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Geographical Agglomeration and Co-agglomeration of Foreign and Domestic
Enterprises: A Case Study of Chinese Manufacturing Industries

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Geographical Agglomeration and Co-agglomeration of Foreign and Domestic Enterprises: A Case Study of Chinese Manufacturing Industries

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Abstract

Industrial agglomeration has been pervasive due to natural advantages, spillover effects and institutional advantages. The co-agglomeration of foreign and domestic enterprises may be a driving force of intra-industrial agglomeration. Theories however provide conflicting predictions to whether foreign and domestic enterprises share similar locations. Based on data from the Annual Survey of Industrial Firms in 2005 in China, this study found that foreign enterprises are remarkably more agglomerated than domestic enterprises, and there exist significant industrial variations in the intra-industry co-agglomeration of foreign and domestic enterprises. Statistical analysis suggests that foreign-specific agglomeration and dependence on intermediate inputs from primary industries discourage the co-agglomeration of foreign and domestic enterprises. Differences in equipment, technology and labor productivity result in distinguished locational patterns of foreign enterprises from domestic enterprises. Meanwhile statistical results confirm the positive role of external economies and knowledge spillover effects in driving the co-agglomeration of foreign and domestic enterprises.

Key Words: Industrial Agglomeration, Co-agglomeration, Foreign Enterprises, China, Manufacturing Industries

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Geographical Agglomeration and Co-agglomeration of Foreign and Domestic Enterprises: A Case Study of Chinese Manufacturing Industries

Introduction

Manufacturing industries are not distributed uniformly in space, but agglomerate in certain places (Ellison and Glaeser, 1997). Since the 1990s, the burgeoning literature has stressed the role of natural advantages, spillover effects and institutional advantages in driving industrial agglomeration (Ellison and Glaeser, 1997; He et al., 2008; Ge, 2009; Lu and Tao, 2009). Those forces may drive the co-agglomeration of some types of enterprises within an industry, leading to the intra-industry agglomeration. For instance, Sharma (2001) studied the intra-industry co-agglomeration of exporters and non-exporters and found that localization economies like input sharing and labor pooling are the main reasons for which exporters and non-exporters within an industry will choose the same location.

In the era of economic globalization, participation of foreign firms in local industries has been remarkable. Theoretically and practically, foreign and domestic enterprises within an industry may or may not agglomerate in the same locales. Empirically, Barrios et al. (2003, 2006) found the co-agglomeration patterns of foreign and domestic enterprises within a number of industries in Ireland, including textiles and textile products, clothing, footwear and leather, wood and wood products, paper and paper products, printing, chemicals, rubber and plastic products, machinery, and motor vehicles. In the United Kingdom, foreign enterprises are also reported to share similar locations with domestic enterprises (Duranton and Overman, 2006). Foreign and domestic enterprises within an industry however differ significantly in many aspects including exports, performance, productivity, technology, R&D intensity, profitability, wages, skills, and institutional treatment, requiring different locations (Ramstetter, 1999; Bellak, 2004; Huang, 2003; Xu et al., 2006). Shaver (1998) found that foreign and domestic establishments do not exhibit the same locational patterns in the United States. Hogenbirk and Narula (2004) also reported dissimilar locational patterns of foreign and national firms in Netherlands. Theories provide conflicting predictions to whether or not foreign and domestic enterprises would co-agglomerate in similar locations. Similar locational patterns can be expected when the drivers of agglomeration are industry-specific while firm-specific agglomerative forces lead to different locational patterns between foreign and domestic enterprises (Shaver, 1998; Co, 2002).

Multinational corporations have heavily invested in Chinese industries, initially in labor-intensive industries and then in capital and technology intensive industries. Foreign enterprises now dominate the output in many industries such as telecommunication and electronic equipment, electric machinery and equipment, office machinery and instruments and meters, transportation equipment, rubber and plastic products, garments making and leather products (He, 2003). Empirical studies have found that industries with foreign ownership are more geographically agglomerated (He et al., 2008; Ge, 2009) and foreign enterprises are

disproportionately concentrated along the coast region (Wei et al., 1999; Cheng and Kwan, 2000; He, 2002, 2003; Cheng, 2007; Cheng and Stough, 2006). Whether and how foreign and domestic enterprises co-agglomerate in similar locations and in what industries remain empirical questions and deserve further investigations.

On the one hand, foreign and domestic enterprises in China may co-agglomerate in similar locations. Knowledge spillovers from foreign enterprises to domestic enterprises in China would stimulate domestic enterprises to locate closer to foreign enterprises (Liu, 2002, 2008; Buckley et al., 2002, 2007). Local content requirements imposed by the authorities may induce industrial linkages between foreign and domestic enterprises, resulting in the co-agglomeration (Sit and Liu, 2000; Eberhardt et al., 2004). Foreign firms are often required to balance foreign currency transactions, indirectly restricting component and material imports and encouraging localized linkages (Rosen, 1999). Moreover, localization economies may motivate foreign enterprises to favor places where an industry is already concentrated, resulting in co-agglomeration (Belderbos and Carree, 2000).

On the other hand, facing serious information asymmetry in local knowledge of social, political, and economic conditions, and business uncertainties in China, foreign investors would rely on information and knowledge spillovers among foreign investors to mitigate business risks and therefore agglomerate in certain locations (Kinoshita and Mody, 2001; He, 2002). Localized business linkages among foreign investors in China result in significant agglomeration of foreign enterprises (Yeung et al., 2006). Foreign investors in China also follow their leaders within firms and from the same nationality to locate within China (Belderbos and Carree, 2000; He, 2003; Shang and Park, 2005; Cheng and Stough, 2006; Cheng, 2007). Foreign investors may simply imitate each other's location choices due to uncertainties (Sun and Wen, 2007). Foreign enterprises in China are relatively late-comers, responding to a different set of locational factors and leading to different locational patterns from domestic enterprises. In addition, China's regional-oriented favorable policies for foreign investment have resulted in over-concentration of foreign investment in special economic zones, open coastal cities and industrial development parks (He, 2002, 2003; Cheng, 2007).

In summary, there are centripetal and centrifugal forces for the co-agglomeration of foreign and domestic enterprises in China. Whether foreign and domestic enterprises share similar locations is indeed an empirical question and deserves further investigations. The investigation of intra-industry co-agglomeration of foreign and domestic enterprises would enrich the understanding of intra-industrial agglomeration. Based on the Annual Survey of Industrial Firms in 2005 in China, this study examined the geographical agglomeration and co-agglomeration of foreign and domestic enterprises across industry at the three-digit level and at the prefecture level. We found more agglomeration for foreign enterprises than domestic enterprises and significant industrial variations in the co-agglomeration of foreign and domestic enterprises. Statistical results suggest that external economies and spillover effects from foreign enterprises would drive the co-agglomeration of foreign and domestic enterprises. Foreign-specific agglomeration and dependence on inputs of agricultural

goods significantly discourage the co-agglomeration of foreign and domestic enterprises. Ownership advantages held by foreign investors would deviate the locations of foreign enterprises from domestic enterprises.

This paper is organized as follows. After the introduction, a theoretical discussion on the co-agglomeration of foreign and domestic enterprises will be provided. The third session will describe the data sources and methods applied in this study, followed by the description of patterns of geographical agglomeration and co-agglomeration of foreign and domestic enterprises. The fifth session will report the statistical results to reveal the driving forces of co-agglomeration of foreign and domestic enterprises. This paper concludes with a summary of empirical findings.

Understanding Co-agglomeration of Foreign and Domestic Enterprises in China

Industrial agglomeration may arise from natural advantages or knowledge spillovers (Ellison and Glaeser, 1997). In transitional economies like China, institutions and policies are additional driving forces (He et al., 2008). Given the significant foreign presence in many Chinese industries, the co-agglomeration of foreign and domestic enterprises would be one of the critical driving forces of industrial agglomeration in China. There are good reasons for the co-agglomeration of foreign and domestic enterprises. As Shaver (1998) argued that similar locational patterns between foreign and domestic establishments can be observed when the drivers of agglomeration are industry-specific. When production factors are geographically concentrated, there are strong incentives for both foreign and domestic enterprises to locate near their inputs due to cost considerations. Because of transportation costs, economic factors might motivate firms to locate close to the purchasers of their products. The cost considerations would motivate foreign and domestic enterprises to co-agglomerate in similar locations.

Localization economies motivate foreign enterprises to locate in regions where an industry is already concentrated, resulting in co-agglomeration. Foreign manufacturing investments in the United States were attracted to the existing industrial concentrations (Ó hUallacháin and Reid, 1996). Japanese firms mimic the location patterns of domestic investors in the same sector in the United States at the state level (Head et al., 1995, 1999). Guimaraes et al. (2000) found that the share of manufacturing employment in the same three-digit SIC as the investor increased the probability that a foreign manufacturing firm located in a particular region in Portugal. In China, Bederbos and Carree (2002) found that Japanese electronic firms favor regions with strong presence of electronic industry. Using data for Korean firms investing in China, Chang and Park (2005) found stronger network externalities from firms in the same industry than from those of different industries.

The local content requirements may further stimulate foreign enterprises to locate in the existing industrial agglomerations and lead to the co-agglomeration of foreign and domestic enterprises in China (Sit and Liu, 2000). For instance, the 1994 China Automotive Industry Policy set clear requirements on the formation of joint ventures with foreign partners. Both joint ventures and domestic firms producing imported vehicle models must undertake localization to raise the contribution of local parts and

processes in assembled vehicles. New assembly joint ventures are required to have a start up local content of 40%. The local content requirement has stimulated the localization of out-sourcing in assembly joint ventures. The two joint ventures of VW in Shanghai and Changchun purchase more than 90% and 85% percent of their out-sourcing parts locally (Sit and Liu, 2000). Eberhardt et al. (2004) conducted face to face interviews with managers in 27 UK-owned operations in China and found that 52% of the firms interviewed are sourcing in excess of 61% of their components and raw materials from local suppliers and 26% source between 80 and 100%.

There is also significant evidence to show that foreign enterprises have strong technology and knowledge spillover effects to domestic firms in China, which may stimulate the co-agglomeration of foreign and domestic firms. Li et al. (2001) found that collective and private-owned enterprises benefit from demonstration and contagion effects from foreign presence and productivity gains of state-owned enterprises largely come from competition with foreign firms. Liu (2002) found that FDI has large and significant spillover effects in that it raises both the level and growth rate of productivity of manufacturing industries in the domestic sector in Shenzhen. Buckley et al. (2002) reported that foreign enterprises generate technological and international market access spillover benefits for Chinese firms. Liu (2008) found that an increase in FDI at the four digit industry level raises the long-term rate of productivity growth of domestic firms in the same industry and spillovers through backward and forward linkages between industries at the two digit level have similar effects on the productivity of domestic firms. The technology and productivity gains would stimulate domestic enterprises to co-agglomerate with foreign enterprises. That occurs more often in competitive and market-driven industries.

However, the strong trend of geographical agglomeration of foreign enterprises in China would discourage the co-agglomeration of foreign and domestic enterprises. Foreign firms face disadvantages owing to their lack of local knowledge of social, political and economic conditions in a host economy (He, 2002). Foreign investors in transitional economies are confronted with operational risks and uncertainties as the rules of the game in these economies are different from those in developed market economies (Luo, 1997). Information and knowledge spillovers among foreign firms can attenuate the disadvantages and business uncertainties (Kinoshita and Mody, 2001). Foreign investors may seek information concerning the functioning of labor markets, the regulatory policies, and partnership selection strategies by contacting with other foreign investors. They can acquire information on how to access the local labor force, distribution channels, infrastructure, raw materials required for the conduct of business in a region through direct investment experiences or by learning from other foreign investors. Information spillovers among foreign investors would motivate foreign enterprises to agglomerate. Familiarity with a market reduces the costs of serving it, and this, in turn, increases the possibility that a foreign firm will serve that market through direct investments (Cui, 1998). Multinationals' sequential investments further stimulate the geographical agglomeration of foreign enterprises (Chung and Song, 2004; Chang and Park, 2005).

In transitional economies like China, foreign investors may imitate each other's location choices due to business uncertainties and risks. Since foreign investors face greater uncertainties than local firms in the host country, they may interpret the presence of foreign firms as a positive signal of a location's attractiveness (Liu, 1998). Henisz and Delios (2001) reported that Japanese firms lacking international experience relied more heavily on the past international expansion decisions of other firms in their reference group as cues for their own entry decisions. Chung and Song (2004) found that Japanese electronics firms in the United States tended to co-locate with other Japanese firms when they had less prior experience. In China, Sun and Wen (2007) argued that imitative location behaviors result in the over-concentration of foreign R&D in Beijing and Shanghai.

Strong industrial linkages among foreign firms would also generate incentives for them to locate in proximity to each other. Smith and Florida (1994) found Japanese auto-related parts suppliers tend to locate near Japanese assembly plants in the United States. Head et al. (1995) showed the strong co-location of Japanese affiliates in the same region due to the vertical linkages between affiliates within a Japanese group. Yeung et al. (2006) reported that the Xingwang Industrial Park in Beijing is comprised of Nokia-Capital (the assembler) and up to 30 major suppliers which are foreign firms to be coordinated by one logistics agent. Amity and Javorcik (2008) found the significant effect of forward and backward linkages in a multinational firm's location choice across Chinese provinces. Firms choose to locate in a region where they can easily supply their intermediate goods to others or purchase intermediate goods from other firms.

Foreign enterprises from the same country of origin and the same business group tend to co-agglomerate in the host economies in China (Bederbos and Carree 2002; He, 2003; Chang and Park, 2005). Foreign firms may find it easy to communicate with fellow nationals and are likely to have frequent contacts and opportunities for information exchange. Maintenance of established trading relationships, easy information exchanges, and imitation of the behavior of national corporation leaders draw firms to locate in specific regions in host economies. He (2003) found that new foreign manufacturers in China are inclined to choose locations favored by their fellow pioneers. Korean firms also tend to concentrate in the same regions in China (Chang and Park, 2005). There may be externalities within firms in the same business group, such as Japanese Keiretsu. Member firms within vertical Keiretsu or the "core" firm itself often manufacture specialized components of which the design specification is determined in close cooperation with other member firms. Economies of scale in the production of specific components can be reaped with larger Keiretsu activities in the location, attracting further Keiretsu investments. Bederbos and Carree (2002) found that the number of electronics plants belonging to the same vertical keiretsu in a region is significantly and positively related to the probability that Japanese electronics firms enter the region in China, confirming the Keiretsu agglomeration. Korean firms in China also follow their member firms in the same business group when choosing locations (Chang and Park, 2005).

Overall, foreign enterprises have good reasons to highly agglomerate in certain

places due to foreign-specific agglomerations, which would significantly discourage the co-agglomeration of foreign and domestic enterprises in China. In addition, the disadvantages foreign enterprises face in the host economies and ownership advantages they possess may result in different locational patterns from domestic enterprises (Shaver, 1998). Foreign firms face disadvantages in a host economy compared to domestic firms and offset these disadvantages by bringing with them firm-specific advantages or intangible assets. Because of disadvantages that foreign firms face or the intangible assets that possess, they might be attracted to regions with different characteristics compared to their domestic counterparts (Co, 2002).

Finally, foreign enterprises are latecomers to an industry compared to domestic enterprises since they are only allowed to enter China from the late 1970s. China's regional-oriented open door policy and the evolutionary transition process of marketization, globalization and decentralization have gradually improved its investment climates (He et al., 2008). Market and global forces largely drive the locations of some liberalized and globalized industries. The optimal locations for industries in China have shifted to the coastal region, resulting in different locational patterns with domestic enterprises. Moreover, most foreign investors enter China through Greenfield investments by establishing joint ventures or wholly foreign-owned enterprises, leading to dissimilar locations from domestic enterprises. In a word, foreign and domestic enterprises within an industry may or may not share similar locations in China since there are forces driving their co-agglomeration and also forces discouraging it. The following session is to describe and interpret the co-agglomeration of foreign and domestic enterprises in China.

Data Sources and Methods

Data are compiled from the Annual Survey of Industrial Firms in 2005, which is conducted by the State Statistics Bureau of China and covers all Chinese industrial state-owned enterprises and non-state-owned enterprises with annual sales of five millions RMB or more. The dataset provides detailed information on firms' identification, location, capital structure, ownership, total profits, total employees, total shipments, exported shipments, and intermediate inputs among others.

Following Wen (2004), this study applies the widely applied Gini coefficient to quantify the geographical agglomeration of foreign and domestic enterprises. The Gini coefficient for each industry i is computed as follows:

$$G_i = \frac{1}{2n^2 \bar{s}_i} \sum_{k=1}^n \sum_{j=1}^n |s_{ij} - s_{ik}|$$

where s_{ij} is the share of industry i in prefecture j , s_{ik} is the share of industry i in prefecture k , n is the number of prefectures and \bar{s}_i is the mean of shares. The industrial Gini coefficient is equal to twice the area between a 45° line and a Lorenz curve. For each industry i , the Lorenz curve is derived by ranking s_{ij} in descending

order and plotting its cumulative on the vertical axis against the cumulative of the number of provinces on the horizontal axis (with each interval having the same width, equal to $1/n$). The closer the distribution of industry i is to a uniform distribution, the smaller the index is. If an industry is equally distributed across all prefectures, the index will equal zero. An index close to one suggests that an industry is entirely concentrated in one prefecture.

This study investigates the co-agglomeration of foreign and domestic enterprises at the prefecture level to understand the formation of industrial agglomeration in China. We apply the location similarity index to quantify the extent that foreign and domestic enterprises in an industry may share similar locations,

$$COAGG = \frac{\sum_{i=1}^N D_i F_i}{\sqrt{\sum_{i=1}^N D_i^2 \sum_{i=1}^N F_i^2}}$$

where D_i and F_i are the gross outputs of foreign and domestic enterprises in the industry considered in prefecture i .

To further understand why foreign and domestic enterprises in some industries are more likely to share similar locations, we perform a systematic test of the determinants of co-agglomeration of foreign and domestic enterprises. First, based on the theoretical discussion, foreign and domestic enterprises co-agglomerate in similar locations to share immobile resource inputs. To test the argument, this study introduces two dummy variables. One is for sectors with more than 5% of intermediate inputs in total inputs from metal and nonmetal mineral mining industries (MINE5). The other is for sectors with more than 5% of intermediate inputs in total inputs from primary industries (AGRI5). Both variables are expected to have positive regression coefficients.

Second, foreign and domestic enterprises may or may not co-agglomerate due to the influence of external economies. Strong foreign-specific agglomerations associated with information spillovers, business linkages and locational imitations among foreign enterprises may discourage the co-agglomeration of foreign and domestic enterprises. Meanwhile, localization economies would stimulate foreign enterprises to locate in regions with a large number of domestic enterprises, leading to the co-agglomeration of foreign and domestic enterprises. To test the propositions, we introduce the extent of agglomeration of foreign enterprises (FAGG10) and domestic enterprises (DAGG10) in the models. Both variables are the share of industrial output in the top ten cities. The expected signs of the coefficients on FAGG10 and DAGG10 are negative and positive, respectively. Specifically, strong localized business linkages among foreign enterprises would discourage the co-agglomeration of foreign and domestic enterprises while business linkages between foreign and domestic enterprises would stimulate their co-agglomeration. Following Javorcik (2004), we measure the business linkages among foreign enterprises as *Horizontal_FDI*, *Upstream_FDI* and *Downstream_FDI*.

Horizontal_FDI _{j} = $Y_j_Foreign / Y_j_All$, where $Y_j_Foreign$ stands for

industrial output by foreign enterprises in industry j , Y_{j_All} is the gross industrial output of industry j . $Horizontal_FDI_j$ captures the extent of foreign presence in industry j and horizontal linkages and is expected to have a positive regression coefficient.

$Downstream_FDI_i$ is a proxy for foreign presence in industries that are being supplied by industry i . It captures the extent of potential contacts between domestic suppliers and foreign enterprises. It is defined as

$Downstream_FDI_i = \sum a_{ji} Horizontal_FDI_j$ where a_{ji} represents for the proportion of industry j 's output supplied to industry i taken from the 2002 input output matrix of China. The proportion is calculated excluding products supplied for final consumption but including imports of intermediate products. Inputs supplied within the industry are not included since this effect is already captured by the $Horizontal_FDI$ variable. The greater the foreign presence in industries supplied by industry j and the larger the share of intermediates supplied to industries with foreign presence, the higher value of the variable.

$Upstream_FDI_i$ is defined as the weighted share of output in upstream industries produced by foreign enterprises. As only intermediates sold in the domestic market are relevant to this study, goods produced by foreign enterprises for exports are excluded,

$$Upstream_FDI_i = \sum \sigma_{ij} (Y_{j_Foreign} - Export_{j_Foreign}) / (Y_{j_All} - Export_{j_All})$$

where σ_{ij} is the share of inputs purchased by industry i from j in total inputs sourced by industry i . For the same reason as before, inputs purchased within the industry are excluded. $Export_{j_Foreign}$ is the exports by foreign enterprises in industry j ,

$Export_{j_All}$ is the total exports of industry j .

In addition, technology spillovers from foreign enterprises may stimulate the co-agglomeration of foreign and domestic enterprises. As a consequence, spillover effects could equalize the labor productivity of foreign and domestic enterprises. This study applies the ratio of value added per worker among foreign enterprises to that among domestic enterprises (FDPROD) to test the influence of spillover effects on the co-agglomeration of foreign and domestic enterprises. The expected sign on the coefficient of FDPROD is negative.

Third, foreign and domestic enterprises in an industry may significantly differ in many aspects, leading to different locational patterns. We apply several variables to quantify the differences of industrial attributes. The first is the ratio of the average number of workers per enterprise among foreign enterprises to that among domestic enterprises (FDSIZE), quantifying the differences in ownership advantages between foreign and domestic enterprises. The second is the ratio of the fixed assets per worker in foreign enterprises to that in domestic enterprises (FDFIX), which measures the differences in equipment and technology between foreign and domestic enterprises.

The third is the ratio of the share of exports in industrial output among foreign enterprises to that among domestic enterprises (FDEXPT), which indicates differences in market-orientation between foreign and domestic enterprises. The last is the ratio of value added tax in sales revenues among foreign enterprises to that among domestic enterprises (FDTAX), which measures the differences in tax contribution and possibility of local protection between foreign and domestic enterprises. The differences in industrial attributes between foreign and domestic enterprises in an industry would lead to different locational patterns. Therefore, all four variables expect negative coefficients.

Last, in a transitional economy like China, policies may influence the locations of foreign and domestic enterprises. To study the possible impact of industrial policies, we introduce two variables in the model. The first (FAVOR) is a dummy variable for industries encouraging the utilization of foreign investment according to the 2002 *Catalogue for the Guidance of Foreign Investment Industries*. The encouraged industries are key strategic industries and local governments would favor both foreign and domestic investments, leading to their co-agglomeration. The second (TAX) is the ratio of value added tax in sales revenues. Regional decentralization results in fierce interregional competition and local protectionism, and local governments typically have strong incentives to develop industries, which significantly contribute to their local revenues (Bai et al., 2004). High tax contribution would lead to the co-agglomeration of foreign and domestic enterprises. The dependent and independent variables are summarized in Table 1.

Since the co-agglomeration index has values ranging between 0 and 1, we conduct a logistic transformation of the dependent variable and consider the following function,

$$\begin{aligned} \ln \frac{Coagg}{1-Coagg} = & \beta_0 + \beta_1 AGR5 + \beta_2 MINE5 + \beta_3 FAGG10 + \beta_4 DAGG10 + \beta_5 Horizontal_FDI \\ & + \beta_6 Downstream_FDI + \beta_7 Upstream_FDI + \beta_8 FDPROD + \beta_9 LnSIZE + \beta_{10} FDSIZE + \beta_{11} FDFIX \\ & + \beta_{12} FDEXPT + \beta_{13} FDTAX + \beta_{14} FAVOR + \beta_{15} TAX + \varepsilon \end{aligned}$$

where β_i stands for the regression coefficient and ε is the residual. We apply the OLS method to estimate the parameters in the model.

Geographical Agglomeration and Co-agglomeration of Foreign and Domestic Enterprises in Chinese manufacturing industries

To understand the locational patterns of Chinese manufacturing industries, we map the gross industrial output at the prefecture level. Figure 1 compares the spatial distribution of industrial output of foreign and domestic enterprises. Domestic enterprises are clearly more geographically scattered than foreign enterprises. Compared with domestic enterprises, foreign enterprises are highly agglomerated along the coastal region, particularly the Pearl River Delta, the Yangtze River Delta and the Bohai Sea Rim. Meanwhile, foreign enterprises concentrate in places hosting significant domestic enterprises. Using the Lorenz Curve, Figure 2 contrasts the locational dissimilarity of foreign and domestic enterprises, confirming that foreign enterprises are more geographically agglomerated.

We compute the Gini coefficient of industrial output for each two-digit manufacturing industry at the prefecture level in 2005 to quantify industrial agglomeration (Table 2). Foreign enterprises have larger values of Gini coefficients in all industries. Foreign enterprises are significantly more agglomerated than their domestic counterparts in the following industries: food processing and manufacturing, beverage manufacturing, timber processing, paper making and products, printing and copying, chemical materials and products, medical and pharmaceutical products, non-metal mineral products, ferrous metal smelting and pressing, non-ferrous metal smelting and pressing, general purpose machinery, and special purpose machinery. Foreign enterprises in those resource-based or resource intensive industries are apparently more concentrated in the coastal region. Foreign investment in machinery has also deviated from the traditional industrial bases such as the Northeast China to the coastal cities. Meanwhile, foreign and domestic enterprises in the following industries show fairly similar extent of industrial agglomeration, including cultural, education and sporting goods, chemical fiber, textiles, clothing and other fibers, leather and fur, rubber products, electrical machinery and equipment, electronics and telecommunication equipment, instruments, meters and office machinery. Enterprises in those industries are mainly driven by market and global forces to increasingly agglomerate in the coastal region, which has the best access to the international markets and enjoys location and institutional advantages.

Foreign and domestic enterprises in an industry may or may not agglomerate in similar locations. We further compute the similarity index of locational distributions of foreign and domestic enterprises (see Figure 3). Significant industrial variations exist in the co-agglomeration of foreign and domestic enterprises among Chinese industries. Foreign enterprises are more likely to share similar locations with their domestic counterparts in the following industries, including food processing, textiles, clothing and other fiber, cultural, education and sports goods, medical and pharmaceutical products, non-metal mineral products, metal mineral products, electrical machinery and equipment, electronics and telecommunication equipment. Those industries are either resource-based or highly globalized or liberalized. Foreign and domestic enterprises may share localized resource inputs in resource-based industries and share the coastal location advantages in the globalized industries, leading to their co-agglomerations. Foreign investment has enhanced the traditional industrial bases by investing in those industries. The similarity indices of gross industrial outputs in 2000 and 2005 indicate that foreign and domestic enterprises are increasingly co-agglomerated during the period of 2000-2005 in most industries but beverage manufacturing, timber processing, furniture making, paper making and products, and special purpose machinery. Meanwhile, foreign enterprises are less likely to co-agglomerate with domestic enterprises in beverage manufacturing, tobacco processing, petroleum refining and coking, chemical fibers, rubber products, non-ferrous metal smelting and pressing, and instruments, meters and office machinery. The utilization of foreign direct investment has created new production bases for those industries.

Larger differences in the co-agglomeration of foreign and domestic enterprises

exist among the three-digit industries (see Figure 4). The industrial variations of co-agglomeration of foreign and domestic enterprises almost follow the normal distribution. The locational similarity index ranges from 0.0019 to 0.9399. The least and most co-agglomerated three digit industries are reported in Table 3.

Foreign and domestic enterprises are most likely to concentrate in similar locations in silk textiles, aquatic products, knitwear and knit, brick, stone and other construction materials, with the co-agglomeration index greater than 0.80. Among the most co-agglomerated sectors, many are resource-based or resource-intensive sectors, in which both foreign and domestic enterprises utilize similar localized resources. Natural advantages may drive the co-agglomeration of foreign and domestic enterprises. There may be strong industrial linkages between foreign and domestic enterprises in transportation equipment and device, general-purpose components and parts, wire, cable and electrical equipment, leading to co-agglomeration. There is almost no co-agglomeration between foreign and domestic enterprises in pulp making, other tobacco products, cured tobacco, alcohol making and cellulose, fiber materials and fiber products. Indeed, there is little foreign investment in those industries. Among the least co-agglomerated sectors, many are heavily dependent on intermediate inputs from the agriculture, forestry, livestock and fishery. The utilization of foreign investment has indeed restructured the geography of the least co-agglomerated industries, facilitating the formation of new production bases.

Statistical Results

To understand industrial variations in the co-agglomeration of foreign and domestic enterprises, we perform a systematic test on the significance of the theoretical effects discussed above. Table 4 presents the correlation coefficients between explanatory variables, showing some moderate correlations. The coefficient between FAGG10 and DAGG10 is 0.602. The coefficients between Horizontal_FDI and FDSIZE, and between FDFIX and FDPROD, are 0.668 and 0.533, respectively. Other correlation coefficients are fairly small. We first separately test the significance of resource inputs (Model 1), agglomeration economies (Model 2) and differences in industrial attributes (Model 3). In the Model 4, we test the simultaneous impacts of all possible effects (Table 5). The Breusch-Pagan tests indicate the existence of heteroskedasticity in the estimations and the results are corrected for heteroskedasticity.

The statistical results do not support the argument that sharing immobile results leads to the co-agglomeration of foreign and domestic enterprises within an industry. The variable MINE5 is insignificant, indicating that sharing metal and nonmetal mineral inputs does not necessarily lead to the co-agglomeration of foreign and domestic enterprises since foreign enterprises may rely on the imported mineral inputs. However, the coefficient on AGRI5 is highly significant but with an unexpected sign, implying that foreign and domestic enterprises in sectors heavily dependent on inputs from primary industries are located in different places. In model 4, the standardized coefficient on AGRI5 is -0.316, ranking the second among all explanatory variables. There are some exceptions with co-agglomeration indices greater than 0.70 in those agricultural-goods based industries, including vegetable,

fruit and nuts processing (0.7564), aquatic products processing (0.9115) and silk textiles (0.9399). Foreign and domestic enterprises in food manufacturing, beverage manufacturing, furniture making, medical and pharmaceutical products indeed show different locational patterns, with co-agglomeration indices smaller 0.40. As latecomers in those industries, foreign enterprises are more likely to concentrate in the coastal region and the central cities than domestic enterprises, which may develop based on localized resources (He et al., 2008). The coastal region is also the core market for those industries. Utilization of foreign investment in those industries has created new production bases and reshaped China's economic geography.

There is strong evidence showing that the geographical agglomeration of foreign enterprises would significantly discourage the co-agglomeration of foreign and domestic enterprises within an industry. The coefficient on FAGG10 is negative and highly significant, implying that more agglomeration of foreign enterprises is associated with less co-agglomeration of foreign and domestic enterprises. In the Model 4, the standardized coefficient on FAGG10 is also the largest. Facing a variety of disadvantages, foreign enterprises have strong incentives to take advantages of foreign-specific agglomeration, which may derive from information spillovers, business linkages and the rational imitation locational behaviors among foreign enterprises. Foreign-specific agglomeration economies stimulate the disproportionate geographical agglomeration of foreign enterprises, leading to different locational patterns from the domestic enterprises (He, 2003; Amiti and Javorcik, 2008). The finding suggests that foreign investment contributes to industrial agglomeration in China mainly by clustering themselves.

The coefficient on DAGG10 is expectedly positive but insignificant, indicating that localization economies may be a potential driver of the co-agglomeration of foreign and domestic enterprises within an industry. The negative coefficient on LnSIZE suggest that foreign and domestic enterprises may locate in similar places when an industry is dominated by small and medium enterprises, confirming the importance of localization economies in driving the co-agglomeration of foreign and domestic enterprises. Localization economies may arise from sharing labor pool, information spillovers and business linkages. Results suggest that business linkages may not lead to the co-agglomeration of foreign and domestic enterprises. Sharing labor pool and information spillover effects may be the drivers of co-agglomeration. *Downstream_FDI*, quantifying foreign enterprises' business linkages with their customers and have an insignificant coefficient while *Upstream_FDI* measures foreign enterprises' linkages with their suppliers and has a surprisingly significant negative coefficient. Unexpectedly, strong forward linkages would discourage the co-agglomeration of foreign and domestic enterprises. On the one hand, foreign enterprises may largely purchase localized supplies from other foreign enterprises, leading to the geographical agglomeration of foreign enterprises. The development of automobile and electronics and telecommunication equipment manufacturing industries in Beijing illustrates the importance of foreign suppliers. For instance, the Shunyi district in Beijing has attracted more than 30 suppliers of car components and parts since the entry of Korean Hyundai in 2002. Some are from South Korea and

have established strong business linkages with the Korean Hyundai (He, 2008). The Xinwang industrial park in Beijing Economic and Technology Zone houses a manufacturing cluster of mobile telecommunication equipment centered on Nokia and more than 30 foreign suppliers (Yeung *et al.*, 2006). On the other hand, foreign enterprises may largely import components and parts from abroad, discouraging the importance of localized intermediate inputs (Krugman and Elizondo, 1996).

Strong vertical linkages along a value chain may not result in the intra-industry co-agglomeration of foreign and domestic enterprises. Horizontal linkages of foreign enterprises however may motivate the co-agglomeration of foreign and domestic enterprises. The coefficient on the variable of *Horizontal_FDI* is positive and highly significant, suggesting that the share of industrial output by foreign enterprises is positively associated with co-agglomeration of foreign and domestic enterprises in an industry. Strong presence of foreign investment in an industry has significant knowledge spillover effects, and domestic enterprises may be motivated to benefit from being located closer to foreign enterprises. Industries with significant foreign participation are more liberalized and globalized, and both foreign and domestic enterprises are driven by market and global forces to the coastal region. The negative coefficient on *FDPROD* indicates that smaller productivity differences between foreign and domestic enterprises are associated with more co-agglomeration, further confirming the role of technology and knowledge spillover effects in driving the co-agglomeration of foreign and domestic enterprises. Larger differences in productivity however discourage the co-agglomeration of foreign and domestic enterprises in an industry. Foreign and domestic enterprises may specialize in different products and be furnished with different technologies and equipment, leading to different productivity and locational requirements (Shaver, 1998).

There is some evidence to support the argument that different attributes in foreign and domestic enterprises lead to different locational patterns. The coefficient on *FDFIX* is negative and significant in both Model 3 and Model 4, implying that similarity in the fixed assets per worker of foreign and domestic enterprises would lead to their co-agglomeration. Fixed assets per worker in an industry are a good proxy for equipment and technology. A larger value of fixed assets per worker in an industry corresponds to advanced equipment and technology. Utilization of similar technology and equipment encourages the co-agglomeration of foreign and domestic enterprises. A large value of *FDFIX* indicates that foreign enterprises are more capital-intensive and equipped more advanced technology, leading to different locational requirements and discouraging the co-agglomeration of foreign and domestic enterprises. Coefficients on *FDSIZE* are negative but insignificant at 0.10 significant level. Size differences between foreign and domestic enterprises may potentially discourage their co-agglomeration. The coefficient on *FDTAX* is negative and significant in the model 3 but turns positive and insignificant in the model 4. The finding indicates that tax rate may play a role in locating foreign enterprises when no agglomeration economies exist. Difference in export-intensity has no significant impact. The statistical results suggest that ownership advantages and internalization advantages held by foreign investors allow them to establish larger enterprises

equipped with better equipment and advanced technology, concentrating in different places from domestic enterprises and discouraging the co-agglomeration of foreign and enterprises.

Finally, both FAVOR and TAX have insignificant coefficients with unexpected signs. Foreign and domestic enterprises in industries favored and protected by local governments may not significantly co-agglomerate. Industries encouraging foreign investment are highly concentrated in the coastal cities, possibly leading to different locational patterns between foreign and domestic enterprises. Industries with higher tax rates are more geographically dispersed, indicating that local governments, including those in the central and western regions, have strong incentives to develop more taxable industries (Bai et al., 2004; He et al., 2008). Foreign enterprises however largely remain in the coastal cities. The different locational patterns would discourage the co-agglomeration of foreign and domestic enterprises.

Summary

The geographical agglomeration of manufacturing industries has been pervasive due to natural advantages, spillover effects and institutional advantages. The co-agglomeration of foreign and domestic enterprises may be a driving force of intra-industrial agglomeration. Theories however provide conflicting predictions about whether foreign and domestic enterprises share similar locations. Foreign and domestic enterprises may co-agglomerate due to localization economies, spillover effects and business linkages, meanwhile they may display significantly different locational patterns because of foreign-specific agglomeration and different industrial attributes.

Based on data from the Annual Survey of Industrial Firms in 2005, this study found that foreign enterprises are remarkably more agglomerated than their domestic counterparts in all two digit manufacturing industries. Foreign enterprises are more likely to share similar locations with their domestic counterparts in some resource based or globalized industries. Foreign enterprises however show significant different locational pattern from domestic enterprises in beverage manufacturing, tobacco processing, petroleum refining and coking, chemical fibers, rubber products, non-ferrous metal smelting and pressing, and instruments, meters and office machinery. The findings indicate that foreign investment has played a different role in restructuring the economic geography of individual Chinese industries.

Statistical analysis suggests that foreign-specific agglomeration and dependence on intermediate inputs from primary industries have significantly discouraged the co-agglomeration of foreign and domestic enterprises. Differences in equipment, technology and labor productivity result in distinguished locational patterns of foreign enterprises from domestic enterprises within an industry. Foreign and domestic enterprises in industries dominated by small and medium enterprises and with significant foreign participation are more likely to co-agglomerate in similar places. The convergence of labor productivity between foreign and domestic enterprises is also associated with their co-agglomeration. The findings suggest that external economies and knowledge spillovers drive the co-agglomeration of foreign and domestic enterprises.

The empirical findings have some policy implications. Foreign enterprises show distinguished locational behaviors in many industries and some may not value the existing industrial bases when choosing locations. Industrial specific policies need to be implemented to attract foreign investment. Cluster policy may not be efficient in drawing more foreign investment.

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Table 1 Definitions of dependent and independent variables and expected signs

Variables	Definitions	Sign
COAGG	Co-agglomeration index of foreign and domestic enterprises within three digit manufacturing industries	
AGRI5	Dummy variable, 1 for sectors with more than 5% of intermediate inputs from the primary industries, 0 for others	+
MINE5	Dummy variable, 1 for sectors with more than 5% of intermediate inputs from metal and nonmetal mineral industries	+
FAGG10	Share of industrial output by foreign enterprises in top ten cities	-
DAGG10	Share of industrial output by domestic enterprises in top ten cities	+
Horizontal_FDI	Share of industrial output by foreign enterprises in gross industrial output	+
Downstream_FDI	Backward Business linkages of foreign enterprises	+
Upstream_FDI	Forward Business linkages of foreign enterprises	+
FDPROD	Ratio of value added per worker among foreign enterprises to that among domestic enterprises	-
LnSIZE	The log of the average number of workers per enterprise	+
FDSIZE	Ratio of the average number of workers per enterprise among foreign enterprises to that among domestic enterprises	-
FDFIX	Ratio of the fixed assets per worker in foreign enterprises to that in domestic enterprises	-
FDEXPT	Ratio of the share of exports in industrial output among foreign enterprises to that among domestic enterprises	-
FDTAX	Ratio of value added tax in sales revenues among foreign enterprises to that among domestic enterprises	-
FAVOR	Dummy variable for industries encouraging the utilization of foreign investment	+
TAX	Ratio of value added tax in sales revenues	+

Table 2 Gini Coefficients at the prefecture level based on Gross Industrial Output in 2005

Sector	Code	Total	Domestic	Foreign
All manufacturing Industries		0.7304	0.6701	0.8842
Food processing	S13	0.6849	0.6634	0.8549
Food manufacturing	S14	0.7718	0.7385	0.8955
Beverage manufacturing	S15	0.7199	0.7195	0.8749
Tobacco processing	S16	0.8971	0.8972	0.9885
Textiles	S17	0.8267	0.8263	0.8899
Clothing and other fibers	S18	0.8805	0.8739	0.9089
Leather and fur products	S19	0.8860	0.8837	0.9188
Timber processing	S20	0.7590	0.7691	0.8570
Furniture making	S21	0.8778	0.8447	0.9377
Paper making and paper products	S22	0.7863	0.7570	0.9169
Printing and copying	S23	0.8405	0.8205	0.9287
Cultural, education and sports goods	S24	0.9145	0.9120	0.9369
Petroleum refining and coking	S25	0.8776	0.8779	0.9681
Chemical materials and products	S26	0.7473	0.7198	0.9088
Medical and pharmaceutical products	S27	0.7575	0.7461	0.8795
Chemical fibers	S28	0.9259	0.9368	0.9562
Rubber products	S29	0.8762	0.8803	0.9318
Plastic products	S30	0.8362	0.8036	0.9179
Non-metal mineral products	S31	0.7048	0.6871	0.8722
Ferrous metal smelting and pressing	S32	0.8087	0.8153	0.9338
Non-ferrous metal smelting and pressing	S33	0.7853	0.7947	0.9012
Metal mineral products	S34	0.8412	0.8215	0.9161
General purpose machinery	S35	0.8307	0.8116	0.9311
Special purpose machinery	S36	0.8042	0.7880	0.9214
Transportation equipment	S37	0.8650	0.8409	0.9376
Electrical machinery and equipment	S40	0.8640	0.8452	0.9281
Electronics and telecommunication equipment	S41	0.9511	0.9110	0.9640
Instruments, meters and office machinery	S42	0.9190	0.8804	0.9576

Table 3 The Least and most co-agglomerated three-digit industries by industrial output in 2005

Most Co-agglomerated Sectors	Code	Index	Least Co-agglomerated Sectors	Code	Index
Transportation equipment and other transportation device	379	0.6687	Pulp making	221	0.0019
Wire, cable, Electrical equipment	393	0.6764	Other tobacco products	169	0.0168
Arts and crafts	421	0.6860	Cured tobacco	161	0.0172
Feathers processing and products	194	0.6898	Alcohol making	151	0.0300
General purpose components and parts	358	0.6933	Cellulose, fiber materials and fiber products	281	0.1023
Cement and gypsum products	312	0.6939	Daily and medical rubber	295	0.1314
Battery	394	0.7218	Other manufacturing	429	0.1348
Textile products	175	0.7236	Veterinary drugs	275	0.1429
Plastic box and container	306	0.7378	Soft beverage	153	0.1763
Stainless steel and daily metal product	348	0.7450	Aviation and space equipment	376	0.1822
Paint, ink, pigments and similar product	264	0.7498	Instant food	143	0.1832
Ceramics products	315	0.7546	Other Agricultural product processing	139	0.1841
Vegetables, fruits and nuts processing	137	0.7564	Condiment and fermentation products	146	0.1883
Textile and apparel	181	0.7659	Oven, furnace and electric furnace	356	0.1925
Cultural products	241	0.7662	Common non-ferrous metal smelting	331	0.1955
Cap making	183	0.7694	Machinery for primary industries	367	0.2007
Brick, stone and other construction materials	313	0.8292	Grain grinding	131	0.2061
Knitwear and knit	176	0.8497	Wine making	152	0.2191
Aquatic products	136	0.9115	Bamboo and rattan furniture	212	0.2293
Silk textiles	174	0.9399	Rubber boots	296	0.2327

Table 4 Correlation Coefficients among Independent Variables

	AGRI5	MINE5	FAGG10	DAGG10	H_FDI	D_FDI	U_FDI	FDPROD	LnSIZE	FDSIZE	FDFIX	FDEXPT	FDTAX	FAVOR	TAX
AGRI5	1.000														
MINE5	-.230	1.000													
FAGG10	-.086	-.151	1.000												
DAGG10	-.040	-.202	.602	1.000											
Horizontal_FDI	-.089	-.332	.132	.272	1.000										
Downstream_FDI	.128	-.119	-.213	-.173	-.024	1.000									
Upstream_FDI	-.341	-.295	.155	.232	.442	-.102	1.000								
FDPROD	-.009	.057	.190	-.127	.009	-.059	-.137	1.000							
LnSIZE	-.096	.139	.251	.376	.134	-.220	-.044	.149	1.000						
FDSIZE	.038	-.280	.171	.209	.668	.042	.259	-.226	-.011	1.000					
FDFIX	.048	.169	-.077	-.251	-.217	.117	-.248	.533	-.061	-.335	1.000				
FDEXPT	-.236	-.056	-.012	-.181	-.010	.055	.184	-.131	-.225	.103	-.012	1.000			
FDTAX	.205	-.024	.040	-.065	-.296	-.022	-.143	.314	.165	-.353	.150	-.080	1.000		
FAVOR	-.194	.116	.016	-.045	-.112	-.220	.026	.116	.066	-.272	.037	.005	.027	1.000	
TAX	.158	.209	.001	-.196	-.388	-.074	-.215	.123	-.028	-.252	.138	-.114	.351	.057	1.000

Table 5 Regression Results for the Co-agglomeration of Gross Industrial Output

Variables	Model 1	Model 2	Model 3	Model 4	
				Coefficient	Standardized Coefficient
Constant	-0.046	3.302 ^{***}	0.667 [*]	5.642 ^{***}	
AGRI5	-0.579 ^{***}			-0.696 ^{***}	-0.316
MINE5	-0.177			0.110	0.030
FAGG10		-2.862 ^{***}		-2.876 ^{***}	-0.360
DAGG10		0.436		0.429	0.062
LnSIZE		-0.302		-0.509 ^{**}	-0.238
Downstream_FDI		-0.103		0.010	0.004
Upstream_FDI		-0.028		-0.663 ^{**}	-0.169
Horizontal_FDI		1.250 ^{***}		1.437 ^{***}	0.263
FDPROD		-0.260 [*]		-0.091	-0.064
FDSIZE			-0.105	-0.141	-0.091
FDFIX			-0.395 [*]	-0.385 ^{**}	-0.305
FDEXPT			0.027	-0.008	-0.021
FDTAX			-0.289 [*]	0.205	0.096
FAVOR				-0.006	-0.003
TAX				-11.085	-0.142
Breusch-Pagan	39.79	102.80	36.18	106.02	
F Statistics	5.42	6.459	5.101	6.257	
# of Obs.	157	157	157	157	
R ²	0.066	0.233	0.118	0.400	

Note: Results corrected for heteroskedasticity.

*, **, ***, significant at 0.10, 0.05 and 0.01 levels, respectively.

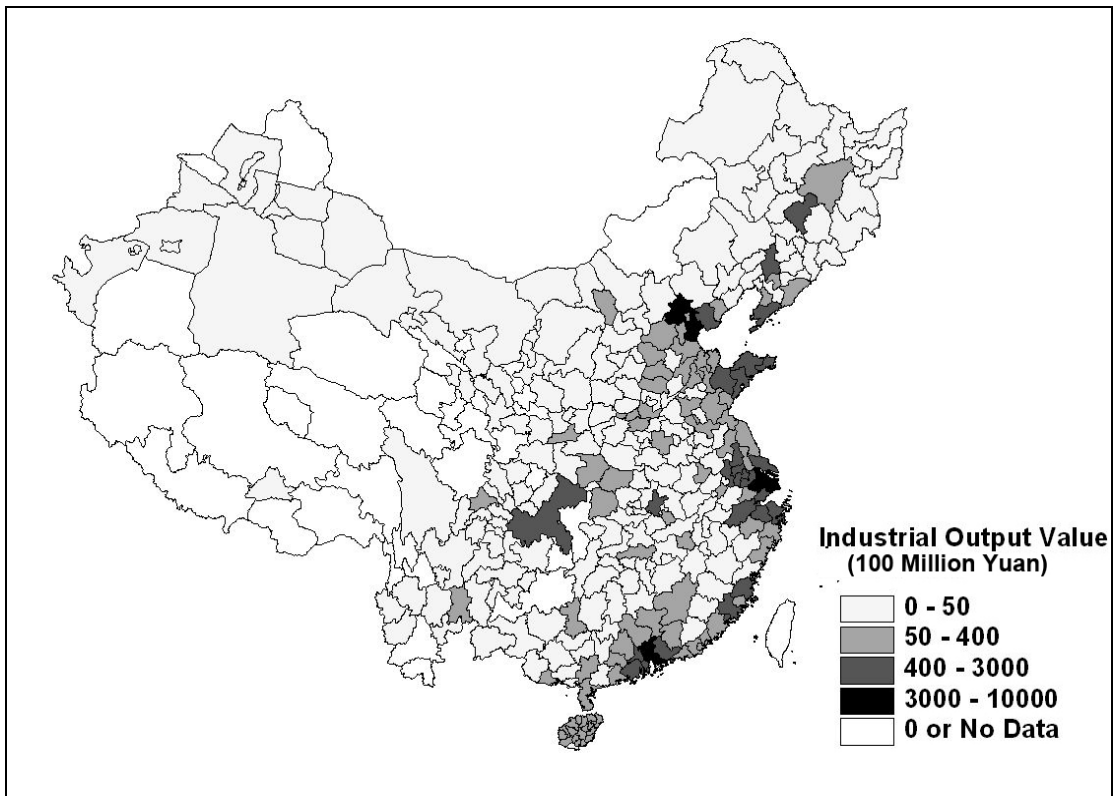
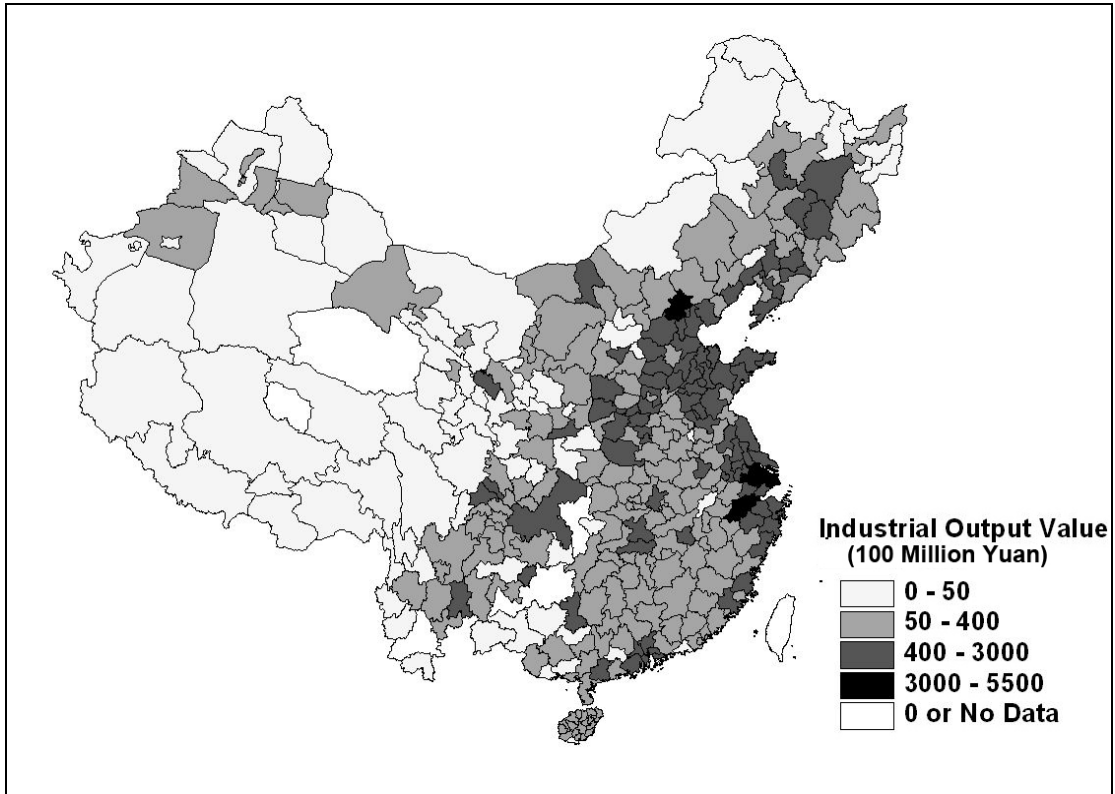


Figure 1 Spatial distribution of gross output of domestic (upper) and foreign (bottom) enterprises at the prefecture level in 2005

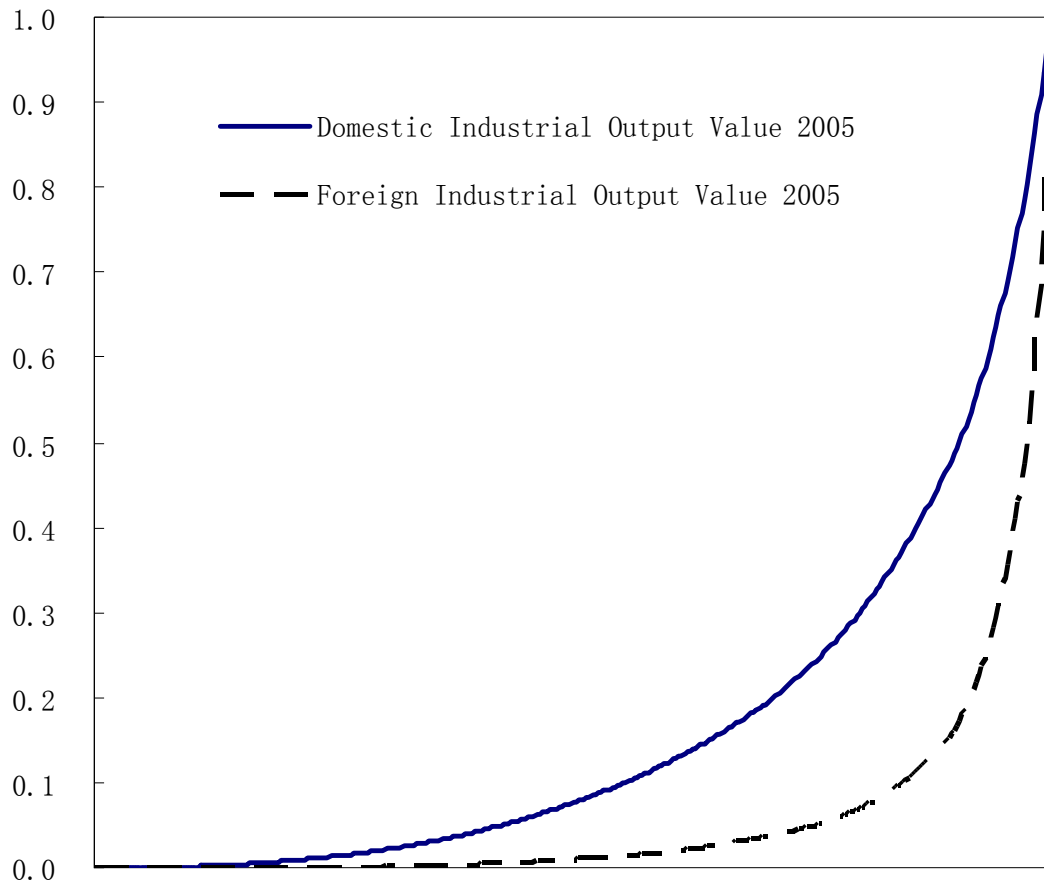


Figure 2 Lorenz Curves of Industrial Output in 2005: Foreign vs Domestic Enterprises

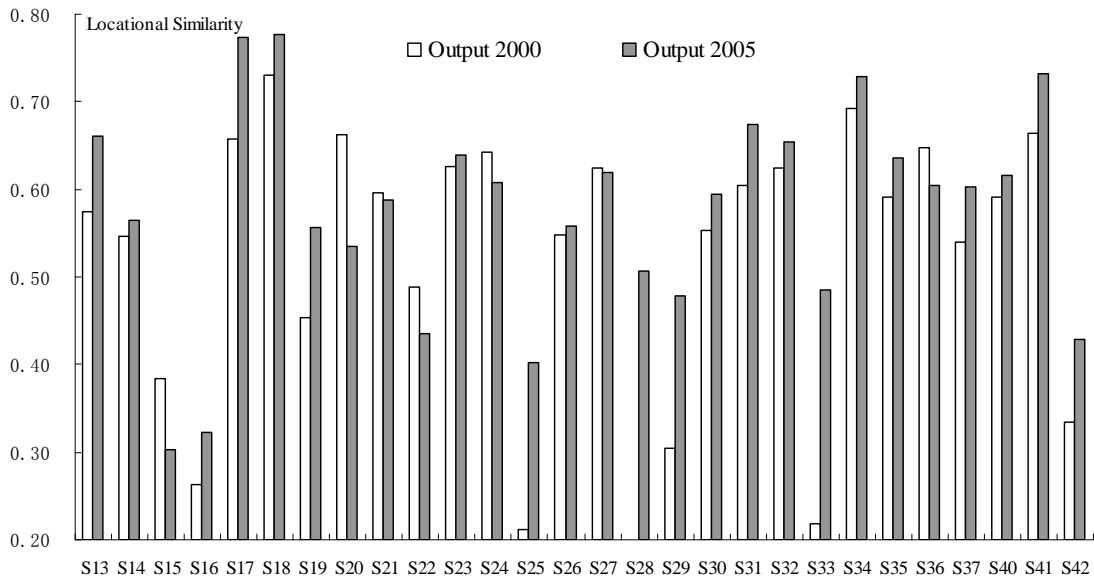


Figure 3 Locational Similarity Index based on Gross Industrial Output in 2000 and 2005

Note: The industrial code is reported in Table 2.

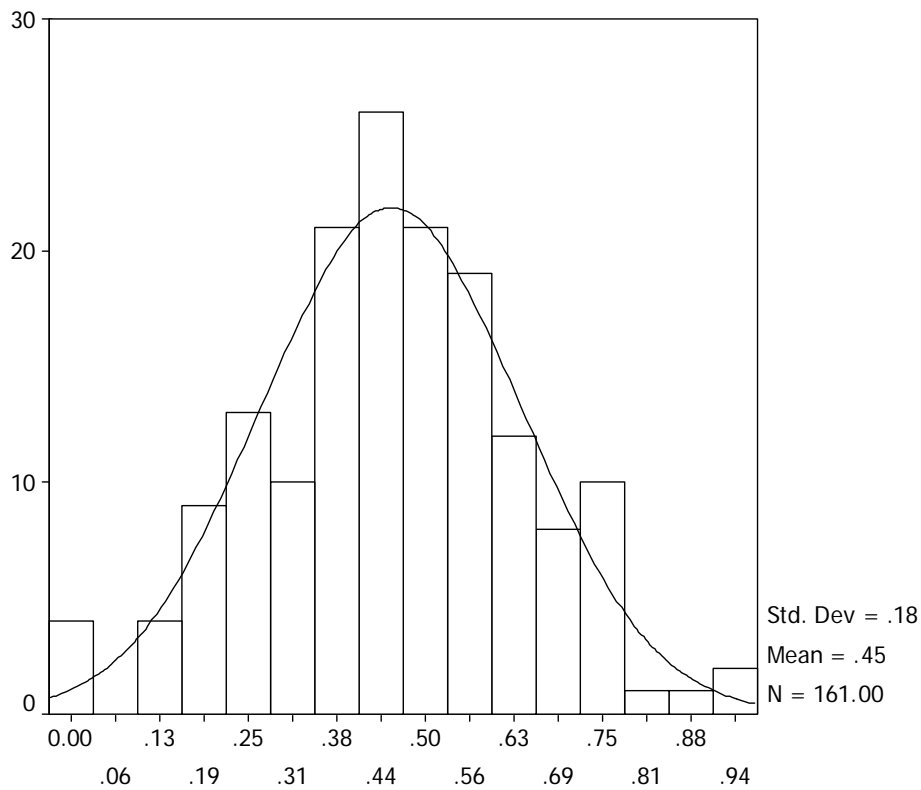


Figure 4 Frequency distribution of co-agglomeration index of industrial output of foreign and domestic enterprises at the three-digit level in 2005