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# Agglomeration and Trade with Heterogeneous Firms <sup>\*</sup>

Churen Sun<sup>†</sup> Zhihao Yu<sup>‡</sup> Tao Zhang<sup>§</sup>

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## Abstract

The paper proposes a model to investigate the influences of agglomeration on heterogeneous firms' exporting behaviors. Competition and thus selection effect caused by agglomeration forces less productive firms to exit the market while agglomeration externalities increase firms' productivity and decrease industrial fixed entry, fixed and variable exporting costs, and effective labor wage. The former decrease while the latter increase firms' exporting possibilities and sales. The model shows that agglomeration has a final positive effect on firms' exporting possibilities and sales. Higher natural-productivity firms benefit more productivity premium from agglomeration, which explains why larger and more productive firms in larger cities are more possible to export and exports more. Empirical results based on data from Chinese Industrial Enterprises between 1998 and 2007 verify the theoretical results. The paper also investigates the influences of different agglomeration patterns on firms exports, including home market effect, urban economies and competition effect and diversification effect. It shows that only localization economy exerts a positive while the other economies have a negative influence on firms' exporting behaviors.

**Keywords:** Agglomeration, Export, Productivity heterogeneity

**JEL Subject classification:** F12, R19

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## 1 Introduction

In the past three decades, China gained a rapid economic growth, with average yearly growth rate 9%. At the same time, spatial distribution of manufacturing labors and firms change significantly and they takes on apparently an agglomeration state (see Figure 1 and Figure 2 for spatial distributions of manufacturing firms and labors in 1998 and 2007, respectively, for details). It can be seen from Figure 1 and Figure 2 that East Costal China has more dense manufacturing firms and labors, and manufacturing firms and labors agglomerated gradually to East Costal China between 1998 and 2007. The agglomeration of manufacturing firms and labors generated great externality under the environment of limited capitals and technological abilities and low labor quality in China, so that locally absolute or comparative advantages in foreign trade have been created in several cities and they pushed the rapid growth of China's Export, which grew from 2.64 in 1978 to 22580.7658 billion Yuan in 2011, when China became the second large trade economy in the world. In this process, export in manufacturing industries, played an extremely important role. According to data from the World Bank, manufacturing industries occuppies 93.6 percents of China's total export. However, export in manufacturing industries in China distributes much unevenly in space, see, e.g., Figure 3, the spatial distribution of export of manufacturing industries across 283 prefecture-level cities. According to China Department of Commerce, more than 90 percents of their export occurs in Guangdong, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Beijing, Liaoning, Xinjiang, Neimenggu, and more than 96 percents of their export takes place only in Guangdong, Shanghai, Jiangsu, Zhejiang, Shandong and Beijing. Interestingly, the spatial distribution of export in manufacturing industries matches consistently with that of their labors. From Figure 2 and 3, we can see that labors and export in Chinese manufacturing industries agglomerate consistently to East Costal China and their distributional configurations are very similar. This consistence implies that there's an intrinsic relationship between agglomeration and export, which, however, has not been systematically explored.

That the spatial distribution of China's export across space is uneven can not be explained directly by traditional trade theories. The Ricardian Model, the HO Theory and the New Trade Theory all explain countries' but not regional trade pattern. They all assume that factors distribute evenly in a country's internal space and thus trade shall distributes evenly across space. If we consider regions in China as independent countries, it's difficult for us to deal with the fact that factors such as labors moves freely between regions, which, however, is prohibited in these theories. Even if we allow uneven distribution of factors in a country's internal space,

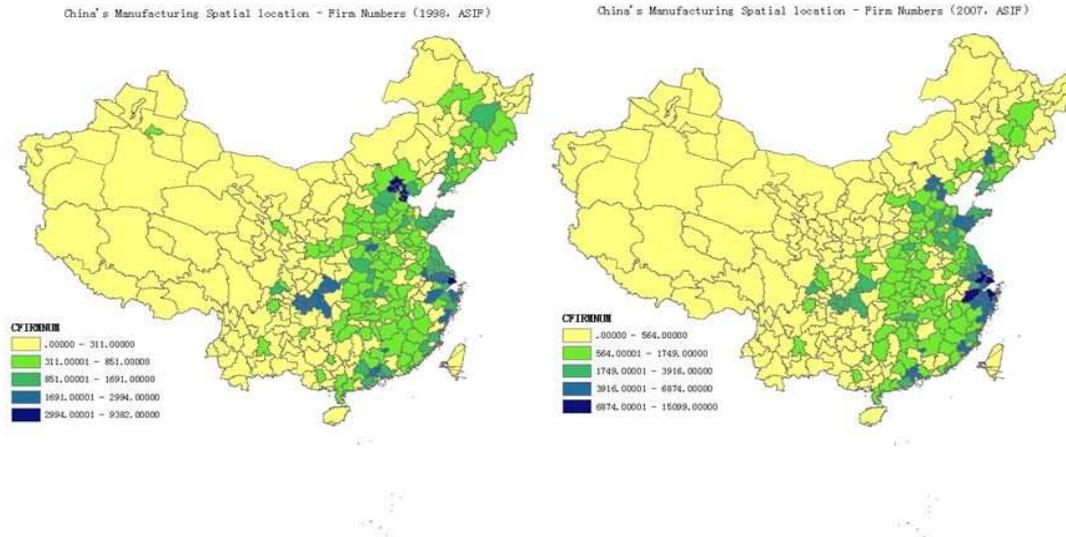


Figure 1: Spatial distributions of manufacturing firms above scale 5 million Yuan in 1998 and 2007

**Note:** The geographic unit is prefecture-level city. 283 prefecture-level cities are included in the above figure.

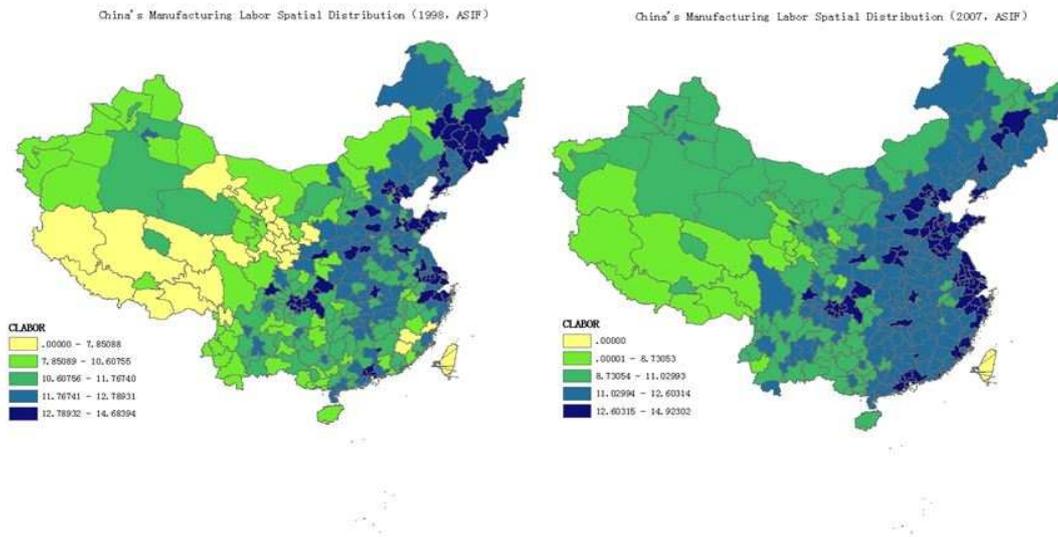


Figure 2: Spatial distributions of manufacturing labors above scale 5 million Yuan in 1998 and 2007

**Note:** The geographic unit is prefecture-level city. 283 prefecture-level cities are included in the above figure.

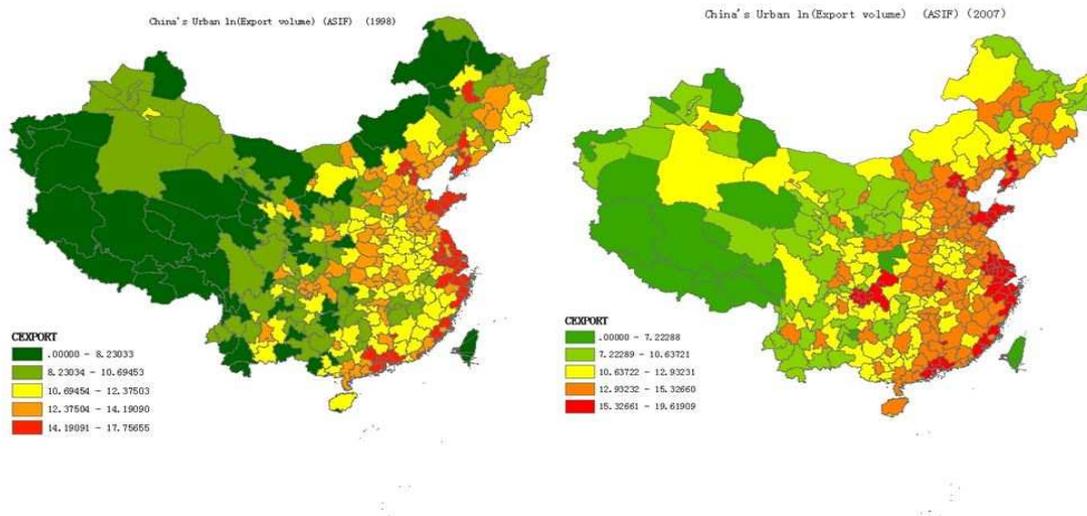


Figure 3: Spatial distributions of manufacturing export above scale 5 million Yuan in 1998 and 2007

**Note:** The geographic unit is prefecture-level city. 283 prefecture-level cities are included in the above figure.

firms' exporting behaviors, including exporting possibilities and sales, shall be the same, if the distributions of firm productivity in different regions and industrial fixed production, fixed and variable exporting costs are the same, according to the 'New' New Trade theory developed in Melitz (2003) and Bernard et al. (2003). However, as we will show, firms' exporting behaviors in different cities are different. Figure 4 and 5 show, respectively, that firms' ex ante exporting possibility (calculated as the ratio of number of exporting firms over that of total firms) and average exporting sale (calculated as the ratio of total exporting sales over the number of exporting firms) in cities are increasing in the scale of manufacturing labor.<sup>1</sup> Though this may be explained by heterogeneity in industrial fixed production, fixed and variable exporting costs across cities, these costs can not be specifically observed and thus the explanation is not testable.

The spatial distribution of firms' exporting behaviors connects to the fields of international trade and 'New' New Economic Geography. The pioneered work of the "New Economic Geography", Krugman (1991), constructs a novel model to examine the relationship between transportation cost and regional specialization pat-

<sup>1</sup>We can show that firms' ex ante exporting possibility and average exporting sale in cities are also increasing in the density of manufacturing labor, where density is computed using cities' total land area, see Figure 8 and 9 in the Appendix. In fact, they are also increasing city population and population density, we ignore the corresponding figures here because of pages limited.

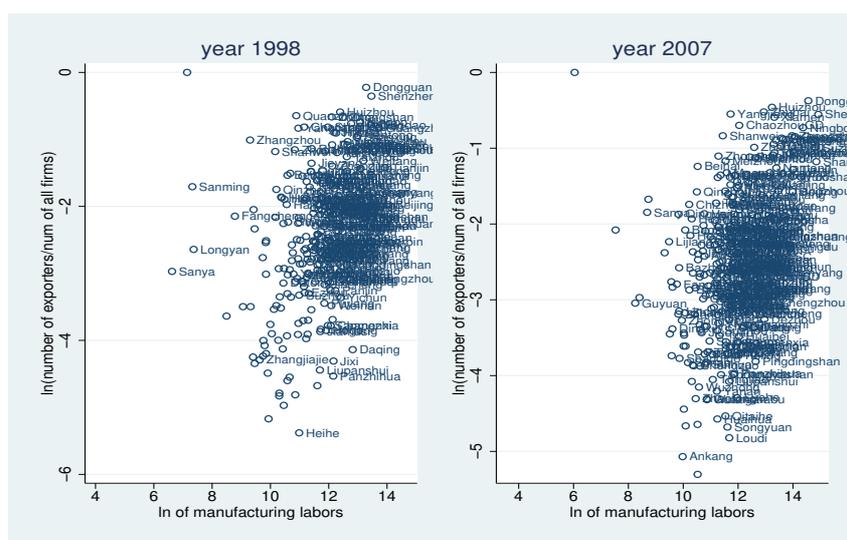


Figure 4: Firms' ex ante exporting possibility and manufacturing labors in 1998 and 2007 across prefecture-level cities

**Note:** The geographic unit is prefecture-level city. 283 prefecture-level cities are included in the above figure.

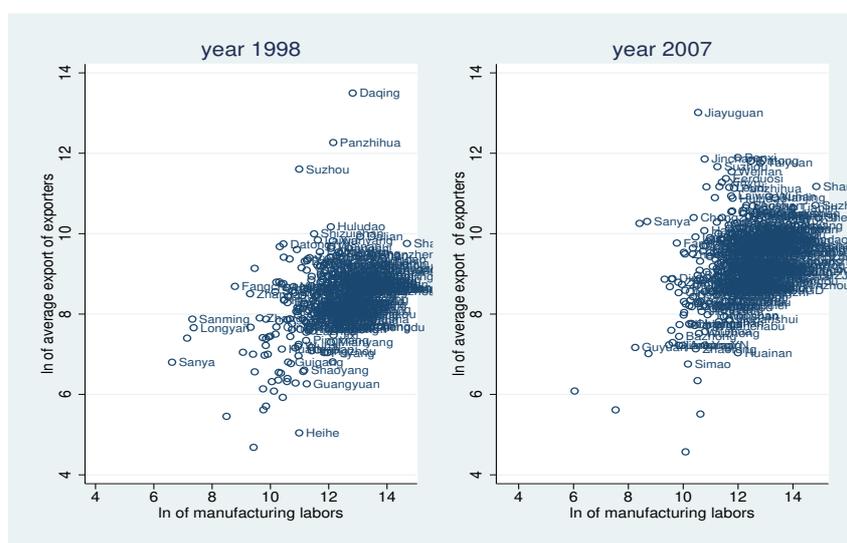


Figure 5: Incumbents' average exporting sale and manufacturing labors in 1998 and 2007 across prefecture-level cities

**Note:** The geographic unit is prefecture-level city. 283 prefecture-level cities are included in the above figure.

tern, which triggers the research on the relationship between agglomeration and trade. Recently, some researchers even incorporate Meltiz (2003)'s heterogeneous firm model into Krugman (1991)'s CP model to explore the effect of firms' productivity on industrial agglomeration, such as Okubo (2007). On the empirical side, there are some researches on the influences of trade liberalization on industrial agglomeration for different countries, such as Gao (2003) and Ge (2006) for Chinese industrial-level data, Puga and Venables (1998) for French firm data, Gatto et al. (2008) for Italian firm-level data, Sjoberg and Sjobholm (2002) for Indonesian industrial-level data.

There is also some work on the reversal problem, i.e., the influences of agglomeration on trade, or more specifically in this paper, the influences of agglomeration on firms' exports. The motivation originates from the emerging findings of empirical literatures that firms benefits from agglomeration much differently, such as Baldwin et al. (2007) and Strajer Madsen et al. (2003). These results shows that firms active in international trade are different from non-traders in terms of using inputs or capital as well as in terms of performance. For example, as shown in Bernard and Bradford (1999), firms engaging in international trade employ more skilled workers, pay higher wages, invest more R&D, and are more productive than those only selling domestically. This implies that agglomeration has different influences on firms' performance, and thus their exports. In fact, Harasztosi and Bekes (2009) shows that international traders benefits twice as much as non-traders from agglomeration in productivity using Hungarian manufacturing data in 1992 and 2003. This implies that trade requires special knowledge and inputs. If agglomeration offers to firms better input sharing and knowledge spillover for trading firms, then it must have positive effects on firms exports.

The mechanism of positive effects of agglomeration on firms' exports is as follows. First, it offers a better environment for sharing of inputs which are specialized for firms to export, where firms can acquire inputs and distributes outputs with lower trading costs in case of scale economies. Input sharing also increases firms' productivity by increasing numbers of specialized intermediate inputs for exports they can use. Second, agglomeration forms pools of skilled or specialized labor for firms' exports, which reduces their costs of searching and training and keeps them out of ineffective matches. Third, international competition requires more specialized knowledge, information, high-quality human capital, management and learning skills, absorption capacity of technology and knowledge, etc. (for production and trade). For example, exporting fixed cost consists of marketing, repackaging, finding distributional channels, and it depends on information of the foreign

market. While agglomeration enhances the production of these factors and their spillover by decreasing the cost of face-to-face exchange of them and that of the mobility of human capital among firms. [Lovely et al. \(2005\)](#) finds that firms exporting to difficult-to-access countries tend to agglomerate. Agglomeration makes its knowledge spillover and thus reduces exporting fixed cost. Fourth, agglomeration of exporting firms yields export spillovers, which influences extensive or intensive margin of trade of local firms. For example, [Kneller and Pisu \(2007\)](#) and [Anwara and Nguyen \(2011\)](#) find that affiliates of foreign multinationals increases the extensive and intensive margins of trade among local firms.

Empirical results confirm the above postulation. [Cassey and Schemeiser \(2010\)](#) finds that exporting firms agglomerate geographically with respect to their shipment's destination in addition to agglomerate around ports using Russian customs data. To explain this finding, the authors build on [Melitz \(2003\)](#) and [Chaney \(2008\)](#) to show that agglomeration affects firms' exports as it reduces costs of internationally shipping of goods. In a model of industry location with endogenous transaction costs, [Duranton and Storper \(2005\)](#) constructs a theoretical model to show how and under which conditions a decline in transport costs can lead to an increase in the total cost of trade. Note that decreasing transportation cost leads to less agglomeration, while increasing trade cost leads to less trade, their result implies that less agglomeration leads to less trade. More recently, [Yilmazkuday \(2011\)](#) also finds that country-side trade patterns are closely related with state-level agglomeration using data from U.S. industries based on counter-factual analysis.

In this paper, we investigate the uneven distribution of manufacturing export in space from the view of agglomeration externality. Specifically, the paper explores the influences of agglomeration on firms' exports theoretically and empirically. Agglomeration affects firms' exports in two ways. First, it may decrease their fixed and variable exporting costs by increasing firms' efficiency of inputs through channels discussed above. Second, it will increase firms' productivity through two channels. One is that it increases all firms' productivity while higher-productivity firms benefits more from it [Combes et al. \(2011\)](#). Suppose the demand from the exporting market is constant. Then this channel implies that less productive firms' exporting probability and sales will decrease while those of higher-productivity ones will increase with regional agglomeration level. The other is that it selects less productive firms out of the agglomeration area so that regional market competition becomes tougher and thus concentration degree of regional productivity distribution becomes more concentrated. This channel implies that firms are less possible to export and exports more in more agglomerative regions. They interact with

each other and thus the aggregate effect is theoretically unknown.

We propose a theoretic model to investigate the influence of agglomeration on heterogeneous firms' exports in this paper. In this model, agglomeration yields technology spillover so that the efficiency of inputs (specifically, labor, in this paper) increases, while the more productive ones benefit more from this, which in return increases firms' productivity and decreases their fixed entry, fixed and variable exporting costs so that more firms enter into the industry and exporting market. However, the tougher competition due to agglomeration will force less productive firms to exit the market. The synthetic effect is that industrial productivity distribution is right-dilated and agglomeration has a positive effect on firms' exporting choices and firms' exporting elasticity of productivity is increasing in agglomeration. However, the common export effect of agglomeration takes on an inverted-U shape for all firms without considering their productivity differences. Empirical results using data from Chinese manufacturing enterprises verifies these results. The results implies that firms in more labor-dense cities are more possible to export and export more. The latter result can be easily understood because agglomeration increases each firm's productivity. The former is indirectly to derive, and few scholars proposed explanations for this.<sup>2</sup>

We also investigate the influences of different agglomeration patterns on firms exports, including home market effect, urban economies and competition effect and diversification effect. We show that the former two patterns exert a positive while the latter two have a positive influence on firms' exporting behaviors.

The structure in the sequel of the paper is as follows. We construct a local-equilibrium trade model with heterogeneous firms in section 2 and show that agglomeration will increase firms' exporting possibilities and their exporting sales. Moreover, the larger is the region, the larger is the exporting elasticity of productivity of firms there. In section 3, we introduce the empirical models in this paper. Section 4 describes the data used in this paper and its treatments. Section 5 sums up the empirical results and relevant robust analysis. The paper is concluded in Section 6.

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<sup>2</sup> Holmes et al. (2011) shows that the exporter share is larger in the larger city in a closed-economy model by incorporating the BEJK model (Bernard et al. 2003) into the new economic geography proposed in Krugman (1991), with labors freely moves between two cities.

## 2 Agglomeration and Trade: A Simple Model

Suppose there are only two countries (China, denoted by  $C$ , and the rest of the world, denoted in short by  $F$  hereafter) in the economy. In China, there are totally  $M$  regions, within each region  $j$  are there  $N_j$  workers and each worker owns one unit of labor. The land area  $A_j$  of region  $j$  is assumed to be 1 for simplification while its price is  $r_j$ . The land rents in each region is equally shared by workers. Suppose the labor wage in region  $j$  is  $w_j$ , which is common in the same region but may differ across regions. Herein the scale of each city is exogenous given. And the agglomeration of labors is represented by the worker density  $dens_j = N_j/A_j = N_j$  for each region  $j$ . We also assume that the aggregate expenditure  $Y_F$  in  $F$  is exogenously given. Moreover, we assume further that the price index in  $F$  is not influenced by China's export. While for China, the aggregate expenditure  $Y_C = \sum_{j=1}^M (w_j N_j + r_j A_j)$ . We suppose that  $M$  is sufficiently large and the variation among  $N_j$ s is not so large, so that the change of  $N_j$  does not change  $Y_C$ ,  $P$  and  $P^*$  much. Finally, goods are traded with no costs within the same country.

### 2.1 Consumer's utility maximization problem

Suppose all the workers in the two countries are homogenous and they have the following form of utility function<sup>3</sup>

$$U = \left( \sum_{j=1}^M X_j^{\frac{\sigma_C-1}{\sigma_C}} \right)^{\frac{\alpha \sigma_C}{\sigma_C-1}} \left( \int_{j \in \Omega_F} x(i)^{\frac{\sigma_F-1}{\sigma_F}} dj \right)^{\frac{(1-\alpha)\sigma_F}{\sigma_F-1}}, \quad (1)$$

where

$$X_j = \left( \int_{i \in \Omega_j} x_j(i)^{\frac{\sigma_j-1}{\sigma_j}} di \right)^{\frac{\sigma_j}{\sigma_j-1}},$$

and the elasticity of substitution between goods produced in country  $F$  is  $\sigma_k$ , that between two aggregate goods produced in two regions in country  $C$  is  $\sigma_C$ , and that between two varieties produced in region  $j$  in country  $C$  is  $\sigma_j$ .  $\Omega_F$  is the set of goods produced in country  $F$ , and  $\Omega_{Cj}$  is that produced in region  $j$  in country  $C$  available for consumption. We assume that  $\sigma_C < \sigma_j$ , that is, the substitution elasticity between varieties produced in the same region is larger than that between produced

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<sup>3</sup>For the use of such kind of utility function, we refer the readers to [Yilmazkuday \(2011\)](#) and [Cassey and Schemeiser \(2010\)](#).

in two different regions.

Given (1), demand for Chinese good  $i$  produced in regional  $j$  from  $F$  and  $C$  are, respectively

$$x_j^*(i) = \frac{p_j^*(i)^{-\sigma_j} (P_j^*)^{\sigma_j - \sigma_C}}{(P^*)^{1 - \sigma_C}} \alpha Y_F, x_j(i) = \frac{p_j(i)^{-\sigma_j} P_j^{\sigma_j - \sigma_C}}{P^{1 - \sigma_C}} \alpha Y_C, \quad (2)$$

where  $P$  is the aggregate price index for Chinese goods,  $P_j$  is that for Chinese goods produced in region  $j$  at home,  $p_j(i)$  is the price of variety  $i$  at home, while  $p_j^*(i)$ ,  $P_j^*$  and  $P^*$  are accordingly the price variables in  $F$ .

## 2.2 Firms' profit maximization problem

### 2.2.1 Domestic market

In each region  $j$ , there is only one industry, i.e., manufacturing industry. A firm in region  $j$  must pay  $f_j$  unit fixed entry cost in terms of land before it observes its "natural" productivity  $\theta$ , which has not been influenced by agglomeration economies in the region, where  $\theta$  is drawn from the probability distribution function  $G_j(\theta)$  (with density function  $g_j(\theta)$ ). Herein  $G_j$  and thus  $g_j$  are closely related with the agglomeration economies in region  $j$ . As the firm's productivity  $\theta$  is randomly drawn from the distribution  $G_j$ , we denote the firm by its productivity  $\theta$ . After the firm enters the industry, it starts production. We assume that any firm is not free to change regions and it has to determine how much to produce to supply domestic and foreign demands. We assume that the production function in region  $j$  without agglomeration economy is  $x_j(\theta) = \theta l_j(\theta)$ , where  $x_j(\theta)$  is the output and  $l_j(\theta)$  is the quantity of workers hired for production. Involving agglomeration, we assume that there exists knowledge spillover in labor market among regions. Each worker is made more productive by interactions (such as exchanging diverse ideas) with other workers. Such interactions among workers can be found in Fujita and Ogawa (1982) and Lucas and Rossi-Hansberg (2002) among others. According to these papers, there exists spatial decay in interactions. Specifically, following Combes et al. (2011), we assume that the effective labor supplied by one individual worker in firm  $\theta$  in region  $j$  is  $a(N_j + \delta \sum_{i \neq j} N_i) \theta^{D_j - 1}$ , where  $a(0) = 1$ ,  $a' > 0$ ,  $a'' < 0$ ,  $D_j = \ln d(N_j + \delta \sum_{i \neq j} N_i)$ ,  $d(0) = 1$ ,  $d' > 0$ ,  $d'' < 0$ , and  $\delta \in [0, 1]$  is the decay parameter measuring the strength of across-region relative to within-region interactions. Thus, the production function of firm  $\theta$  in region  $j$  with agglomeration economy is  $x_j(\theta) = a(N_j + \delta \sum_{i \neq j} N_i) \theta^{D_j} l_j(\theta)$ . Solving firm  $\theta$ 's profit maximization yields its

domestically optimal pricing rule and domestic sale quantity, as follows

$$p_j(\theta) = \frac{\bar{m}_j w_j}{a_j \theta^{D_j}}, x_j(\theta) = P^{\sigma_C - 1} P_j^{\sigma_j - \sigma_C} \left( \frac{a_j \theta^{D_j}}{\bar{m}_j w_j} \right)^{\sigma_j} \alpha Y_C, \quad (3)$$

where  $\bar{m}_j = \frac{\sigma_j}{\sigma_j - 1}$ . Thus, its net profit is

$$\pi_j(\theta) = \frac{R_j(\theta)}{\sigma_j} - r_j f_j, \quad (4)$$

where  $R_j(\theta)$ , the domestic sale of firm  $\theta$ , is defined as

$$R_j(\theta) = p_j(\theta) x_j(\theta) = P^{\sigma_C - 1} P_j^{\sigma_j - \sigma_C} \left( \frac{a_j \theta^{D_j}}{\bar{m}_j w_j} \right)^{\sigma_j - 1} \alpha Y_C. \quad (5)$$

From (4), we can get the cut-off productivity condition of non-exporters as follows

$$P^{\sigma_C - 1} \alpha Y_C n_j^{\frac{\sigma_j - \sigma_C}{1 - \sigma_j}} \left( \frac{\bar{m}_j w_j}{a_j} \right)^{1 - \sigma_C} \underline{\theta}_j^{D_j(\sigma_j - 1)} \tilde{\theta}_j^{\sigma_C - \sigma_j} = \sigma_j r_j f_j. \quad (6)$$

As there is not fixed production cost after entry, each firm must start production and sell at home country. Suppose there are  $n_j$  firms selling domestically in region  $j$  at equilibrium. Then the price index  $P_j$  of varieties produced in region  $j$  and that at home are, respectively,

$$P_j = n_j^{\frac{1}{1 - \sigma_j}} \frac{\bar{m}_j w_j}{a_j \tilde{\theta}_j}, P = \left( \sum_{j=1}^M \left( \frac{\bar{m}_j w_j}{n_j^{\frac{1}{\sigma_j - 1}} a_j \tilde{\theta}_j} \right)^{\sigma_C - 1} \right)^{\frac{1}{\sigma_C - 1}}, \quad (7)$$

where

$$\tilde{\theta}_j \triangleq \left( \int_0^{+\infty} \theta^{D_j(\sigma_j - 1)} dG_{jD}(\theta) \right)^{\frac{1}{\sigma_j - 1}}$$

is the average productivity level in region  $j$ , where  $G_{jD}(\theta)$  is the ex post probability distribution function of productivity of firms in region  $j$  defined as follows:

$$G_{jD}(\theta) = \begin{cases} \frac{G_j(\theta)}{1 - G(\underline{\theta}_j)} & \theta \geq \underline{\theta}_j, \\ 0 & \text{else,} \end{cases} \quad (8)$$

where  $\underline{\theta}_j$  is the productivity cutoff below which a non-exporter obtains negative

profits and thus exits the market.

### 2.2.2 Foreign market

We assume that a firm in region  $j$  at home has to pay another fixed cost  $f_{xj}$  units of lands to export its output abroad. We also assume that exporting any variety from each region  $j$  to abroad entails an "Samuelson" type of iceberg cost  $\tau_j > 1$ , which is common in each region, but may differ across regions. That is, to sell one unit of product abroad,  $\tau_j$  unit must be shipped out of region  $j$  in China. This cost may involve transportation costs, tariff barriers, distribution costs, marketing costs, repackaging costs, etc.

A firm with productivity  $\theta$  locating in region  $j$  must choose the Bertrand pricing rule to maximize its exporting profit. Similarly to the deduction in the former subsection, the firm's optimal pricing rule and its optimal export are respectively

$$p_j^*(\theta) = \frac{\bar{m}_j \tau_j w_j}{a_j \theta^{D_j}} = \tau_j p_j(\theta), x_j^*(\theta) = \frac{(P^*)^{\sigma_C - 1}}{(P_j^*)^{\sigma_C - \sigma_j}} \left( \frac{a_j \theta^{D_j}}{\tau \bar{m}_j w_j} \right)^{\sigma_C j} \alpha Y_F. \quad (9)$$

Thus, its net profit is

$$\pi_j^*(\theta) = \frac{X_j(\theta)}{\sigma_j} - r_j f_{xj}, \quad (10)$$

where  $X_j(\theta)$  is the foreign sale of firm  $\theta$  defined as follows

$$X_j(\theta) = (P^*)^{\sigma_C - 1} (P_j^*)^{\sigma_j - \sigma_C} \left( \frac{a_j \theta^{D_j}}{\bar{m}_j \tau_j w_j} \right)^{\sigma_j - 1} \alpha Y_F. \quad (11)$$

From (10), we can get the cut-off productivity condition of exporters

$$(P^*)^{\sigma_C - 1} \alpha Y_F n_{xj}^{\frac{\sigma_j - \sigma_C}{1 - \sigma_j}} \left( \frac{\tau_j \bar{m}_j w_j}{a_j} \right)^{1 - \sigma_C} \underline{\theta}_{xj}^{D_j(\sigma_j - 1)} \tilde{\theta}_{xj}^{\sigma_C - \sigma_j} = \sigma_j r_j f_{xj}. \quad (12)$$

Then the price index  $P_j^*$  and  $P^*$  are accordingly

$$P_j^* = n_{xj}^{\frac{1}{1 - \sigma_j}} \frac{\bar{m}_j \tau_j w_j}{a_j \tilde{\theta}_{xj}}, P^* = \left( \sum_{j=1}^M \left( \frac{\bar{m}_j \tau_j w_j}{n_{xj}^{\frac{1}{\sigma_j - 1}} a_j \tilde{\theta}_{xj}} \right)^{\sigma_C - 1} \right)^{\frac{1}{\sigma_C - 1}}, \quad (13)$$

where

$$\tilde{\theta}_{xj} \triangleq \left( \frac{1}{1 - G_j(\underline{\theta}_{xj})} \int_{\underline{\theta}_{xj}}^{+\infty} \theta^{D_j(\sigma_j-1)} dG_j(\theta) \right)^{\frac{1}{\sigma_j-1}} \quad (14)$$

is the average productivity level of exporting varieties from region  $j$  of China in the foreign country,  $\underline{\theta}_{xj}$  is the cutoff of productivity of exporting firms, at which a firm is indifferent from exporting or only selling domestically, and  $n_{xj}$  is the number of exporting firms in region  $j$ . Only those firms whose productivity is higher than  $\underline{\theta}_{xj}$  will export so that there holds

$$n_{xj} = \frac{1 - G_j(\underline{\theta}_{xj})}{1 - G_j(\underline{\theta}_j)} n_j, \quad (15)$$

where  $\varsigma_j \triangleq \frac{1 - G(\underline{\theta}_{xj})}{1 - G(\underline{\theta}_j)}$  is the ex ante expected exporting probability of incumbents in the domestic market.

### 2.2.3 Equilibrium

At equilibrium, both the labor market and the land market in each region clear. Thus we have

$$n_j f_j + n_{xj} f_{xj} = A_j, \quad (16)$$

$$\int_0^\infty R_j(\theta) dG_{jD}(\theta) + \frac{1}{\tau_j} \varsigma_j \int_{\underline{\theta}_{xj}}^\infty X_j(\theta) dG_{jX}(\theta) = \bar{m}_j w_j N_j, \quad (17)$$

where  $G_{jX}(\theta)$  is the ex post productivity distribution of exporters in region  $j$ .

Firm's equilibrium entry condition is

$$\int_0^\infty \pi_j(\theta) dG_{jD}(\theta) + \varsigma_j \int_{\underline{\theta}_{xj}}^\infty \pi_j^*(\theta) dG_{jX}(\theta) = 0. \quad (18)$$

(12) together with (15)-(18) determines the market equilibrium given foreign expenditure  $Y_F$ .

According to (15) and (16), We have

$$n_j = \frac{A_j}{f_j + f_{xj} \varsigma_j}, n_{xj} = \frac{A_j \varsigma_j}{f_j + f_{xj} \varsigma_j}, \quad (19)$$

which implies that  $\underline{\theta}_{xj}$  is decreasing in  $n_j$ . According to (12) and (19), we have

$$\underline{\theta}_{xj} = \left\{ \left( \frac{\kappa_j}{\kappa_j - D_j(\sigma_j - 1)} \frac{A_j \varsigma_j}{f_j + f_{xj} \varsigma_j} \right)^{\frac{\sigma_j - \sigma_C}{\sigma_j - 1}} \left( \frac{\tilde{m}_j \tau_j w_j}{a_j} \right)^{\sigma_C - 1} \frac{\sigma_j r_j f_{xj}}{\bar{Y}_F} \right\}^{\frac{1}{D_j(\sigma_C - 1)}}. \quad (20)$$

where  $\bar{Y}_F = \frac{\alpha Y_F}{(P^*)^{1 - \sigma_C}}$  is the real incomes of the foreign country consuming goods produced in China.

Let

$$\mathcal{A}_j = \int_0^\infty R_j(\theta) dG_{jD}(\theta), \mathcal{B}_j = \int_{\underline{\theta}_{xj}}^\infty X_j(\theta) dG_{jX}(\theta). \quad (21)$$

Combining (12) with (17), (18) (7) and (13) yields the relationship between  $\mathcal{A}_j$  and  $\mathcal{B}_j$

$$\mathcal{B}_j = \Delta^{-1} \tau_j^{1 - \sigma_C} \left( \frac{n_{xj}}{n_j} \right)^{\frac{\sigma_j - \sigma_C}{1 - \sigma_j}} \left( \frac{\tilde{\theta}_{xj}}{\tilde{\theta}_j} \right)^{\sigma_C - 1} \mathcal{A}_j, \quad (22)$$

where  $\Delta$  is the relative income between China and the foreign country defined as  $\Delta = \frac{\bar{Y}_C}{\bar{Y}_F}$ , wherein  $\bar{Y}_C = \frac{\alpha Y_C}{P^{1 - \sigma_C}}$  is the real incomes of China consuming goods produced in China, respectively.

## 2.3 Parameterization

To find analytic solutions of the above equilibrium, we follow Antras and Helpman (2004), Helpman et al. (2004), Melitz and Ottaviano (2008), Eaton et al. (2011) and other many papers to assume that  $G_j(\theta)$  follows a Pareto distribution of the following form

$$G_j(\theta) = \begin{cases} 1 - \left( \frac{b_j}{\theta} \right)^{\kappa_j} & \theta \geq b_j, \\ 0 & \text{else,} \end{cases}$$

where  $\kappa_j$  is the configuration parameter (also called the concentration degree) and  $b_j$  is the lower bound of industrial productivity distribution. Under this assumption, the average productivity of all the incumbents and the exporters are, respectively,

$$\tilde{\theta}_j = \left( \frac{\kappa_j}{\kappa_j - D_j(\sigma_j - 1)} \right)^{\frac{1}{\sigma_j - 1}} \underline{\theta}_j^{D_j}, \tilde{\theta}_{xj} = \left( \frac{\kappa_j}{\kappa_j - D_j(\sigma_j - 1)} \right)^{\frac{1}{\sigma_j - 1}} \underline{\theta}_{xj}^{D_j}. \quad (23)$$

Dividing (6) by (12) and substituting (23) into the resultant equation, we conclude the following expression

$$\varsigma_j = \left( \frac{\theta_j}{\theta_{xj}} \right)^{\kappa_j} = \left( \frac{f_j}{f_{xj} \Delta \tau_j^{\sigma_C - 1}} \right)^{\frac{D_j(\sigma_C - 1)}{\kappa_j} - \frac{\sigma_C - \sigma_j}{\sigma_j - 1}}. \quad (24)$$

Thus, according to (22), we have

$$\mathcal{B}_j = \frac{f_{xj}}{f_j} \mathcal{A}_j. \quad (25)$$

Suppose now that the difference between  $\sigma_C$  and  $\sigma_j$  is not too large. Furthermore, we make the following assumption.<sup>4</sup>

**Assumption 1**  $\sigma_C < \sigma_j$ ,  $f_j = f$ ,  $f_{xj} = f_x$ ,  $\tau_j = \tau$ ,  $\forall j$ , and  $f < f_x \Delta \tau^{\sigma_C - 1}$ .

Under Assumption 1, there holds  $\frac{D_j(\sigma_C - 1)}{\kappa_j} > \frac{\sigma_C - \sigma_j}{\sigma_j - 1}$  for each  $j$  as  $\sigma_C < \sigma_j$ , which is satisfied in most common situation as competition between firms within a region usually is tougher than that among regions. Thus, under Assumption 1 and according to (24), we conclude that  $\varsigma_j(N_j) = \varsigma(N_j)$  is increasing in  $N_j$ .

**Proposition 1** *Suppose agglomeration of region  $j$  does not affect the whole economy much (i.e., change of  $N_j$  does not affects  $\Delta$  much) and Assumption 1 holds. The firms in larger cities are more possible to export, i.e.,  $\varsigma_j(N_j) > \varsigma_k(N_k)$  if  $N_j > N_k$ , ceteris paribus.*

In the sequel, we will empirically test Proposition 1 using firm-level data from Chinese manufacturing enterprises.

Combining (6), (7), (12), (13), (17), (18), (24) and (25), we can find that

$$\mathcal{A}_j = \frac{\sigma_j r_j f_j \kappa_j}{\kappa_j - D_j(\sigma_j - 1)}, \mathcal{B}_j = \frac{\sigma_j r_j f_{xj} \kappa_j}{\kappa_j - D_j(\sigma_j - 1)}. \quad (26)$$

which together with (21) yields

$$\frac{w_j N_j}{r_j A_j} = (\sigma_j - 1) [f_j + \varsigma_j f_{xj} / \tau_j]. \quad (27)$$

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<sup>4</sup>We get straightforward that firms' exporting possibility  $\varsigma_j$  in region  $j$  is decreasing in the fixed exporting cost  $f_{xj}$ , the variable exporting cost (transportation cost)  $\tau_j$  and the relative real income  $\Delta$  between the two countries, and is increasing in the fixed entry cost  $f_j$  under Assumption 1. which coincides with our intuition and many empirical results verified in many new-new trade literatures, e.g., Melitz (2003).

Plugging (27) into (24) and combining the resulted expression with (6) and (12) yields  $M$  equations with  $2M$  unknown variables  $w_j$  and  $r_j$  for  $j = 1, \dots, M$ . Substituting (24) and (19) into (26), we get another  $M$  equations with unknown variables  $w_j$  and  $r_j$  for  $j = 1, \dots, M$ . Solving the total  $2M$  equations yields all  $w_j$  and  $r_j$ .

Substituting (12), (19) and (24) into (16) and (17), we have

$$\begin{aligned}
 X_j(\theta) &= \bar{Y}_F^{\frac{\sigma_j-1}{\sigma_C-1}} \left( \bar{m}_j \tau_j \frac{w_j}{a_j} \right)^{1-\sigma_j} \underbrace{\left( \frac{\varsigma_j f_j}{f_j + f_{xj} \varsigma_j} \frac{\bar{m}_j \tau_j w_j N_j}{\tau_j f_j + \varsigma_j f_{xj} \kappa_j - D_j(\sigma_j - 1)} \frac{\kappa_j}{\kappa_j} \right)^{\frac{\sigma_C - \sigma_j}{\sigma_C - 1}}}_{\text{common export effect caused by agglomeration}} \\
 &\times \underbrace{\theta^{D_j(\sigma_j-1)}}_{\text{heterogeneous export effect}} \tag{28}
 \end{aligned}$$

In the above expression, we divide the effect of agglomeration on firms' export into two forms. The first is common for all the firms in each region, called the **common export effect of agglomeration**. The second is idiosyncratic across firms as their productivity is heterogeneous, which is called **heterogeneous export effect**. As  $D_j = \ln d(N_j + \delta \sum_{i \neq j} N_i)$  is increasing in  $N_j$ . Define the exporting elasticity of productivity in region  $j$  as  $\varepsilon_j = D_j(\sigma_j - 1)$ . Then we conclude immediately the following proposition from (28).

**Proposition 2** *The exporting elasticity of productivity is increasing in the scale of all the regions.*

Proposition 2 implies that a firm's exporting sale is more sensitive if it locates in a city with more denser city. This holds because firms' productivity distribution becomes more concentrated so that firms' competition for export becomes more tougher. Thus, a firm' export increases more rapid with its productivity.

If  $\sigma_j = \sigma_C$ , then it's easy to conclude the following result.

**Corollary 1** *Suppose  $\sigma_j = \sigma_C$ . Then the common export effect of agglomeration in region  $j$  increases with its agglomeration level.*

Corollary 1 holds only if  $\sigma_j = \sigma_C$ . It implies that agglomeration has a positive influence on each firm's exporting sale with the increase of integration of domestic economy. The decrease of market segregation will eventually lead a country to engage more deeply into the international division of labor. However, this is not the case for most regions. In the general situation, agglomeration affects firms' exports in a complicate way. Note that  $\bar{Y}_F$  is the real income consuming Chinese goods in the foreign country,  $\frac{w_j}{a_j}$  is the effective wage, and  $\mathcal{B}_j$  is the firm-level average export in region  $j$ . Suppose  $\bar{Y}_F$  is not influenced by agglomeration, and the effective wage

in region  $j$  decreases with agglomeration. As  $r_j$  increases with  $N_j$ , the firm-level average export increases with agglomeration. Moreover,  $\frac{\varsigma_j}{f_j+f_{xj}\varsigma_j}$  is increasing in  $\varsigma_j$ . We conclude that  $\left(\bar{m}_j\tau_j\frac{w_j}{a_j}\right)^{1-\sigma_j}$  (which can be considered as one unit of variable cost of foreign sale as  $\frac{\bar{m}_j\tau_jw_j}{a_j}$  is each worker's effective wage for producing goods selling oversea) increases, while  $\left(\frac{f_j}{f_{xj}}\frac{\varsigma_j}{f_j+f_{xj}\varsigma_j}\mathcal{B}_j\right)^{\frac{\sigma_C-\sigma_j}{\sigma_C-1}}$  (which can be considered as each firm' average exporting sale per unit of fixed exporting cost) decreases with agglomeration in region  $j$ . Thus its difficult to identify the direction of the synthetic common export effect of agglomeration in the region. In practice, agglomeration in one region will influences both the (relative) real incomes consuming Chinese goods between the two countries. It may increase the effective labor wage in the region. It may also affects fixed entry cost, fixed and variable exporting costs. Thus, it's very difficult to judge how agglomeration affects firms' export behaviors in the general case. We left it to empirical analysis to be stated in the sequel.

However, under a certain condition, we have the following scenario.

**Hypothesis 1** *Suppose Assumption 1 holds and  $\sigma_j \neq \sigma_C$ . Assuming that agglomeration in region  $j$  does not change the real income consuming Chinese goods of the foreign country, decrease labors' effective wage and increase the region's firm-level average export. If agglomeration induces more exporting competition between firms so that the decrease of each firm's average exporting sale per unit of fixed exporting cost dominates the increase of the save of each unit of variable exporting cost in the first agglomerating stage while it reverses in the second agglomerating stage, then the synthetic common export effect of agglomeration on firms' exporting sales takes on a Parabola-shape pattern.*

In the sequel , we will use firm-level data from Chinese manufacturing enterprises to test and show that Hypothesis 1 holds for China's case.

### 3 Econometric model

From Proposition 1, we know that an incumbent's exporting probability is increasing in the regional agglomeration level (measured in labor density in the region) under some conditions. Carefully investigating (28), we set the econometrical model of estimating firms' exporting choices as follows

$$\mathbb{X}_{rjit} = \phi \ln dens_{rt} + \psi \ln A_{rt} + Z_{rjit}\zeta + \alpha_r + \beta_j + \gamma_i + \eta_t + cons + \varepsilon_{rjit}, \quad (29)$$

where  $r, j, i, t$  are indices of region, industry, firm and time, respectively,  $\mathbb{X}_{rjit}$  is firm  $i$ 's exporting decision variable in time  $t$ , which is 0 if it does not export and is 1 if it exports.  $\alpha_r, \beta_j, \gamma_i$  and  $\eta_t$  are respectively the regional, the industrial, the firm and the time fixed effect,  $dens_{rj} = \frac{N_{rj}}{A_r}$  is the density of industrial activity in industry  $j$  in regional  $r$ , which is measured by the number of employment (industrial workers) per square kilometer,  $N_{rj}$  is the sum of the employment of firms in industry  $j$  in region  $r$ ,  $A_r$  is the area of the county in square kilometer, and  $Z_{rjit}$  is the vector of control variables for firm  $i$  in industry  $j$  in region  $r$  in time  $t$ . In our empirical analysis,  $Z_{rjit}$  includes fiscal expenditure, human capital, institute level in region  $j$ , ownership (state-owned, collective owned or private owned, etc.), belonging relationship (referring to whether a firm belongs to the central government, a local one, etc.), operating status (newly established, incumbent, exiting/ closed), size dummies of firm  $i$  in industry  $j$  in region  $r$  in year  $t$ , and industry dummy in time  $t$ . Note that in (29) the term  $\Delta = \frac{P^{\sigma_C - 1} Y_C}{(P^*)^{\sigma_C - 1} Y_F}$  is incorporated into the three fixed effect terms.

According to Proposition 1,  $\phi$  shall be larger than 0. Here we add the land area to the regression equation as it causes the change of labor wage and firms' entry into industries. As the increase of land area in a city induces more firms to enter into industries and thus more labors move to the city at equilibrium, the labor size in the city increases, which further increases firms' ex ante exporting possibility. Thus we conclude that  $\psi$  shall also be larger than 0.

For firms' exporting sales, our estimation equation is as follows:

$$\begin{aligned} \mathbb{X}_{rjit} = & \phi \ln dens_{rj} + \varphi \ln dens_{rj}^2 + \psi \ln A_r + \lambda \ln dens_{rj} \ln \theta_{rjit} + Z_{rjit} \zeta \\ & + \alpha_r + \beta_j + \gamma_i + \eta_t + cons + \varepsilon_{rjit}, \end{aligned} \quad (30)$$

where  $\mathbb{X}_{rjit}$  is 0 if a firm does not export and is the logarithm of the foreign sale  $\ln X_{rjit}$  if its exporting sale is positive,  $\ln \theta_{rjit}$  is firm  $i$ 's total factor productivity in industry  $j$  in region  $r$  at time  $t$ , and  $Z_{rjit}$  contains the same variables as in (29).

In (30), we use the cross term  $\ln dens_{rj} \ln \theta_{rjit}$  to investigate whether the exporting elasticity of firm productivity in region  $r$  is increasing in the agglomeration level  $dens_{rj}$ . According to Proposition 2, its coefficient  $\lambda$  shall be larger than 0. Moreover, We involve a quadratic term of  $\ln dens_{rj}$  in (30) to investigate whether agglomeration has an synthetic inverted-U common export effect on firms' exporting sales. If Hypothesis 1 holds, there shall be  $\phi > 0$  and  $\varphi < 0$ .

To further investigate how agglomeration affects firms' exporting behaviors. We also add two basic agglomeration economies, the specialization (or localization) economy (denoted by  $loc_{rjit}$ ) and the Jacob economy, to (29) and (30), respective. Following Martin et al. (2008), we also divide the urbanization economy into two

sides, one is the diversity economy (denoted by  $div_{rjit}$ ), and another is the urbanization economy (denoted by  $urb_{rjit}$ ). Considering competition caused by agglomeration affects firms' productivity, entry and export, we also add the competition economy to (29) and (30) to investigate its influence. All these four indices are measured following the way proposed in Martin et al. (2008). The influences of these four dimensions of agglomeration are theoretically unknown as there's no literature to investigate this topic.<sup>5</sup>

## 4 Data description and treatments

### 4.1 Data Source

According to the nature of this research, our empirical dataset is composed and organized in two folds: Chinese city-level and firm-level data. The formal city-level data is collected from three major sources: *China Urban Statistic Yearbook*, *China Statistic Yearbook* and *China Regional Statistic Yearbook*. The later firm-level data comes from the Annual Survey of Industrial Firms (ASIF) cross-sectional data collected by China National Bureau of Statistics between 1998 and 2007.

The data description section here mainly discusses the usage and treatments of ASIF dataset. The whole ASIF contains all detailed information for all state-owned and non-state firms above designated scale (above 5 million Yuan) with all operational, financial and managerial items (e.g. there are 135 variables describing firm information in year 2004) in (1) mining, (2) manufacturing and (3) production and distribution of electricity, gas and water sector with all 40 industries, and 90 4-digits and 600 6-digits sub-industries (see the appendix of industrial categories). The number of firms covered by this dataset is 165,118 in 1998 and 336,768 in 2007, respectively. The industry section of *China Statistic Yearbook* and reports in *China Markets Yearbook* are compiled and based on this dataset, which covers 95% of the industry gross output in these yearbooks (Lin et al. 2009; Lu and Tao 2009; Brandt et al. 2011).

### 4.2 Variables Definition and Consistency

To facilitate this research, we take variables closely related to the firm-idiosyncratic variables with all commonly used operational, managerial and financial statistics.

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<sup>5</sup>Martin et al. (2008) shows that the localization, urbanization and competition economies have significant positive influences while the diversity economy has a significant negative influence on firms' productivity.

Notably, since year 2003, the China National Bureau of Statistics started to implement new National General Specifications of Industry (GBT/4757), therefore there were two systems registered and coded in this dataset: before 2003 and afterwards. In this research, we adjust all industry-related codes by new GBT/4757 system. Apart from these direct changes, some variables in different years are noted differently or partially, which requires close examination on their explicit definitions - some attributive descriptions varied for different situations.<sup>6</sup> Since year 2004, the total value of sales was no longer surveyed.<sup>7</sup> By adjusting the above major statistics changes, we try to make sure the whole dataset is consistent and tractable both in terms of cross-section and longitudinal manner.

### 4.3 Missing variables, missing values and treatments

Missing values in **ASIF** can be found in year 2001 to 2007. Some are due to statistical index changes or accounting system adjustment,<sup>8</sup> some are due to miss accounting,<sup>9</sup> and some of these variables can be computed by accounting principles.<sup>10</sup> Missing variables like 'total export value' can only be measured by matching whole **ASIF** among the same firms of different years by linear interpolation method.

We treat missing values with two principles: leave all accounting variables (operational, financial and managerial variables) unchanged; 2) match and refill all possible firm-idiosyncratic variables not related to accounting variables, e.g. firm id, location and postal address, operation status, founding year, registration type, belonging, stock share. First of all, we checked the dataset's firm id yearly. Not as simple as previous research (Lin et al. 2009; Lu and Tao 2009; Brandt et al. 2011) claimed that the **ASIF** contains unique firm id for each firm throughout 10 year period. Instead, there are repetitive firm ids in each year.<sup>11</sup> Comparing with the over two million firms dataset, those firms seems minute and not harmful. However, they are influential both in terms of local gross domestic product, revenue, taxa-

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<sup>6</sup>For example, words like gross value, net value, total value, sum amount are missing in some case or years, 'fixed capital' refers to net value of fixed capital, 'asset' refers to the gross value of asset, 'employment' refers to the average employment numbers, etc.

<sup>7</sup>Instead, this term was replaced by sum income of major revenue. Moreover, the geographic codes were largely extended to 12 digits since 2004 (6 digits for province-city-county, plus other 6 digits for village-district-street accordingly).

<sup>8</sup>For example, 'total production value constant value' and 'product sale value' (2004-2007, both variables are no longer accounted in the national survey).

<sup>9</sup>For example, 'firm status' (2001), 'firm size' (2002, 2004), 'total value of fixed capital' (2003), 'total export value' (2004), 'current value of gross output' (2004) and 'current value of sales' (2005).

<sup>10</sup>For example, the 'total value-add' (2001, 2004) equalizes 'sum of current value of output' - 'middle inputs plus' + 'value add tax'.

<sup>11</sup>There are totally 463 firms and one wrongly registered firm in the dataset.

tion income, industrial forward-backward linkages as well as local employment.<sup>12</sup> Deleting those repetitive firms could cause the very problem of selection bias. To deal with such a problem, we match these firms' locations, owners' name (legalistic representative name), major product items accordingly, identify, assign and add these firms with new firm ID in the **ASIF** dataset respectively. Secondly, we examine our newly defined firm-idiosyncratic variables accordingly.<sup>13</sup> Based on the above techniques, we match missing values in variables like location, operation status, founding year, registration type, belonging and stock shares respectively.

#### 4.4 Further discussion of data treatment

Some noteworthy drawbacks in the **ASIF** dataset need further discussions. We believe these characteristics are partial reasons causing the estimates' standard errors comparatively large and less converging in our later empirical tests. The first is that the manufacturing firms covered in the sample period increased dramatically since the year 2004. Apart from more and more firms having annual sales reached the official statistical category, the year 2004 was an industry census year, there was more comprehensive survey coverage in that year, which may explain the jump from 2003 to 2004 in the number of firms (Lu and Tao 2009). The second is the **ASIF** does not cover small non-state-owned firms with annual sales less than five million Yuan, which could cause the sample estimation upward biased. The third and most challenging problem is that **ASIF** does not provide organization relation information among multi-plant firms. We could only recognize all dataset as individual plant

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<sup>12</sup>we are arguing that many of those firms are large SOEs, such as provincial petro line companies, regional tobacco companies and provincial electricity groups who are sharing the same registered names and controlled by the central government. Some of them are even 80 times than some 'ordinary' surveyed firms.

<sup>13</sup>To save the miss value treatment discussion, here we list two examples. Take the operational status in year 1999 as the first case. There are 3,904 firms are either missing or noted as 0, capital A or letter a. We take these lots as the sub-database to match with year 1998, 2000 to 2007 firm survey data accordingly. Our rationale is that if these firms exited after year 1998, they would not be accounted or noted in the 1999 survey, vice versa, if they appear in the 2000 or later years' survey, it means their operational status are active instead of frozen or closed. In fact, there are 3,276 firms being noted in 1998 survey, and the other 628 firms have 471 firms not exist in the following years' survey since 2000. We can safely conclude that these 471 firms only exist in year 1999, and by the end of this year, their operational status shall be registered as "canceled" (not belonged to status as 'establishing', 'operating', 'frozen', or 'other'). Another example is treating the missing values of location. Take the location variable in year 2000 as the case. There are 67 firms' location codes are missing, noted as 0 or wrongly registered (some letters replaced the literal 6 digits location codes). Following the same mechanism as previous case, we match and sort these firms with pre and after years' survey data. There are 57 firms being confirmed with 1998-1999 survey data, 6 of 10 firms are found in the 2001-2007 survey data. We match the left 4 firms with their exclusive information - phone number, mail address, firm name, major products, owner names, and assign their location codes accordingly.

and ignore the situation that enterprises having more than one plants in different regions. The disaggregate composition of plant TFP could not review some multi-plant firms real performance.

Comparing with researches applied with the same data source, this research designed not delete firms with zero monetary inputs or outputs (gross assets, net sum of fixed capital value, sales, gross output) or employment less than 10 persons (Jefferson et al. 2008; Cai and Liu 2009). The endogeneity issue of firm behavior is our major concern. We are arguing that if researchers need to observe firms endogenous behavior, henceforth estimate their self-adjustments in capital and labor investment and yearly middle inputs from year to year, the zero monetary accounting is useful and sensitive in indicating their entry and exit dynamics. Since we assume firms are aware of their productivity changes, so as the profitability, there is less solid ground to assume they have static decision making for each year's productivity shock. Levinsohn and Petrin (2003) proposed method on firm-level productivity estimation only requiring middle input information as the state variable of capital stock. Here we apply the Levinsohn-Petrin methods to investigate firm dynamics of market entry-exit in each year. To provide the analytical benchmark, we also apply the pooled OLS and Fixed effect panel data methods. The purpose of applying these estimation methods are solely for seeking consistent and robust results for accounting firm level capital stock and productivity estimation.

For the computation of total factor productivity, gross production value, net sales of the plants, investment, middle inputs and all other monetary variables were deflated using price deflators (1978 as the benchmark year).

#### **4.5 Firm Productivity Estimation**

There are different methods in measuring productivity. In this paper, we apply econometric approach to observe the productivity change and its sources. The plant-level estimates of TFP are computed using the LP method that was first proposed in Levinsohn and Petrin (2003). The LP method has several advantages over the other methods, such as the pooled OLS method, the fixed-effect method, etc. (see Sun et al. (2011) for detailed comparisons about these methods as well as the OP method proposed in Olley and Pakes (1996)). Primarily, the assumption of constant returns to scale is not required here. And, perfectly competitive market is not realistic to developing countries, and factors are not compulsorily be paid their marginal product.

## 5 Econometric results

We do the econometric analysis in two steps. In the first step, we regress Equation (29) by applying the Probit model to investigate how agglomeration affects firms' exporting choices by controlling other factors. In the second step, we examine the influence of agglomeration on exporters' foreign sales by regressing (30) using the Tobit model.

In our empirical analysis, a region unit is a prefecture-level city. A region's area  $A$  is the area of its central district. The density of the employment  $dens$  in a city is measured by the density of workers employed in manufacturing industries in it (however, in the robust analysis, we replace this density by that of the total employment in the second industry). To control some other factors that may affect firms' exports, we involve firms' ownership structure, belonging relationship, size levels and their operating status for firm-level characteristics (which are defined by China Statistical Bureau in the original dataset), human capital, FDI density, per capita GDP, per capita road area, per capita bus, per capita taxi, per capita postoffice and the distance to the nearest harbor (which also controls the regional characteristics) for city-level characteristics, institute level for province-level one, and exchange rate. We also consider the influence of industrial characteristics, which is controlled by industry dummy. In our baseline empirical analysis, firms' total factor productivity is estimated applying LP (Levinsohn-Petrin method). However, the results do not change even using productivity estimated using OLS method, which we do not provide here. Figure 6 provides the kernel-kdensity curves for firm productivity estimated by LP and OLS method. We can see from it that they are very similar, except that the OLS productivity has a higher mean.

### 5.1 Agglomeration and exporting choice

Dilation effect of agglomeration on firms' exporting choices can be found in various estimations combining different controlling variables. Agglomeration, taken manufacturing-labor density as proxies, exerts uniformly a contributing source to firms' exporting possibilities, which thus verifies Proposition 1. Table 1 shows the five estimation results in the first step by controlling the city-level, province-level, firm-level, and industry-level characteristics. It shows that the coefficients of log of manufacturing-labor density is positive and significant at 0.1% significance level. This implies that agglomeration has a significant influence on firms' exporting choices with firm-, industrial, and regional characteristics controlled gradually, which verifies Proposition 1. The explanation is that agglomeration of manufacturing labors

increases all firms' productivity by positive externality and selecting low-productivity firms out of market so that firms' average exporting sale is higher in more agglomerated cities, while firms' with higher natural productivity benefits more from agglomeration, and thus the distribution of firms' productivity is more concentrated, which increases firms' ex ante exporting possibility.

One other interesting result deserve noting here. We see from Table 1 that city size has also a significant influences on firms' exporting choices. This can be derived by revising our assumption that each region's area is 1. The result implies that city size may interact with firms' characteristics (such as productivity), which results finally in their more possible exporting behaviors.

## 5.2 Agglomeration and exporting sale

According to Equation (30), the effect of agglomeration on firms' exporting sales can be divided into two terms. The first is common for all the firms in the same region, which is called the "**common export effect of agglomeration**". The second is idiosyncratic across firms as their productivity is heterogeneous, which is called the "**heterogeneous export effect of agglomeration**". That is to say, we need to specify and testify Proposition 2 and Hypothesis 1. That is, the exporting elasticity of productivity is increasing in the scale of all the regions, and agglomeration in region  $j$  has a inverted-U shape influence on each incumbent's exporting sale without considering its initial productivity level.

Table 2 shows the estimation result in the second step. We can see directly that the coefficient of the crossing term between firm productivity and manufacturing-labor density is significantly positive at 1% significance level, which verifies Proposition 2, i.e., firms' export elasticity of productivity increases with manufacturing-labor density. The result holds because that firms with higher natural productivity benefits more from agglomeration and that a firm benefits more from more dense cities. However, this result does not implies a firm must get a higher real profit in a larger city due to higher wage, land rent and other variable costs. Hence, it does not implies that firms will agglomerate into the same largest city. In fact, as also shown in Table 2, the common export effect caused by agglomeration takes significantly on a Parabola shape, which verifies Hypothesis 1. This Parabola shape implies that a firm does not necessarily export more in a larger city. For those with in-sufficiently high productivity, their exports may decrease when they enter into a larger city. Thus, there must be an equilibrium so that exporting firms will not concentrate in only one city.

## 5.3 Robust analysis

### 5.3.1 Regression results with alternative productivity and labor density

As firms' productivity is different when estimated using different method, which may affect the regression results of (29) and (30), we thus regress (29) and (30) with firms' productivity estimated using OLS method. The results are similar to those given in Table 1 and Table 2, and thus are not provided here. As the data of city land area includes both urban districts but also rural ones, while firms mainly locates in central district area, we also calculated city-level manufacturing-labor density by using the land area of its central districts and re-do the regression for (29) and (30). The results are shown in Table 3) and Table 4 in the appendix. It's easy to see that their results are much similar to those in Table 1 and Table 2. For the exporting choice equation, the coefficient of manufacturing-labor density is significantly positive at 1% significance level for all the models. For the exporting sale equation, the coefficient of the crossing term between manufacturing-labor density and firm productivity is significantly positive at 1% significance level, and the common export effect of agglomeration takes on significantly a parabola shape.

### 5.3.2 Regression results with natural productivity

In the former one-step estimation, we did not deal with the endogeneity between agglomeration and firms' productivity. However, firms' productivity estimated using the LP (or the OLS) method is not the one ex ante given prior to the spatial agglomeration. Instead, it is the one influenced ex post by agglomeration patterns. This endogeneity issue could jeopardize the validity of estimation of the effect of agglomeration on firms' exports. To identify the real effect of agglomeration on trading activities, we first estimate firms' natural productivity by ruling out the influence of agglomeration. And then we use this natural productivity to re-estimate (29) and (30).

First, we estimate firms' natural productivity by regressing the following equation:

$$\ln \theta_{rjit} = \phi \ln dens_{rjt} + \psi \ln A_{rt} + X_{rjit} \zeta + \alpha_r + \beta_j + \gamma_i + \eta_t + cons + \varepsilon_{rjit} \quad (31)$$

by controlling the regional-, industry-, and firm- fixed effects  $\alpha_r, \beta_j, \gamma_i$  and  $\eta_t$ , and firms' ownership, size, operating status, belonging characteristics, cities' location, per capital FDI, GDP and their infrastructure, including per capita bus, taxi, road

area and postoffice and provincial institution.<sup>14</sup> Considering agglomeration affects firms' productivity not only by density, but also by specialization and urban economies, as explored and stated in enormous literatures of economic geography, we involve these two indices of agglomeration into (31). Following Martin et al. (2008), we also add indices of industrial diversity and competition economy into (31). All these indices are measured in the ways proposed in Martin et al. (2008). These indices together with firm-, city-, industry- and province-level characteristics are included in  $X_{rjit}$ .

We estimate the above equation by controlling firm-, city-, industry- and province-level characteristics first. Controlling industry dummies as well as firm-specific effect, stock, belonging relationship, operating status and size dummies, this estimation provides us an opportunity to inspect the pre-assumption that manufacturing-labor density and other regional effects have significant influences on firms' productivity. Then we generate log of firm-level natural productivity as the firm fixed effect plus constant. Here we do not use the residual as the natural productivity as it's only the productivity affected by various random factors, but not a firm's inborn productivity. We also do not use the productivity which is derived from  $\ln \theta_{rjit}$  by ruling out the influence of agglomeration as the natural productivity because it includes the influences of firm characteristics of belonging, size, ownership, operating status for firms with the same these characteristics and city- and provincial characteristics that are common for all firms. In fact, the above three kinds of productivity have similar distributions (see Figure 7).<sup>15</sup>

Table 5 shows the regression results of firm productivity with respect to agglomeration controlling firm-, city-, industry- and province-level characteristics. From Table 5, it is straightforward that manufacturing-labor density has a positive effect on firms' productivity. So does the region-specific effect, such as city GDP, human capital, city area, provincial institution quality, etc. However, some variables in infrastructure, such as per capita taxi and per capita postoffice, take on negative effects on firm productivity, which arises maybe because they are collinear with per capita GDP and human capital. We can see that various agglomeration patterns such as localization and urbanization economy, has significant influences on firm productivity. Industrial competition and diversity effects, also significantly affect

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<sup>14</sup>Here, ruling out other factors, such as regional agglomeration patterns and intra- and inter industries activities, we suppose that a firm's inborn productivity is determined only by its inherent characteristics (ownership structure, operating status, size, belonging relationship, etc.) as well as local **amenities**, which are measured by cities' per capita bus, taxi, road area and postoffice.

<sup>15</sup>However, even if we use the productivity which is derived from  $\ln \theta_{rjit}$  by ruling out the influence of agglomeration as the natural productivity to estimate (30), the result does not change, see Table 7.

firm productivity. The influence directions of localization, urbanization, competition economy and industrial diversity on firm productivity are the same to those in Martin et al. (2008).

Second, we re-estimate (30) by replacing firm productivity by the firm-level natural productivity calculated as the firm fixed effect plus constant that are estimated from (31). The results are shown in Table 6. We can see that the coefficients of log of manufacturing-labor density and the cross term between log of manufacturing-labor density and log of firm-level natural productivity have the same signs with those in Table 4 and are significant in all the five models. This implies that agglomeration represented by manufacturing-labor density has a significantly positive influence on firms' exporting possibilities. For exporting sale, it takes on an inverted-U **common export effect**, as predicted in Hypothesis 1, while contradicting to Corollary 1. Table 6 indicates that the interaction between firms' inborn characteristics and agglomeration has a positive effect on exporting sale. This further testifies Proposition 2. This result implies that the foreign sales of firms with higher productivity are influenced more by agglomeration, as is predicted in Proposition 2.

### 5.3.3 Agglomeration patterns and firms' exports

Up till now, the estimation results proposed in the above sections has confirmed us for sure Proposition 1, 2 and Hypothesis 1 hold in Chinese firm-level data. However, they just show that agglomeration represented by manufacturing-labor density has significant influences on firms' exporting behaviors, but not show how agglomeration affects firms' exports. In this subsection, we involve agglomeration patterns including localization and urbanization economy into (29) and (30) to examine its influencing channels but replacing firm productivity by its natural productivity, as done in Section 5.3.2. Following Martin et al. (2008), we also add industrial diversity and competition economy into (29) and (30) by controlling the industrial effects caused by agglomeration.

Table 8 shows that manufacturing-labor density still has a significantly positive effect on firms' exporting choice. Table 9 shows that it takes on an inverted-U shape effect on firms' exporting sales by controlling the two agglomeration patterns, localization and urbanization economy, and the two industrial effect, industrial diversity and competition economy in nearly all the estimations (model (2) to (4)). These results verify again the declarations stated in Proposition 1, 2 and Hypothesis 1. Controlling the agglomeration patterns within the direct effect of agglomeration, manufacturing-labor density, Table 8 and 9 indicate that localization econ-

omy has a significantly positive while urbanization takes on a significantly negative effect on firms' exports. This result is a little different from [Martin et al. \(2008\)](#), where it shows that urbanization economy has a positive effect on firms' productivity. However, our result does not contradict to it as firms' productivity does not determine their exporting possibilities and exports uniquely, which are also determined by fixed and variable exporting costs. As also shown in these two tables, diversification and competition effects both negatively affect firms' exports, which is different from previous literatures in urban economics. The more diversified is the local labor market, the less backward and forward linkages are provided for local firms' exporting choices. As firms could not find substantial firms dedicating on the up- and down-stream production and services, the exporting conditions are comparatively poor. Also, local industrial competition pushing low productivity firms out of the market. Only firms with high productivity could survive in the increasing market competition, which is consistent with the results asserted in the Melitz model ([Melitz, 2003](#)). The negative effects of diversification and competition to exporting dynamics are counter-factual to classic predictions in urban economic theories but realistic in emerging nations with market segmentations. On the other hand, the localization and urbanization economies are all promising factors to most firms' exporting choices. Different with diversification and competition indices that measure industry- and region- correlation, localization and urbanization indices measure the local "firm-industry" distributional differences. Firms benefit from local home market effects instead of from other effects. The more fragmented or distorted is the local market, the more protection or less competition firms are faced with. Firms are conscious about the labor pool effects and market size (employment density and region size as the proxies). However, how they rank themselves within the particular market is more important than how strong is competition they are faced with. Consistent with [Proposition 1](#), the empirical estimation implies some crucial findings that firms enjoy more from the home-market effects which were "localized" and fragmented by heterogeneous locations if the national/regional income and population are given constant. Such findings are explicitly revealing the trade-geography mechanism caused by spatial competition. The more protection and isolated is a region, the more benefits firms receive in stimulating their production and exporting propensities in it.

## 6 Conclusion

Different from classic literatures on trade induced agglomeration (TIA) studies, our paper investigates the influences of agglomeration on heterogeneous firms' exporting behaviors (AIT).

The timing for firms making exporting decisions are of two steps. Firstly, firms decide which location to start up their production facing sunk costs whose productivity levels are heterogeneous. This setting is sufficient to explain the spatial heterogeneity on firms exporting decisions. As pre-assumed, firms are consciously aware of externalities in potential locations. Such externalities can be explained as local labor pool effects, home market effect, and regional amenities in terms of fiscal expenditure, etc. These "X factors" are common to all firms, which provide positive influences on aggregate industrial productivity.

Secondly, after firms enter the local market, the story of technological spillover is no longer new to each new-entry or incumbent firm. The previous "unobserved" local market magnification effects enlarge the demand and supply premier for firms, while there are new decisions for firms to make. After large and productive firms paid their sunk costs to enter into large cities that have higher level of productivity spillovers and labor pools, they make their decisions on how they interact with other firms and industries. How firms compete and self-organize themselves become the "neo-X factor" for productivity growth and exporting dynamics. That is to say, agglomeration patterns matters exogenously given local home market effect for "New Firms in Town!"

In all, firm-level exporting dynamics is threefold. Firm-level productivity determines its initial preference of export, local market effect increases firms' productivity and export potential while the self-organizing of firms - agglomeration patterns enhances the selection and sorting mechanism for individuals firms. The first and third dynamics are firm-made, while the second is more or less exogenous to firms.

Based on the above thought, the paper proposes a model to investigate how agglomeration affects firms' exporting behaviors. Competition and thus selection effect caused by agglomeration forces less productive firms to exit the market while agglomeration externalities increase firms' productivity and decreases industrial fixed entry, fixed and variable exporting costs, and effective labor wages. The former factors decrease while the latter increase firms' exporting possibilities and sales. Higher-productivity firms benefit more export premium from agglomeration, which plays the most important role in determining the influencing direction of agglomeration on firms' exports. The model shows that firms in more labor-dense cities are more possible to export. Except that, the heterogeneous export effect of ag-

glomeration is increasing in agglomeration while the common export effect caused by agglomeration takes on a parabola pattern. Empirical results based on data from Chinese Industrial Enterprises between 1998 and 2007 verify the theoretical results.

The paper also investigates the influences of different agglomeration patterns on firms exports, including specialization effect, urban economies and competition effect and diversification effect. It shows that the former two patterns exert a positive while the latter two have a positive influence on firms' exporting behaviors.

The policy suggestion is nothing fancy but straightforward. Providing supportive local amenities and services to attracting firms is important for a local government. How firms interact with each other is as private as their heterogeneous nature could be less intervened by government policies.

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## Appendix

Table 1: The influence of agglomeration on firms' exporting choices (manufacturing-labor density)

export dummy	(1)	(2)	(3)	(4)	(5)
log of manufacturing-labor density	0.676**** (147.42)	0.319**** (39.69)	0.296**** (36.44)	0.261**** (32.35)	0.152**** (19.59)
log of land area	0.543**** (111.15)	0.131**** (11.61)	0.0745**** (6.51)	0.0662**** (5.83)	0.0190* (1.72)
log of human capital		-0.0670**** (-6.89)	-0.128**** (-12.91)	-0.172**** (-17.44)	-0.177**** (-18.40)
log of per capita GDP		0.459**** (51.19)	0.617**** (48.32)	0.607**** (47.81)	0.603**** (48.45)
log of dist to nearest harbor		-0.387**** (-70.03)	-0.311**** (-55.69)	-0.337**** (-61.82)	-0.208**** (-40.74)
log of per capita road area		-0.0533**** (-6.24)	-0.249**** (-27.92)	-0.261**** (-29.30)	-0.235**** (-27.35)
log of per capita bus		-0.105**** (-12.63)	-0.0731**** (-8.58)	-0.0700**** (-8.32)	-0.0690**** (-8.47)
log of per capita taxi		-0.305**** (-45.08)	-0.227**** (-30.64)	-0.226**** (-30.72)	-0.134**** (-18.38)
log of per capita post office		0.152**** (29.18)	0.118**** (21.92)	0.144**** (26.87)	0.113**** (21.89)
Provincial institute level			0.135**** (44.59)	0.116**** (37.50)	0.117**** (38.40)
log of exchange rate			8.202**** (83.85)	8.935**** (45.74)	8.763**** (45.25)
Constant	-12.57**** (-224.13)	-7.159**** (-66.52)	-26.33**** (-96.51)	-25.84**** (-57.17)	-26.45**** (-58.54)
stock dummy	no	no	no	yes	yes
status dummy	no	no	no	yes	yes
size dummy	no	no	no	yes	yes
belong dummy	no	no	no	yes	yes
industry dummy	no	no	no	no	yes
lnsig2u					
Constant	3.322**** (866.65)	2.689**** (580.51)	2.649**** (564.24)	2.421**** (484.46)	2.015**** (359.34)
sigma					
obs	2091025	1738007	1738007	1736249	1736246

Note:  $t$  statistics in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ , \*\*\*\*  $p < 0.001$ .

**Table 2: The influence of agglomeration on firms' exporting sales (manufacturing-labor density)**

log of exporting sale	(1)	(2)	(3)	(4)	(5)
log of manufacturing-labor density	2.764**** (47.81)	0.110**** (6.58)	2.012**** (28.53)	2.228**** (31.79)	1.654**** (23.63)
log of manufacturing-labor density <sup>2</sup>	-0.145**** (-29.38)	-0.00822**** (-5.78)	-0.157**** (-27.24)	-0.176**** (-30.77)	-0.151**** (-26.53)
log of manufacturing-labor density×log of firm productivity	0.105**** (102.01)	0.0459**** (133.86)	0.123**** (101.36)	0.106**** (87.02)	0.116**** (94.57)
log of land area	1.192**** (87.08)	0.136**** (15.25)	0.225**** (6.80)	0.228**** (6.92)	0.135**** (4.08)
log of human capital		-0.153**** (-19.72)	-0.520**** (-18.19)	-0.694**** (-24.37)	-0.687**** (-24.11)
log of per capita GDP		0.376**** (39.23)	1.410**** (40.62)	1.365**** (39.27)	1.449**** (41.33)
log of dist to nearest harbor		-0.238**** (-53.34)	-1.283**** (-76.67)	-1.353**** (-81.51)	-0.912**** (-56.28)
log of per capita road area		-0.170**** (-26.37)	-0.703**** (-30.95)	-0.689**** (-30.39)	-0.667**** (-29.32)
log of per capita bus		-0.0383**** (-6.11)	-0.0913**** (-4.17)	-0.0537** (-2.46)	-0.0631** (-2.87)
log of per capita taxi		-0.137**** (-23.59)	-0.605**** (-29.18)	-0.629**** (-30.43)	-0.405**** (-19.43)
log of per capita post office		0.119**** (28.95)	0.170**** (12.25)	0.224**** (16.15)	0.189**** (13.59)
Provincial institute level			0.296**** (37.51)	0.232**** (28.62)	0.242**** (29.51)
log of exchange rate			19.38**** (81.44)	21.65**** (44.44)	22.84**** (45.89)
Constant	-32.34**** (-165.46)	-15.66**** (-78.90)	-64.48**** (-90.81)	-65.40**** (-56.78)	-73.86**** (-62.17)
stock dummy	no	no	no	yes	yes
status dummy	no	no	no	yes	yes
size dummy	no	no	no	yes	yes
belong dummy	no	no	no	yes	yes
industry dummy	no	no	no	no	yes
sigma_u					
Constant	11.51**** (577.17)	2.802**** (892.19)	10.70**** (527.46)	10.13**** (508.77)	8.901**** (468.45)
sigma_e					
Constant	3.346**** (784.19)	1.642**** (1377.34)	3.410**** (673.47)	3.399**** (669.03)	3.466**** (672.61)
sigma					
obs	1802370	1465207	1465207	1463533	1463533

Note: *t* statistics in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ , \*\*\*\*  $p < 0.001$ .

**Table 3: The influence of agglomeration on firms' exporting choices (manufacturing-labor density calculated using central districts)**

export dummy	(1)	(2)	(3)	(4)	(5)
log of manufacturing-labor density	0.670**** (103.19)	0.420**** (52.43)	0.398**** (49.22)	0.357**** (44.49)	0.220**** (28.29)
log of city area	0.523**** (110.64)	0.0394*** (3.26)	0.0694**** (5.72)	0.0191 (1.59)	-0.0369*** (-3.21)
log of human capital		-0.0311*** (-3.21)	-0.160**** (-16.24)	-0.163**** (-16.57)	-0.150**** (-15.85)
log of per capita GDP		0.476**** (52.83)	0.609**** (47.82)	0.600**** (47.35)	0.592**** (47.69)
log of dist to nearest harbor		-0.390**** (-70.32)	-0.318**** (-56.92)	-0.341**** (-62.54)	-0.210**** (-41.14)
log of per capita road area		0.00590 (0.68)	-0.188**** (-20.93)	-0.198**** (-22.01)	-0.188**** (-21.60)
log of per capita bus		-0.0323**** (-3.87)	-0.00157 (-0.18)	-0.00131 (-0.15)	-0.0176** (-2.14)
log of per capita taxi		-0.209**** (-30.80)	-0.133**** (-17.68)	-0.136**** (-18.00)	-0.0649**** (-8.68)
log of per capita post office		0.140**** (26.86)	0.108**** (20.07)	0.133**** (25.00)	0.104**** (20.14)
Provincial institute level			0.129**** (43.22)	0.113**** (36.65)	0.116**** (38.19)
log of exchange rate			7.877**** (80.32)	8.487**** (43.38)	8.385**** (43.19)
Constant	-12.92**** (-198.43)	-8.940**** (-80.12)	-27.25**** (-100.52)	-26.43**** (-58.65)	-26.73**** (-59.29)
stock dummy	no	no	no	yes	yes
status dummy	no	no	no	yes	yes
size dummy	no	no	no	yes	yes
belong dummy	no	no	no	yes	yes
industry dummy	no	no	no	no	yes
lnsig2u					
Constant	3.385**** (884.47)	2.691**** (581.23)	2.652**** (565.80)	2.421**** (485.76)	2.013**** (359.87)
sigma					
N	2090242	1738007	1738007	1736249	1736246

Note:  $t$  statistics in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ , \*\*\*\*  $p < 0.001$ .

**Table 4: The influence of agglomeration on firms' exporting sales (manufacturing-labor density calculated using central districts)**

log of exporting sale	(1)	(2)	(3)	(4)	(5)
log of manufacturing-labor densit	2.230**** (13.78)	1.536**** (6.55)	2.841**** (12.01)	3.711**** (15.69)	3.023**** (12.77)
log of manufacturing-labor density <sup>2</sup>	-0.0494**** (-5.25)	-0.0470**** (-3.36)	-0.131**** (-9.27)	-0.187**** (-13.22)	-0.166**** (-11.73)
log of manufacturing-labor density×log of firm productivity	0.0768**** (103.98)	0.0797**** (92.94)	0.0899**** (103.36)	0.0780**** (89.18)	0.0858**** (96.84)
log of central district area	1.396**** (114.24)	0.347**** (11.39)	0.404**** (13.16)	0.247**** (8.06)	0.0592* (1.91)
log of human capital		-0.272**** (-11.40)	-0.625**** (-25.71)	-0.638**** (-26.18)	-0.556**** (-22.75)
log per capita GDP		0.925**** (38.50)	1.448**** (41.37)	1.439**** (41.14)	1.503**** (42.54)
log of dist to nearest harbor		-1.470**** (-88.25)	-1.273**** (-75.87)	-1.324**** (-79.70)	-0.881**** (-54.30)
log per capita road area		-0.0752**** (-3.39)	-0.570**** (-24.84)	-0.550**** (-24.01)	-0.556**** (-24.15)
log of per capita bus		-0.0119 (-0.56)	0.0281 (1.29)	0.0445** (2.05)	0.0112 (0.51)
log of per capita taxi		-0.562**** (-29.23)	-0.409**** (-19.51)	-0.440**** (-21.07)	-0.243**** (-11.49)
log of per capita post office		0.272**** (19.98)	0.178**** (12.79)	0.235**** (16.94)	0.197**** (14.10)
Provincial institute level			0.281**** (35.90)	0.225**** (27.86)	0.243**** (29.73)
log of exchange rate			19.27**** (80.70)	21.38**** (43.83)	22.61**** (45.32)
Constant	-34.59**** (-49.34)	-21.80**** (-20.55)	-73.86**** (-58.10)	-77.82**** (-50.22)	-84.52**** (-53.62)
sigma_u					
Constant	11.50**** (575.62)	10.88**** (531.92)	10.72**** (528.05)	10.12**** (509.36)	8.890**** (468.72)
stock dummy	no	no	no	yes	yes
status dummy	no	no	no	yes	yes
size dummy	no	no	no	yes	yes
belong dummy	no	no	no	yes	yes
industry dummy	no	no	no	no	yes
sigma_e					
Constant	3.346**** (783.37)	3.417**** (673.74)	3.410**** (673.48)	3.398**** (669.39)	3.465**** (672.72)
sigma					
N	1801605	1465207	1465207	1463533	1463533

Note: *t* statistics in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ , \*\*\*\*  $p < 0.001$ .

Table 5: **Regression results of firm productivity and agglomeration (manufacturing-labor density)**

firm productivity	(1)	(2)	(3)	(4)	(5)
log of manufacturing-labor density	0.430**** (121.96)		0.507**** (17.42)	0.230**** (6.71)	0.192**** (5.44)
log of central district area	0.682**** (208.20)		0.666**** (22.94)	0.174**** (5.06)	0.139**** (3.91)
localization economy		0.0504**** (36.51)	0.0292**** (16.56)	0.0199**** (9.86)	0.0256**** (12.01)
urbanization economy		0.346**** (110.28)	-0.163**** (-5.79)	-0.190**** (-5.75)	-0.172**** (-5.04)
competition economy		0.0339**** (207.30)	0.0312**** (184.53)	0.0154**** (78.68)	0.0151**** (76.75)
industrial diversity		-1.046**** (-29.09)	-1.783**** (-42.27)	-1.218**** (-24.25)	-1.216**** (-24.21)
log of human capital				0.0143*** (3.27)	0.0000476 (0.01)
log of dist to nearest harbor				-0.0872** (-2.30)	-0.0869** (-2.30)
log of per capita road area				0.118**** (33.86)	0.115**** (32.90)
log of per capita bus				0.0276**** (7.77)	0.0178**** (5.03)
log of per capita taxi				-0.0553**** (-13.05)	-0.0609**** (-14.42)
log of per capita post office				-0.0228**** (-10.32)	-0.0152**** (-6.89)
Provincial institute level				0.0241**** (21.49)	0.0241**** (20.58)
log of exchange rate				-5.045**** (-155.52)	-4.886**** (-84.05)
Constant	-1.568**** (-38.43)	0.333**** (9.03)	-0.165**** (-3.97)	15.44**** (68.02)	15.72**** (62.02)
stock dummy	no	no	no	no	yes
status dummy	no	no	no	no	yes
size dummy	no	no	no	no	yes
belong dummy	no	no	no	no	yes
industry dummy	no	no	no	no	yes
sigma	1.466	1.403	1.421	1.353	1.326
N	1801605	1909776	1801605	1465451	1463777

Note:  $t$  statistics in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ , \*\*\*\*  $p < 0.001$ .

**Table 6: The influence of agglomeration on firms' exporting sales (firm productivity replaced by natural productivity computed by fixed effect method)**

log of export	(1)	(2)	(3)	(4)	(5)
log of manufacturing-labor density	-0.460** (-2.05)	0.909**** (3.86)	2.029**** (8.54)	2.869**** (12.11)	2.069**** (8.72)
log of manufacturing-labor density <sup>2</sup>	0.0919**** (6.91)	-0.0620**** (-4.41)	-0.131**** (-9.26)	-0.185**** (-13.07)	-0.162**** (-11.46)
log of manufacturing-labor density×log of natural productivity	0.0784**** (89.66)	0.0828**** (94.09)	0.0825**** (93.71)	0.0780**** (89.00)	0.0863**** (97.09)
log of central district area	1.709**** (124.63)	0.371**** (12.18)	0.371**** (12.08)	0.215**** (7.03)	0.0287 (0.93)
log of human capital		-0.325**** (-13.60)	-0.588**** (-24.15)	-0.614**** (-25.20)	-0.531**** (-21.73)
log of per capita GDP		1.262**** (52.93)	1.447**** (41.34)	1.442**** (41.23)	1.505**** (42.63)
log of dist to nearest harbor		-1.472**** (-88.40)	-1.325**** (-78.82)	-1.379**** (-82.91)	-0.941**** (-57.92)
log of per capita road area		-0.0486** (-2.19)	-0.469**** (-20.44)	-0.465**** (-20.35)	-0.463**** (-20.14)
log of per capita bus		-0.0214 (-1.01)	0.0660*** (3.03)	0.0707*** (3.26)	0.0384* (1.76)
log of per capita taxi		-0.654**** (-33.97)	-0.447**** (-21.31)	-0.479**** (-22.92)	-0.287**** (-13.57)
log of per capita post office		0.206**** (15.18)	0.150**** (10.79)	0.221**** (15.93)	0.182**** (13.02)
Provincial institute level			0.307**** (39.12)	0.246**** (30.49)	0.268**** (32.77)
log of exchange rate			15.10**** (64.06)	17.67**** (36.41)	18.55**** (37.37)
Constant	-30.11**** (-31.62)	-26.03**** (-24.49)	-65.49**** (-51.50)	-69.80**** (-45.14)	-75.68**** (-48.10)
stock dummy	no	no	no	yes	yes
status dummy	no	no	no	yes	yes
size dummy	no	no	no	yes	yes
belong dummy	no	no	no	yes	yes
industry dummy	no	no	no	no	yes
sigma_u					
Constant	11.24**** (539.40)	10.89**** (532.63)	10.78**** (529.69)	10.14**** (509.83)	8.899**** (469.06)
sigma_e					
Constant	3.414**** (670.86)	3.415**** (673.52)	3.411**** (673.15)	3.397**** (669.36)	3.464**** (672.75)
sigma					
N	1463777	1463533	1463533	1463533	1463533

Note:  $t$  statistics in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ , \*\*\*\*  $p < 0.001$ . A firm's natural productivity is calculated as the firm fixed effect of (31).

**Table 7: The influence of agglomeration on firms' exporting sales (firm productivity replaced by natural productivity computed by ruling out of the influence of agglomeration)**

log of export	(1)	(2)	(3)	(4)	(5)
log of manufacturing-labor density	2.059**** (12.73)	1.607**** (6.85)	2.904**** (12.28)	3.751**** (15.87)	3.053**** (12.90)
log of manufacturing-labor density <sup>2</sup>	-0.0364**** (-3.87)	-0.0503**** (-3.59)	-0.133**** (-9.43)	-0.188**** (-13.29)	-0.166**** (-11.76)
log of manufacturing-labor density×log of natural productivity	0.0776**** (103.97)	0.0805**** (93.31)	0.0894**** (102.56)	0.0778**** (88.75)	0.0865**** (97.27)
log of central district area	1.417**** (116.17)	0.329**** (10.82)	0.376**** (12.23)	0.223**** (7.26)	0.0339 (1.10)
log of human capital		-0.270**** (-11.30)	-0.612**** (-25.15)	-0.624**** (-25.61)	-0.541**** (-22.12)
log of per capita GDP		0.974**** (40.66)	1.449**** (41.42)	1.441**** (41.22)	1.504**** (42.59)
log of dist to nearest harbor		-1.469**** (-88.23)	-1.279**** (-76.20)	-1.328**** (-79.89)	-0.882**** (-54.35)
log of per capita road area		-0.0797**** (-3.60)	-0.568**** (-24.77)	-0.547**** (-23.91)	-0.554**** (-24.08)
log of per capita bus		-0.00457 (-0.22)	0.0450** (2.07)	0.0585*** (2.70)	0.0254 (1.16)
log of per capita taxi		-0.572**** (-29.77)	-0.409**** (-19.53)	-0.441**** (-21.13)	-0.244**** (-11.52)
log of per capita post office		0.265**** (19.49)	0.176**** (12.66)	0.233**** (16.84)	0.196**** (14.02)
Provincial institute level			0.289**** (36.91)	0.232**** (28.82)	0.252**** (30.83)
log of exchange rate			18.77**** (78.90)	20.79**** (42.68)	21.99**** (44.15)
Constant	-34.11**** (-48.70)	-22.51**** (-21.23)	-73.08**** (-57.52)	-76.78**** (-49.59)	-83.38**** (-52.93)
stock dummy	no	no	no	yes	yes
status dummy	no	no	no	yes	yes
size dummy	no	no	no	yes	yes
belong dummy	no	no	no	yes	yes
industry dummy	no	no	no	no	yes
sigma_u					
Constant	11.52**** (576.18)	10.89**** (532.56)	10.74**** (528.85)	10.14**** (509.99)	8.899**** (469.07)
sigma_e					
Constant	3.345**** (783.49)	3.415**** (673.81)	3.408**** (673.52)	3.396**** (669.37)	3.464**** (672.76)
sigma					
N	1801605	1465207	1465207	1463533	1463533

Note: *t* statistics in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ , \*\*\*\*  $p < 0.001$ . A firm's natural productivity is calculated as its LP productivity netting out of the influence of agglomeration.

**Table 8: The influence of agglomeration on firms' exporting choices with considering various agglomeration patterns**

export dummy	(1)	(2)	(3)	(4)	(5)
log of manufacturing-labor density	1.436**** (29.62)	0.972**** (18.04)	0.939**** (17.29)	0.477**** (8.68)	0.716**** (11.45)
log of central district area	1.299**** (26.78)	0.617**** (11.28)	0.624**** (11.32)	0.149*** (2.67)	0.472**** (7.48)
localization economy	0.0966**** (23.46)	0.117**** (26.94)	0.116**** (26.57)	0.132**** (30.07)	0.103**** (21.72)
urbanization economy	-0.854**** (-18.89)	-0.701**** (-13.94)	-0.681**** (-13.43)	-0.285**** (-5.55)	-0.625**** (-10.62)
industrial diversity	-0.432**** (-6.03)	-0.901**** (-11.23)	-1.042**** (-12.69)	-1.722**** (-20.44)	-0.932**** (-11.37)
competition economy	-0.0081**** (-15.28)	-0.0142**** (-24.99)	-0.0093**** (-15.68)	-0.0129**** (-21.76)	-0.0132**** (-22.81)
log of human capital		-0.0295*** (-3.04)	-0.153**** (-15.42)	-0.158**** (-16.02)	-0.142**** (-14.92)
log of per capital GDP		0.535**** (57.32)	0.620**** (48.28)	0.618**** (48.43)	0.600**** (48.08)
log of dist to nearest harbor		-0.371**** (-66.40)	-0.305**** (-54.08)	-0.320**** (-58.70)	-0.196**** (-38.32)
log of per capital road area		0.00448 (0.52)	-0.187**** (-20.79)	-0.194**** (-21.50)	-0.181**** (-20.81)
log of per capita bus		-0.0338**** (-4.04)	0.00254 (0.29)	0.00346 (0.41)	-0.0117 (-1.42)
log of per capita taxi		-0.220**** (-32.15)	-0.131**** (-17.35)	-0.136**** (-17.97)	-0.0636**** (-8.51)
log of per capita post office		0.134**** (25.59)	0.107**** (19.92)	0.131**** (24.59)	0.0999**** (19.43)
Provincial institute level			0.134**** (44.06)	0.122**** (39.02)	0.125**** (40.55)
log of exchange rate			7.617**** (76.17)	8.053**** (40.87)	7.857**** (40.15)

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**Table 8 – continued from previous page**

export dummy	(1)	(2)	(3)	(4)	(5)
Constant	-12.59**** (-182.45)	-8.875**** (-77.95)	-26.31**** (-95.44)	-24.92**** (-54.88)	-25.62**** (-56.29)
stock dummy	no	no	no	yes	yes
status dummy	no	no	no	yes	yes
size dummy	no	no	no	yes	yes
belong dummy	no	no	no	yes	yes
industry dummy	no	no	no	no	yes
<hr/>					
Insig2u					
Constant	3.303**** (846.53)	2.664**** (569.66)	2.646**** (561.75)	2.396**** (476.77)	2.008**** (356.99)
<hr/>					
sigma					
N	2090146	1737933	1737933	1736175	1736172

Note:  $t$  statistics in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ , \*\*\*\*  $p < 0.001$ . A firm's natural productivity is calculated as the firm fixed effect of (31).

**Table 9: The influence of agglomeration on firms' exporting sales with considering various agglomeration patterns**

log of export	(1)	(2)	(3)	(4)	(5)
log of manufacturing-labor density	0.986**** (3.54)	2.471**** (8.64)	3.231**** (11.24)	3.093**** (10.80)	3.870**** (12.97)
log of manufacturing-labor density <sup>2</sup>	0.0961**** (7.21)	-0.0748**** (-5.31)	-0.134**** (-9.45)	-0.195**** (-13.79)	-0.170**** (-12.01)
log of manufacturing-labor density× log of natural productivity	0.0791**** (90.20)	0.0833**** (94.43)	0.0832**** (94.24)	0.0787**** (89.64)	0.0868**** (97.60)
localization economy	0.364**** (29.40)	0.320**** (25.75)	0.317**** (25.51)	0.353**** (28.44)	0.198**** (14.38)
urbanization economy	-1.909**** (-12.61)	-1.709**** (-11.28)	-1.489**** (-9.82)	-0.442*** (-2.92)	-1.907**** (-11.12)
industrial diversity	-4.202**** (-18.01)	-4.201**** (-17.30)	-4.753**** (-19.38)	-6.630**** (-26.58)	-4.332**** (-17.24)
competition economy	-0.00270** (-2.18)	-0.0217**** (-16.40)	-0.0094**** (-6.86)	-0.0214**** (-15.43)	-0.0254**** (-18.10)
log of central district area	3.248**** (20.18)	1.778**** (10.92)	1.563**** (9.59)	0.301* (1.85)	1.734**** (9.48)
log of human capital		-0.348**** (-14.49)	-0.602**** (-24.57)	-0.642**** (-26.20)	-0.541**** (-22.01)
log of per capital GDP		1.378**** (55.20)	1.467**** (41.72)	1.481**** (42.16)	1.533**** (43.35)
log of dist to nearest harbor		-1.395**** (-83.34)	-1.261**** (-74.66)	-1.300**** (-77.96)	-0.891**** (-54.85)
log of per capital road area		-0.0577*** (-2.60)	-0.464**** (-20.22)	-0.456**** (-19.91)	-0.451**** (-19.63)
log of per capita bus		-0.0241 (-1.14)	0.0611** (2.79)	0.0767**** (3.52)	0.0522** (2.38)
log of per capita taxi		-0.672**** (-34.62)	-0.446**** (-21.22)	-0.495**** (-23.64)	-0.296**** (-13.99)
log of per capita post office		0.203****	0.158****	0.229****	0.185****

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**Table 9 – continued from previous page**

log of export	(1)	(2)	(3)	(4)	(5)
		(14.92)	(11.35)	(16.49)	(13.24)
Provincial institute level			0.309****	0.262****	0.287****
			(39.03)	(32.12)	(34.70)
log of exchange rate			14.73****	16.57****	17.07****
			(60.77)	(33.64)	(33.93)
Constant	-28.12****	-26.75****	-64.01****	-66.83****	-73.42****
	(-29.35)	(-24.97)	(-50.11)	(-42.96)	(-46.43)
stock dummy	no	no	no	yes	yes
status dummy	no	no	no	yes	yes
size dummy	no	no	no	yes	yes
belong dummy	no	no	no	yes	yes
industry dummy	no	no	no	no	yes
sigma_u					
Constant	11.10****	10.78****	10.67****	10.03****	8.857****
	(534.67)	(528.77)	(525.94)	(506.12)	(468.00)
sigma_e					
Constant	3.420****	3.419****	3.416****	3.401****	3.465****
	(670.44)	(672.97)	(672.69)	(669.09)	(672.58)
sigma					
obs	1463777	1463533	1463533	1463533	1463533

Note:  $t$  statistics in parentheses, \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ , \*\*\*\*  $p < 0.001$ . A firm's natural productivity is calculated as the firm fixed effect of (31).

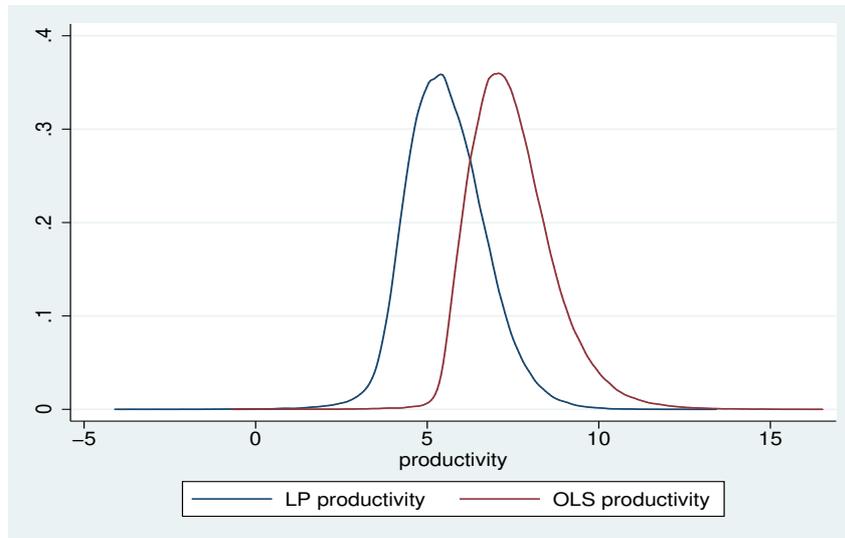


Figure 6: The kernel-density of firm productivity estimated by LP and OLS methods

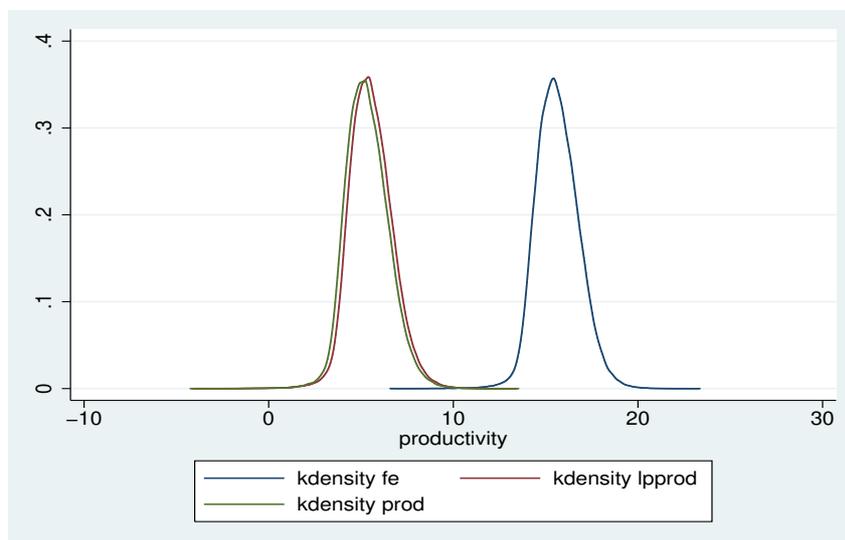


Figure 7: Kernel-densities of LP productivity, fixed-effect productivity and the productivity by ruling out the influence of agglomeration from LP productivity

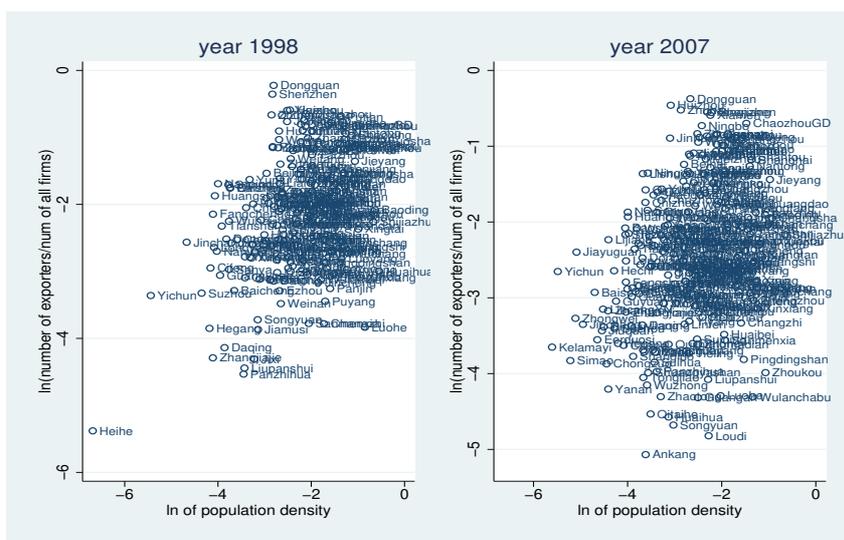


Figure 8: Firms' ex ante exporting possibility and manufacturing-labor density in 1998 and 2007 across prefecture-level cities

**Note:** The geographic unit is prefecture-level city. 283 prefecture-level cities are included in the above figure.

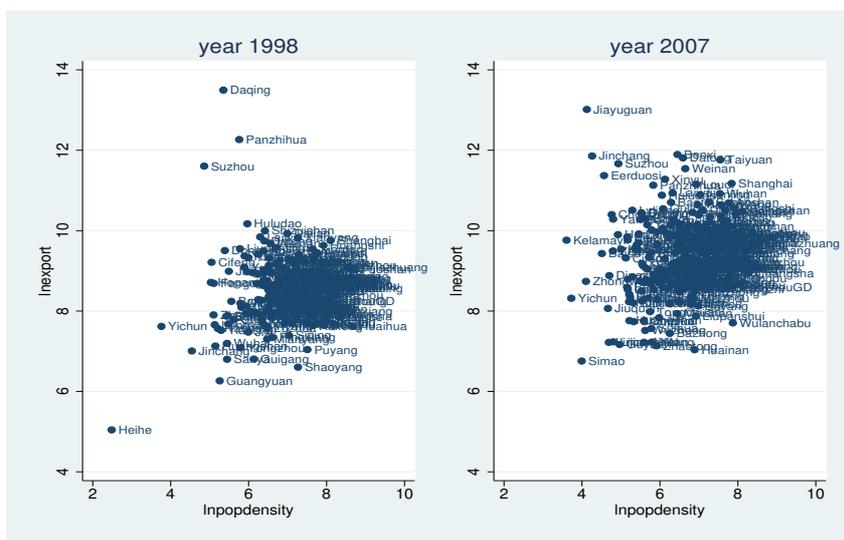


Figure 9: Incumbents' average exporting sale and manufacturing-labor density in 1998 and 2007 across prefecture-level cities

**Note:** The geographic unit is prefecture-level city. 283 prefecture-level cities are included in the above figure.