craft	45	0.084	0.130	0.050
1757 Non-woven fabric	1790 Other textile products	295	0.082	0.091	0.010
932 Rare earth mining*	965 Rare earth mining	20	0.081	0.199	0.127
4154 Photocopying and offset printing equipment	4256 Photocopier 4257 Typewriters and mimeograph	54	0.076	0.121	0.048

Measures are: γ: agglomeration index (Eq. (21)), G: geographic concentration measure (Eq. (22)); H: industrial concentration (Eq. (20)).

*Indicates that the industry was also in the top 20 in 1998.

Table A.10. Twenty most agglomerated regions, 1998

Four-digit industry	1st County Area	2nd County Area	Percentage of employment at County Area		Total number firms	Percentage of firms in County Area		Average firm size by employment	
			1st	2nd		1st	2nd	1st	Other
1024 Boron Mining	Dashiqiao	Kuandian Manchu Autonomous County	59.7	17.2	10	40.0	10.0	246	167
1034 Halite	Yingcheng	Jinshi, Hunan	41.4	13.6	21	28.6	4.8	451	640
1091 Asbestos mining industry	Shimian County	Lenghu	42.4	24.4	18	11.1	16.7	463	629
1093 Graphite mining	Pingdu	Hengshan District	32.0	21.8	43	39.5	4.7	200	424
1100 Mineral mining and processing,not elsewhere specified	Xiuyan Manchu Autonomous County	Yun County, Hubei	54.4	19.1	10	30.0	10.0	130	109
1353 Marinated seafood processing industry	Haicheng, Liaoning	Cangshan County	30.6	12.1	32	12.5	6.3	111	253
1433 Aquatic products canning	Xiangzhou County	Yushui District	41.7	9.1	24	8.3	4.2	137	192
1729 Other cotton textile	Dianbai County	Youxian District	35.9	17.2	22	36.4	4.5	49	88
1830 Footwear	Shunde District	Tianhe District	33.8	21.3	24	16.7	4.2	104	203
2223 Handmade paper	Dongguan	Nanhai District	43.7	4.0	428	12.9	2.1	332	429

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Four-digit industry	1st County Area	2nd County Area	Percentage of employment at County Area		Total number firms	Percentage of firms in County Area		Average firm size by employment	
			1st	2nd		1st	2nd	1st	Other
2411 Stationery	Jing County, Anhui	Jiangyin	59	10.2	17	29.4	11.8	262	182
2415 Pen manufacturing	Qingpu District, Shanghai	Laizhou	30.8	7.7	130	25.4	2.3	131	294
2623 Potassium fertilizer	Golmud	Lucheng District	58.6	19.8	35	37.1	2.9	281	199
3316 Tin smelting industry	Gejiu	Zhongshan County	63.8	16.7	18	16.7	5.6	1828	1038
3652 Medical instruments and equipment manufacturing	Qingpu District, Shanghai	Nankai District	30.3	3.1	161	25.5	2.5	71	164
3674 Sewing machine manufacturing	Qingpu District, Shanghai	Haizhu District	31	8.5	129	19.4	1.6	167	371
3761 Ocean transportation ship manufacturing	Beilin District, Xi'an	Tiexi District, Shenyang	41.2	36.6	19	10.5	10.5	202	289
4080 Electrical machinery repair	Qingpu District, Shanghai	Xigang District	31.8	9.8	70	18.6	2.9	706	1511
4172 Radios, tape recorders	Changqing District	Yinzhou District, Tieling	42.9	19.6	45	8.9	2.2	112	149
4311 Sculpture crafts industry	Hui'an County	Licheng District, Quanzhou	41.4	6.5	292	26.4	3.8	161	227

Table A.11. Twenty most agglomerated regions, 2002

Four-digit industry	1st County Area	2nd County Area	Percentage of employment at County Area		Total number firms	Percentage of firms in County Area		Average firm size by employment	
			1st	2nd		1st	2nd	1st	Other
1095 Precious stones, jade mining industry*	Xiuyan Manchu Autonomous County	Yun County, Hubei	80.6	9.3	6	50.0	16.7	340	82
3316 Tin smelting *	Gejiu	Zhongshan County	83.3	12.4	25	24.0	12.0	3942	249
2623 Potassium fertilizer	Golmud	Wenshui County	59.6	9.6	34	23.5	5.9	687	143
2223 Handmade paper*	Jing County, Anhui	Longhai City	71.7	8.5	14	21.4	7.1	760	82
4313 Lacquer handicraft	Xianyou County	Guangling District	41.2	10.1	32	34.4	3.1	203	152
1774 Silk printing and dyeing industry	Shaoxing County	Wujiang District, Suzhou	35.1	14.6	186	23.1	9.1	449	250
4122 The dedicated radar equipment and parts	Shizhong District,Guangyuan	Dongcheng District, Beijing	39.0	16.1	23	30.4	4.3	783	535
3484 Knives, scissors	Jiangcheng District	Panyu District	35.3	12.5	107	48.6	0.9	167	289
1220 Minerals Mining	Guixi	Zengdu District	41.8	18.5	10	30.0	10.0	316	189
3623 Chemical fiber special equipment manufacturing	Zhangjiagang	Changshu	36.8	14.1	27	25.9	14.8	182	109

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Four-digit industry	1st County Area	2nd County Area	Percentage of employment at County Area		Total number firms	Percentage of firms in County Area		Average firm size by employment	
			1st	2nd		1st	2nd	1st	Other
1714 Ramie fiber preliminary processing	Hanshou County	Jiangyin	35.0	14.8	29	27.6	3.4	261	185
1032 Lake Salt	Alxa Left Banner	Ulan County	42.1	24.3	22	18.2	9.1	899	274
3322 Magnesium smelting	Wenxi County	Huidong County	35.5	7.1	112	21.4	1.8	461	228
1773 Silk spinning	Shaoxing County	Xiaoshan District	28.5	12.5	869	23.2	21.2	297	226
2224 Paper processing	Fuyang, Zhejiang	Xinxiang County	32.3	9.5	266	33.5	0.4	151	159
4112 Exchange equipment	Nanshan District, Shenzhen	Pudong	44.6	7.5	136	8.1	2.9	2782	304
1024 Boron mining*	Gaizhou	Kuandian Manchu Autonomous County	30.3	24.6	13	23.1	15.4	301	208
965 Rare earth mining	Mianning County	Weishan County, Shandong	32.5	14.3	24	29.2	4.2	171	147
1091 Asbestos mining	Shimian County	Aksai Kazakh Autonomous County	27.8	22.7	34	5.9	35.3	1969	319
2510 Synthetic crude oil production	Taiping District,Harbin	Xiashan District	68.9	7.3	17	17.6	5.9	283	27

Table A.12. Twenty most agglomerated regions, 2003

Four-digit industry	1st County Area	2nd County Area	Percentage of employment at County Area		Total number firms	Percentage of firms in County Area		Average firm size by employment	
			1st	2nd		1st	2nd	1st	Other
917 Magnesium Mining and Dressing	Haicheng, Liaoning	Xiuyan Manchu Autonomous County	82.7	11.2	8	25.0	37.5	1555	109
3159 Garden, furnishings, artistic and other ceramic products	Dehua County	Raoping County	66.1	4.6	166	53.6	5.4	436	259
3314 Tin smelting	Gejiu	Babu District	83.0	12.8	30	20.0	6.7	4564	234
3753 Construction and repair of recreational boats and sporting boats	Dongguan	Taishan	53.4	18.8	17	23.5	17.6	362	97
2623 Potassium fertilizer	Golmud	Wenshui County	57.9	8.9	38	26.3	2.6	575	150
1743 Silk dyeing and finishing	Shaoxing County	Wujiang District, Suzhou	35.1	13.1	192	24.0	9.4	442	258
3954 Household kitchen appliances	Shunde District	Cixi City	38.9	8.8	222	12.2	11.3	1440	313
4012 Communication switching equipment	Nanshan District, Shenzhen	Pudong	47.9	6.9	143	7.0	1.4	3600	295
4072 Home audio equipment	Dongguan	Huicheng District	32.3	14.5	345	17.4	6.1	996	438
3424 Knives, scissors and similar household metal tool	Jiangcheng District	Yangdong County	29.5	11.3	207	35.7	11.1	165	219

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Four-digit industry	1st County Area	2nd County Area	Percentage of employment at County Area		Total number firms	Percentage of firms in County Area		Average firm size by employment	
			1st	2nd		1st	2nd	1st	Other
4190 Other instruments manufacture and repair	Bao'an District	Kunshan	34.1	4.7	130.00	8.5	0.8	865	155
1924 Decorative leather gloves and leather products	Gaozhou	Dianbai County	29.5	4.6	248	23.8	3.6	369	275
2120 Bamboo, rattan furniture	Nanhai District	Huiyang District	34.8	10.9	27	18.5	3.7	413	176
1091 Asbestos, mica mining	Shimian County	Aksai Kazakh Autonomous County	25.9	22.0	33	6.1	30.3	1666	307
1742 Silk spinning and silk processing	Shaoxing County	Xiaoshan District	26.2	8.7	1102	19.5	15.6	323	221
3151 Sanitary ceramics products	Nanhai District	Zhangdian District	23.1	16.0	281	31.0	13.9	253	376
4213 Lacquer handicraft	Xianyou County	Taihe County, Jiangxi	30.3	10.4	45	31.1	2.2	176	183
1757 Non-woven fabric	Xiantao	Hanchuan	28.9	3.5	295	10.8	1.4	390	117
932 Rare earth mining	Darhan Muminggan United Banner	Mianning County	29.6	26.4	20	5.0	35.0	969	121
4154 Photocopying and offset printing equipment	Dongguan	Futian District	25.8	14.0	54	14.8	7.4	972	486

Table A.13. Twenty least agglomerated industries, 1998

Four-digit industry	Number of firms	Agglomeration,γ	Geographic concentration,G	Industrial concentration,H
4420 Electricity supplement	1675	-0.0020	0.0018	0.0038
4620 Water supply industry	908	-0.0018	0.0042	0.0059
4411 Thermal power industry	962	-0.0017	0.0045	0.0062
2621 Nitrogen fertilizer	713	-0.0016	0.0019	0.0035
1513 Beer industry	552	-0.0016	0.0026	0.0042
2210 Pulp industry	59	-0.0016	0.0496	0.0511
2687 Matches	67	-0.0015	0.0297	0.0312
3332 Silver smelting industry	11	-0.0015	0.1856	0.1868
2510 Synthetic crude oil production	14	-0.0015	0.1092	0.1105
3387 Rare earth metals rolling processing	41	-0.0015	0.1677	0.1690
1444 Yeast products	22	-0.0015	0.1595	0.1607
3385 Precious metal rolling processing	11	-0.0015	0.4105	0.4114
1493 Milk substitutes manufacturing	9	-0.0015	0.1890	0.1903
4251 Film Machinery Manufacturing	7	-0.0015	0.2302	0.2314
3643 Silvicultural machinery manufacturing	8	-0.0015	0.2304	0.2315
3786 Aircraft repair	23	-0.0015	0.0606	0.0620
4510 Gas production industry	46	-0.0014	0.0544	0.0557
4419 Other power industry	26	-0.0014	0.1130	0.1142
1442 MSG	83	-0.0013	0.0729	0.0741
3719 Other rail transportation equipment	17	-0.0012	0.3832	0.3839

Measures are: γ: agglomeration index (Eq. (21)), G: geographic concentration measure (Eq. (22)); H: industrial concentration (Eq. (20)).

Table A.14. Twenty least agglomerated industries, 2002

Four-digit industry	Number of firms	Agglomeration, γ	Geographic concentration, G	Industrial concentration, H
4610 Water	1351	-0.00073	0.003	0.003
4420 Electricity supplement *	1615	-0.000715	0.007	0.008
4620 Water supply industry *	1028	-0.000514	0.005	0.006
1769 Hosiery, nothing else specified	27	-0.000406	0.23	0.231
2140 Plastic furniture	12	-0.00032	0.178	0.178
1451 Soy bean source	365	-0.000245	0.007	0.007
1513 Beer industry *	480	-0.000215	0.006	0.006
3637 Industrial dedicated equipment for daily silicate products	11	-0.000144	0.214	0.214
3723 Bus	20	-0.000125	0.114	0.114
3323 Titanium smelting	14	-0.00008	0.36	0.36
3644 Livestock machinery	21	-0.000071	0.101	0.101
4226 Meteorological, oceanographic, hydrological, astronomical instrument	6	-0.000061	0.208	0.208
3514 Turbine	22	-0.000039	0.059	0.059
4280 Instrumentation and office machinery repair	11	-0.000025	0.132	0.132
3643 Forest machinery	8	-0.000018	0.412	0.412
4189 Other electronic equipment repair	6	-0.000016	0.2	0.2
3683 Agriculture, forestry, animal husbandry, fishery, irrigation machinery repair	38	-0.000014	0.065	0.065
4251 Film Machinery	8	-0.000012	0.272	0.272
3711 Motorcycle	13	-0.000012	0.129	0.129
2615 Soda	80	-0.00001	0.073	0.073

Measures are: γ: agglomeration index (Eq. (21)), G: geographic concentration measure (Eq. (22)); H: industrial concentration (Eq. (20)).

*Indicates that the industry was also in the top 20 in 1998.

Table A.15. Twenty least agglomerated industries, 2003

Four-digit industry,2003	Four-digit industry,1998	Number of firms	Agglomeration,γ	Geographic concentration,G	Industrial concentration,H
4610 Water	4610 Water* 4620 Water supply industry *	2334	-0.00141	0.001	0.002
4420 Electricity supplement *	4420 Power supply	1625	-0.0009	0.006	0.007
4411 Thermal power	4411 Thermal power	1040	-0.00065	0.004	0.005
2812 Man-made fibers (cellulose fibers)	2812 Viscose fiber 2819 Other cellulosic fiber	100	-0.00053	0.066	0.067
2140 Plastic furniture	2140 Plastic furniture	17	-0.00051	0.106	0.107
1522 Beer	1513 Beer	494	-0.00024	0.007	0.007
2414 Ink	2411 Stationery	19	-0.00011	0.079	0.079
4151 Film Machinery	4251 Film Machinery	9	-0.0001	0.33	0.33
3111 Cement	3110 Cement	4748	-8.7E-05	0	0.001
3693 Postal dedicated machinery	3676 Postal machinery	13	-6.8E-05	0.19	0.19
1462 Soy sauce, vinegar and similar products	1451 Soy sauce, ketchup 1452 Vinegar	378	-5.8E-05	0.007	0.007
3491 Coins, precious metal and laboratory supplies	3499 Other metal products	11	-4.1E-05	0.298	0.298

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Four-digit industry, 2003	Four-digit industry,1998	Number of firms	Agglomeration, γ	Geographic concentration, G	Industrial concentration, H
3692 Geological special equipment	3672 Geological special equipment	29	-3.1E-05	0.099	0.099
939 Other precious metals mining	962 Rare light metals mining 963 Rare refractory metals mining 964 Scattered metal mining 969 Other rare earth metals mining	11	-5E-06	0.29	0.29
933 Radioactive metal ores	966 Rare radioactive metal mining	11	-4E-06	0.222	0.222
2512 Synthetic crude oil	2510 Synthetic crude oil	9	-3E-06	0.18	0.18
1364 Fish Oil Extraction and products	1359 Other aquatic products processing	7	-2E-06	0.286	0.286
922 Silver mining	952 Silver mining	18	-2E-06	0.081	0.081
690 Other coal mining	610 Coal mining	9	-2E-06	0.618	0.618
1461 MSG	1442 MSG	81	0.000011	0.149	0.149

Measures are: γ: agglomeration index (Eq. (21)), G: geographic concentration measure (Eq. (22)); H: industrial concentration (Eq. (20)).

*Indicates that the industry was also in the top 20 in 1998.

Table A.16.The summary of high-tech industries in China

Industry name	1998		2002		2003		2007	
	Number of Employment	Number of firms	Number of Employment	Number of firms	Number of Employment	Number of firms	Number of Employment	Number of firms
Information Chemical	39,249	118	37,705	142	36,300	174	64,170	264
The original drug chemicals	338,248	621	312,937	699	292,663	693	305,713	1,007
Chemical preparations	310,530	880	302,917	968	313,487	989	383,681	1,158
Chinese medicine	45,050	230	74,847	317	73,264	341	99,370	611
Aircraft manufacturing and repair	391,869	100	303,889	101	316,408	123	278,766	150
Spacecraft Manufacturing	71,240	45	48,601	44	23,110	18	21,075	20
Other Vehicle Manufacturing	75,783	134	58,930	146	48,166	148	74,926	274
Communication exchange equipment	80,363	161	68,652	136	75,186	143	131,063	157
Communication Terminal Equipment	70,488	110	126,280	216	92,124	184	103,036	227
Mobile communications and terminal equipment	70,488	110	126,280	216	97,791	86	361,406	275
Radar and ancillary equipment	101,482	54	44,449	50	38,178	47	40,622	46
Broadcasting and TV Equipment	29,926	97	23,901	106	34,013	146	93,951	372
Electronic vacuum device	117,838	103	103,848	100	124,707	113	95,792	153

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Industry name	1998		2002		2003		2007	
	Number of Employment	Number of firms	Number of Employment	Number of firms	Number of Employment	Number of firms	Number of Employment	Number of firms
Discrete semiconductor device	82,156	195	110,411	290	69,718	196	97,314	299
Semiconductor	57,324	117	74,201	175	99,972	202	273,501	416
Optoelectronic devices and other electronic device	82,156	195	110,411	290	85,758	171	384,050	741
Electronics	549,504	1,378	761,479	1,933	885,709	2,208	2,003,680	4,546
Home audio-visual equipment	359,605	465	394,546	581	397,608	598	585,012	948
Other electronic equipment	80,811	367	108,278	489	99,628	434	204,659	772
Computer machine	74,246	131	96,344	122	136,864	160	478,689	166
Computer Network Equipment	102,580	273	219,754	383	18,133	63	39,991	132
Computer peripherals	102,580	273	219,754	383	351,596	434	805,822	906
Photocopying and offset printing equipment	16,516	28	33,612	52	30,135	54	59,216	103
Calculator and money and special equipment	20,913	37	49,143	63	56,909	64	45,307	88
Medical equipment and device	79,454	412	93,923	511	84,846	443	172,530	857
General Instruments	157,875	396	117,905	506	180,389	929	308,169	2,050
Special instrumentation	66,539	252	61,754	324	76,477	337	113,238	648
Optical Instruments	76,993	121	84,517	191	77,246	203	141,399	304
Other instrument manufacturing and repair	17,881	96	11,545	79	27,926	130	27,579	162

Table A.17.. Comparison of γ for US top 20 agglomerated industries, 2002

US	γ	Rank	China (Province level)	γ	Rank
2371 Fur goods	0.63	1	1924 Leather suitcase	0.175	88
			1925 Leather Bag	0.2819	37
			1929 Fur goods,nothing else specified	0.2247	59
			1932 Fur garment industry	0.0314	341
			1939 Other fur products industry	0.1058	161
2084 Wines brandy spirits	0.48	2	1515 Wine industry	0.0942	182
2252 Hosiery not elsewhere classified	0.44	3	1789 Other knitwear industry	0.1067	158
3533 Oil and gas field machinery	0.43	4	3621 Oil field machinery	0.0363	322
2251 Women's hosiery	0.4	5	※	※	※
2273 Carpets and rugs	0.38	6	4317 Carpet	0.1098	155
2429 Special product sawmills not elsewhere classified	0.37	7	2011 Lumber processing	-0.0133	541
3961 Costume jewelry	0.32	8	※	※	※
2895 Carbon black	0.3	9	※	※	※
3915 Jewelers' materials lapidary	0.3	10	※	※	※
2874 Phosphatic fertilizers	0.29	11	2622 Phosphatic fertilizers	0.0091	451
2061 Raw cane sugar	0.29	12	1331 Cane sugar	0.2426	50
2281 Yarn mills except wool	0.28	13	1761 Ramie textile	0.0717	226
			1762 Linen textile	0.2775	38
			1769 Other hemp textile	0.0463	282
			1772 Silk mills	0.2884	36
			1773 Silk textile	0.4215	16
			1779 Other silk mills	0.1946	70
2034 Dehydrated fruits vegetable soups	0.28	14	※	※	※
3761 Guided missiles space vehicles	0.25	15	3779 Other Aerospace manufacturing	0.0794	205

Table A.18. Comparison of γ for France top 20 agglomerated industries, 2002

France	γ	Rank	China	γ (County level)	Rank
Extraction of slate	0.88	1	※	※	※
Extraction of iron ore	0.88	2	※	※	※
Made-to-measure clothing	0.8	3	※	※	※
Extract of minerals for chemical industry and fertilizers	0.76	4	2651 Organic chemical raw materials manufacturing	0.023	123
Steel pipe and tubes	0.69	5	3463 Plumbing parts	0.015	184
Extraction of coal	0.53	6	610 Coal mining	0.002	473
			620 Coal washing	0.010	227
Combed wool spinning mills	0.44	7	1742 Wool spinning	0.017	158
Vehicles hauled by animals	0.42	8	※	※	※
Wool preparation	0.42	9	1742 Wool spinning	0.017	158
			1743 Wool textile	0.006	350
Periodicals	0.4	10	2311 Book, newspaper and periodicals	0.002	470
Watch-making	0.38	11	4260 Watches	0.025	111
Flat glass	0.37	12	3141 Glass products for building field	0.009	259
Screw cutting	0.36	13	※	※	※

(Continued on the next page)

France	γ	Rank	China	γ (County level)	Rank
Lawn and garden equipment	0.36	14	※	※	※
Carded wool weaving mills	0.34	15	1743 Wool weaving	0.0055	350
Essential oils	0.32	16	※	※	※
Book publishing	0.3	17	2311 Book, newspaper and periodicals	0.0022	470
Extraction of uranium ore	0.29	18	※	※	※
Cutlery	0.28	19	3431 Cutting tools	0.0317	83
Carded wool spinning mills	0.25	20	1742 Wool spinning	0.0172	158
Small arms	0.25	21	3900 Weapons and Ammunition	#N/A	#N/A
War vessels	0.24	22	※	※	※
Sound recording	0.24	23	4172 Radios, tape recorders	0.0910	21
Cotton spinning mills	0.24	24	1721 Cotton spinning	0.0003	544

※ Indicates that the four-digit industry didn't located in China or information cannot be provided due to data confidentiality reasons

Table A.19. Comparison of γ for UK top 20 agglomerated industries,2002

UK	γ	Rank	China	District/County Level		Postcode area	
				γ	Rank	γ	Rank
4340 Spinning and weaving of flax	0.711	1	1762 Linen Textile industry	0.0124	202	0.010	98
2330 Extraction salt	0.499	2	1031 Sea salt industry	0.0103	233	0.002	306
			1032 Lake Salt	0.1117	12	0.015	62
			1033 Well Salt Industry	0.0172	160	0.000	520
			1034 Mine Salt	0.0841	24	0.017	57
4350 Jute and polypropylene	0.414	3	※	※	※	※	※
2489 Ceramic goods	0.41	4	3151 Construction, sanitary ceramics manufacturing	0.0373	64	0.013	69
			3153 Industrial ceramics industry	0.0186	151	0.006	142
			3155 Daily ceramic manufacturing	0.0236	119	0.018	51
			3159 Other ceramic products industry	0.0109	220	0.003	254
4395 Lace	0.402	5	※	※	※	※	※
3162 Cutlery	0.338	6	3484 Knives and scissors	0.1269	8	0.047	15
			3488 Barber appliances manufacturing	0.0332	78	0.022	40
3634 Pedal cycles	0.191	7	3740 Bicycle manufacturing	0.0302	87	0.015	63
4363 Hosiery	0.168	8	1781 Cotton knitwear industry	0.0057	345	0.002	320
			1782 Wool knitwear industry	0.0103	230	0.003	269
			1783 Silk knitwear industry	0.0204	137	0.008	114
			1789 Other knitwear industry	0.0257	105	0.007	133

(Continued on the next page)

UK	Postcode area		China	District/County Level		Postcode area	
	γ	Rank		γ	Rank	γ	Rank
4910 Jewellery	0.146	9	※	※	※	※	※
3161 Hand tools	0.139	10	3435 Hand tools	0.0043	397	0.0016	366
4752 Periodicals	0.135	11	2311 Books, newspapers, periodicals	0.0022	470	0.0006	481
4310 Woolen and worsted industry	0.119	12	1742 Wool	0.0172	158	0.0053	170
			1743 Wool textile	0.0055	350	0.0021	322
			1749 Woolen textile,nothing else specified	0.0707	33	0.0671	3
3523 Caravans	0.118	13	※	※	※	※	※
4721 Wall coverings	0.118	14	※	※	※	※	※
4322 Weaving cotton, silk	0.112	15	1743 Wool textile	0.0055	350	0.0021	322
			1773 Silk textile	0.1075	14	0.0117	80
4831 Plastic coated textile fabric	0.111	16	※	※	※	※	※
2235 Other steel forming	0.092	17	※	※	※	※	※
4240 Spirit distilling	0.091	18	1511 Alcohol manufacturing	0.0031	437	0.0013	391
4537 Hats	0.082	19	1820 Hats	0.0224	126	0.0059	149
4150 Fish processing	0.081	20	1352 Dried seafood processing	0.0276	94	0.0069	128
			1353 Marinated seafood processing	0.0234	121	0.0026	284
			1354 Surimi and surimi products processing	0.0048	378	0.0032	248

※ Indicates that the four-digit industry didn't located in China

Table C.1. Size distribution of $firm^a$, 2004

Number of employees in the firm	Percentage of firms	Number of firms	Percentage of employment	Number of employees
0– 1	1.23	263	0.02	262
2	0.76	162	0.02	324
3	1.44	308	0.07	924
4	1.81	387	0.11	1,548
5– 9	16.62	3,549	1.82	25,115
10– 19	25.93	5,536	5.28	73,039
20– 49	28.33	6,050	13.01	179,772
50– 99	12.23	2,612	12.84	177,419
100–199	6.21	1,327	13.08	180,808
200 +	5.42	1,158	53.75	742,859
Total	100	21,352	100	1,382,070

a: We treat enterprises have the same owner, locates in the same region and have the same 4-digit industry code as one firm. We aggregate their number of employees.

Table C.2. Summary of agglomeration in four-digit industries, by two-digit industry,2004

Two-digit industry	Mean γ	Percentage of four-digit industries in quartile (by γ)				Number of four-digit industries
		1 (least)	2	3	4 (most)	
7 Petroleum and natural gas extraction	0.429	0	50	0	50	2
10 Non-metal Ores mining	0.418	0	0	33	67	3
40 Communications equipment, computers and other electronic equipment manufacturing	0.150	36	0	0	64	14
15 Beverages	0.137	30	0	20	50	10
28 Chemical fibers	0.132	33	0	0	67	4
20 Wood processing and wood, bamboo, rattan, brown, grass products	0.108	0	22	33	44	9
42 Artwork and Other Manufacturing	0.107	8	25	25	42	12
19 Leather, fur, feathers (down) processing and its products	0.083	13	25	25	38	8
37 Transportation equipment manufacturing	0.082	13	20	20	47	15
34 Metal manufacturing	0.077	17	30	30	22	23
43 Waste Resources and Materials Recycling and Processing	0.073	50	0	0	50	2
13 Agro-food processing	0.068	38	15	15	31	13
14 Food	0.065	13	33	13	40	15
21 Furniture	0.065	0	33	33	33	3
17 Textiles	0.061	26	26	26	21	19
39 Electrical machinery and equipment manufacturing	0.061	26	17	35	22	23

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Two-digit industry	Mean γ	Percentage of four-digit industries in quartile (by γ)				Number of four-digit industries
		1 (least)	2	3	4 (most)	
35 General equipment manufacturing	0.06	17	37	30	17	30
41 Instrumentation and culture, office machinery manufacturing	0.059	27	40	13	20	15
29 Rubber Products	0.051	11	33	44	11	9
30 Plastic products	0.05	40	10	30	20	10
26 Chemicals	0.049	25	29	25	21	28
27 Pharmaceutical products	0.049	0	43	43	14	7
32 Ferrous metal smelting and rolling processing	0.049	25	25	0	50	4
24 Educational and Sports Goods	0.046	33	17	17	33	12
31 Non-metallic mineral products	0.04	28	36	28	8	25
36 Special equipment manufacturing	0.037	38	15	36	10	39
33 Non-ferrous metal smelting and rolling processing	0.037	29	29	29	14	7
22 Paper and paper products	0.02	40	40	20	0	5
46 Water production and supply	0.018	0	100	0	0	2
44 Electricity, heat producing and supply	0.015	67	0	33	0	3
18 Manufacturing of cloth, shoes and hat	0.013	33	67	0	0	3
25 Coke making , petroleum and nuclear fuel processing	0.01	50	0	50	0	2
23 Printing and copy of record media	0.005	50	50	0	0	4
45 Natural gas production and supply	-0.01	100	0	0	0	1

Quartile boundaries are by γ: 1 (-0.0162, 0.0050) 2. (0.0050,0.0289) 3.(0.0289,0.0742) 4.(0.0742,0.8517)

α:Mean is un-weighted. (3663)Arms and Ammunition Manufacturers has been dropped due to confidential nature of the data

Table C.3. Twenty most agglomerated industries, 2004

Four-digit industry	Number of firms	Agglomeration, γ	Geographic concentration, G	Industrial concentration, H
790 Service activities related to petroleum and natural gas exploration	13	0.852	0.926	0.498
1012 Decorative building stone mining	11	0.771	0.818	0.204
4071 Home video equipment manufacturing	7	0.561	0.736	0.399
1523 Yellow rice wine manufacturing	5	0.512	0.731	0.449
1721 Wool tops processing	5	0.497	0.738	0.479
4130Clocks and timekeeping instruments manufacturing*	29	0.480	0.598	0.227
1019 Clay, other soil and gravel mining	9	0.452	0.574	0.223
2665 Chemical products for information Industry	12	0.428	0.633	0.359
1399 Agro-food processing nothing else specified	69	0.424	0.437	0.024
4052 Semiconductor discrete device manufacturing*	16	0.420	0.597	0.306
3471 Enamel Products for industry production*	6	0.419	0.734	0.543
3577 Weighing machines	10	0.411	0.558	0.248
3479 The enamel products and nothing else specified	9	0.392	0.612	0.362
4215 Plant fibre woven handicraft	11	0.385	0.499	0.184
3122 Concrete structure component manufacturing	41	0.369	0.467	0.156
3911 Generators and turbine manufacturing*	25	0.314	0.463	0.218
3543 Industrial Valves and cocks manufacturing	215	0.298	0.344	0.066
1524 Wine manufacturing*	15	0.289	0.460	0.241
2039 Cork and wood products manufacturing	39	0.280	0.379	0.139
2812 Manmade fibres (cellulose fibres)	7	0.275	0.480	0.283

Measures are: c: agglomeration index (Eq. (6)), G: geographic concentration measure (Eq. (7)); H: industrial concentration (Eq. (5)).

*Indicates that the industry was also in the top 20 in 2008.

Table C.4. Most agglomerated regions, 2004

Four-digit industry	1st postcode area	2nd postcode	Percentage of employment in postcode		Total number firms	Percentage of firms in postcode		Average firm size (employment)	
			1st	2nd		1st	2nd	1st	Other
790 Service activities related to petroleum and natural gas exploration	300452 (Tanggu)	300280 (Dagang)	96.1	3.8	13	30.8	61.5	1541	28
1012 Decorative building stone mining	301901 (Ji)	300408 (Beichen)	90.4	5	11	45.5	9.1	124	11
4071 Home video equipment manufacturing	300457 (TEDA)	300350 (Jinnan)	85.1	11.9	7	57.1	14.3	438	102
1523 Yellow rice wine manufacturing	300480 (Hangu)	300400 (Beichen)	84	16	5	80	20	20	15
1721 Wool tops processing	300382 (Xiqing)	301500 (Ninghe)	84.9	12.8	5	60	20	100	27
4130Clocks and timekeeping instruments manufacturing	300074 (Nankai)	300220 (Hexi)	76.5	11.1	29	20.7	3.4	510	41
1019 Clay, other soil and gravel mining	301900 (Ji)	301901 (Ji)	71.2	25.9	9	66.7	22.2	61	49
2665 Chemical products for information Industry	300220 (Hexi)	300163 (Dongli)	78.6	9.3	12	33.3	8.3	233	32
1399 Agro-food processing nothing else specified	301603 (Jinghai)	300385 (XEDA)	65.3	6.1	69	76.8	2.9	15	26

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Four-digit industry	1st postcode area	2nd postcode	Percentage of employment in postcode		Total number firms	Percentage of firms in postcode		Average firm size (employment)	
			1st	2nd		1st	2nd	1st	Other
3471 Enamel Products for industry production	300350 (Jinnan)	300408 (Beichen)	85.1	8.8	6	66.7	16.7	56	20
3577 Weighing machines	300380 (Xiqing)	300112 (Nankai-Xiqing)	72.2	18.6	10	50	20	67	26
4052 Semiconductor discrete device manufacturing	300457 (TEDA)	300061 (Hexi)	76.1	9.1	16	35.3	5.9	564	96
3479 The enamel products and nothing else specified	301701 (Wuqing)	300380 (Xiqing)	75.9	18.9	9	22.2	33.3	1115	101
4215 Plant fibre woven handicraft	301615 (Jinghai)	301700 (Wuqing)	68.7	12.8	11	45.5	9.1	86	33
3122 Concrete structure component manufacturing	300301 (Dongli)	300400 (Beichen)	67.6	9.5	41	12.2	9.8	548	36
3911 Generators and turbine manufacturing	300400 (Beichen)	300384 (Xiqing)	62.8	27.1	25	52	4	209	134
3543 Industrial Valves and cocks manufacturing	300353 (Jinnan)	300350 (Jinnan)	58.4	7.8	215	30.2	16.3	88	27
1524 Wine manufacturing	300402 (Beichen)	300480 (Hangu)	16.6	5.6	15	33.3	6.7	281	23
2039 Cork and wood products manufacturing	300401 (Beichen)	300385 (XEDA)	61.3	8	39	10.3	2.6	329	24
2812 Man-made fibres (cellulose fibres)	301508 (Ninghe)	301815 (Baodi)	61.5	31.3	7	28.6	42.9	60	15

Table C.5. Industries exit after 2004

Four-digit industries	Number of firms	H	G	Gamma
Crude oil and natural gas exploration	8	0.893	0.894	0.005
Decorative building stone mining	11	0.204	0.818	0.771
Non-metallic mining nothing else specified	5	0.347	0.346	-0.001
1510 Alcohol manufacture	7	0.258	0.427	0.227
1534Milk beverage and vegetable protein beverage manufacturing	5	0.283	0.354	0.099
1721wool tops processing	5	0.479	0.738	0.497
1753Hemp products manufacturing	7	0.196	0.22	0.029
2621Nitrogen fertilizer manufacturing	8	0.458	0.456	-0.004
2821Nylon fibre manufacturing	6	0.301	0.354	0.076
3123Asbestos cement products manufacturing	10	0.166	0.18	0.017
3132Building ceramics products manufacturing	5	0.245	0.244	-0.002
3143Optical glass manufacturing	6	0.52	0.519	-0.002
3491Mint and laboratory supplies of the precious metal, manufacturing	5	0.296	0.299	0.004
3575Spray guns and similar appliances manufacturing	24	0.064	0.124	0.065
3676Agriculture, forestry, animal husbandry and fisheries machinery accessories manufacturing	8	0.213	0.211	-0.003
3722Modified vehicles manufacturing	6	0.558	0.554	-0.008
3731Motorcycle manufacturing	5	0.74	0.738	-0.007
4123Dedicated navigation, meteorological and marine equipment manufacturing	7	0.282	0.281	-0.001
4155Calculator and currency specified equipment manufacturing	5	0.216	0.315	0.126

Figure Appendix

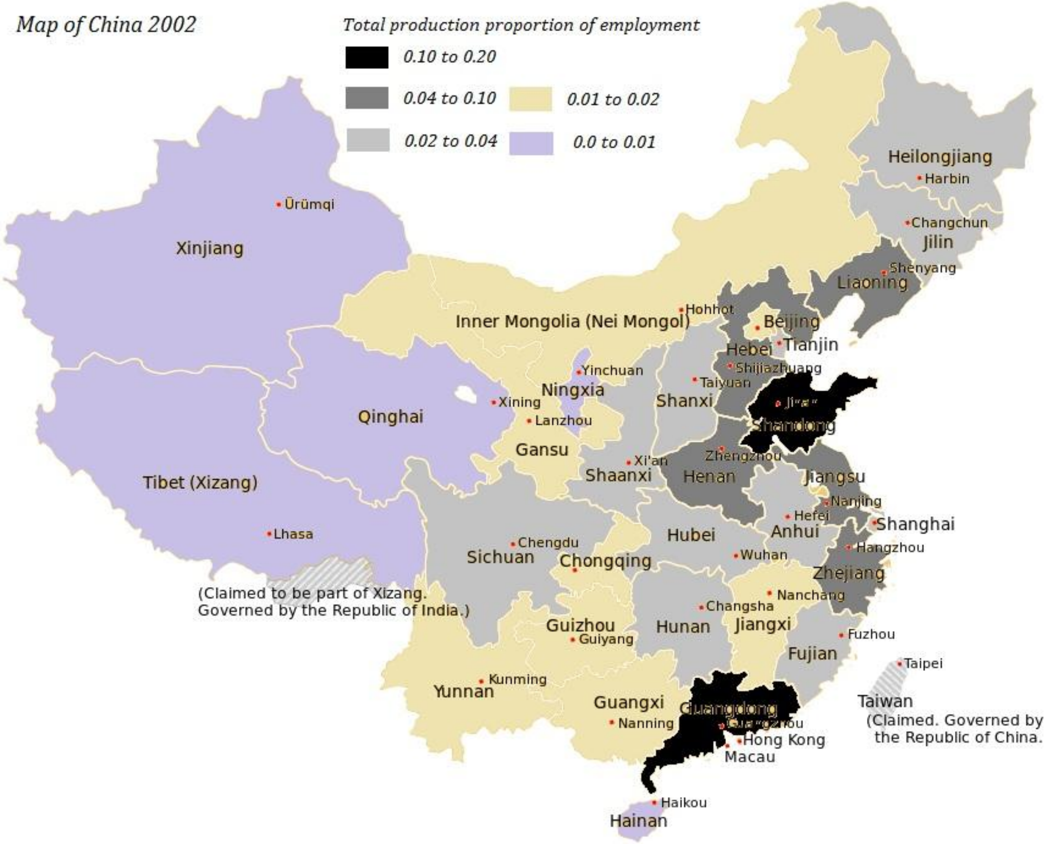


Figure A.1. The share distribution of production employment, 2002

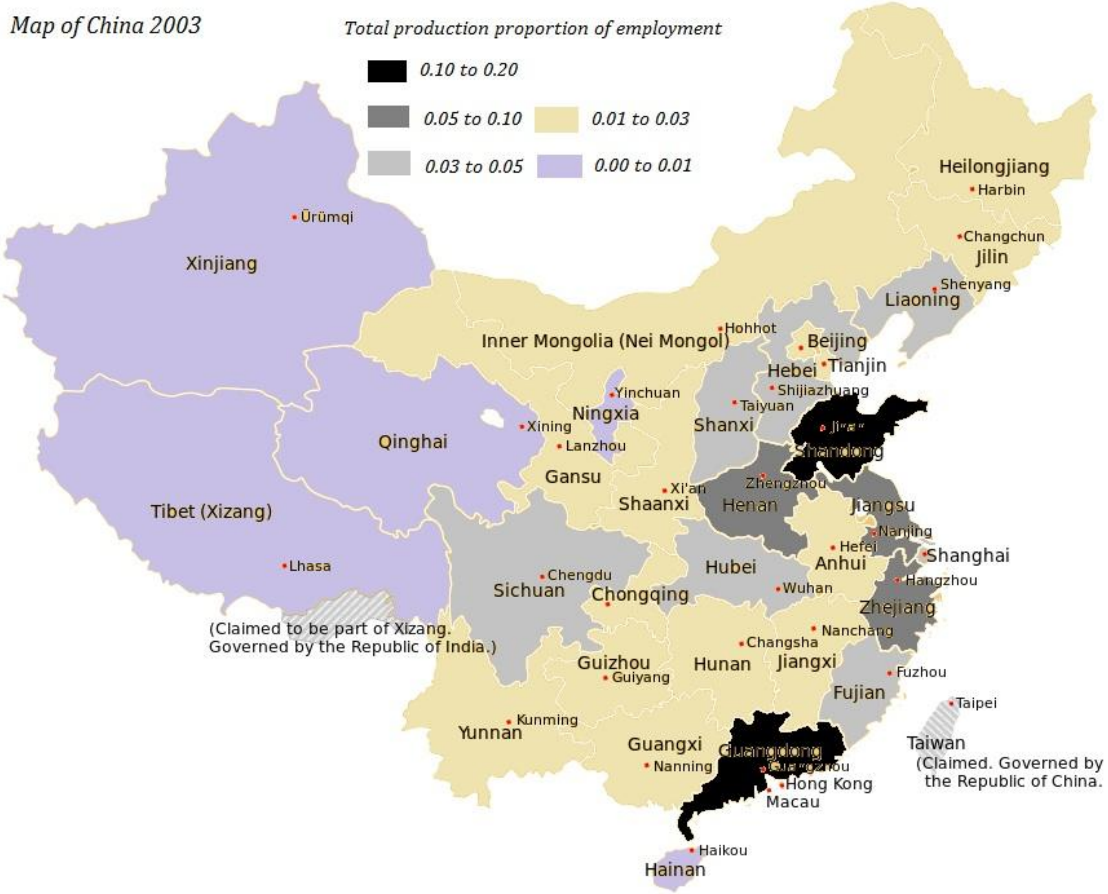


Figure A.2. The share distribution of production employment, 2003

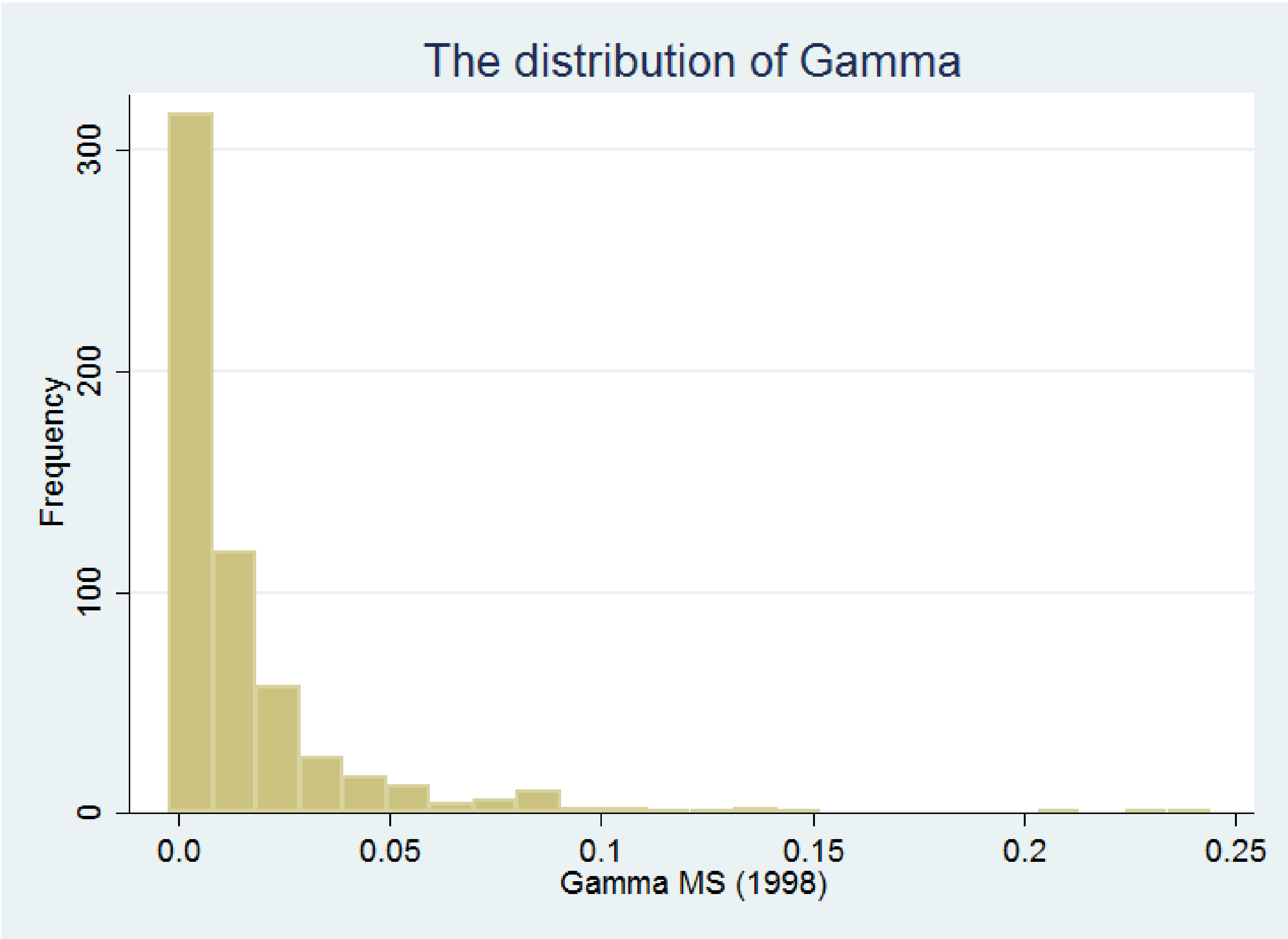


Figure A.3. The distribution of Gamma, 1998

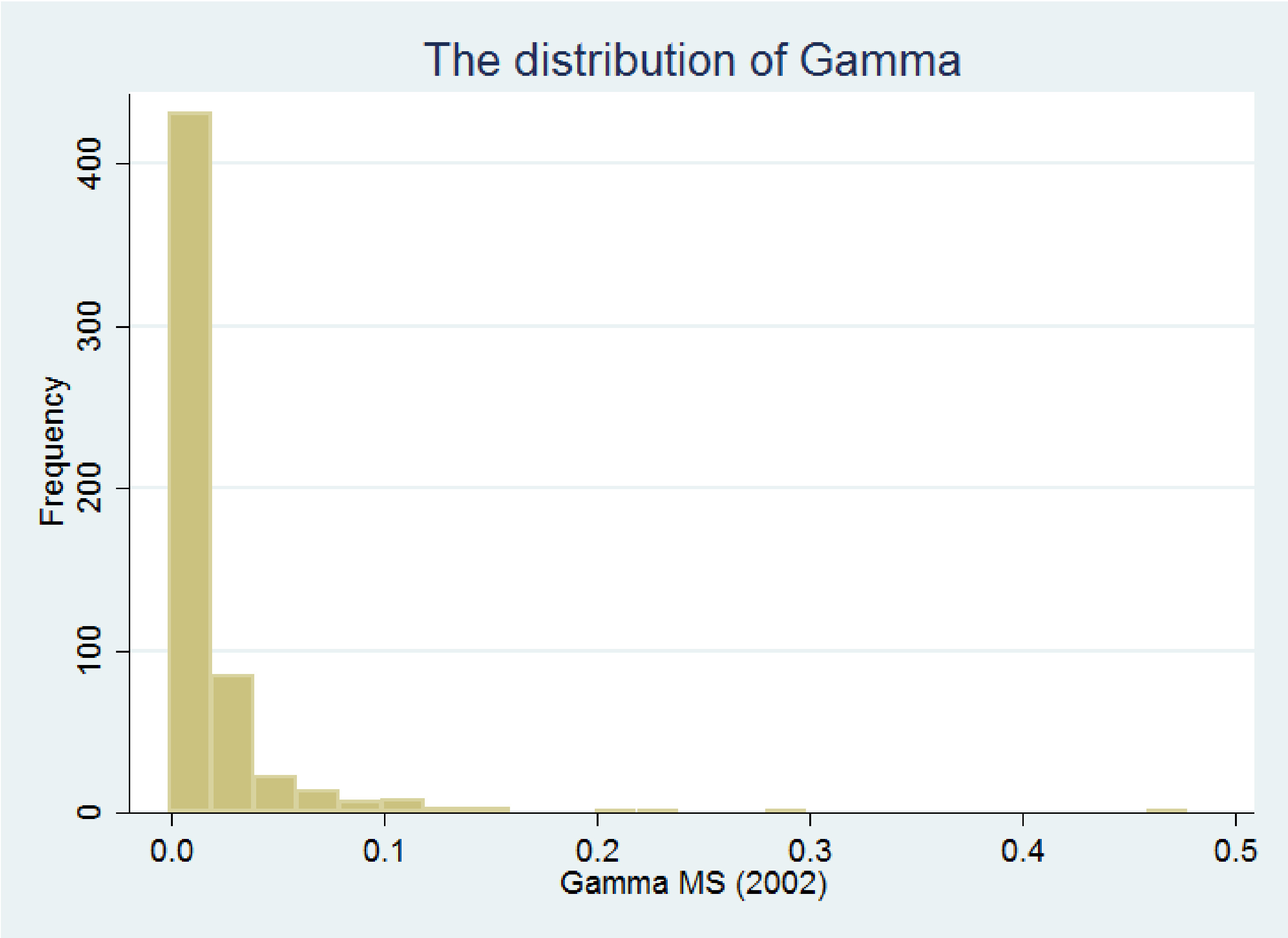


Figure A.4. The distribution of Gamma, 2002

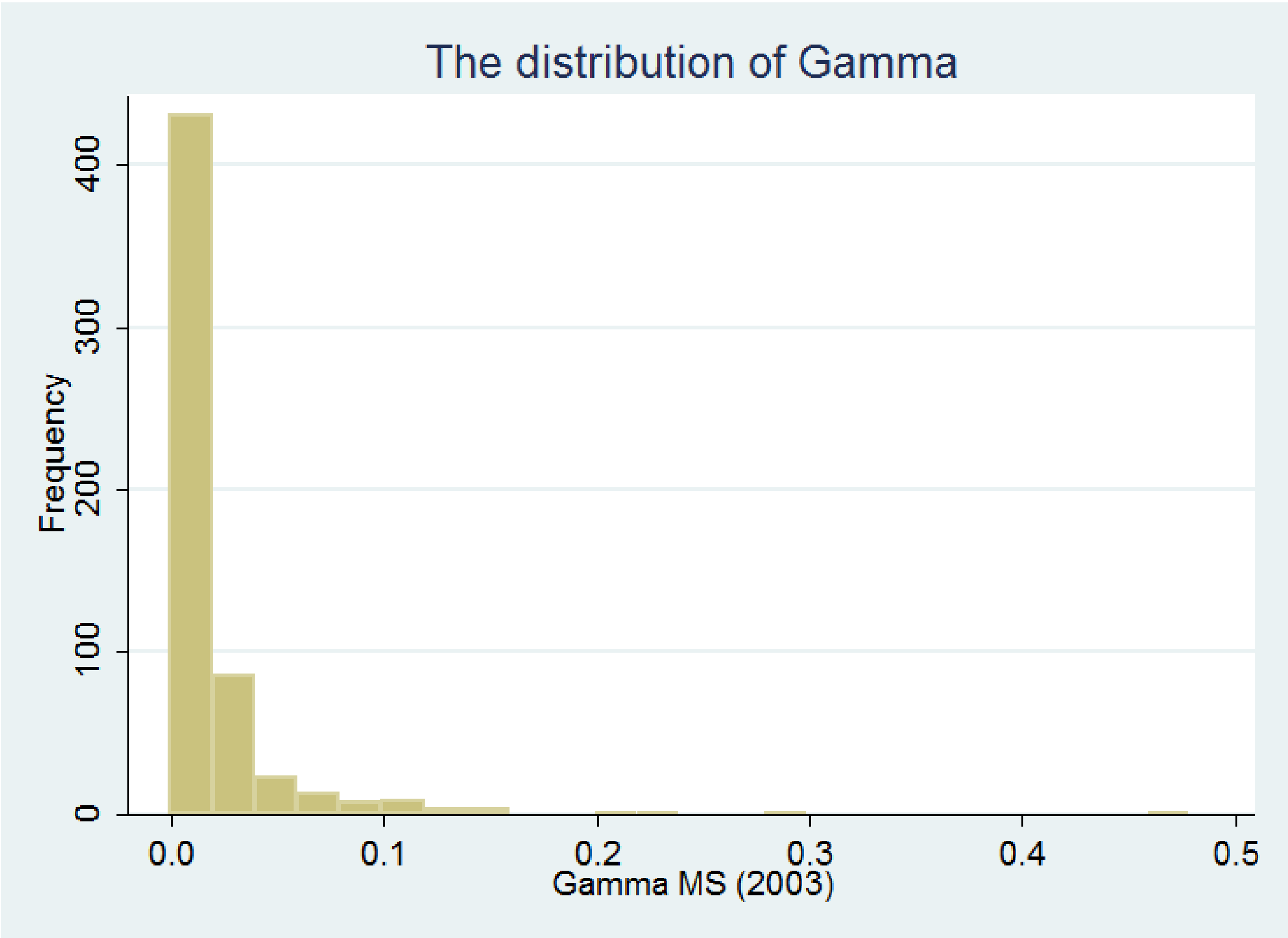


Figure A.5. The distribution of Gamma, 2003

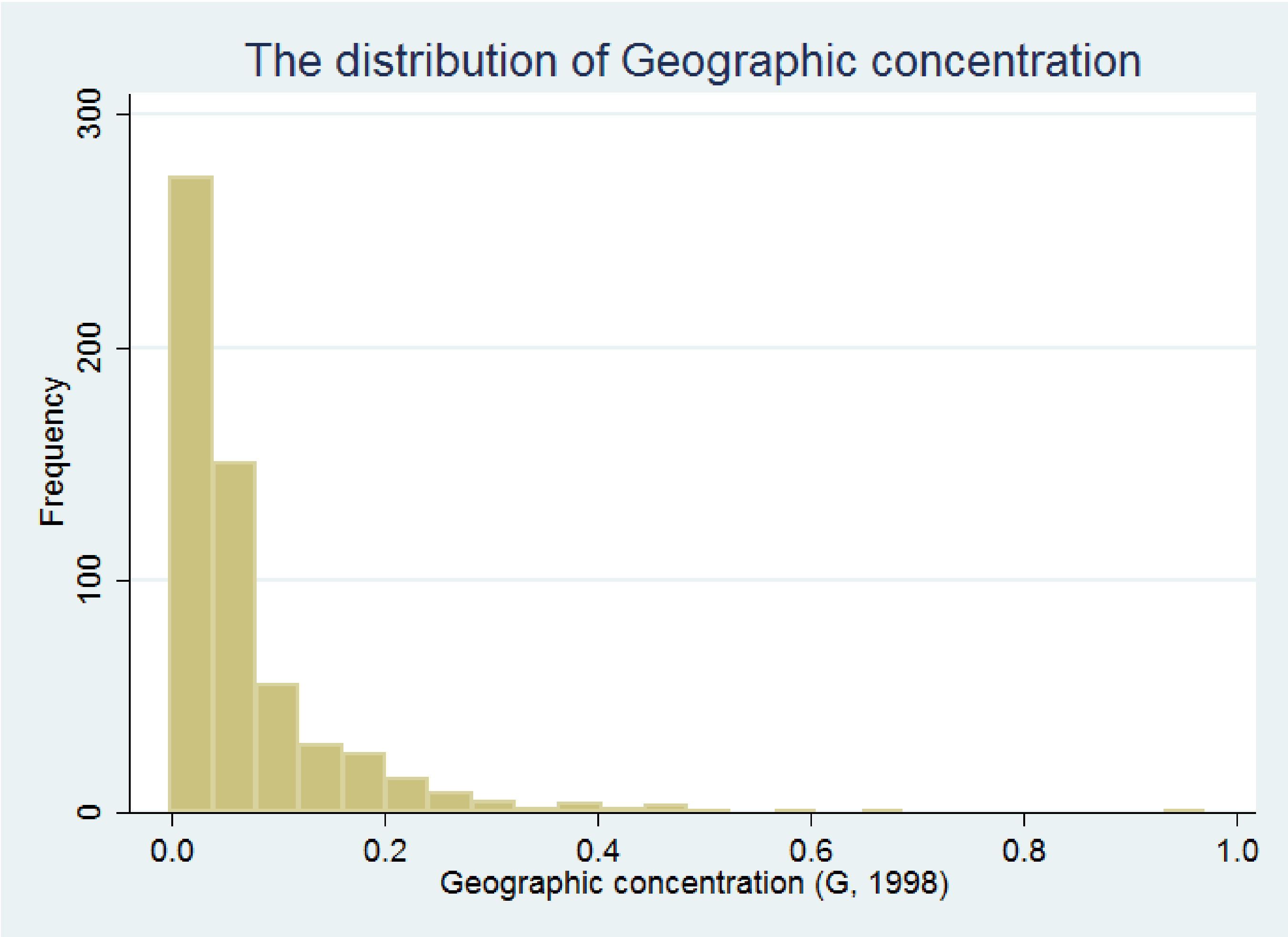


Figure A.6. The distribution of geographic concentration, 1998

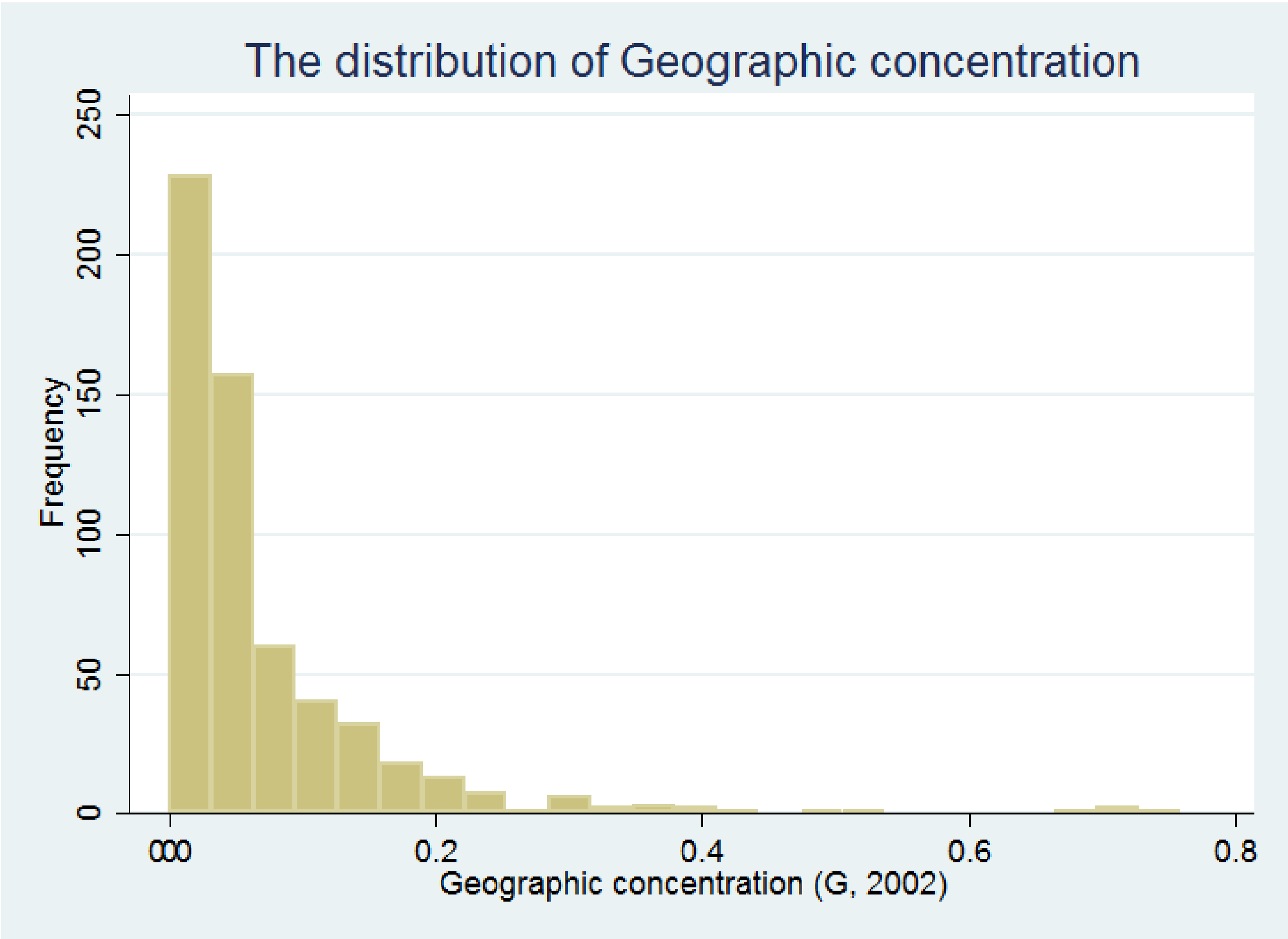


Figure A.7. The distribution of geographic concentration, 2002

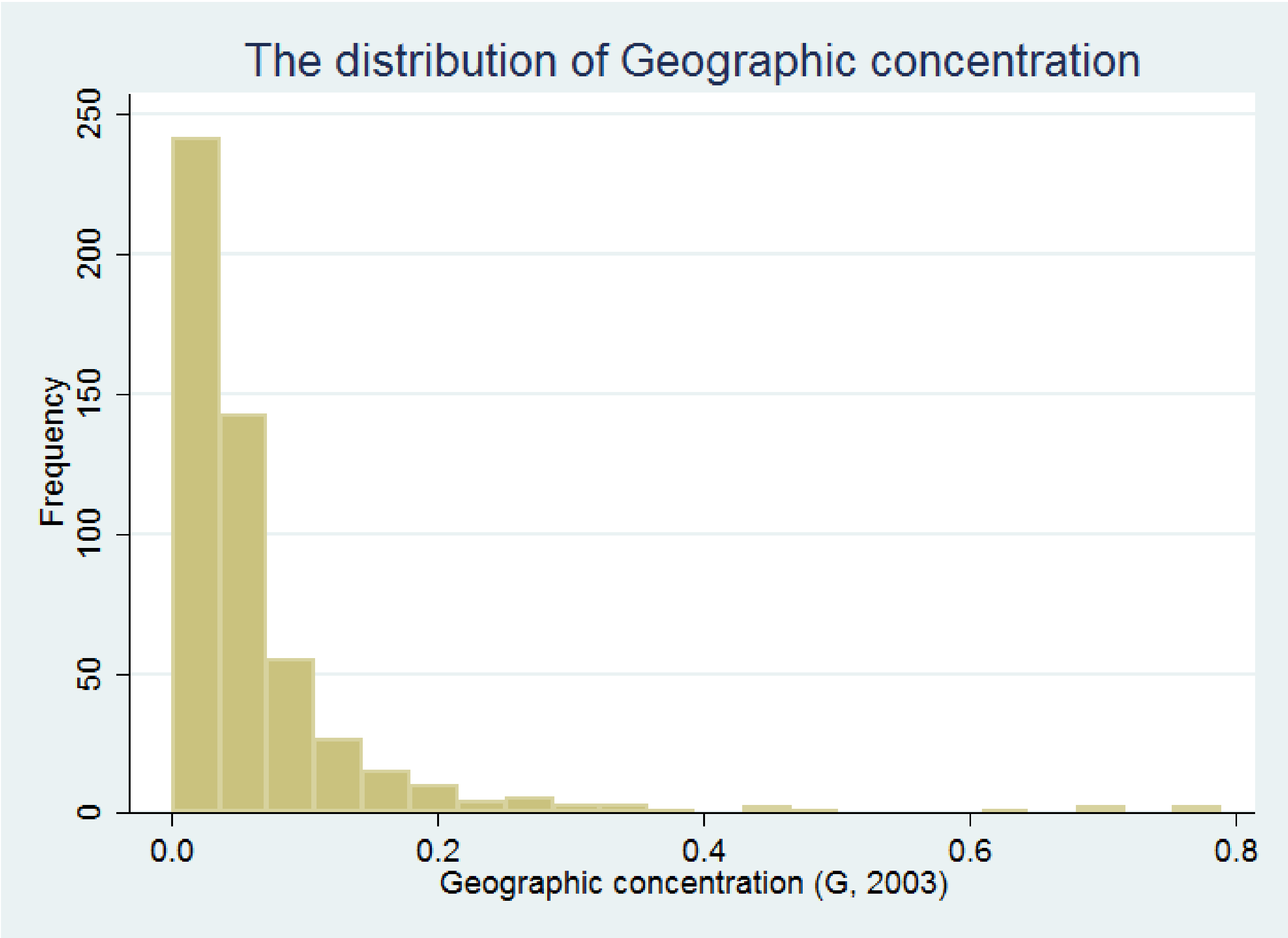


Figure A.8. The distribution of geographic concentration, 2003

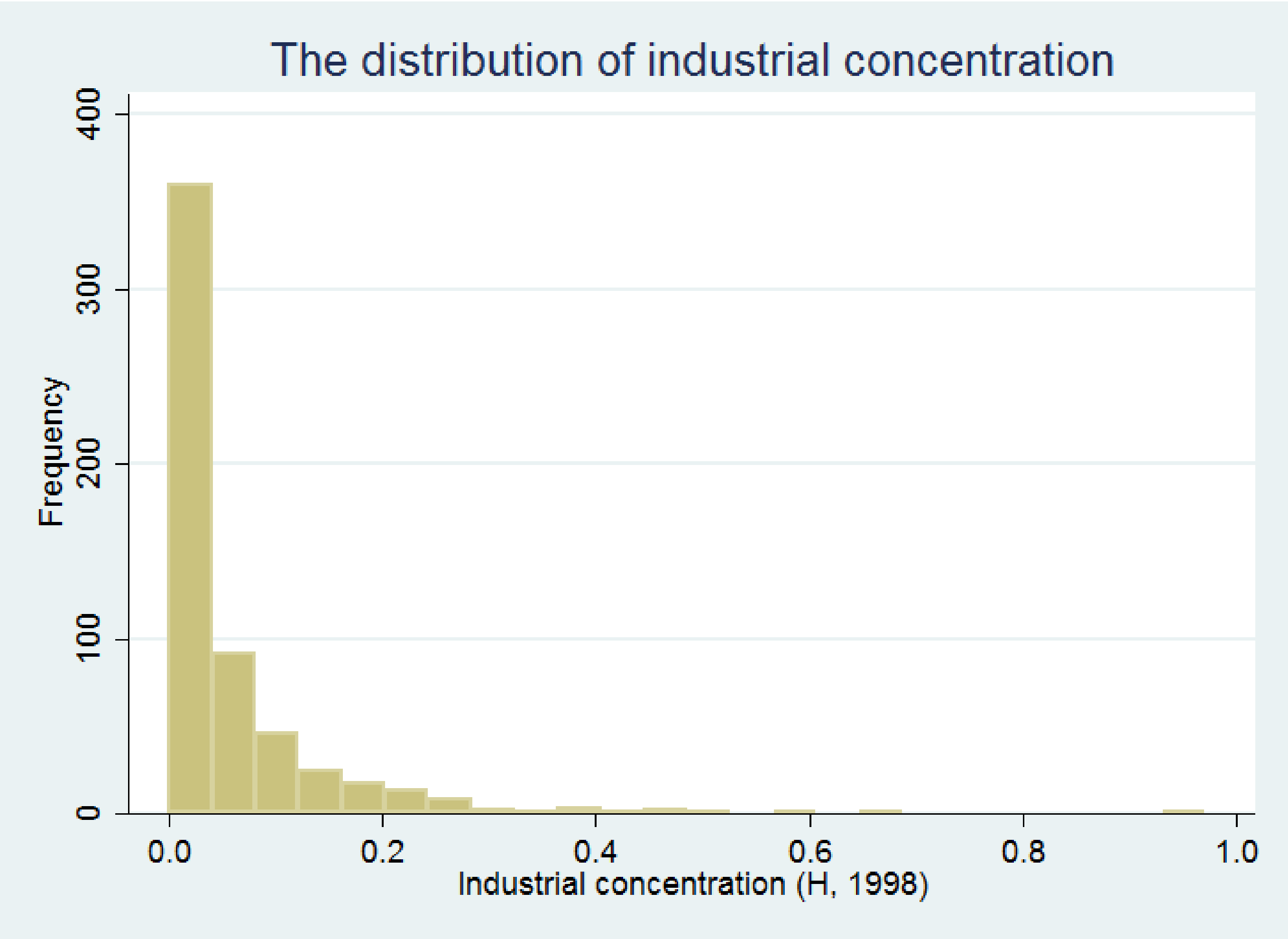


Figure A.9. The distribution of industrial concentration, 1998

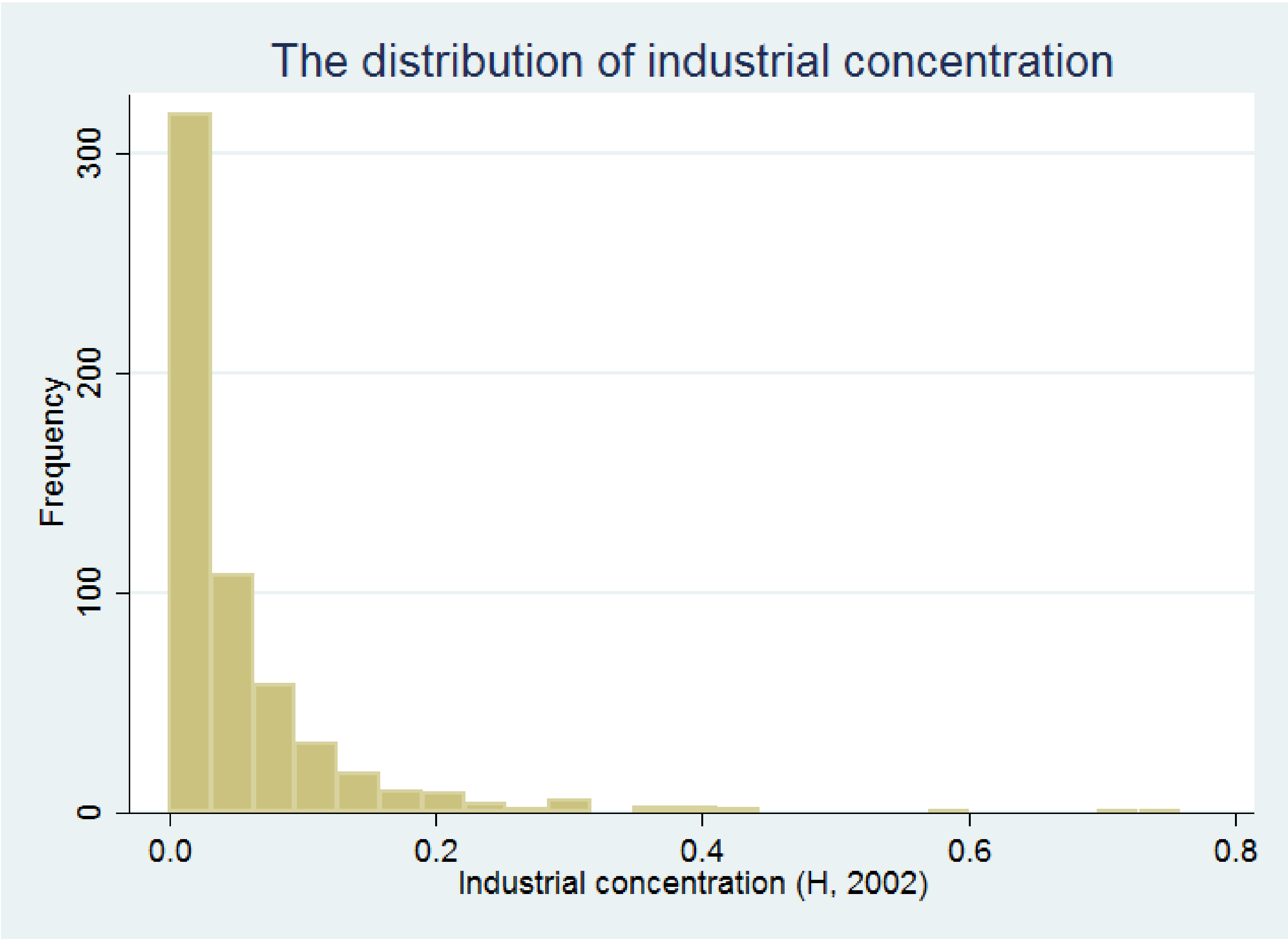


Figure A.10. The distribution of industrial concentration, 2002

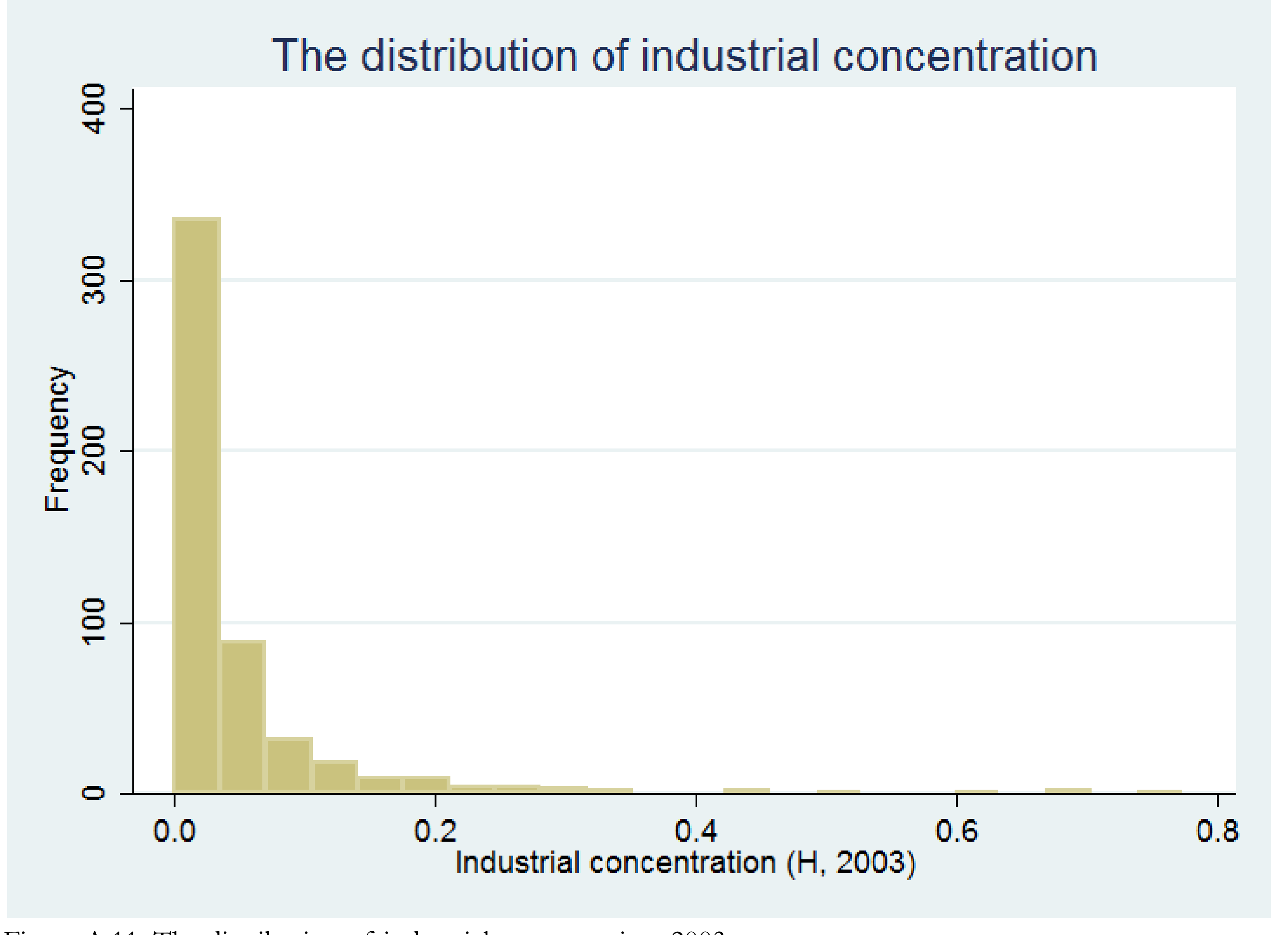


Figure A.11. The distribution of industrial concentration, 2003

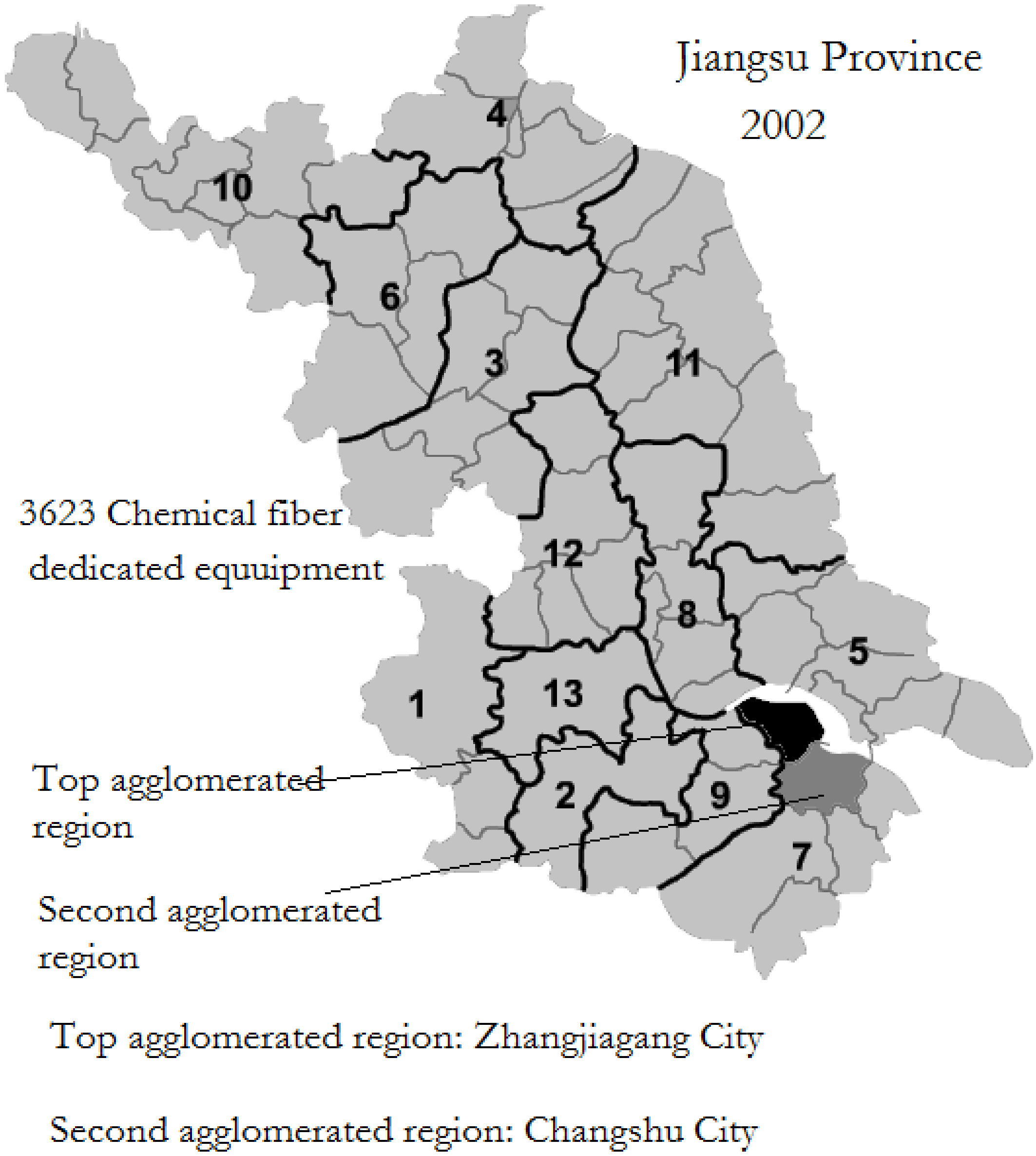
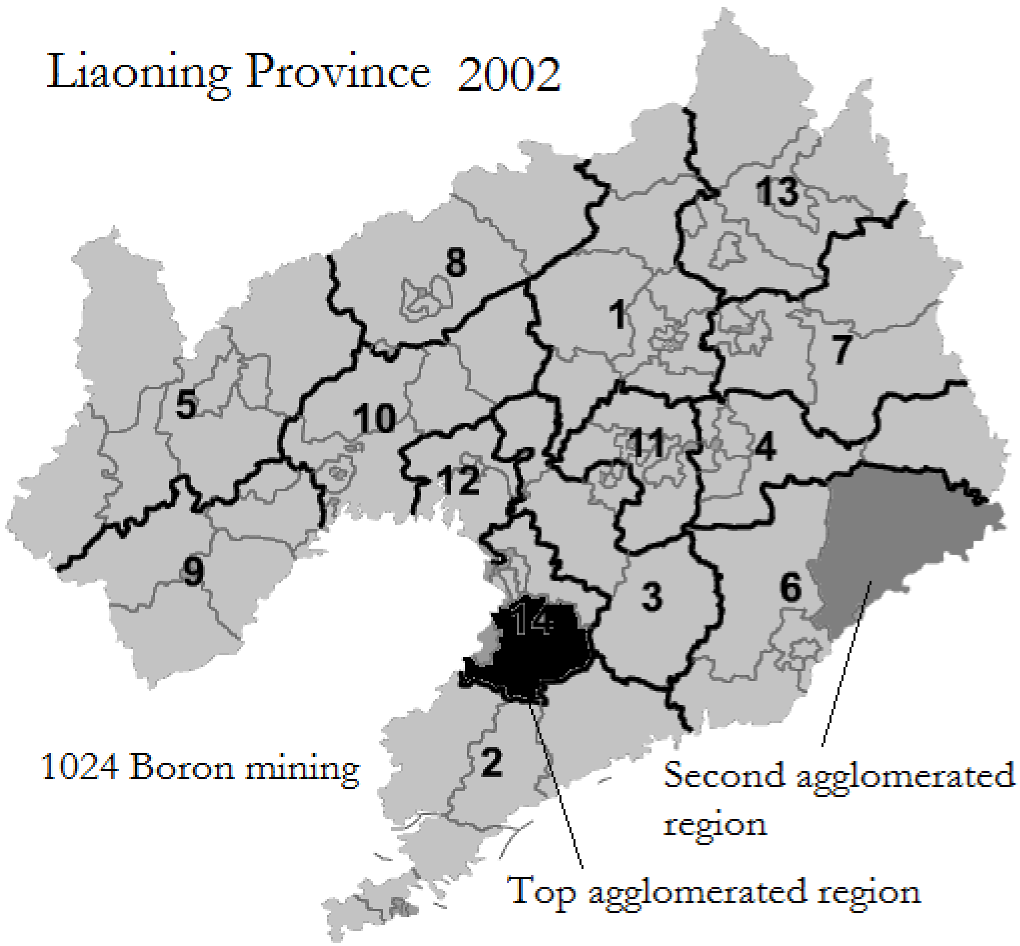


Figure A.12. The top and second industrial agglomerated region, Chemical fiber dedicated equipment(SIC-3623) in 2002



Top agglomerated region: Gaizhou City

Second agglomerated region: Kuandian Manchu Autonomous County

Figure A.13. The top and second industrial agglomerated region, Boron mining (SIC-1024) in 2002

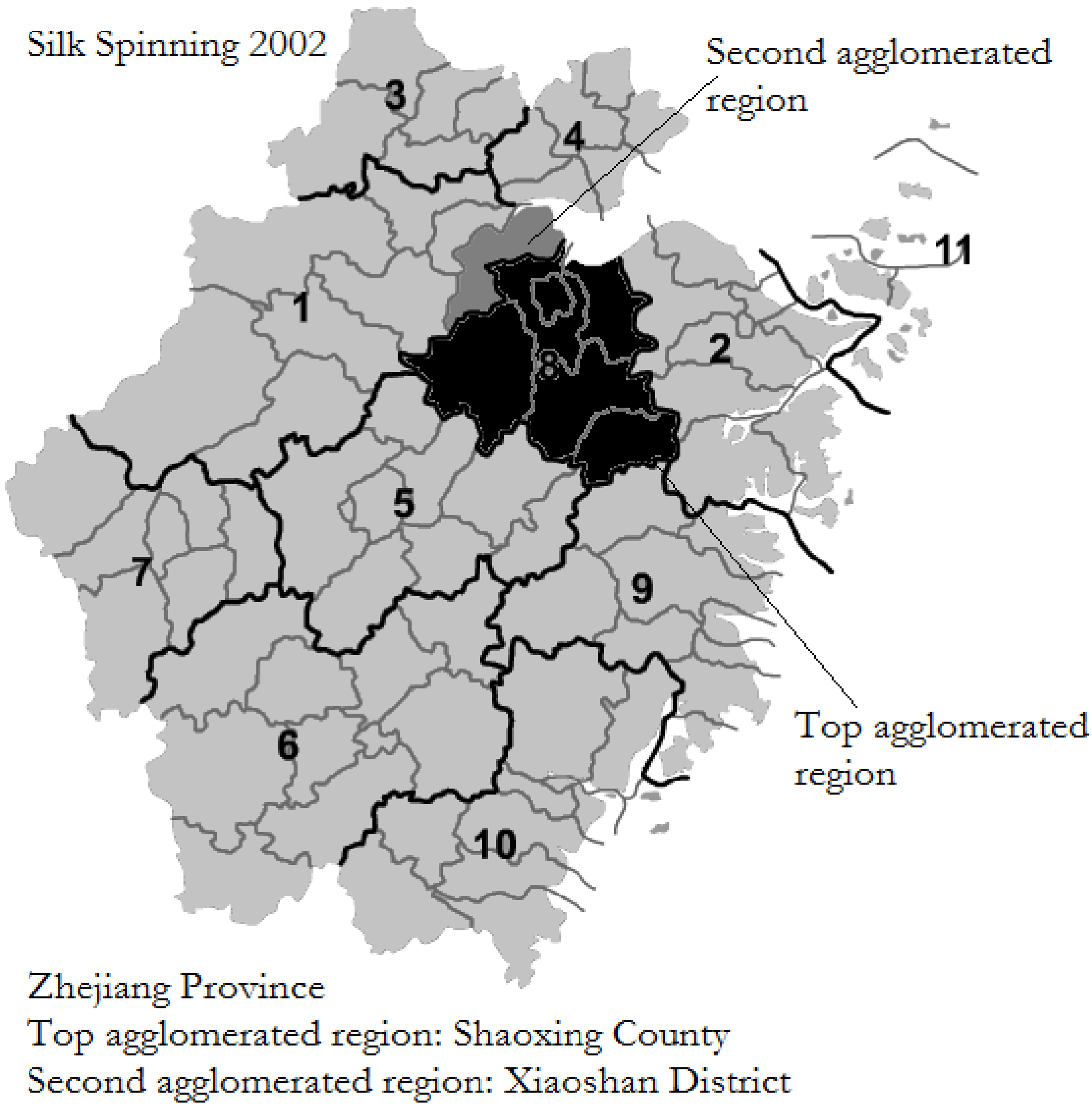


Figure A.14. The top and second industrial agglomerated region, Silk spinning (SIC-1774) in 2002

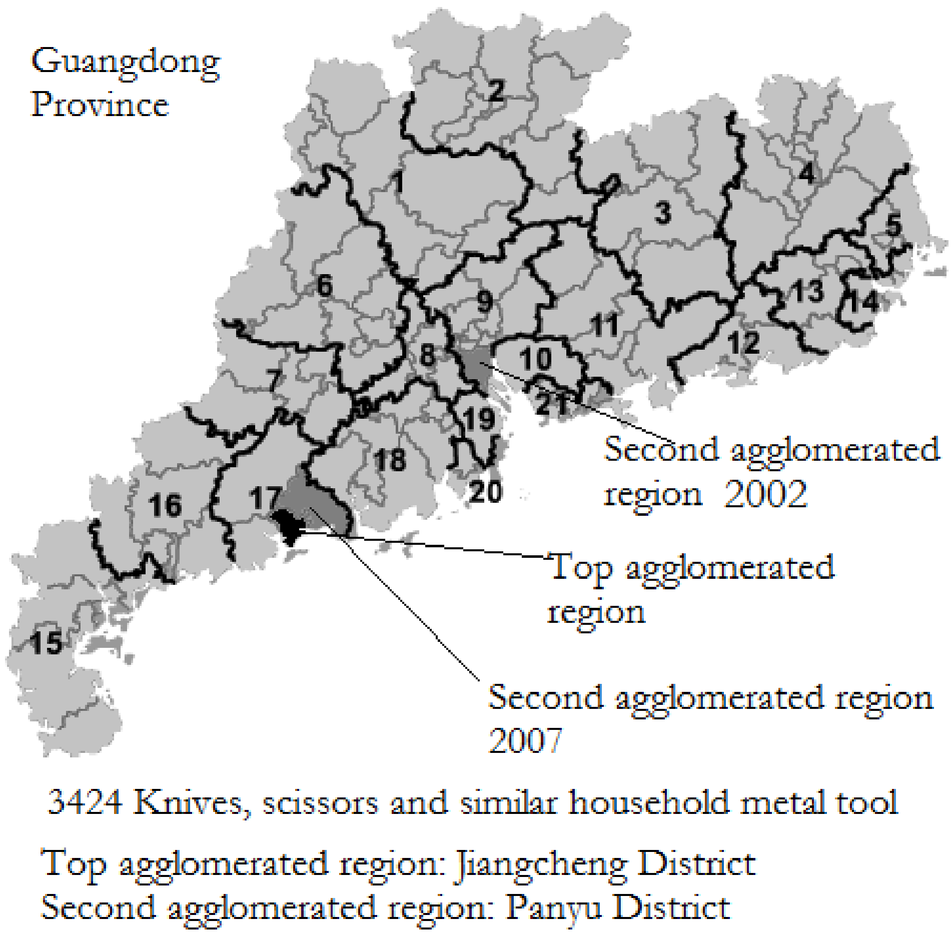


Figure A.15. The top and second industrial agglomerated region, Knives, scissors (SIC-3484) in 2002 and 2007

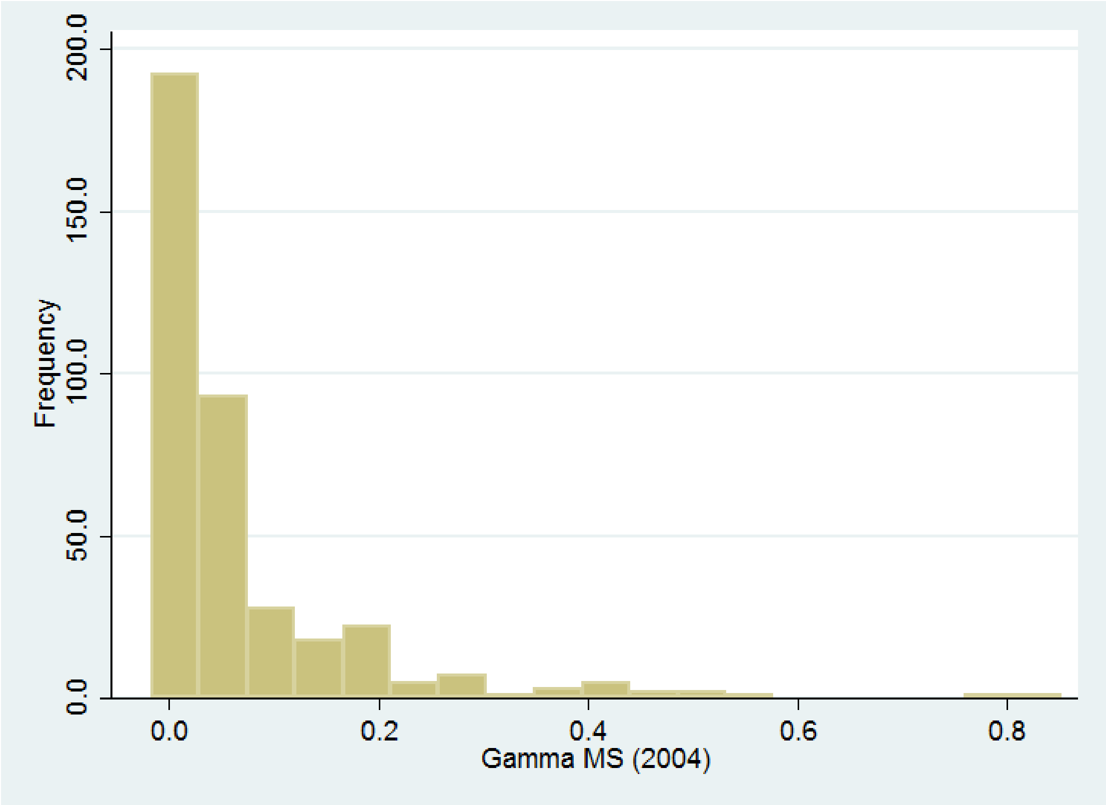


Figure C.1. Distribution of gamma MS agglomeration index (2004)

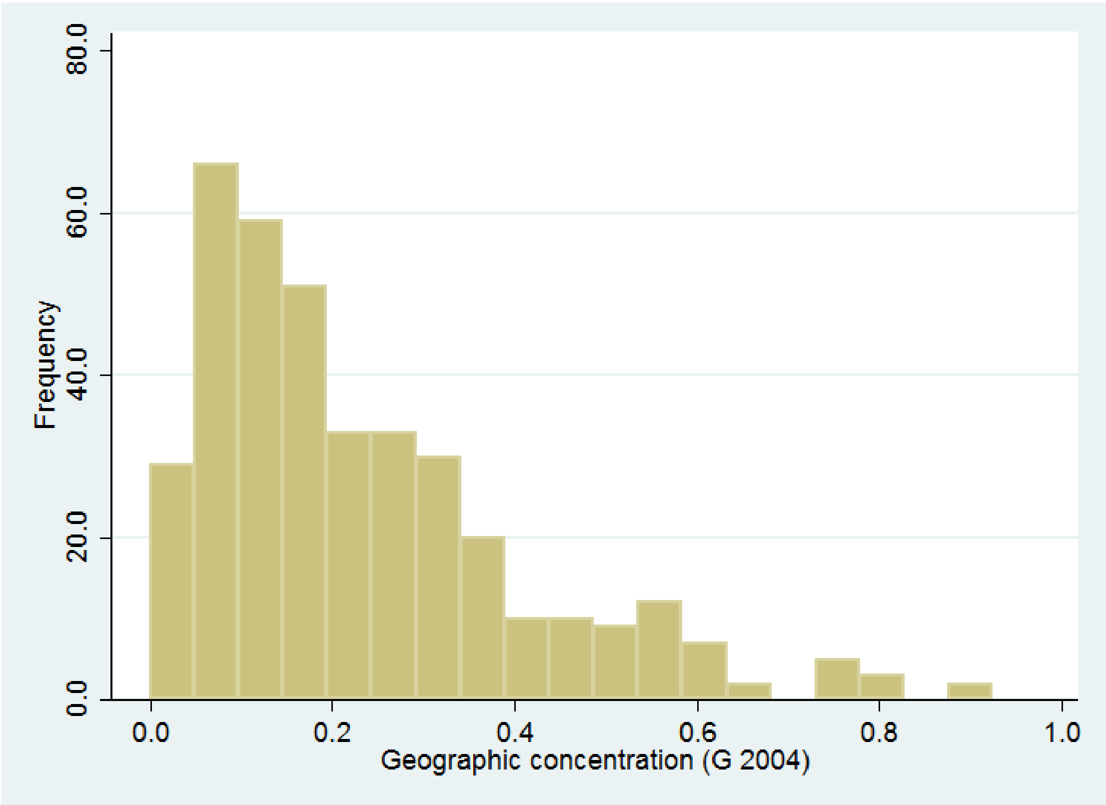


Figure C.2. Distribution of G adjusted geographic concentration measure (2004)

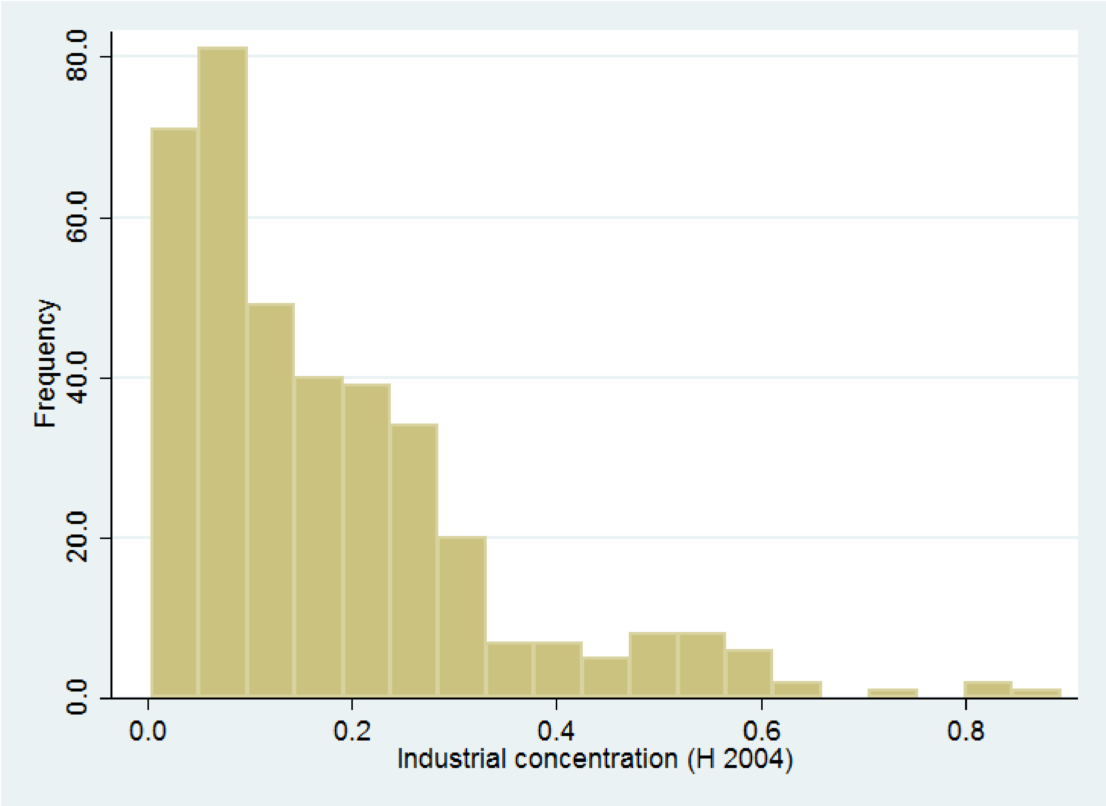


Figure C.3. Distribution of H industrial concentration (2004)

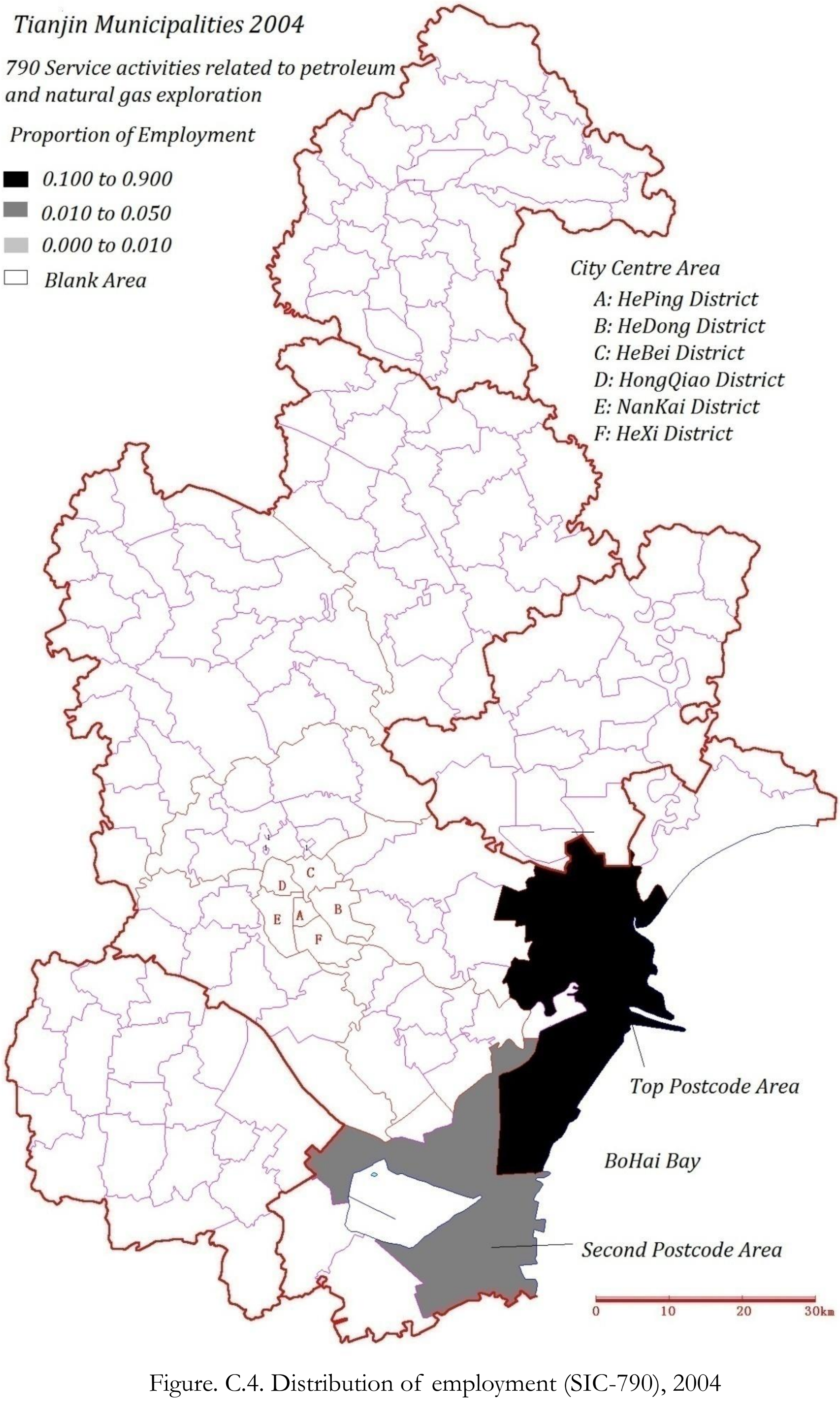


Figure. C.4. Distribution of employment (SIC-790), 2004

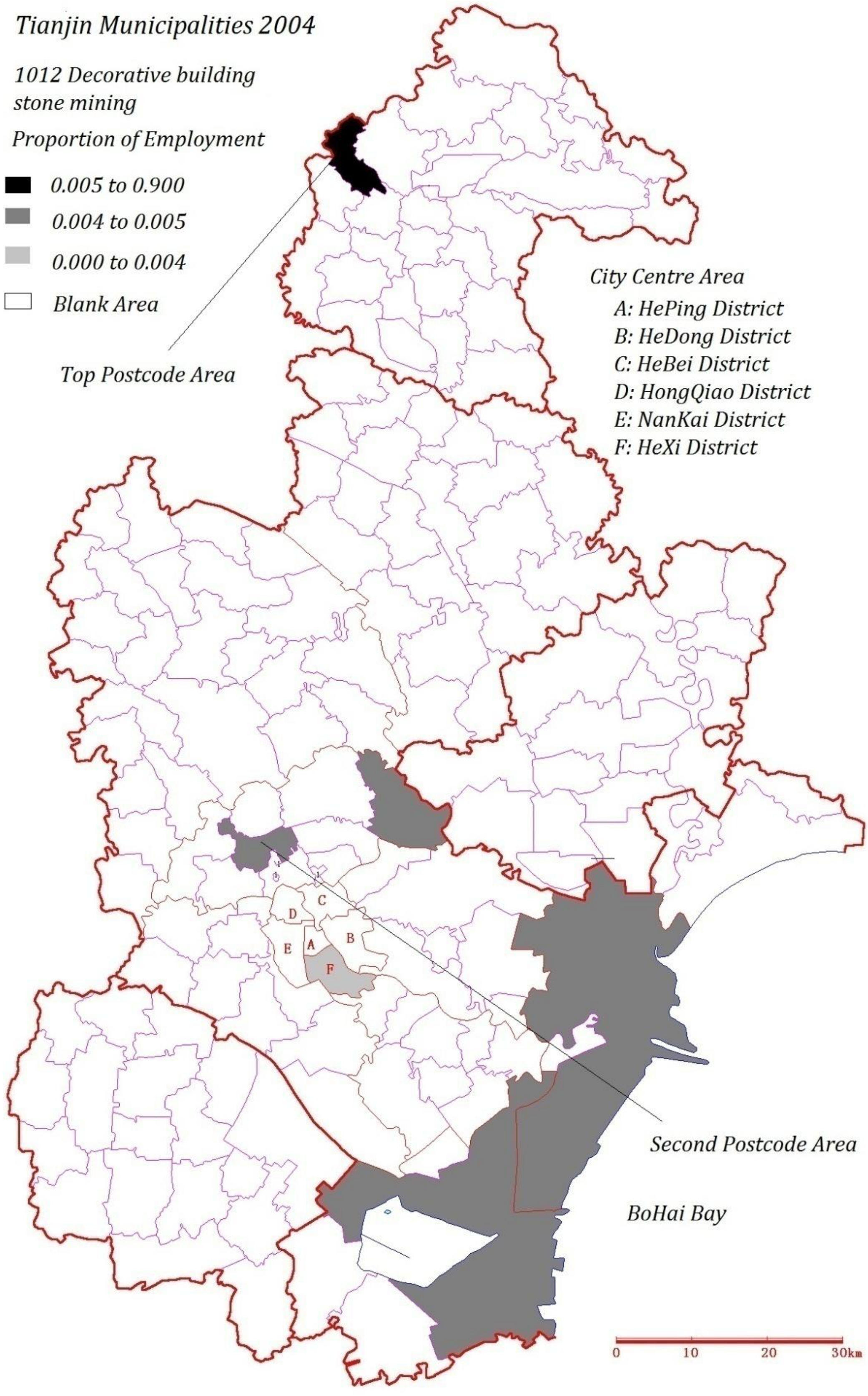


Figure. C.5. Distribution of employment (SIC-1012), 2004

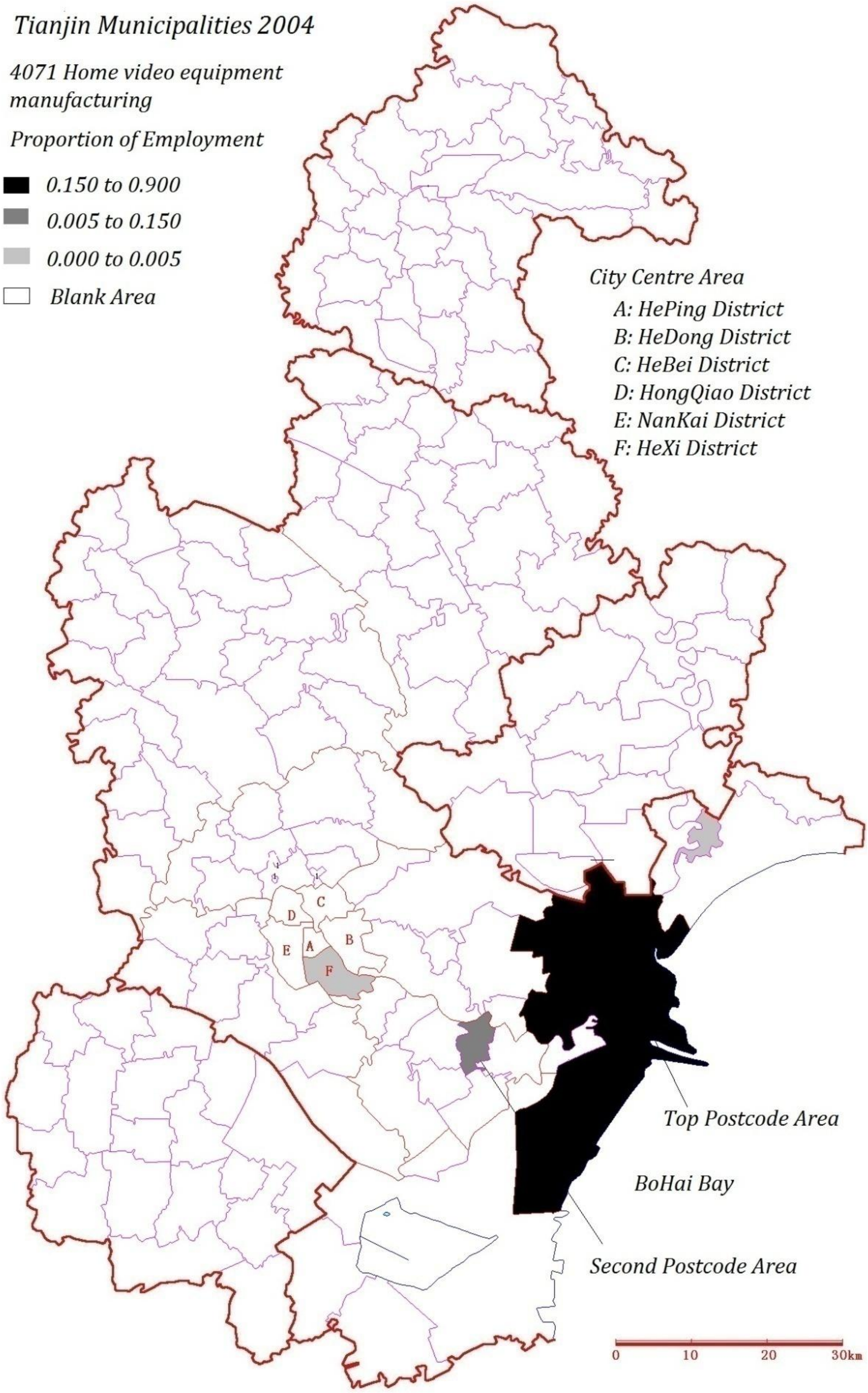


Figure. C.6. Distribution of employment (SIC-4071), 2004

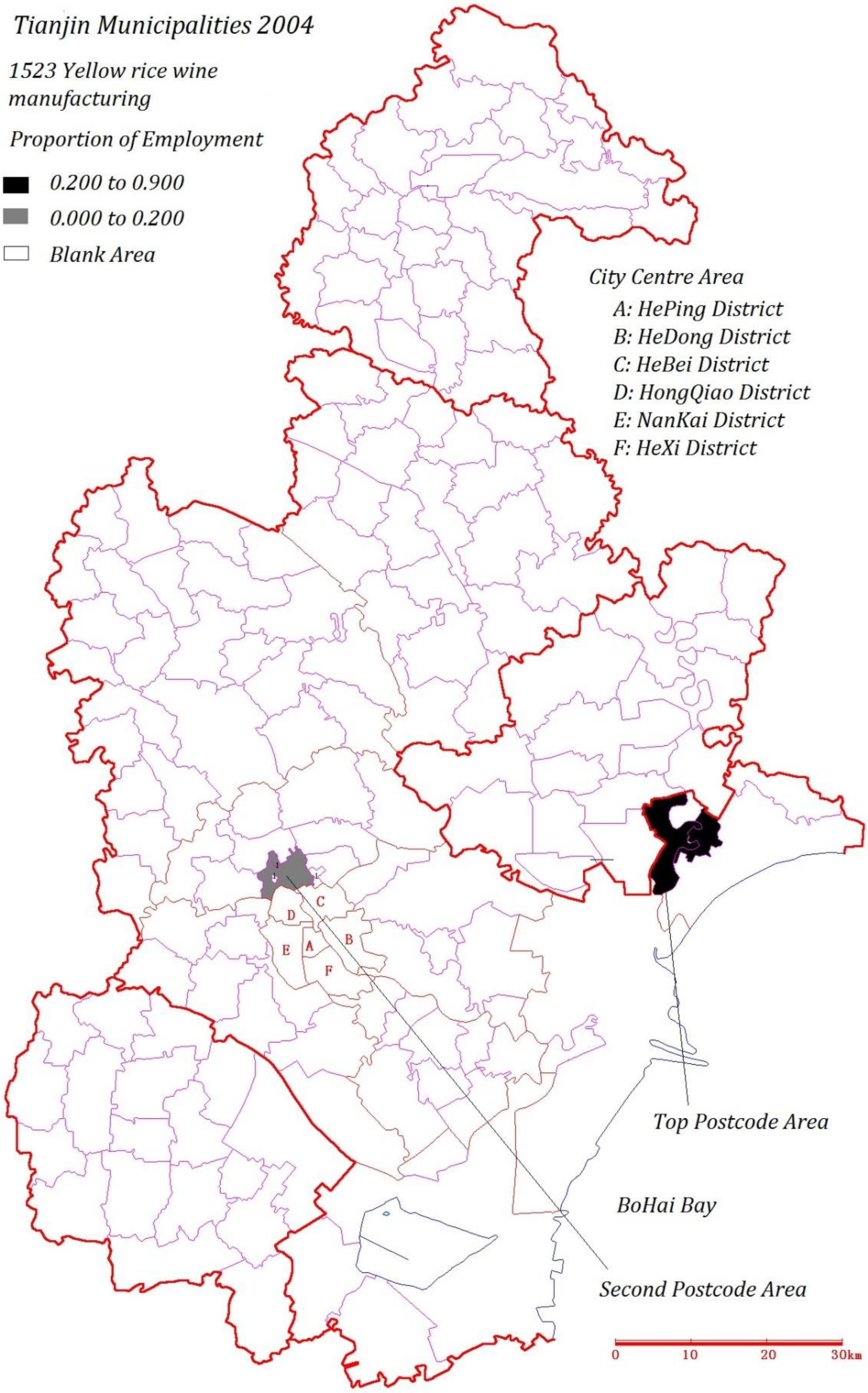


Figure. C.7. Distribution of employment (SIC-1523), 2004

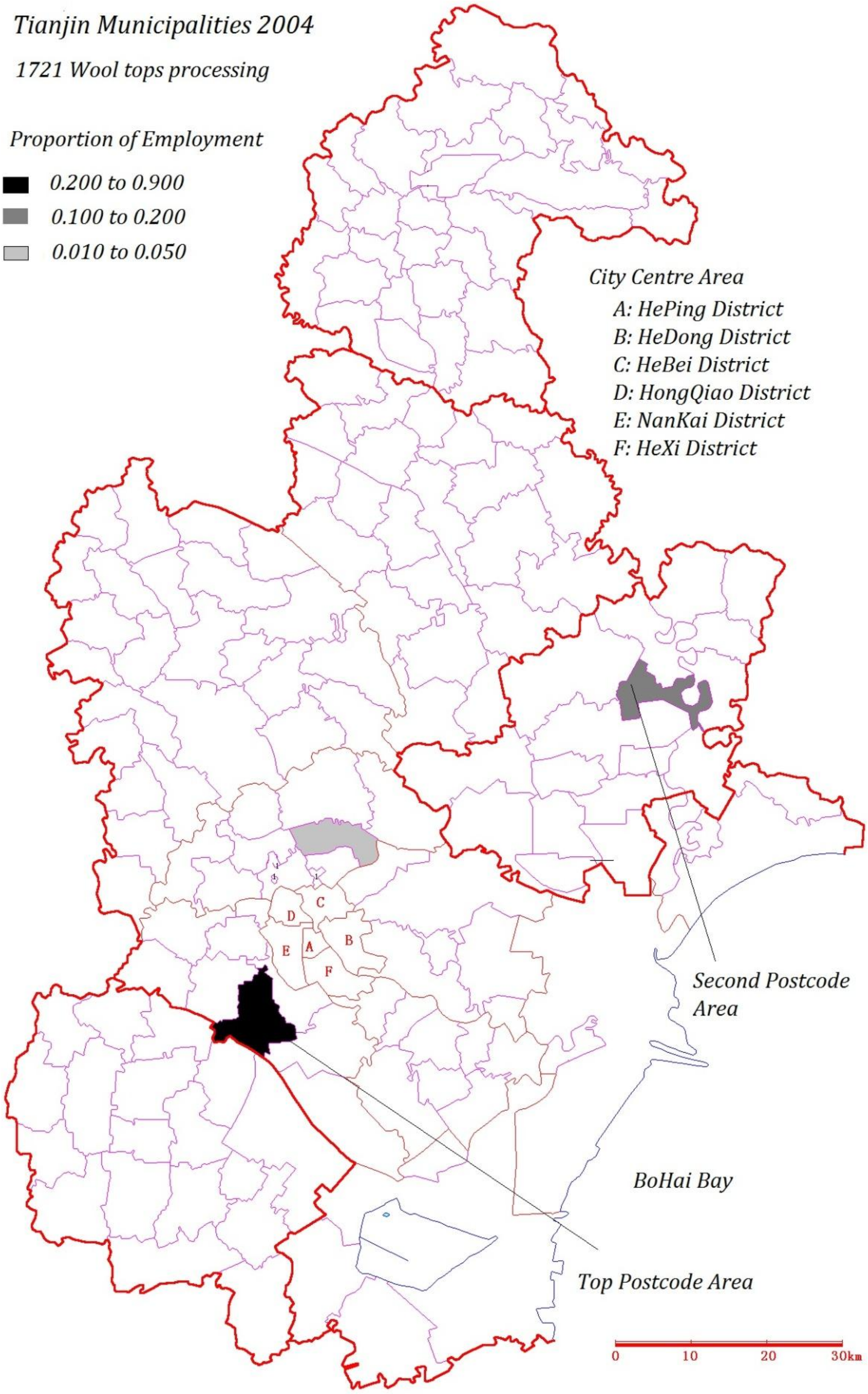


Figure. C.8. Distribution of employment (SIC-1721), 2004

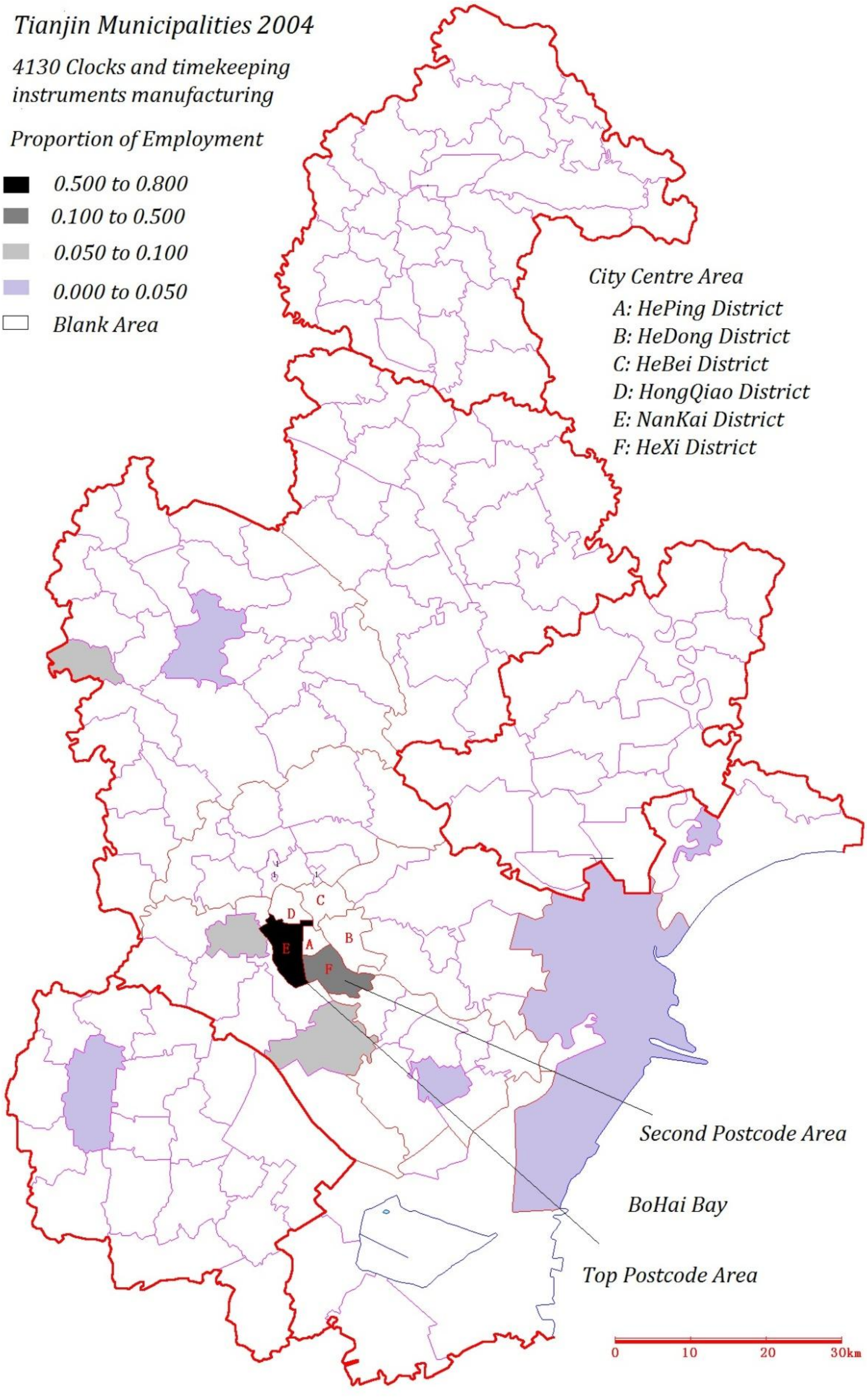


Figure. C.9. Distribution of employment (SIC-1721), 2004

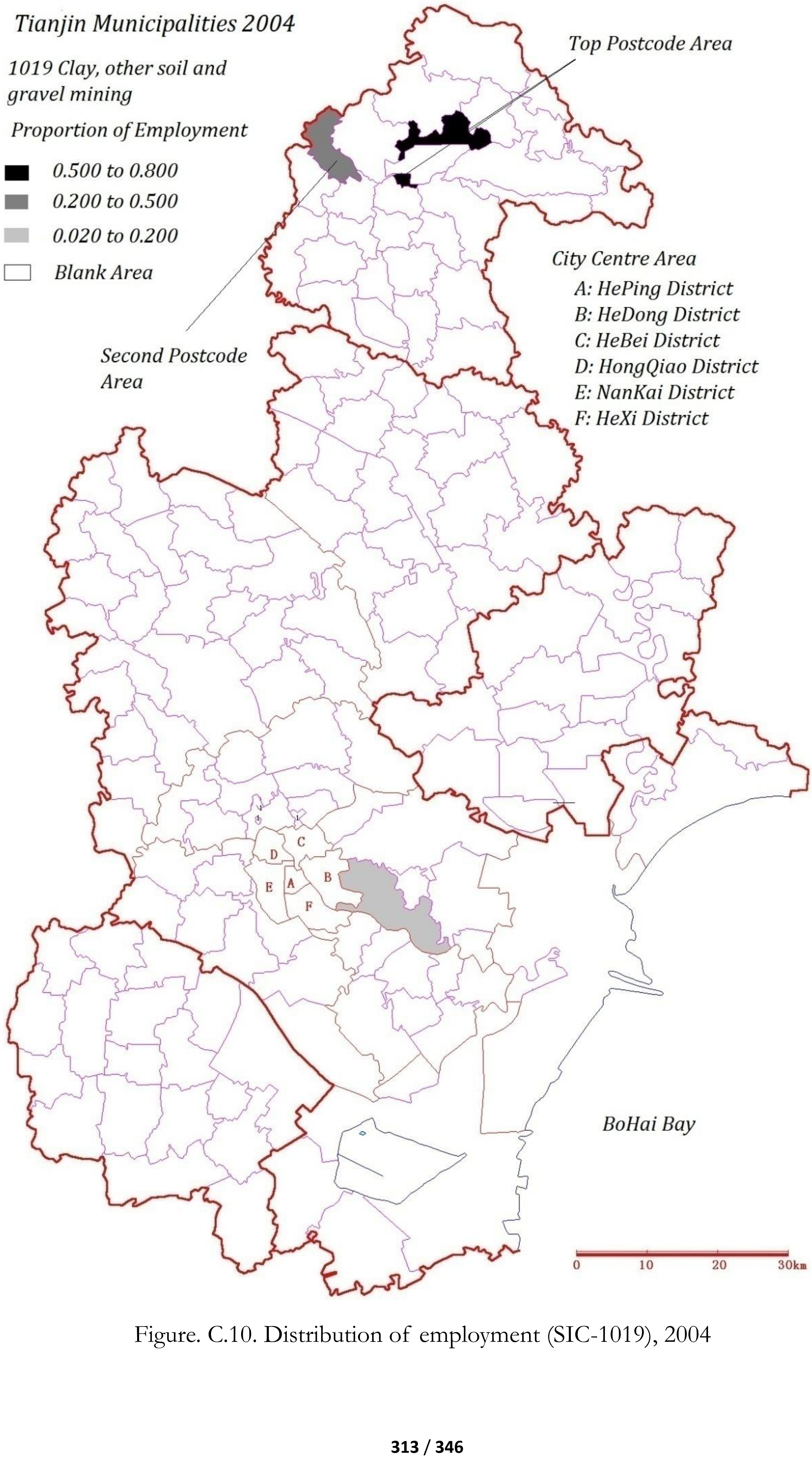


Figure. C.10. Distribution of employment (SIC-1019), 2004

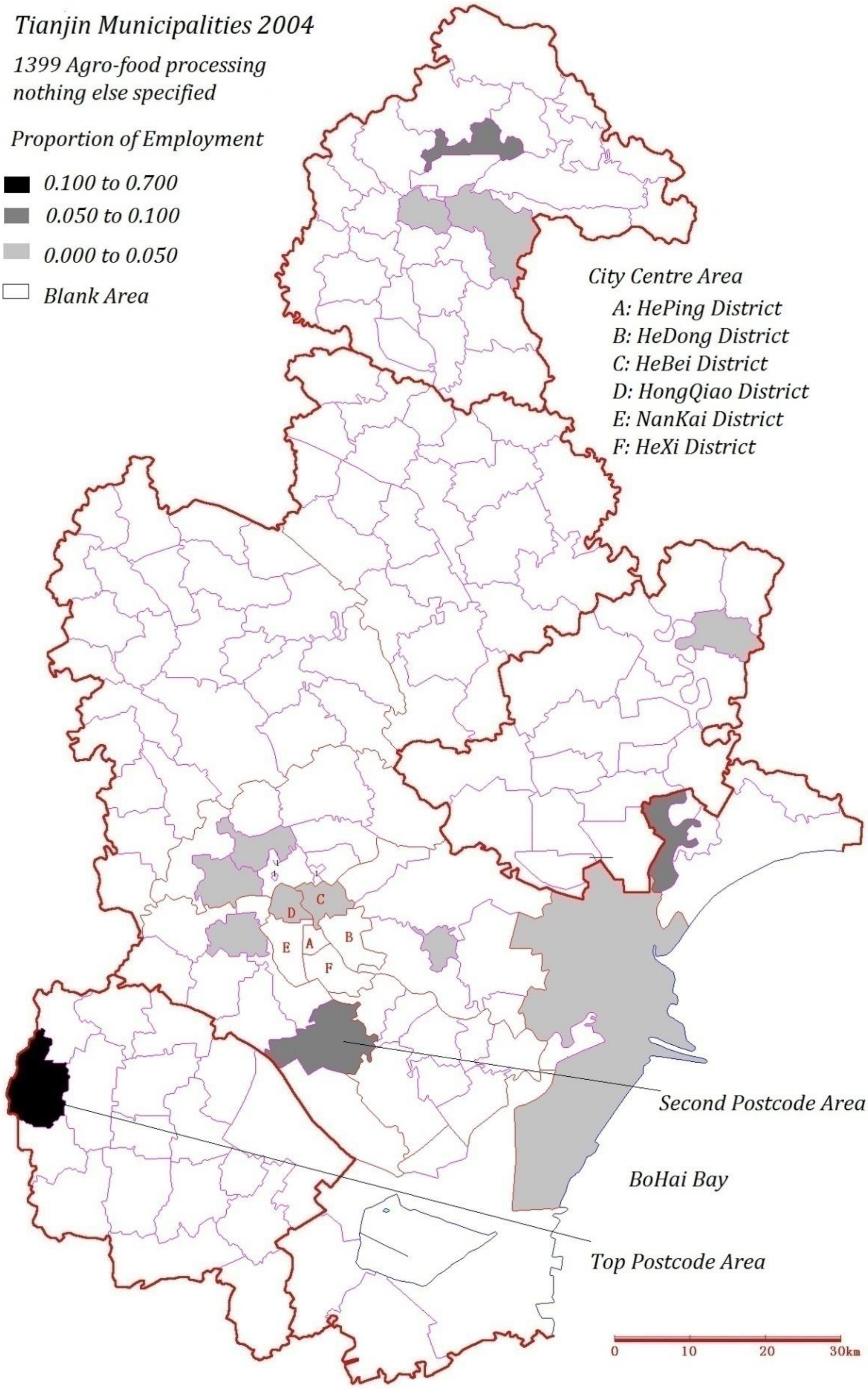


Figure. C.11. Distribution of employment (SIC-1399), 2004

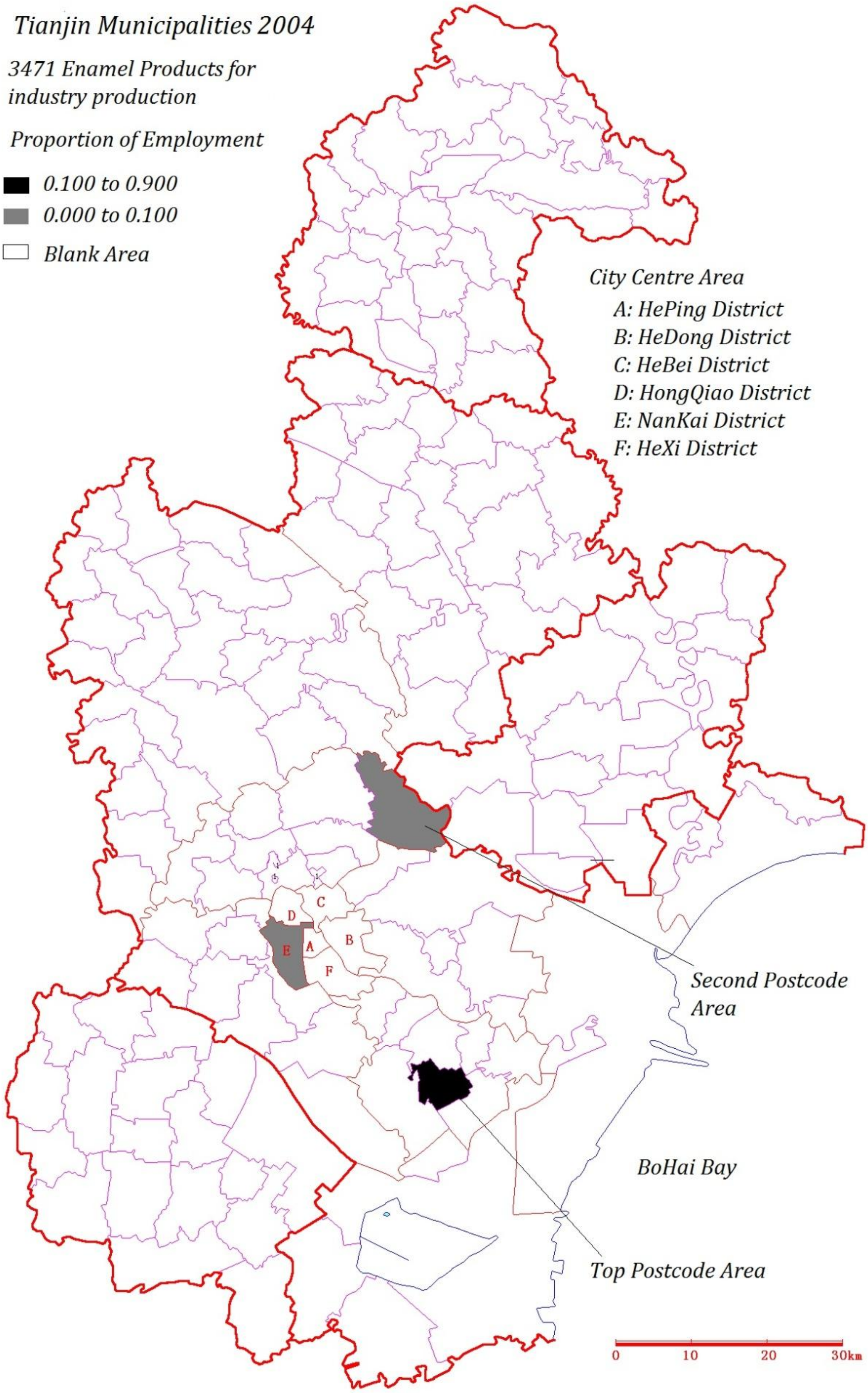


Figure. C.12. Distribution of employment (SIC-3471), 2004

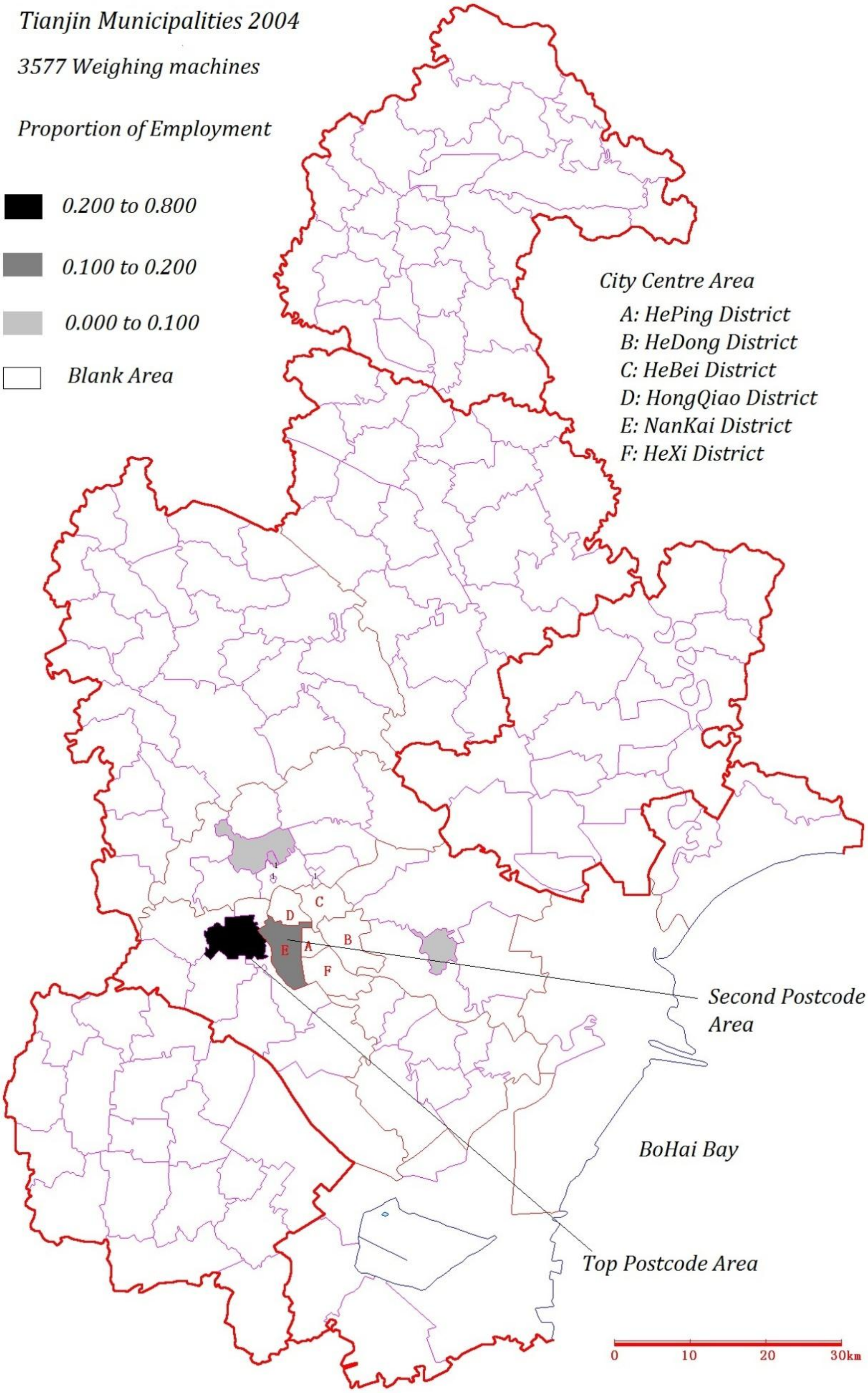


Figure. C.13. Distribution of employment (SIC-3577), 2004

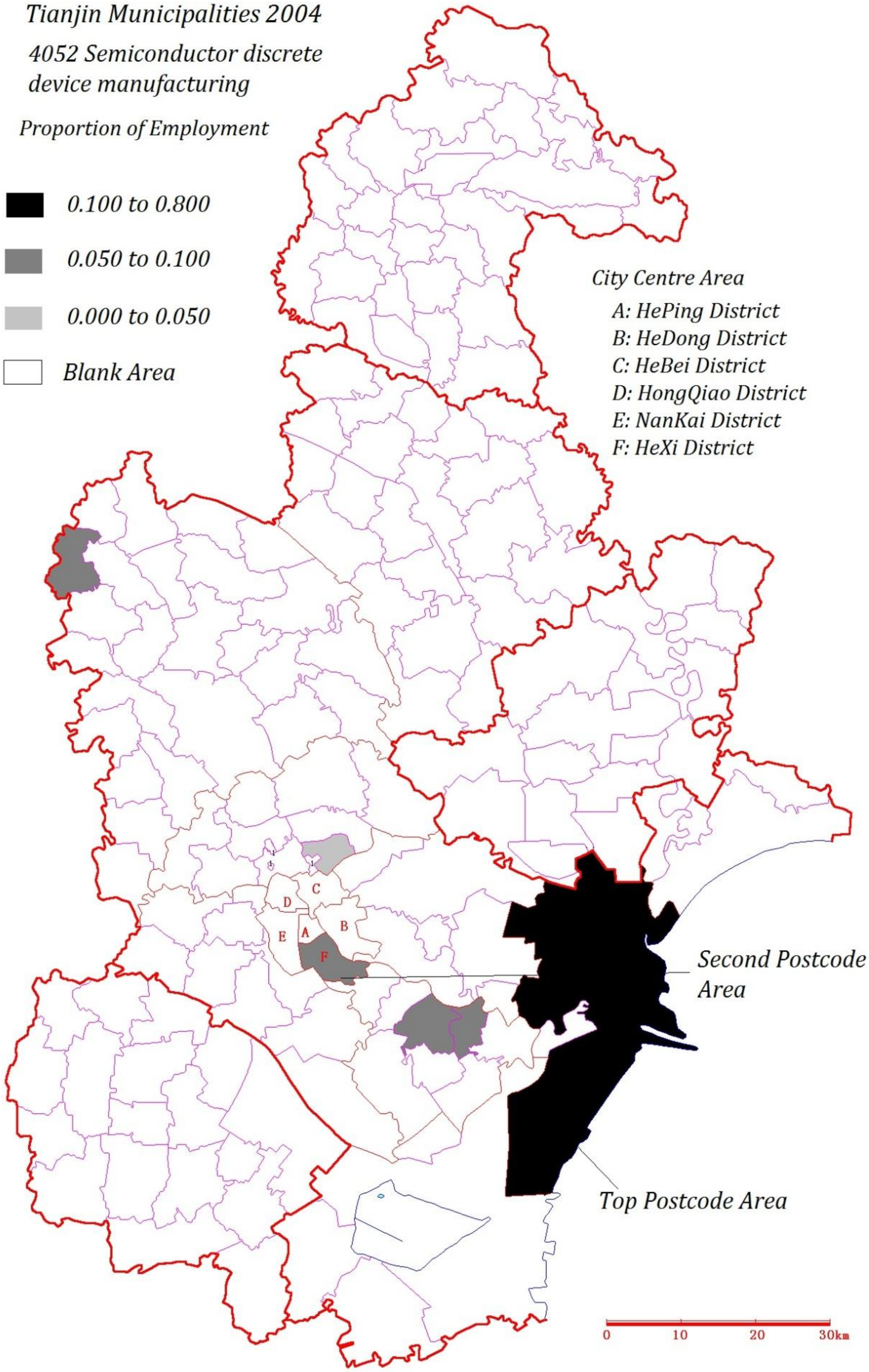


Figure. C.14. Distribution of employment (SIC-4052), 2004

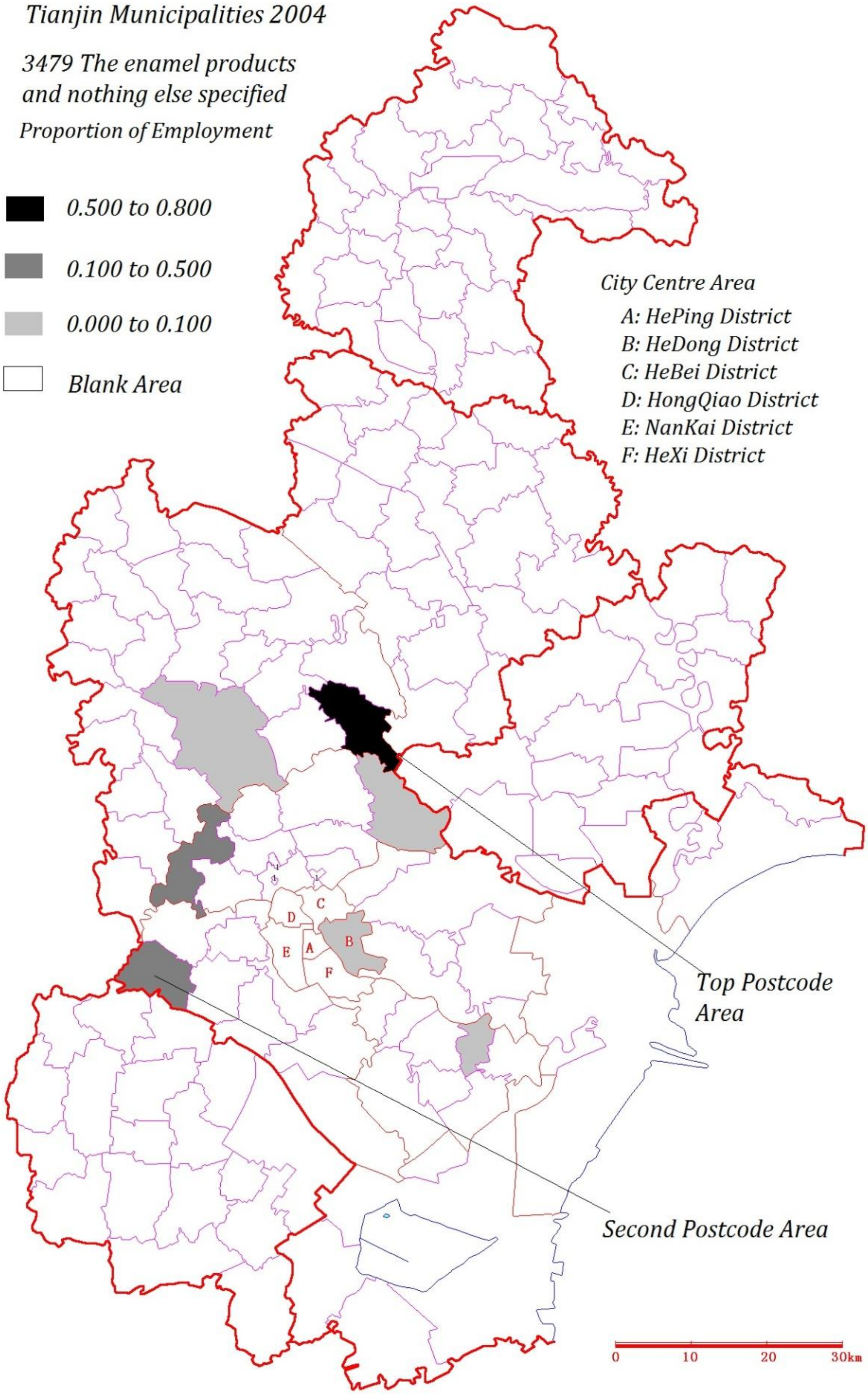


Figure. C.15. Distribution of employment (SIC-4052), 2004

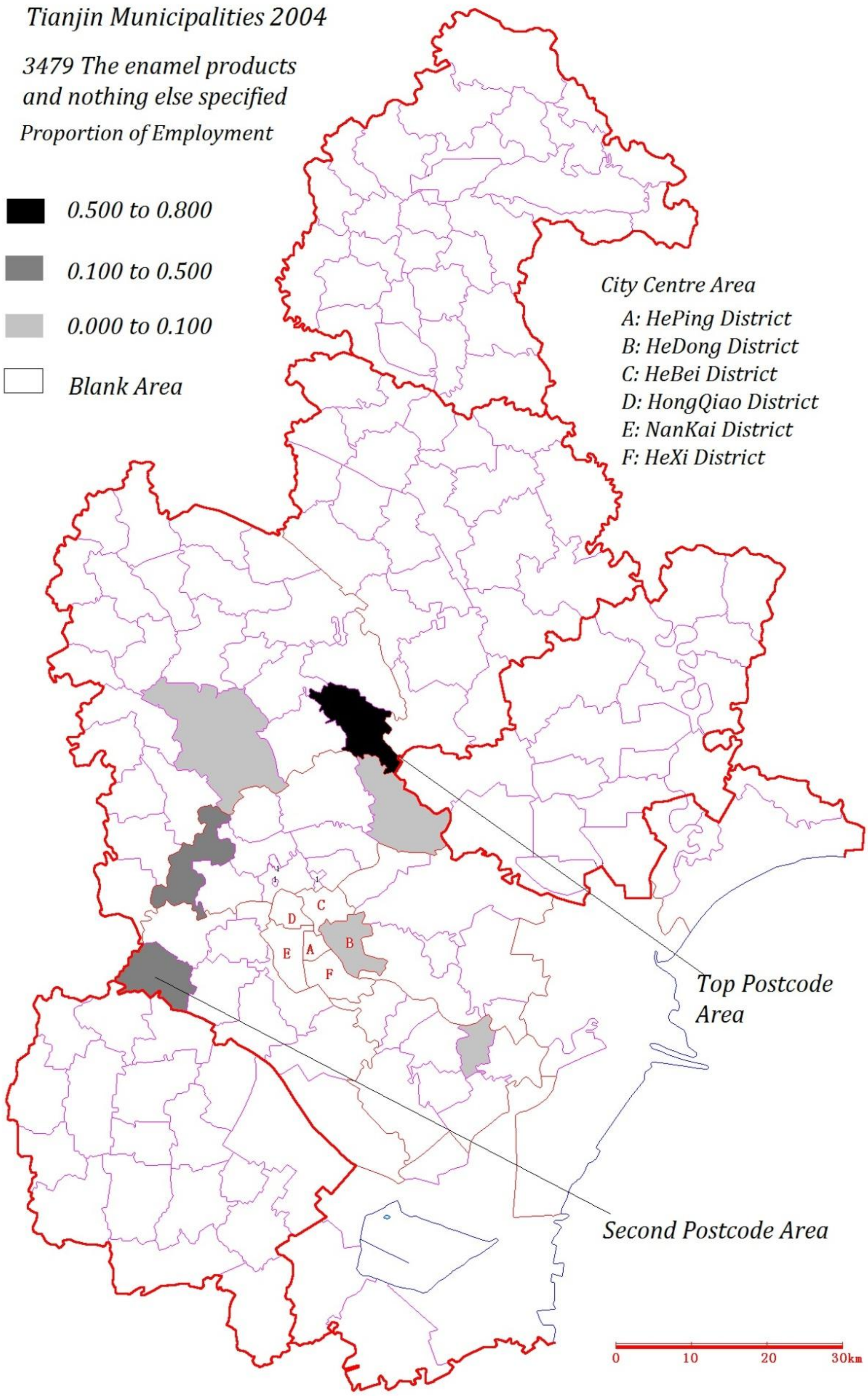


Figure. C.16. Distribution of employment (SIC-3479), 2004

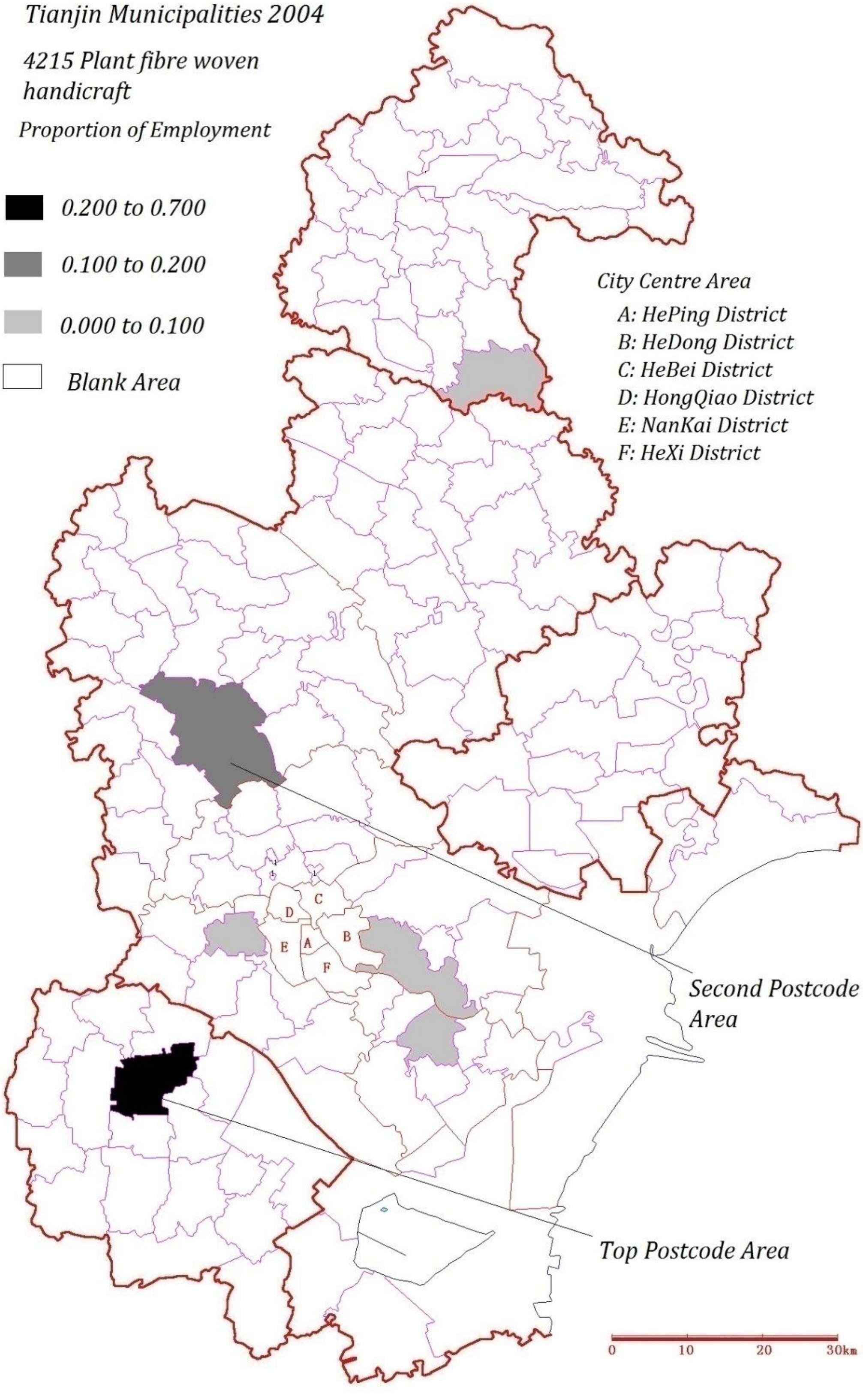


Figure. C.4.17. Distribution of employment (SIC-4215), 2004

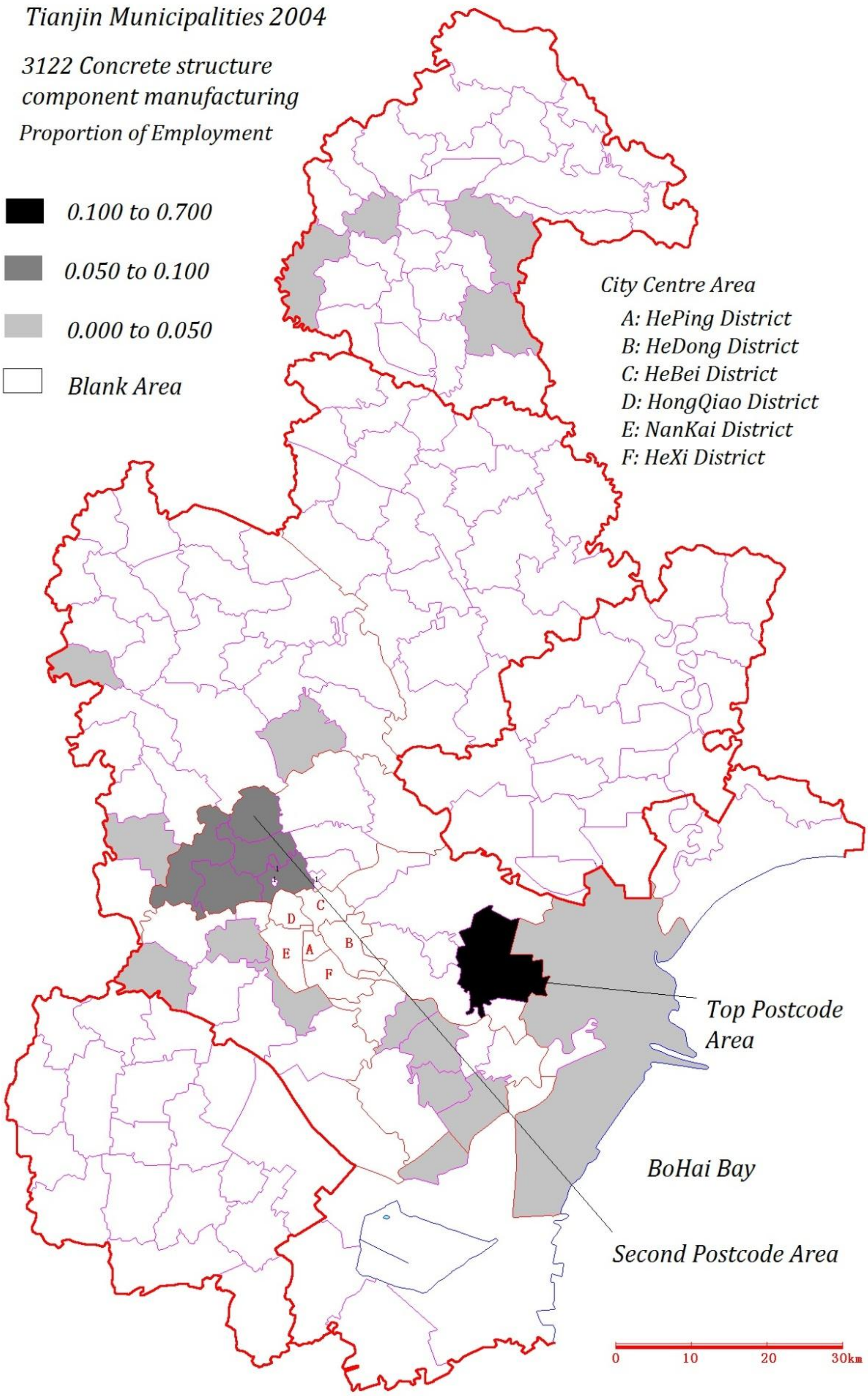


Figure. C.18. Distribution of employment (SIC-3122), 2004

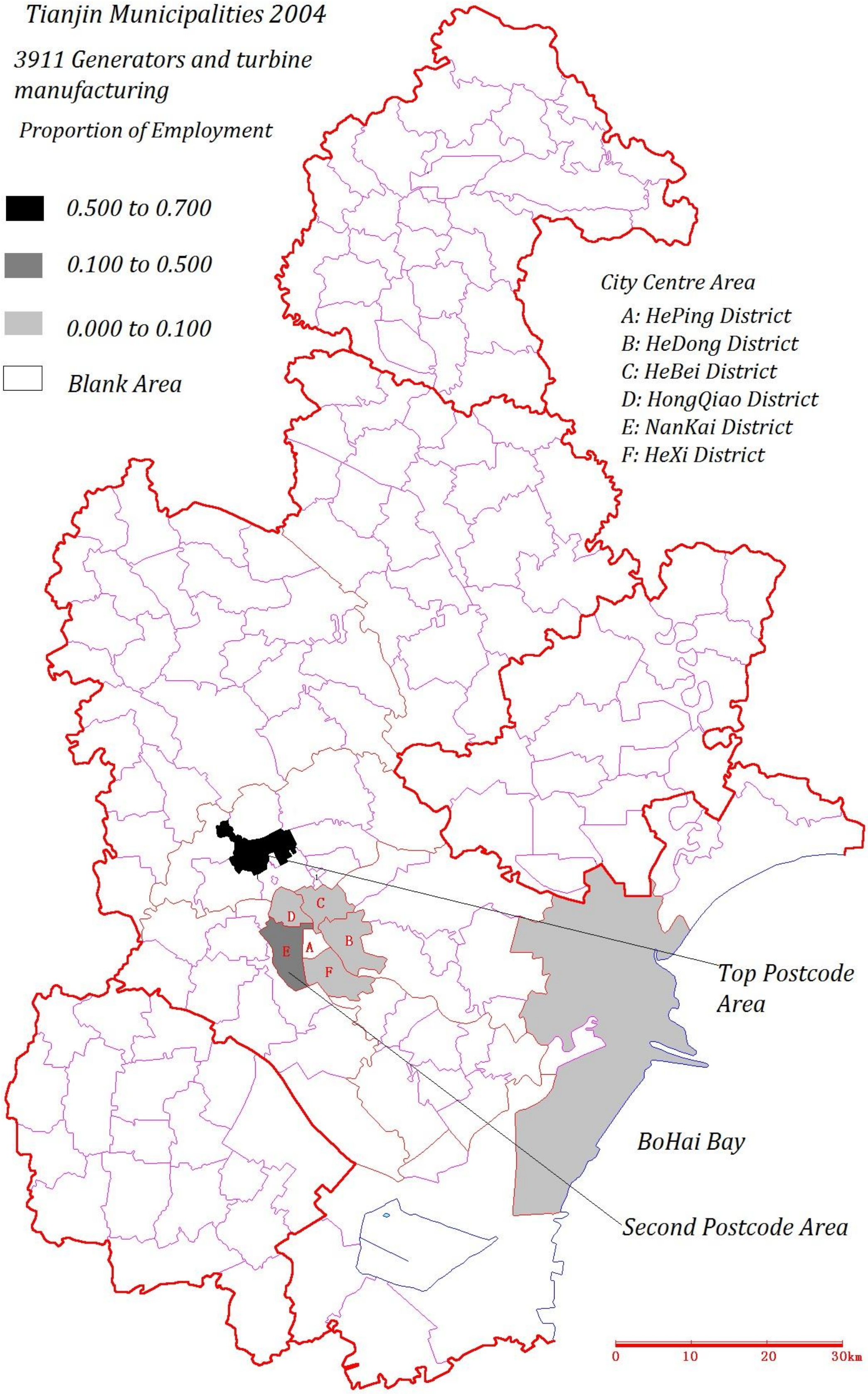


Figure. C.19. Distribution of employment (SIC-3911), 2004

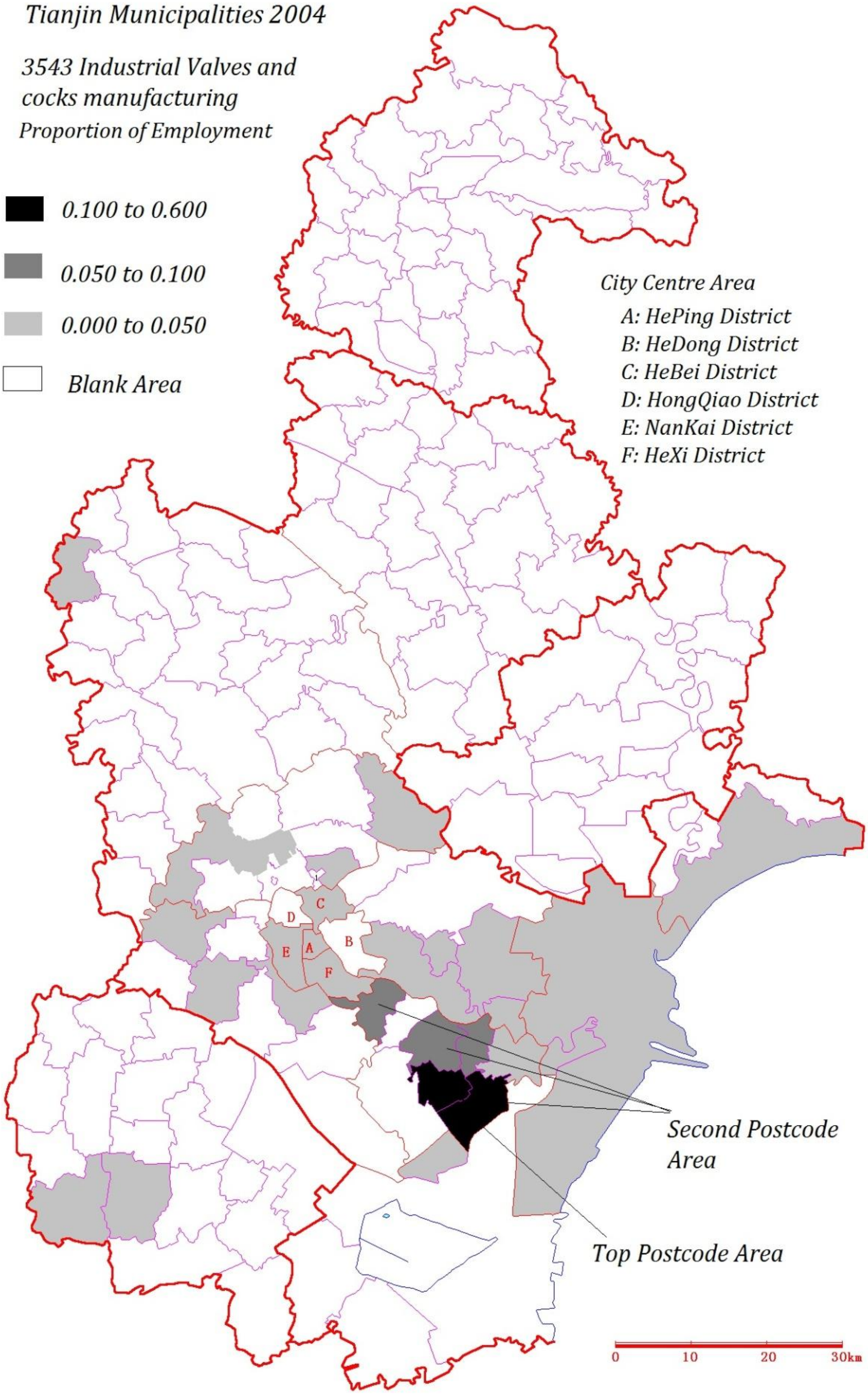


Figure. C.20. Distribution of employment (SIC-3543), 2004

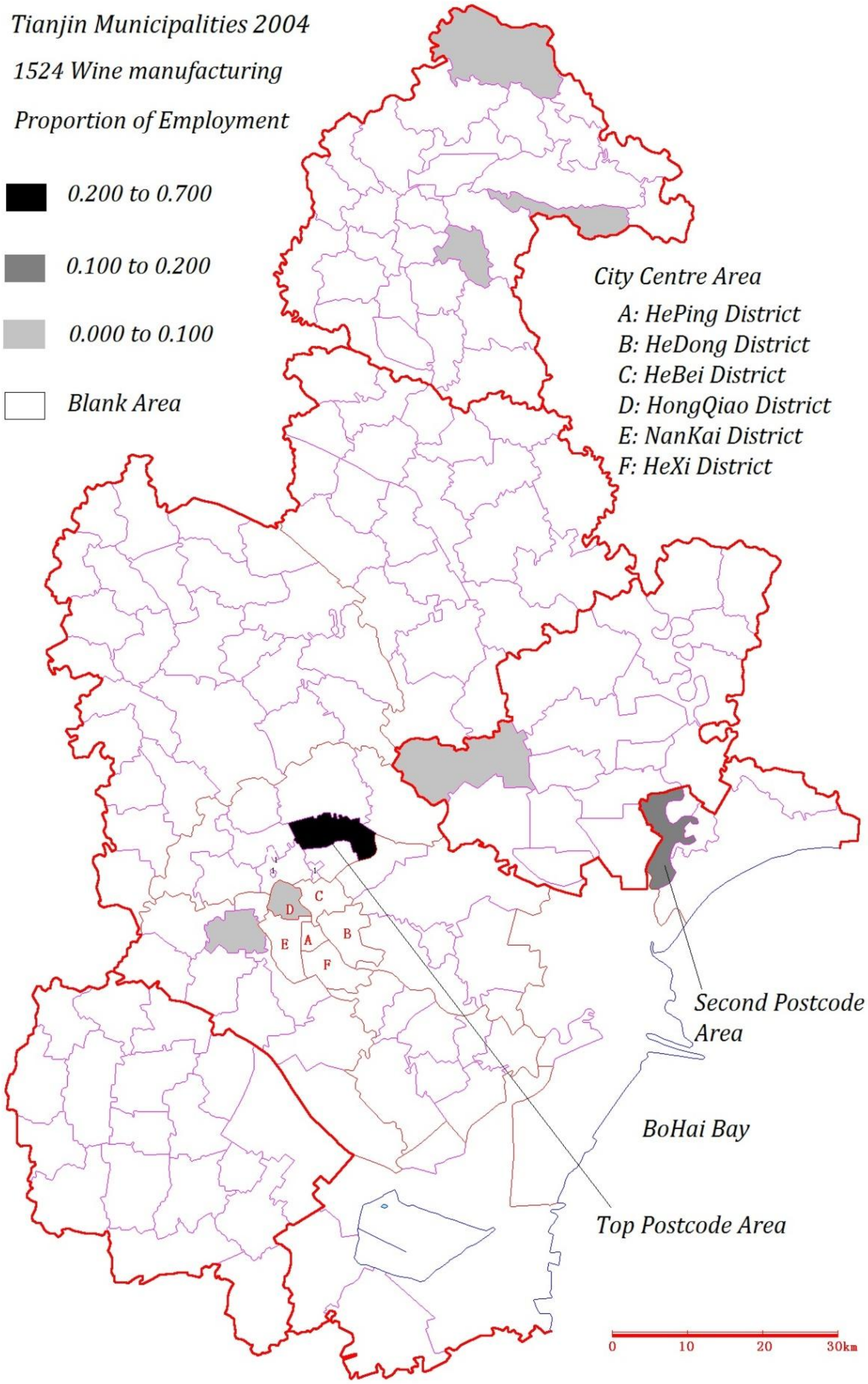


Figure. C.21. Distribution of employment (SIC-1524), 2004

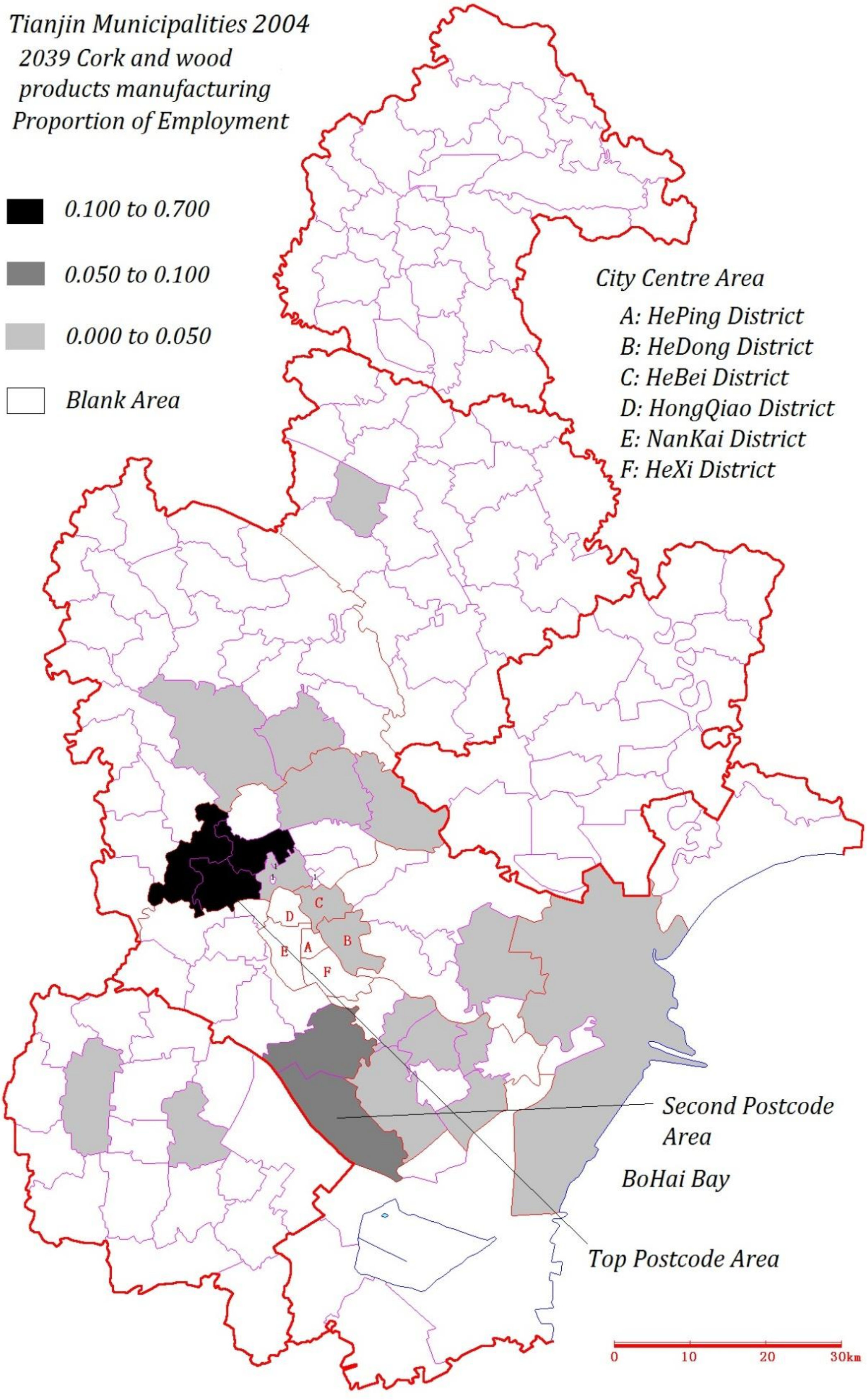


Figure. C.22. Distribution of employment (SIC-2039), 2004

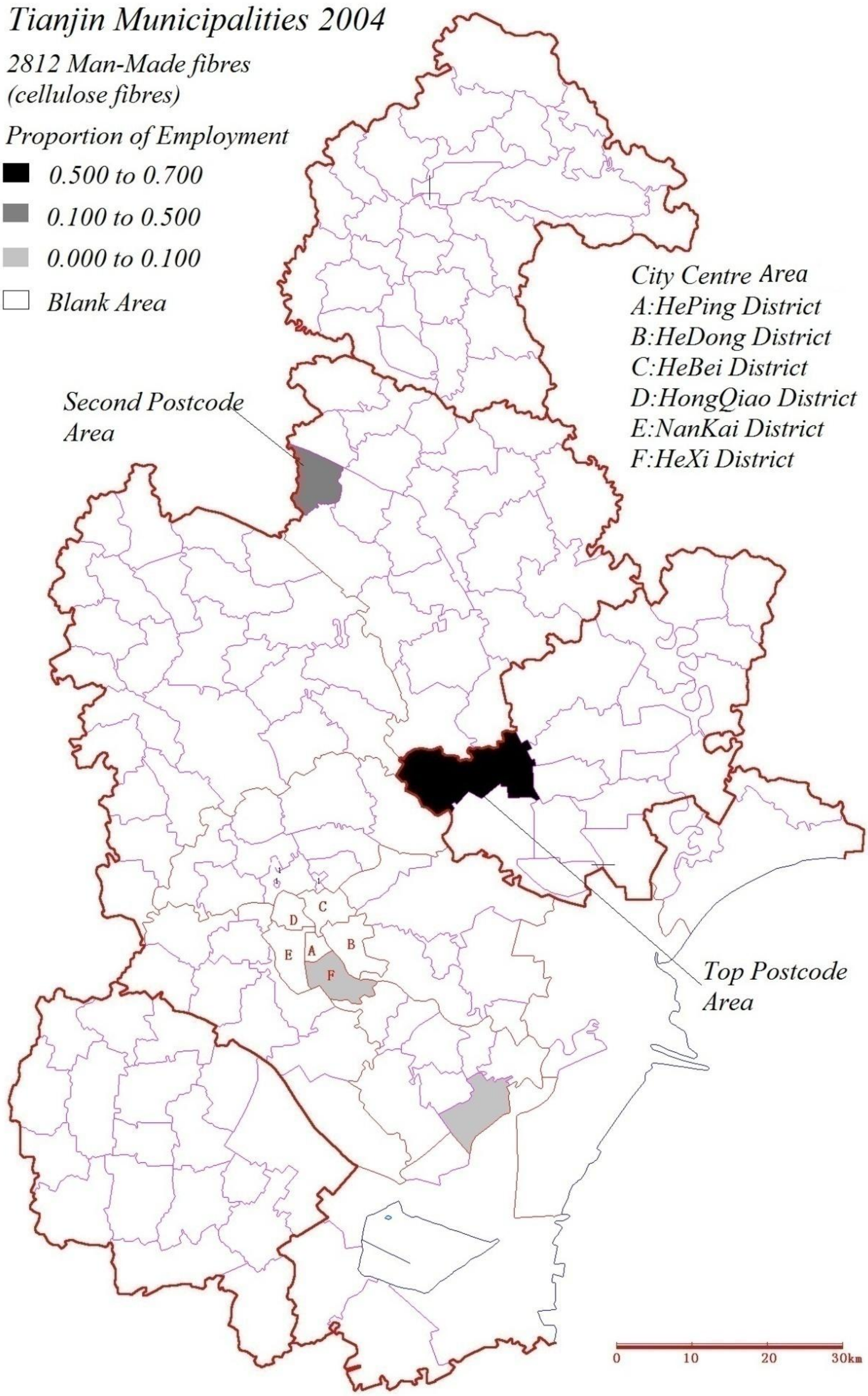


Figure. C.23. Distribution of employment (SIC-2812), 2004

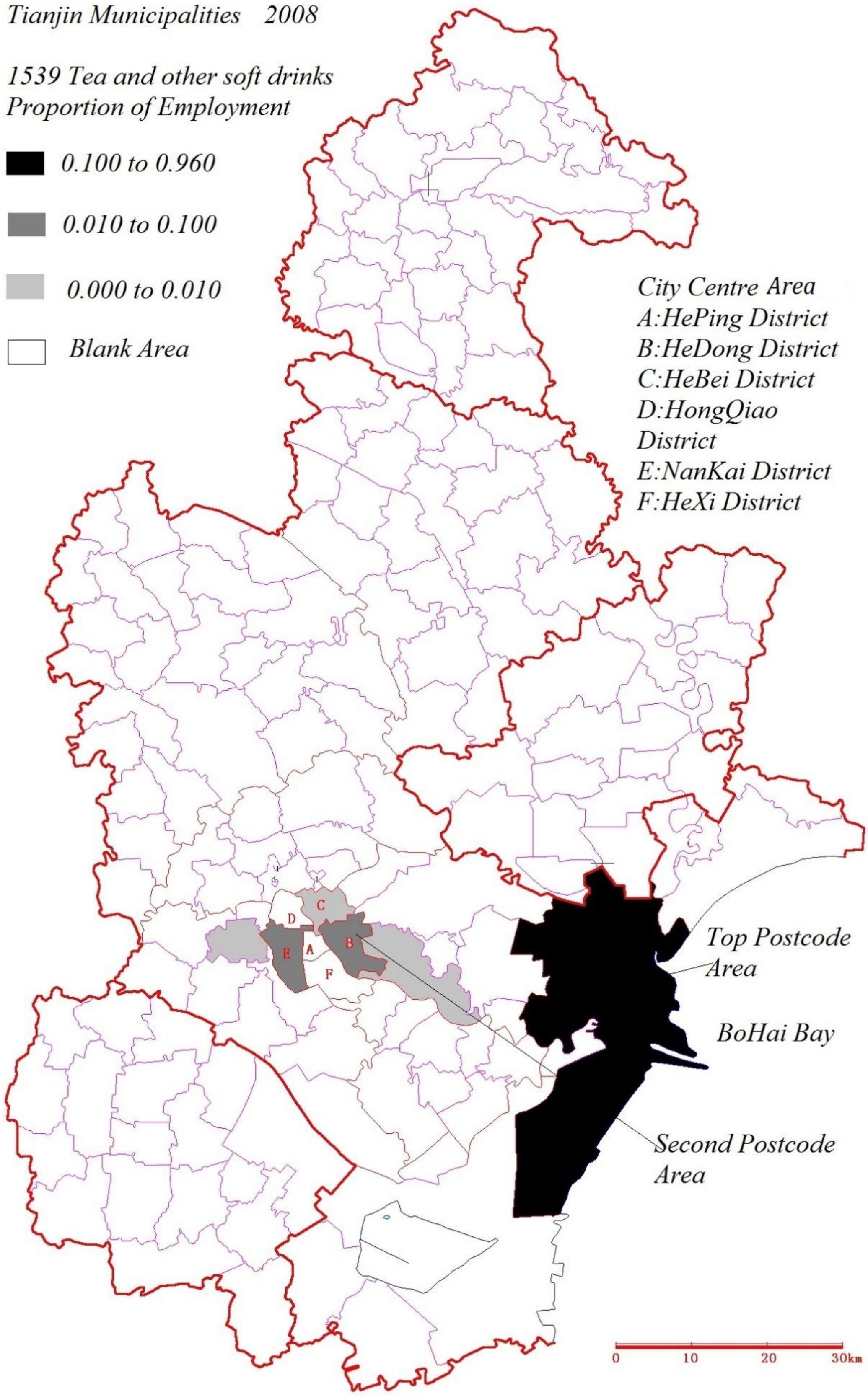


Figure. C.24. Distribution of employment (SIC-1539), 2008

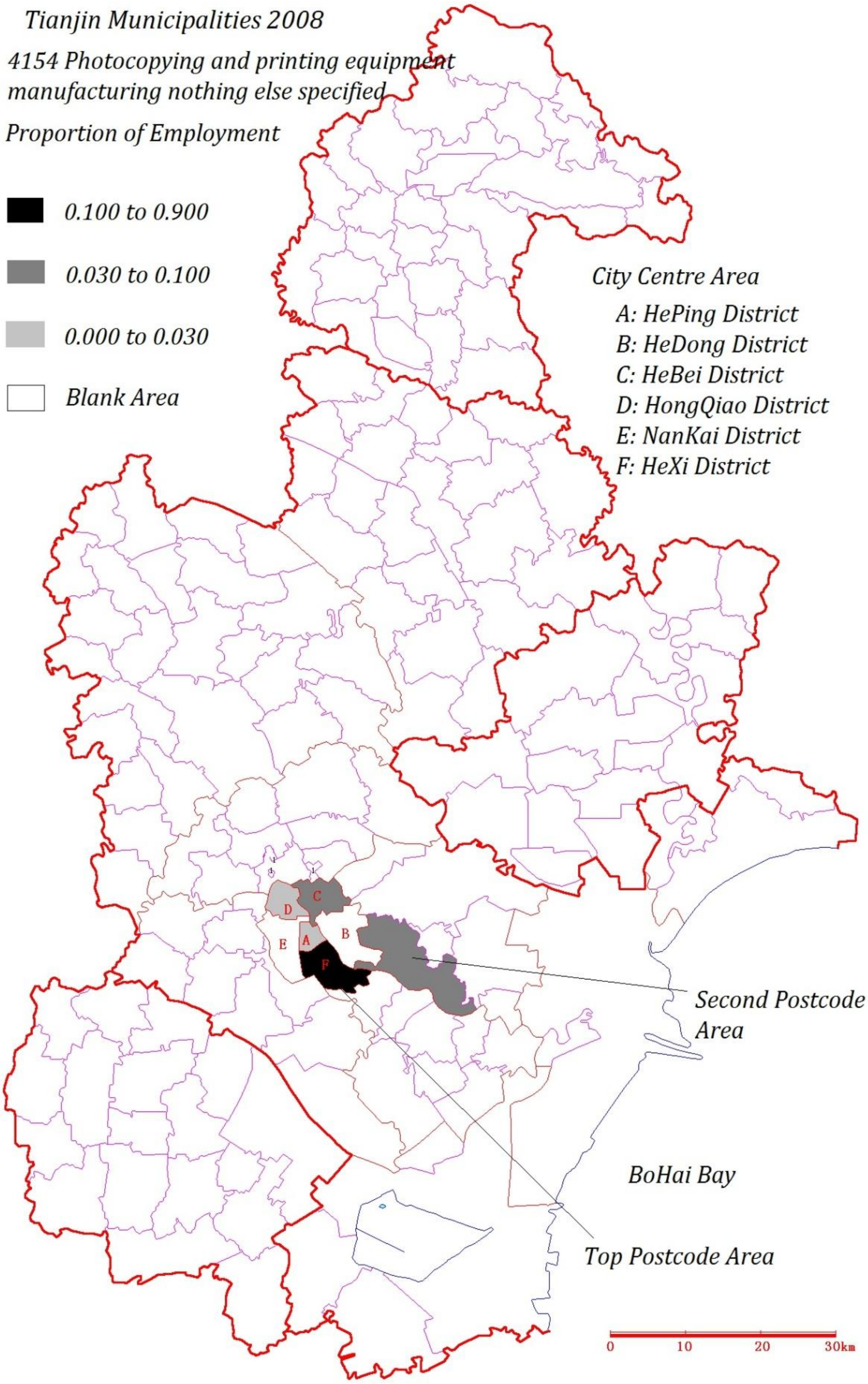


Figure. C.25. Distribution of employment (SIC-4154), 2008

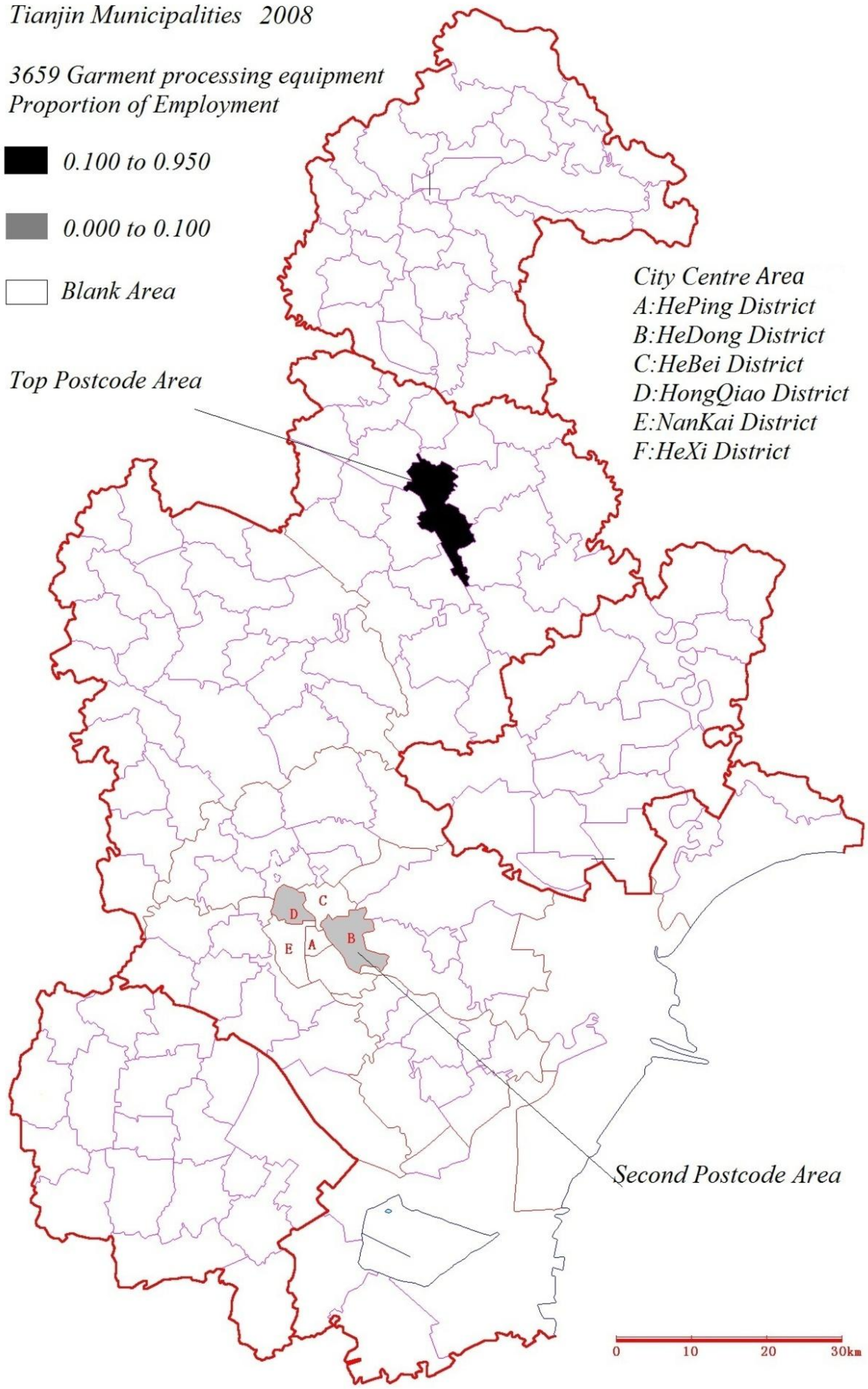


Figure. C.26. Distribution of employment (SIC-3659), 2008

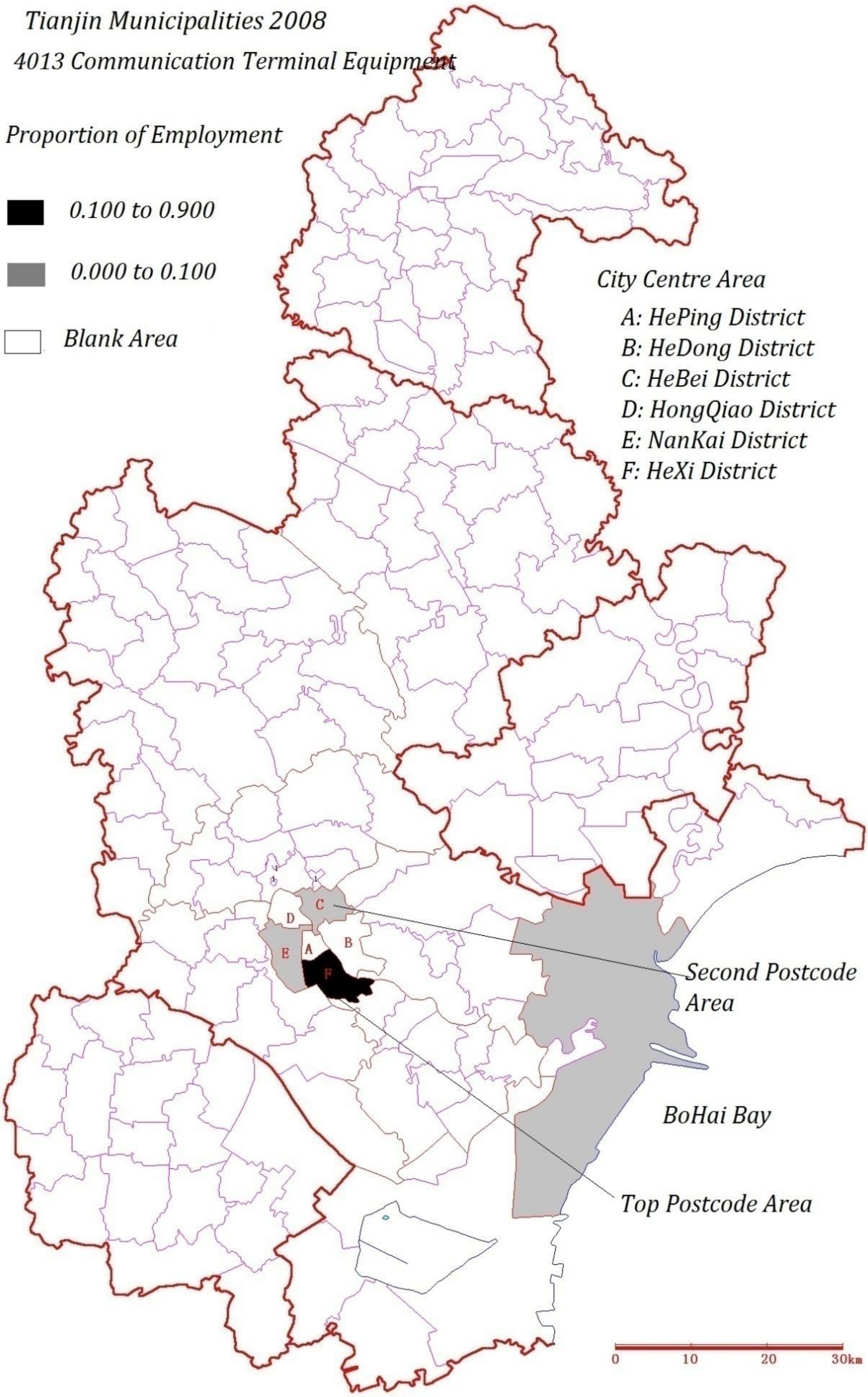


Figure. C.27. Distribution of employment (SIC-4013), 2008

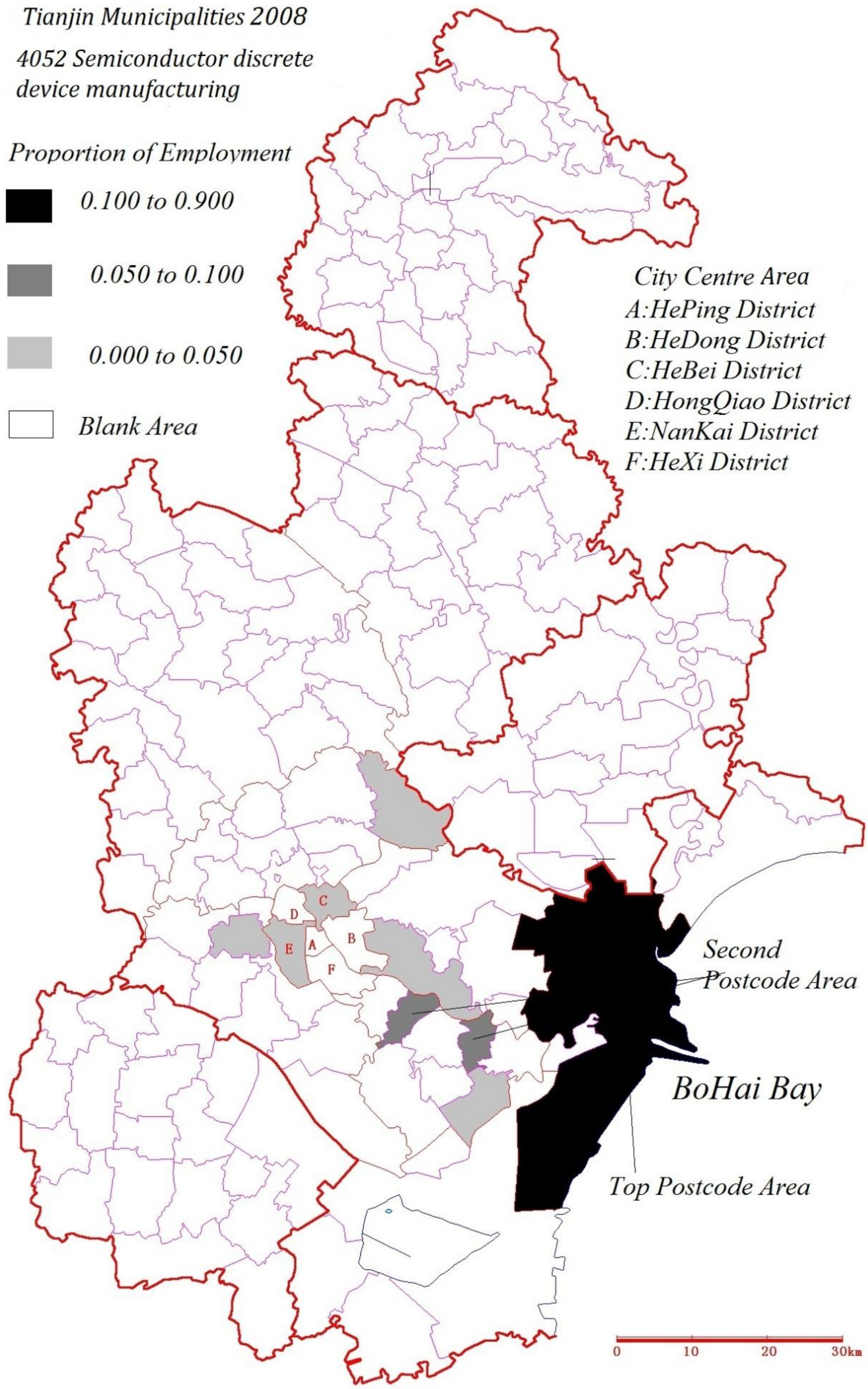


Figure. C.28. Distribution of employment (SIC-4052), 2008

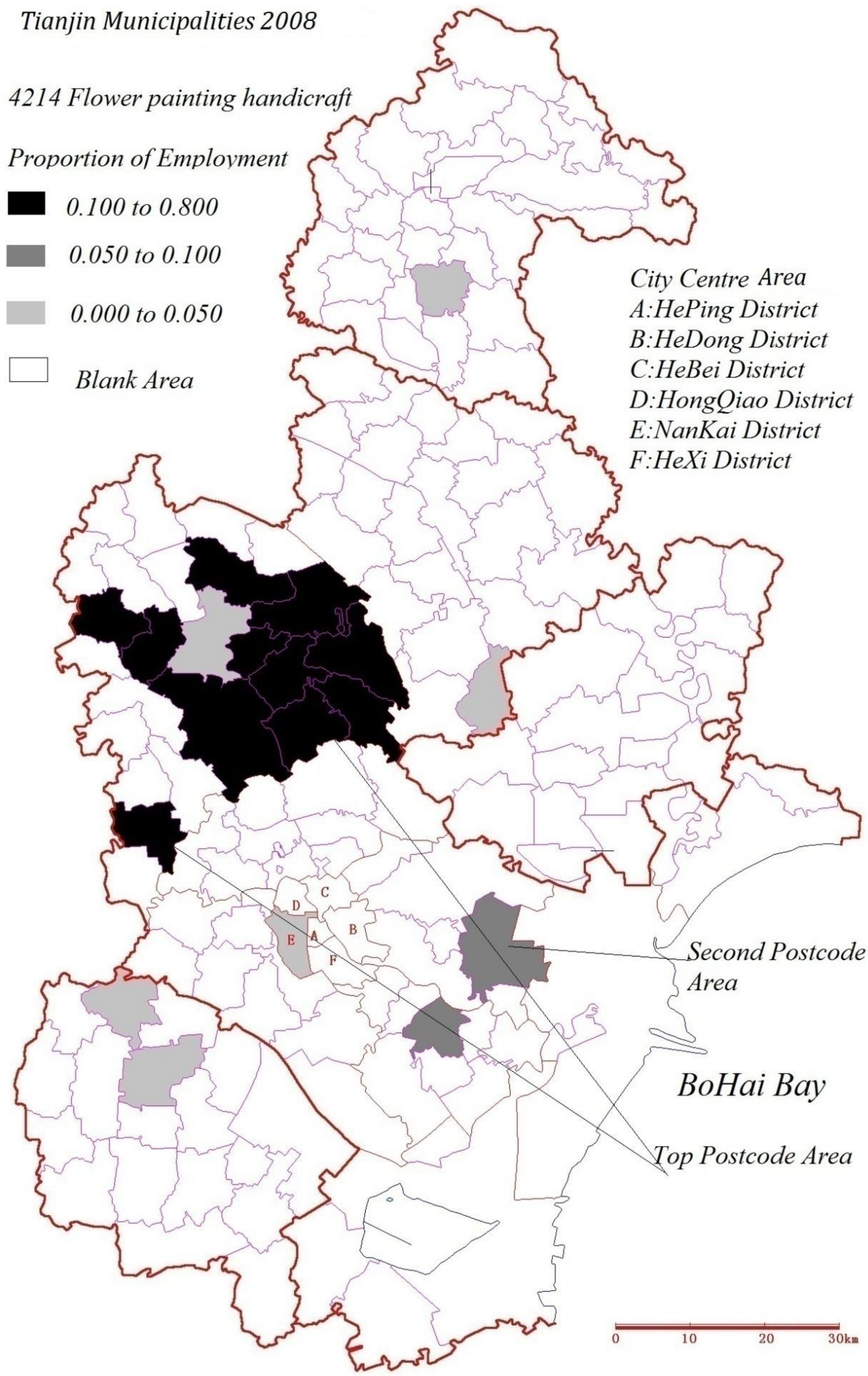


Figure. C.29. Distribution of employment (SIC-4214), 2008

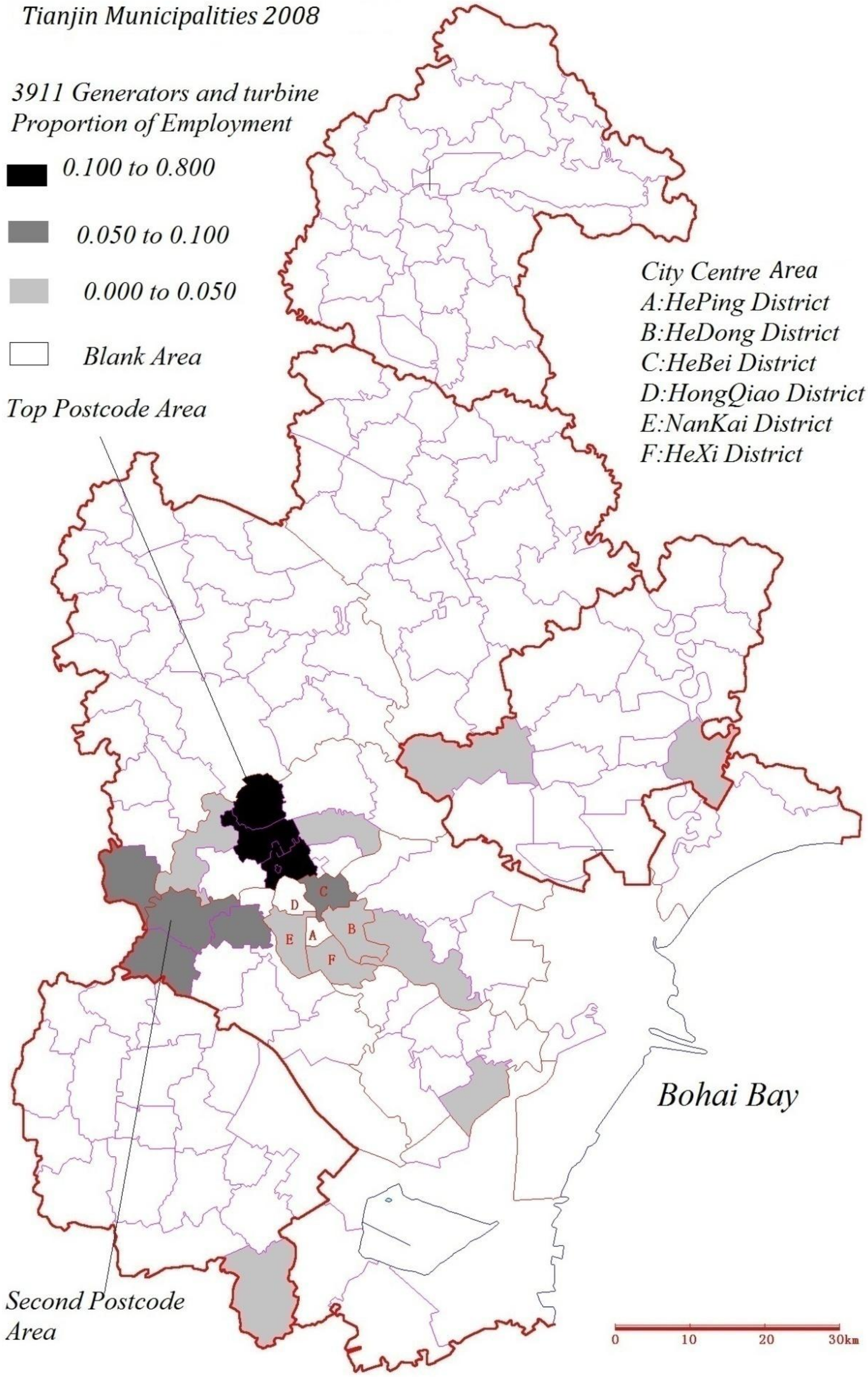


Figure. C.30. Distribution of employment (SIC-3911), 2008

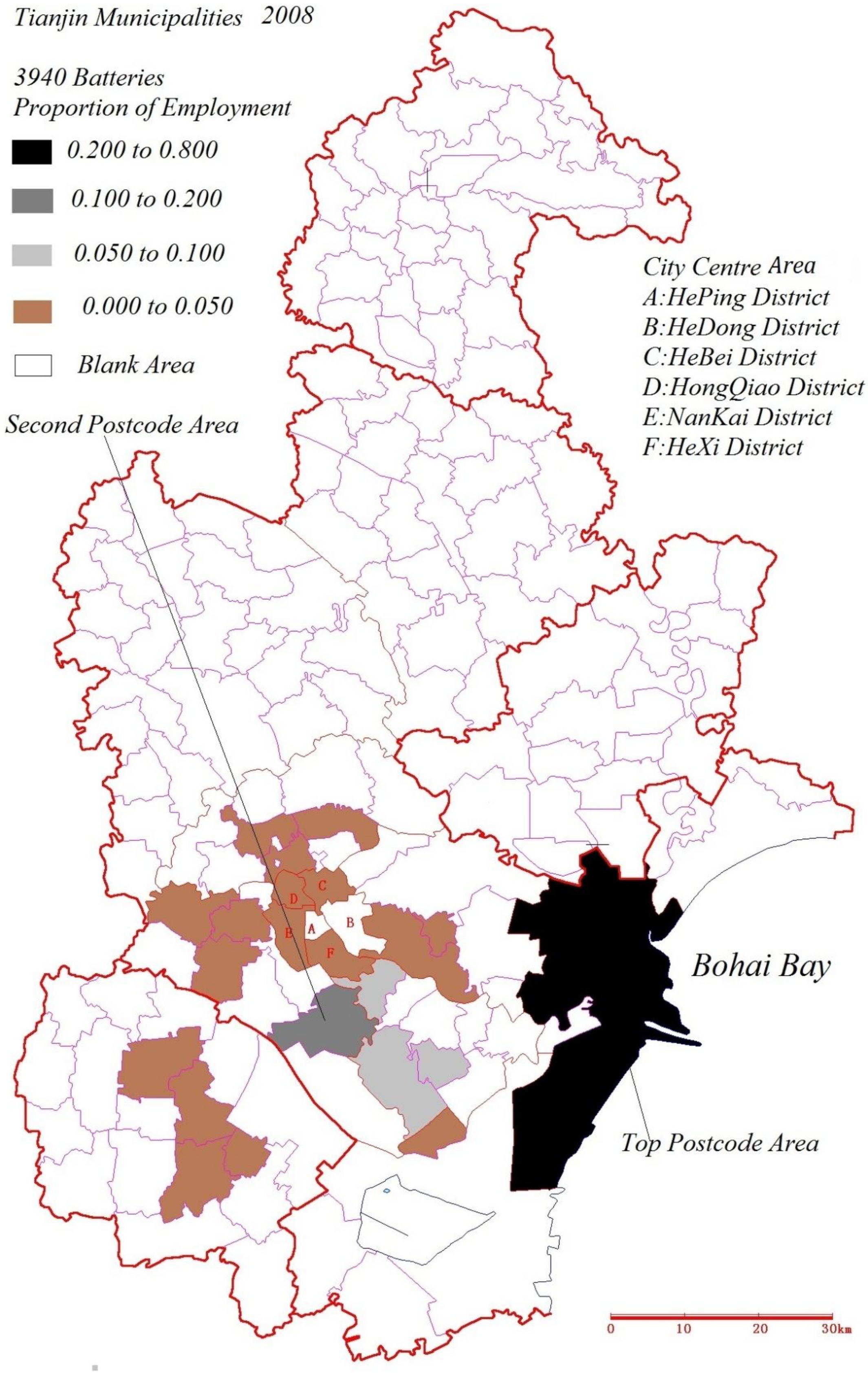


Figure. C.31. Distribution of employment (SIC-3940), 2008

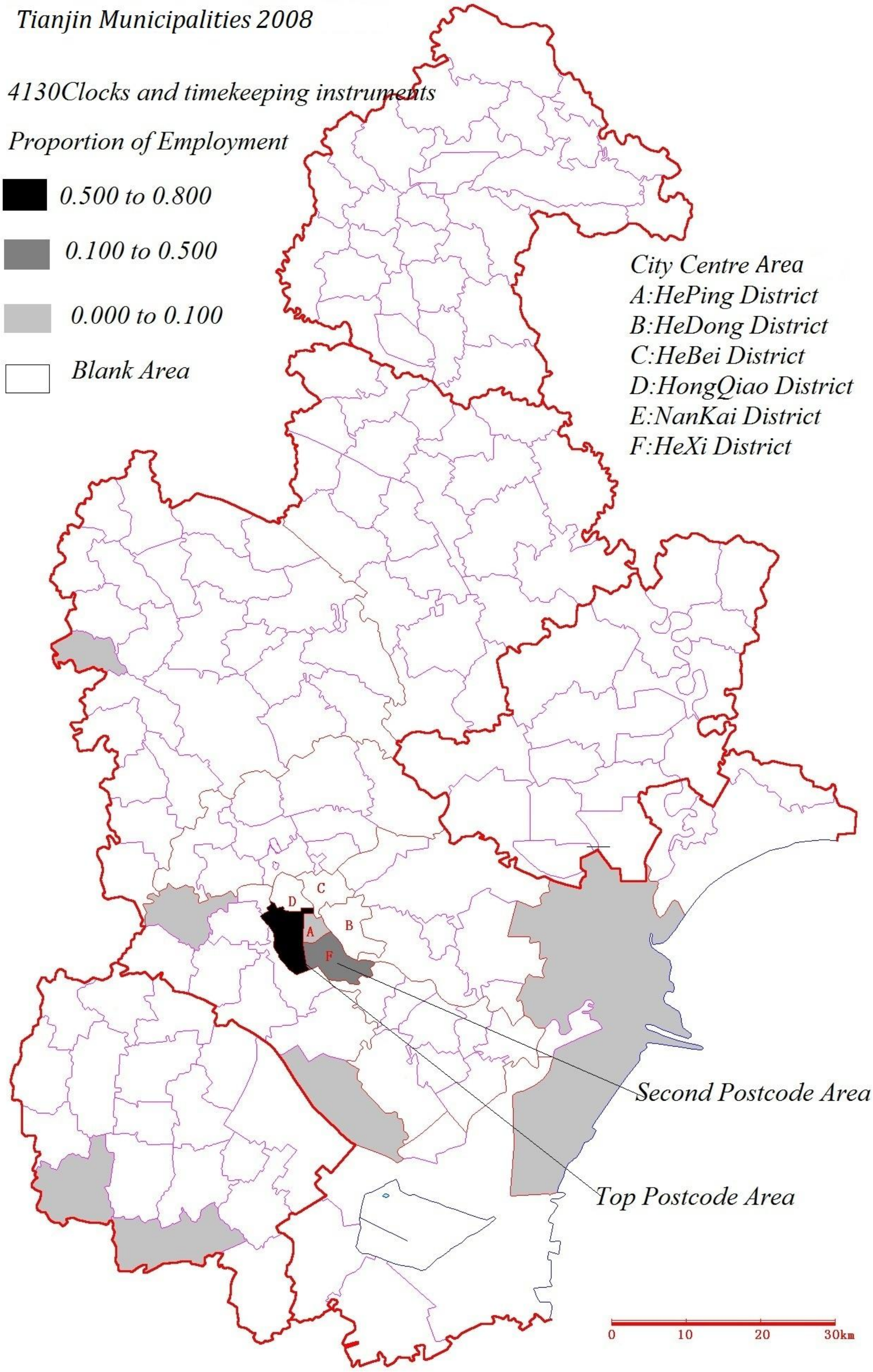


Figure. C.32. Distribution of employment (SIC-4130), 2008

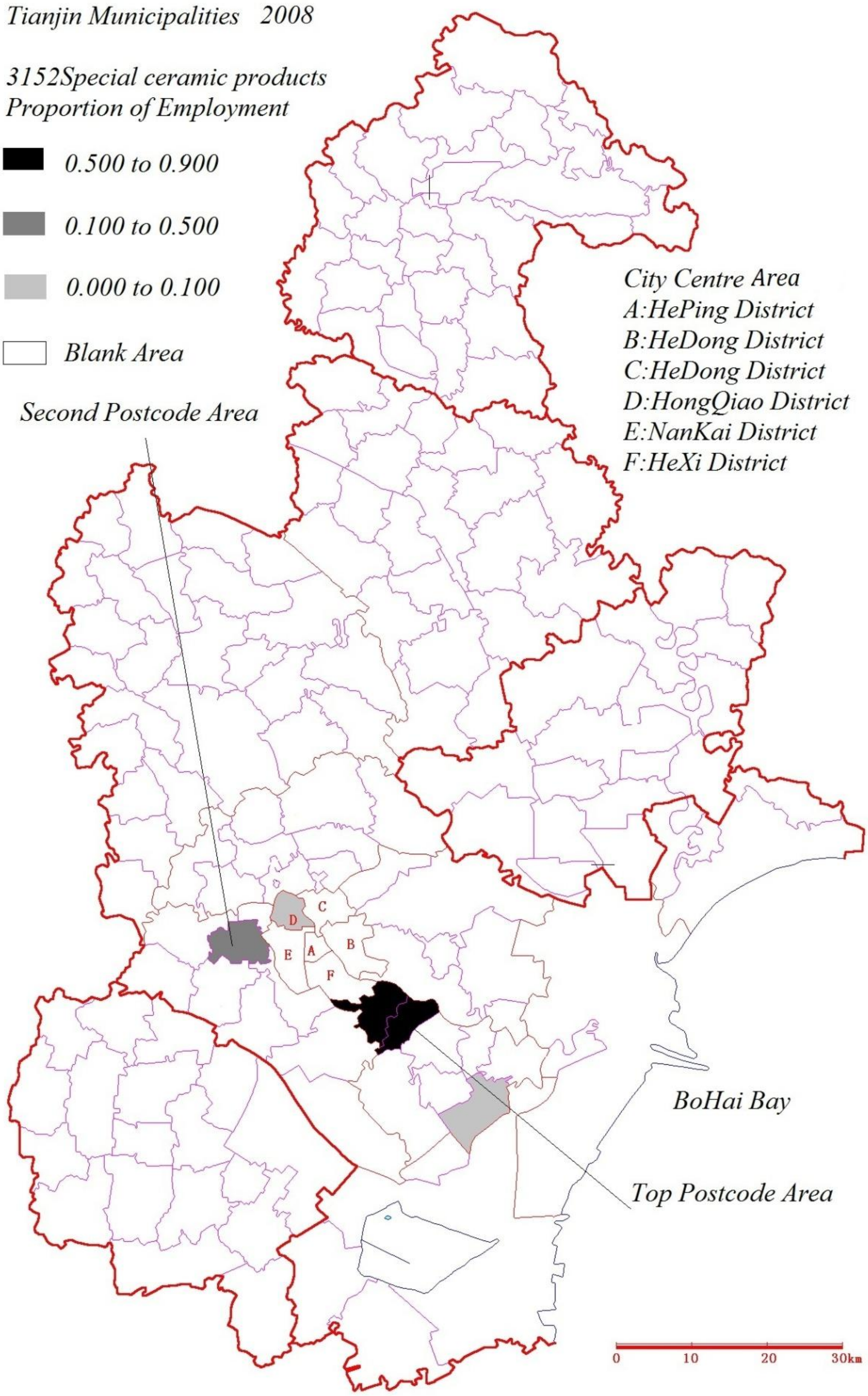


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Figure. C.33. Distribution of employment (SIC-4130), 2008

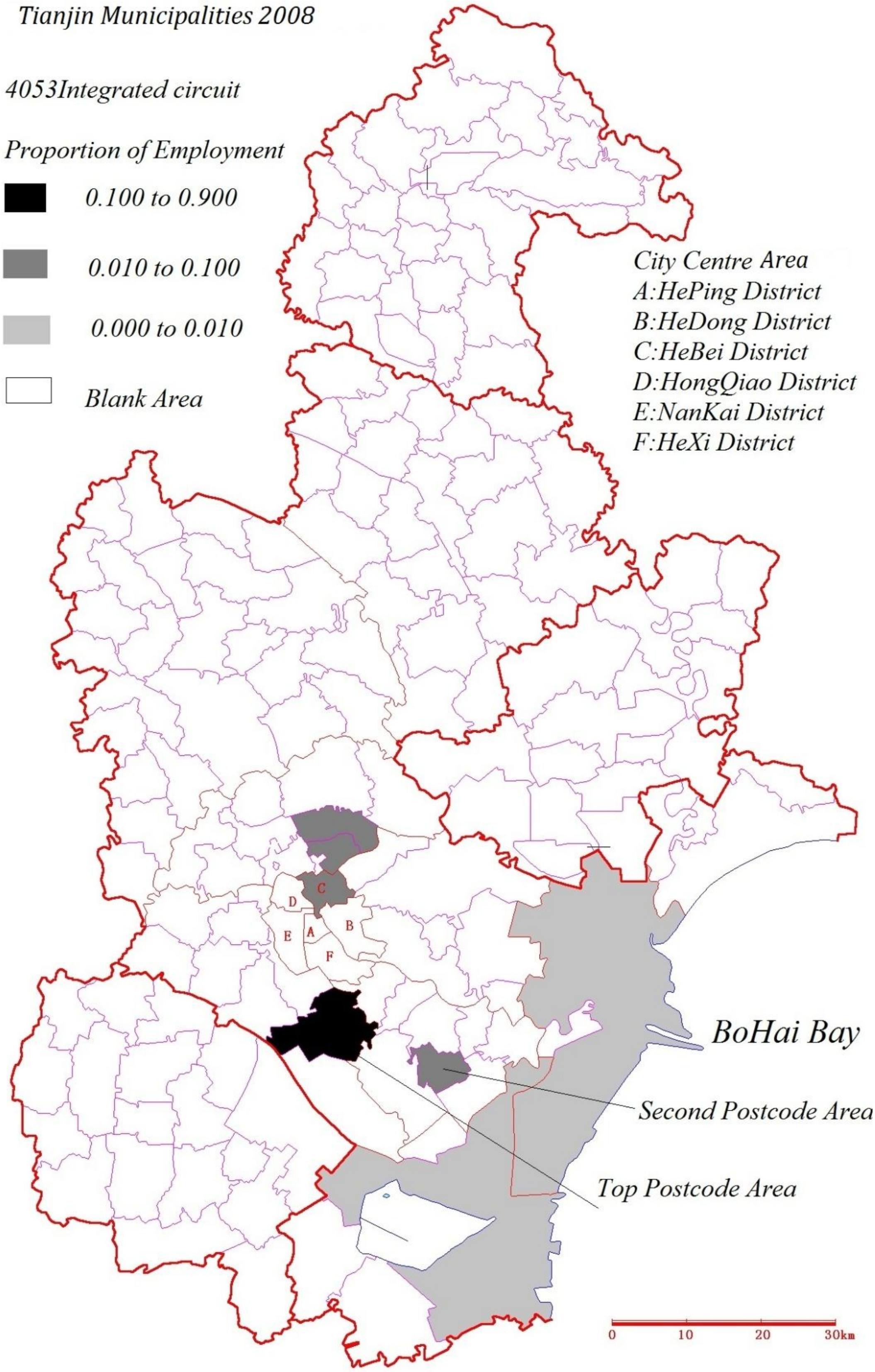

Figure. C.34. Distribution of employment (SIC-4053), 2008

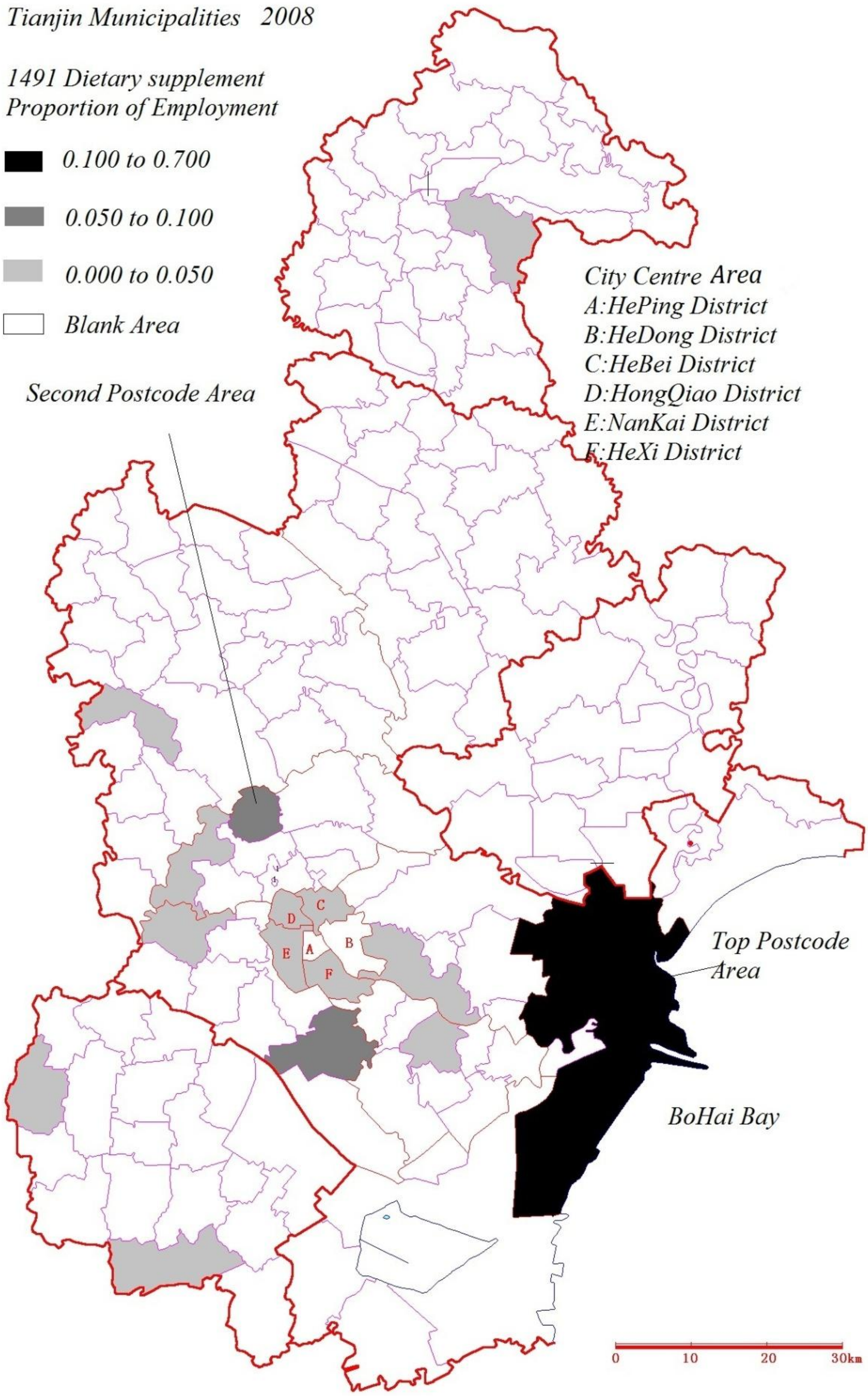

Figure. C.35. Distribution of employment (SIC-1491), 2008

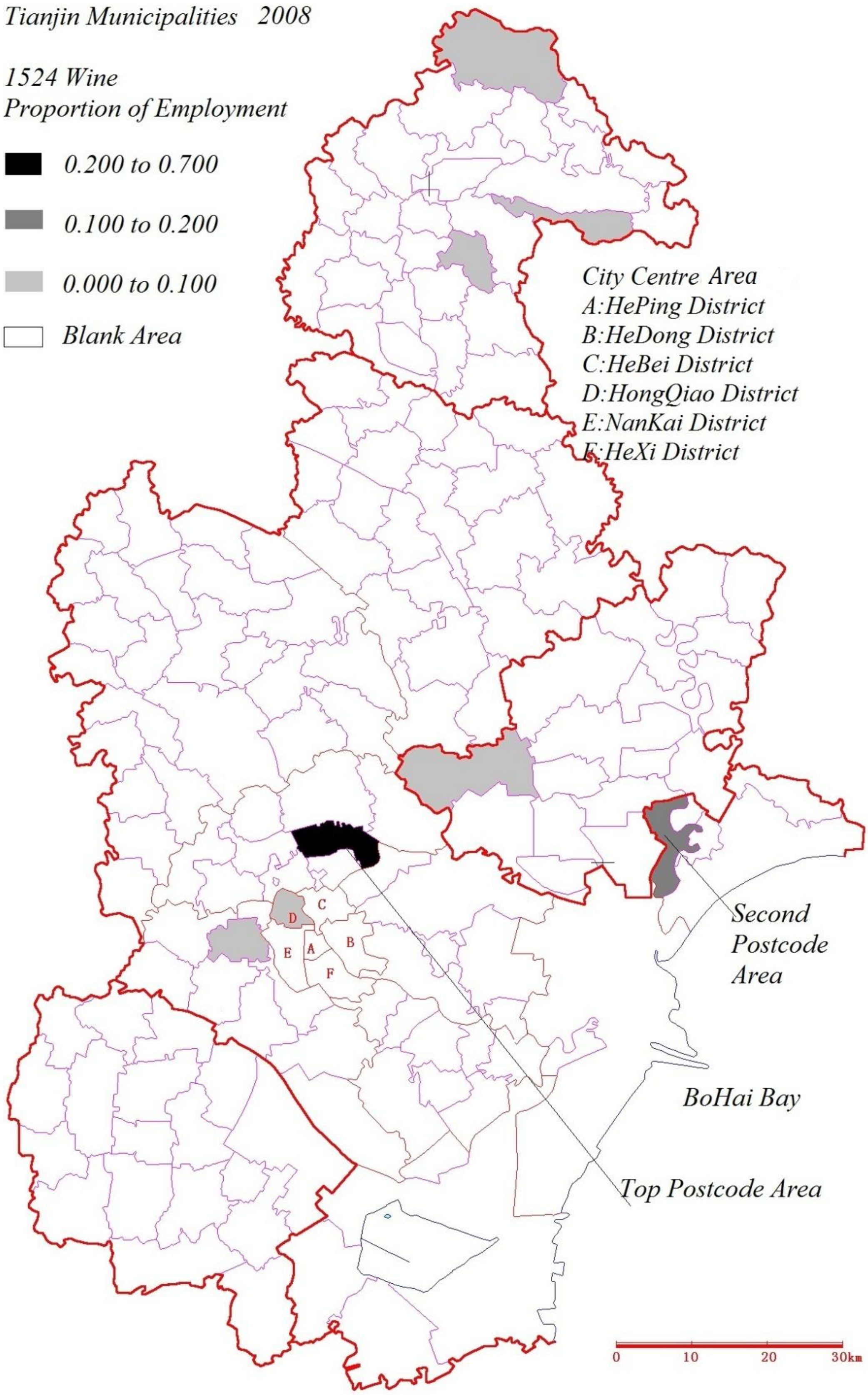

Figure. C.36. Distribution of employment (SIC-1524), 2008

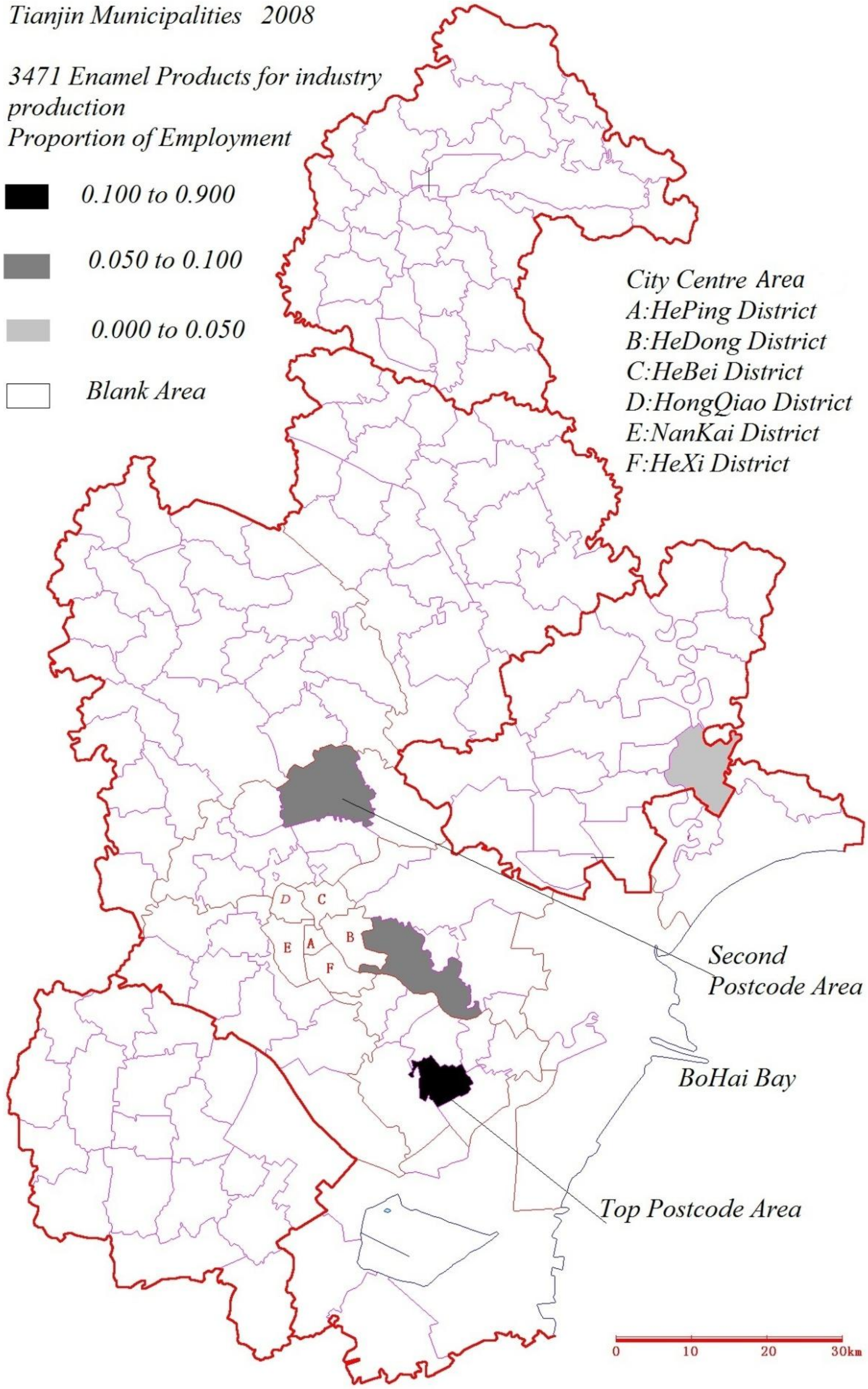

Figure. C.37. Distribution of employment (SIC-3471), 2008

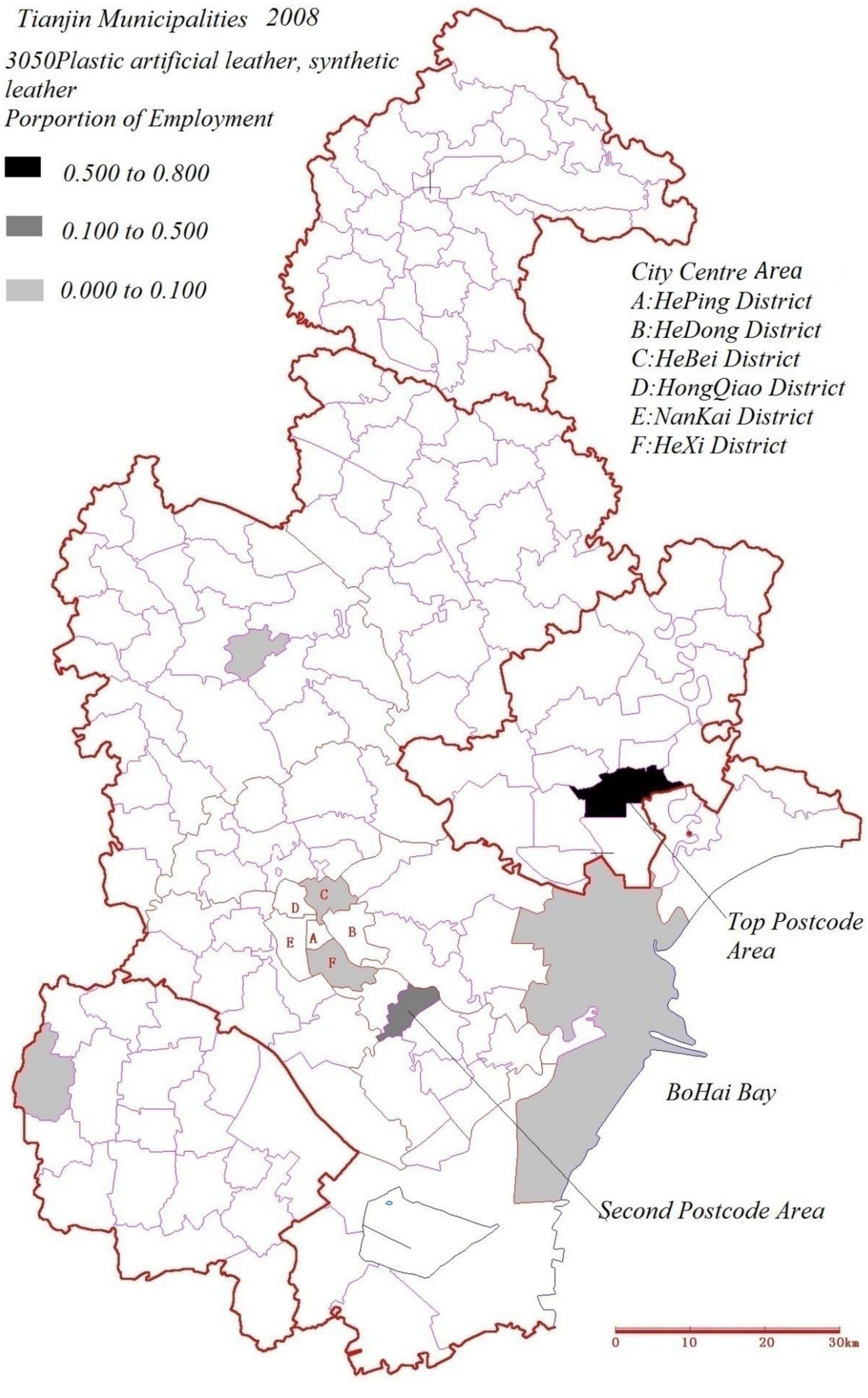

Figure. C.38. Distribution of employment (SIC-3050), 2008

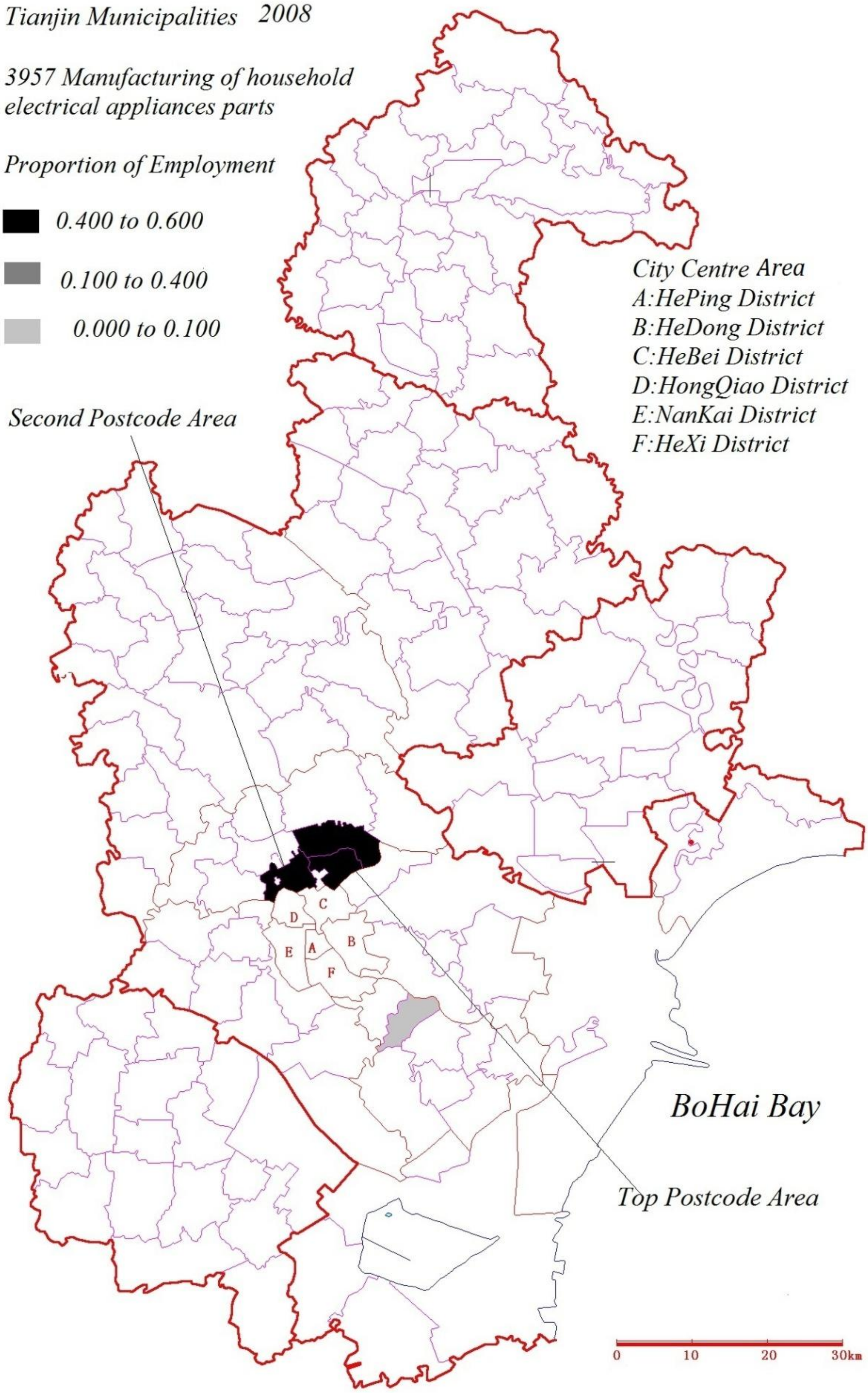

Figure. C.39. Distribution of employment (SIC-3957) 2008

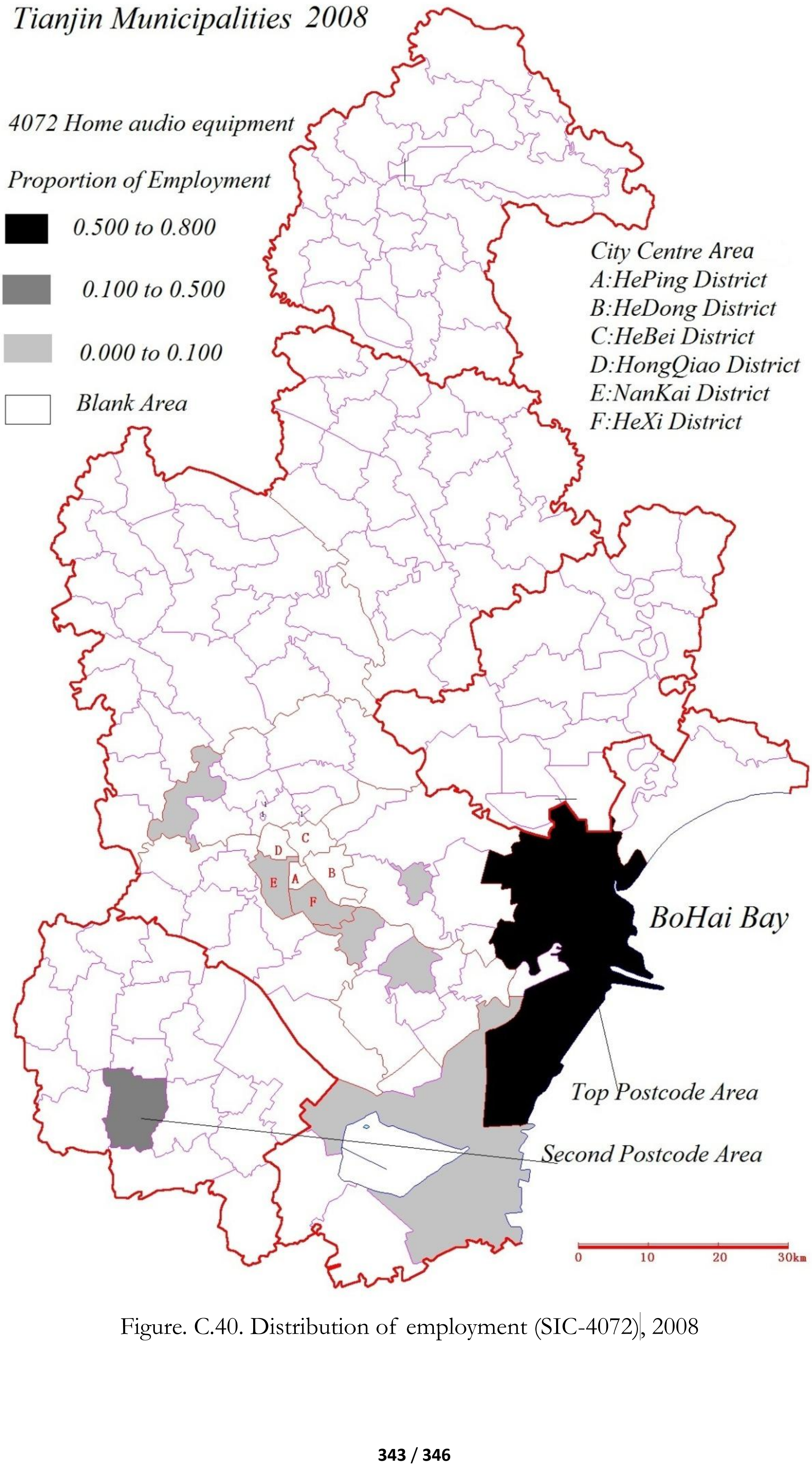

Figure. C.40. Distribution of employment (SIC-4072), 2008

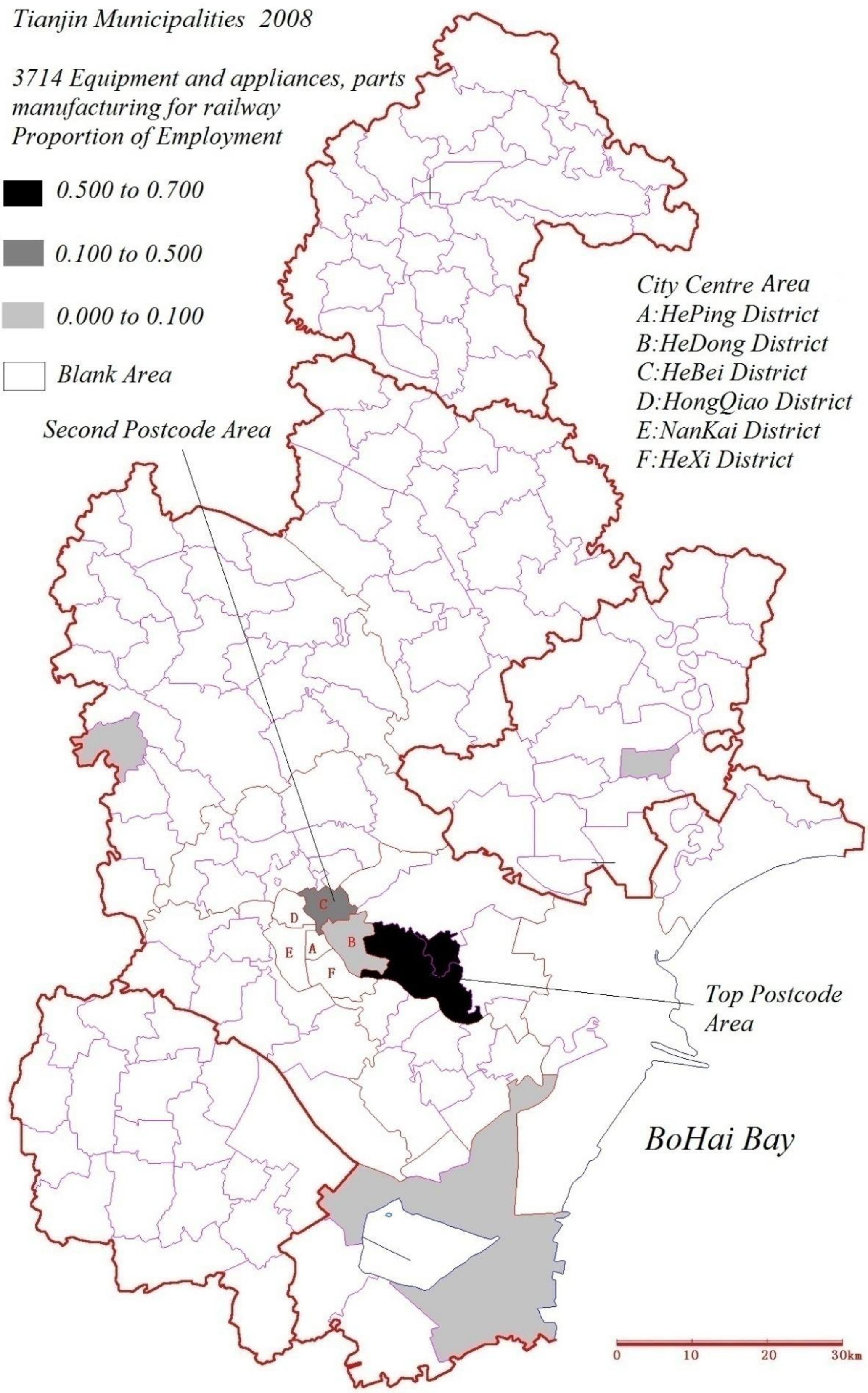

Figure. C.41. Distribution of employment (SIC-3714), 2008

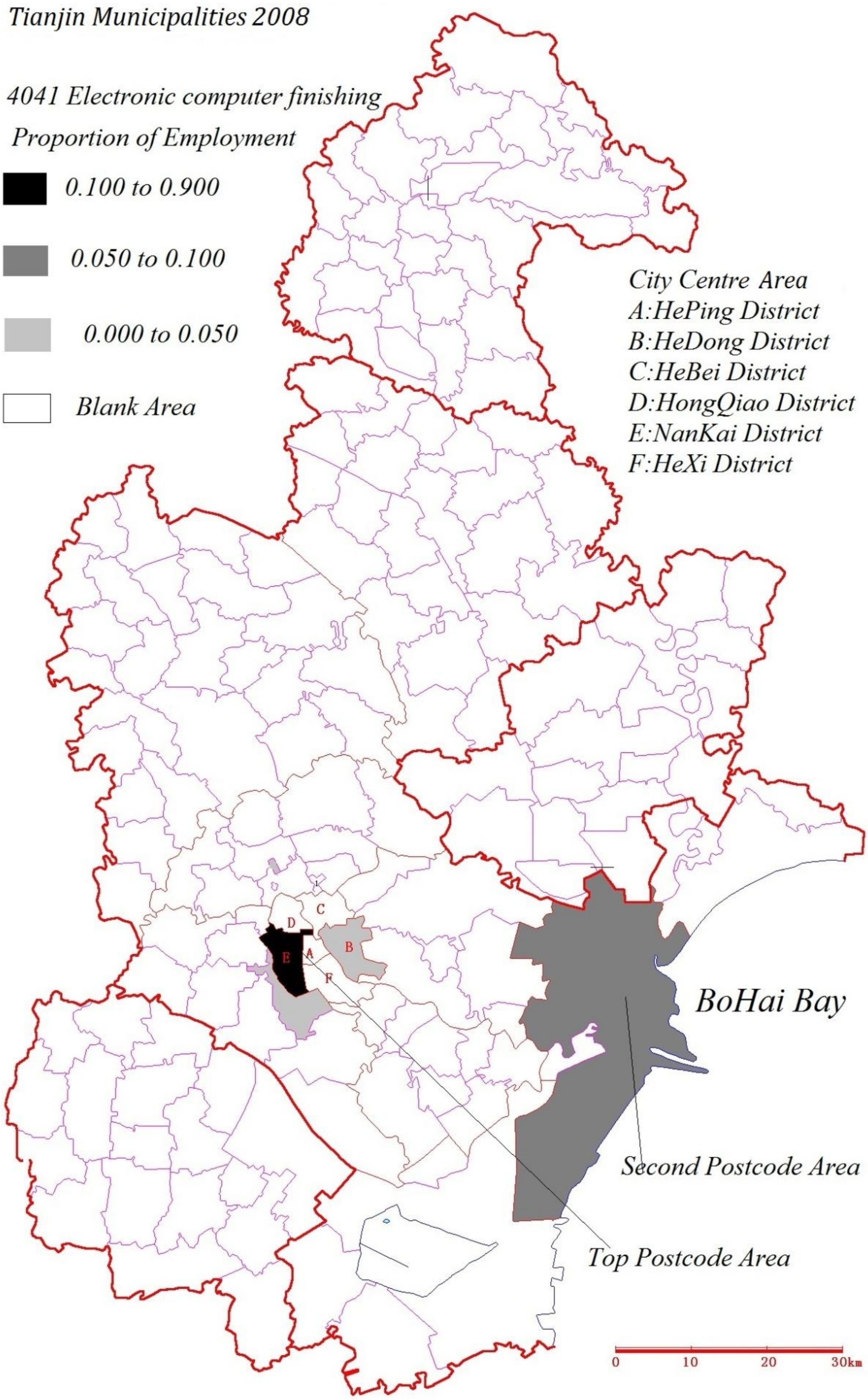

Figure. C.42. Distribution of employment (SIC-4041), 2008

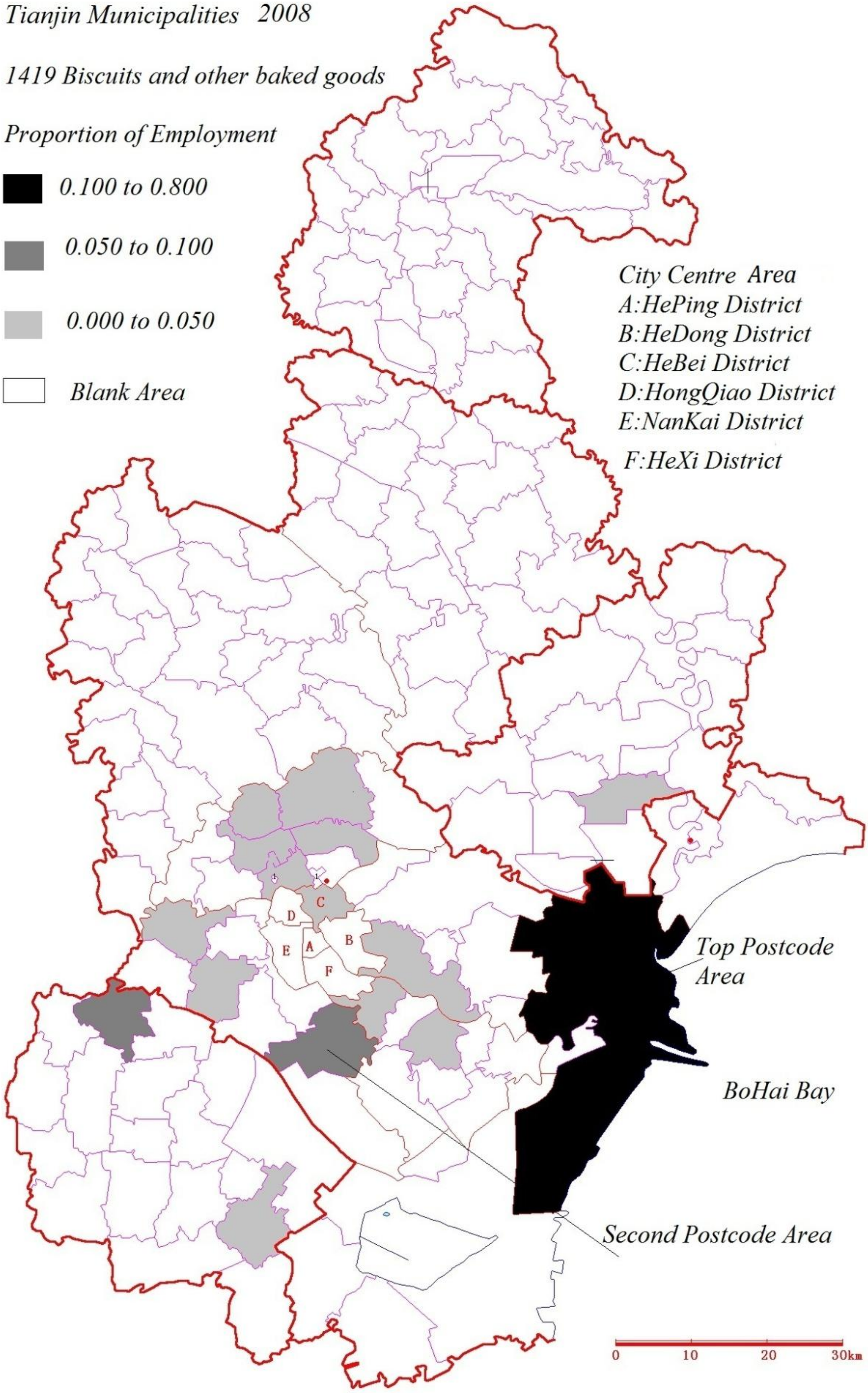

Figure. C.43. Distribution of employment (SIC-1419), 2008