Spatial spillovers from FDI agglomeration : evidence from the Yangtze River Delta in China

著者	Tanaka Kiyoyasu, Hashiguchi Yoshihiro
権利	Copyrights 日本貿易振興機構（ジェトロ）アジア経済研究所 / Institute of Developing Economies, Japan External Trade Organization (IDE-JETRO) http://www.ide.go.jp
journal or publication title	IDE Discussion Paper
volume	354
year	2012-06-01
URL	http://hdl.handle.net/2344/1179

INSTITUTE OF DEVELOPING ECONOMIES

IDE Discussion Papers are preliminary materials circulated
to stimulate discussions and critical comments

IDE DISCUSSION PAPER No. 354

Spatial Spillovers from FDI Agglomeration: Evidence from the Yangtze River Delta in China

Kiyoyasu TANAKA* and Yoshihiro HASHIGUCHI

June 2012

Abstract

Foreign firms have clustered together in the Yangtze River Delta, and their impact on domestic firms is an important policy issue. This paper studies the spatial effect of FDI agglomeration on the regional productivity of domestic firms, using Chinese firm-level data. To identify local FDI spillovers, we estimate the causal impact of foreign firms on domestic firms in the same county and similar industries. We then estimate a spatial-autoregressive model to examine spatial spillovers from FDI clusters to other domestic firms in distant counties. Our results show that FDI agglomeration generates positive spillovers for domestic firms, which are stronger in nearby areas than in distant areas.

Keywords: FDI, multinational firms, spillovers, productivity, China
JEL classification: C21, F21, F23, R12, R58

* *Corresponding author*: Inter-Disciplinary Studies Center, Institute of Developing Economies; address: 3-2-2 Wakaba, Mihama-ku, Chiba-shi, Chiba, 261-8545, Japan; e-mail: kiyoyasu_tanaka@ide.go.jp

The Institute of Developing Economies (IDE) is a semigovernmental, nonpartisan, nonprofit research institute, founded in 1958. The Institute merged with the Japan External Trade Organization (JETRO) on July 1, 1998. The Institute conducts basic and comprehensive studies on economic and related affairs in all developing countries and regions, including Asia, the Middle East, Africa, Latin America, Oceania, and Eastern Europe.

INSTITUTE OF DEVELOPING ECONOMIES (IDE), JETRO
3-2-2, WAKABA, MIHAMA-KU, CHIBA-SHI
CHIBA 261-8545, JAPAN

Spatial Spillovers from FDI Agglomeration: Evidence from the Yangtze River Delta in China[†]

Kiyoyasu TANAKA[ζ]

Institute of Developing Economies

Yoshihiro Hashiguchi[§]

Institute of Developing Economies

June 2012

Abstract:

Foreign firms have clustered together in the Yangtze River Delta, and their impact on domestic firms is an important policy issue. This paper studies the spatial effect of FDI agglomeration on the regional productivity of domestic firms, using Chinese firm-level data. To identify local FDI spillovers, we first estimate the causal impact of foreign firms on domestic firms in the same county and similar industries. We then estimate a spatial-autoregressive model to examine spatial spillovers from FDI clusters to other domestic firms in distant counties. Our results show that FDI agglomeration generates positive spillovers for domestic firms, which are stronger in nearby areas than in distant areas. Thus, the presence of spatial externalities provides a basis for regional policy coordination in attracting foreign investment.

Keywords: FDI, multinational firms, spillovers, productivity, China

JEL classification: C21, F21, F23, R12, R58

[†] We would like thank Toshiyuki Matsuura for data assistance and the seminar participants at the Institute of Developing Economies and National Graduate Institute for Policy Studies for their useful comments and discussions. All remaining errors are our own.

[ζ] *Corresponding author*: Inter-Disciplinary Studies Center, Institute of Developing Economies; address: 3-2-2 Wakaba, Mihama-ku, Chiba-shi, Chiba, 261-8545, Japan; e-mail: kiyoyasu_tanaka@ide.go.jp

[§] Development Studies Center, Institute of Developing Economies; address: 3-2-2 Wakaba, Mihama-ku, Chiba-shi, Chiba 261-8545, Japan. e-mail: yoshihiro_hashiguchi@ide.go.jp

1. Introduction

The past decades have seen considerable interest among academics and policymakers regarding inward foreign direct investment (FDI) and potential spillovers from foreign to domestic firms. A number of developing countries have attempted to attract foreign investors with preferential fiscal incentives in order to build an industrial cluster and participate in global value chains, whereby local firms can absorb advanced technology brought in by multinational firms through various channels, such as the imitation of advanced production technology, the mobility of skilled workers, and buyer-supplier linkages on intermediate goods. Policies for FDI have been justified by potentially positive externalities from highly productive multinationals and the spatial agglomeration of industrial activities.

Motivated by these reasons, a large number of empirical studies have estimated the spillover effects of FDI in a wide variety of countries and industries. However, the evidence so far has been quite mixed, and the existing evidence is inconclusive as to whether we should promote FDI for local industry development (Görg and Greenaway, 2004).[1] To reconcile the mixed evidence, recent studies have examined the geographic scope of FDI spillovers because knowledge transfers tend to be localized over space (Jaffe et al, 1993; Audretsch and Feldman, 2004). Specifically, the studies, such as Barrios et al. (2006), Girma and Wakelin (2007), Halpern and Muraközy (2007), and Nicolini and Resmini (2007), examine whether local firms tend to benefit more from foreign firms in nearby locations than those in distant locations. These studies generally suggest that spillover effects are regional in space and are stronger for the local firms closer to the presence of foreign firms.

An unexplored question in the previous studies is whether local FDI spillovers could yield any further spatial externalities over other regions. Given that domestic firms in one region benefit directly from foreign firms in the same region, it is plausible that additional knowledge transfers could occur from one region to another among a group of local firms. Through spatial interactions between firms in proximate regions, other domestic firms in neighboring regions may also benefit from knowledge transfers that stem from FDI activity in distant locations. Meanwhile, there are two forces in determining the extent of such spatial knowledge transfers from FDI. First, the distance would gradually dissipate knowledge transfers because the quality of knowledge decays over distance (Keller, 2002). Second, the agglomeration of FDI activity could

[1] Supporting evidence for vertical spillovers from FDI has been relatively stronger than horizontal spillovers. Havranek and Irsova (2011) conducted a meta-analysis to show that the average spillover to suppliers is quantitatively large.

strengthen the density of knowledge flows, which in turn could mitigate the decay process of spatial multiplier effects. The net spatial externality from FDI will be determined by the spatial distance of knowledge flows and the density of FDI activity. To the best of our knowledge, such a hypothesis has not been subject to formal analysis, and its assessment should provide an important implication for policies on FDI attraction and industrial clusters.

This paper seeks to quantify a local spillover from foreign-owned firms to domestically owned firms and its spatial multiplier effects from FDI agglomeration. For this task, we employ a firm-level dataset on Chinese manufacturing firms in the four provinces of the Yangtze River Delta area: Shanghai, Jiangsu, Zhejiang, and Anhui. This region provides an interesting case for our investigation. As is well known, coastal regions have received a substantial amount of FDI inflows and achieved higher economic growth compared with inland provinces in China (Xu and Sheng, 2012). Foreign investors have been attracted to the eastern region not only for its natural advantage such as access to marine ports, but for policy measures taken by local governments. Nevertheless, a spatial concentration of FDI varies significantly even within this region; for instance, foreign firms tend to concentrate more in Shanghai than in Anhui. Thus, the spatial distribution of FDI in this region provides an ideal setting for investigating whether FDI agglomeration yields spatial spillovers.

We design an empirical strategy in two steps. First, we estimate the extent of local spillovers from foreign to domestic firms in the same county and similar industries. Computing the average productivity of domestic firms for each county and industry, we relate the regional productivity to FDI agglomeration as measured by foreign firms number, employment, or value added. While we control for the other determinants of regional productivity, the potential endogeneity of FDI agglomeration poses a challenge for causal inference. For instance, the more productive local firms may cluster together around an area with larger FDI, which would introduce an upward bias in the estimate of local FDI spillovers. To address this issue, we exploit the fact that FDI activities are concentrated around Shanghai province for better access to marine ports. Thus, we use a variation in the county's distance from Shanghai port as an instrument for the presence of foreign firms. In the estimation, we check the validity of our instruments and examine the direction of endogeneity bias.

Second, we specify a spatial-autoregressive model to estimate spatial spillovers from foreign to domestic firms. The model explicitly takes into account the spatial dependence of the regional productivity of domestic firms by a spatial-weighting matrix. This implies that regional productivity is influenced more by other domestic firms in nearby locations and less in distant locations. A reduced-form of the model shows that regional productivity in each industry and county is related to a spatial diffusion process of local spillovers from foreign to domestic firms. The spatial-weighting matrix allows us to consider the role of distance in the spillover processes of FDI agglomeration.

Our findings can be summarized as follows. First, we find that FDI agglomeration has a significantly positive impact on the regional productivity of domestic firms. For instance, a 10% increase in the number of foreign firms in a given sector and county is associated with a 1.5% increase in regional productivity. This finding is robust to a variety of alternative specifications, such as the measurement of productivity and FDI agglomeration. Second, an estimation method of instrumental variables shows that an estimated coefficient of FDI agglomeration is systematically larger than that in an ordinary-least-squares estimation. We interpret these results as suggesting that an endogeneity bias is downward toward zero, possibly because less productive domestic firms tend to cluster in the areas with FDI agglomeration. Third, we find that FDI agglomeration has a significantly positive effect even after controlling for the spatial dependence of regional productivity. Based on a conservative estimate of FDI clusters, we simulate a spatial multiplier effect of increasing the number of foreign firms in each province. Mapping out the average effects on regional productivity, we find that spillovers from foreign to domestic firms are strong in the same location and decay over distance toward the other provinces.

The evidence of FDI agglomeration in the Yangtze River Delta is in stark contrast with previous studies on agglomeration economies in China. For instance, Ke (2010) investigates an effect of industrial agglomeration on urban labor productivity, using 617 Chinese cities in 2005. Measuring agglomeration by employment density, he finds little evidence of agglomeration economies. On the other hand, Hashiguchi and Chen (2012) employ a Bayesian spatial econometric approach to study agglomeration economies in Shanghai, Jiangsu, and Zhejiang for 2009, using county-level data. Consistent with the findings in Ke (2010), they also find that agglomeration economies are weak. Our analysis here implies that industrial agglomeration of high productive firms such as foreign investors tend to generate a positive externality, but such positive spillovers could be offset by a congestion effect of the agglomeration of low productive domestic firms. Thus, overall industrial agglomeration may not yield positive externalities.

The rest of this paper is organized as follows. Section 2 describes data sources and compares productivity between foreign and domestic firms, followed by the mapping of the location of foreign firms. Section 3 explains an empirical framework to quantify local spillovers from FDI by addressing an endogeneity issue. We also specify a spatial model to estimate a spatial effect from FDI. Section 4 shows estimation results and presents a geographic distribution of spatial multiplier effects from a hypothetical increase in FDI activity. Section 5 summarizes the analysis and discusses policy implications.

2. Data Description

This section starts to explain data sources, followed by a description of firm-level productivity estimation and a productivity comparison between foreign and local firms. Then, we map out the location of foreign-owned firms in the Yangtze River Delta in China to illustrate the spatial concentration of foreign firms.

2.1. Data Sources

A main source of data is the Chinese industry statistical database by China's National Bureau of Statistics. This database is based on the annual survey of manufacturing enterprises in mainland China with sales of 5 million renminbi or more, including state-owned enterprises, privately owned firms, and foreign-invested enterprises. Since the survey is mandatory for firms to respond, the sample coverage is comprehensive.[2] This dataset is also used in prior research, such as Brandt et al. (2011).

This paper exploits a cross-sectional variation in firm activities during 2004 for two reasons. The 2004 survey is more comprehensive than other years' surveys in that the survey information includes the level of education for employees. Such information is critical for measuring the quality of labor used for manufacturing production. In addition, our objective is to examine whether local firms in one region benefit more from FDI agglomeration than those in another region in the long run. A cross section dataset is appropriate for a spatial econometric model, which allows us to explore the long-run impact of FDI agglomeration on domestic firms.[3]

Using the 2004 database, we first construct valued added for each firm from output, value-added tax, and intermediate input. The sample firms with negative values for their estimated value added and out-of-operation status are excluded. Capital is measured by the sum of fixed and intangible assets. Labor consists of the total of employees with varying levels of education: primary and secondary school, community college,

[2] For instance, the survey for 2007 covered 330,000 enterprises in China, which accounted for nearly 90% of total industrial output as reported in the Chinese Statistical Yearbook.

[3] In this paper, we do not examine whether a short-run change in FDI agglomeration improves the economic performance of local firms in one region more than those in another region. Martin et al. (2011) examined the short-run effect of industrial agglomeration on plant-level productivity for French firms.

university, and graduate school. Finally, our measure of agglomeration is constructed by aggregating the number of foreign-owned firms in manufacturing across counties and industries. Finally, we exclude the firms in the tobacco industry, which are strictly regulated by the Chinese government.

Our analysis focuses on four provinces in the Yangtze River Delta area: Shanghai, Jiangsu, Zhejiang, and Anhui. These provinces constitute the three major areas of industrial agglomeration in China; other areas include the Bohan ring area around Beijing and Tiangjin and the Pearl River Delta area in Guangdon. The remarkable growth of industrial activities and international trade in these major areas has driven the Chinese economy and attracted a substantial amount of foreign investment. Thus, this region is ideal for analyzing the impact of industrial clusters on firm-level performance.

Other data sources used for analysis include the Chinese population census in 2000 and the geographic information files. From the population census, we use information on the total population and urban population in each county. The information on the latitudes and longitudes of each county is used to measure a geographic area and the distance between the Shanghai marine port and other counties.

2.2. A Productivity Comparison between Foreign and Domestic Firms

A crucial premise in investigating FDI spillovers is that knowledge flows should occur mainly from more productive firms to less productive firms, rather than vice versa. Some firms are more efficient in production and sales than other firms due to their superior managerial know-how, production technology, marketing skills, and corporate brand. Indeed, these firm-specific assets in knowledge capital allow foreign firms to invest abroad and operate their production plants in a more difficult market than their home market (Markusen, 2002). However, there is no prior evidence that foreign firms in the region of interest are more productive than domestic firms. Thus, we compare productivity between foreign and domestic firms to validate the premise of our study.

As we focus exclusively on cross-sectional variation in our dataset, we simply require a measure of productivity that indicates a relative ranking of one firm over another at a point in time.[4] Intuitively, one firm is more productive than another if it produces more output from the same amount of input or if it is able to produce the same output with less input. To capture this relative efficiency ranking, our first measure is labor productivity defined as $\ln(q_i/H_i)$ for firm i, where q_i is the value added of firm i and H_i is the amount of efficient labor employed by that firm:

[4] For this reason, we do not use more sophisticated measures of productivity, for instance, by Olley and Pakes (1996) and Levinsohn-Petrin (2003).

$$H_i = \sum_s \exp(\phi s) L_i(s). \quad (1)$$

ϕ is an indicator of returns to investment in education via public schooling, and s is the years of schooling. $L_i(\cdot)$ is the number of workers with the corresponding education s. Following a comprehensive survey on returns to investment in education by Pasacharopoulos and Patrinos (2004), we set ϕ at 0.17. This suggests that an additional year of education increases labor efficiency by 17%.

Our second measure is total factor productivity (TFP). We assume that production function for firm i is described by a Cobb-Douglas form, $q_i = A_i K_i^{\beta_k} H_i^{\beta_h}$, where A_i is its efficiency level that is observed by a producer, but not by an econometrician; K_i is capital input. We use an ordinary-least-squared estimator (OLS) to estimate a log-linear form of the above production function for individual firms in each industry at the two-digit level. Based on the OLS estimates of the elasticity of capital and efficient labor to value added, we calculate the log of the residuals as a proxy for $\ln(TFP_i)$.

We compute both labor productivity and TFP for the sample of 97,947 firms. A correlation coefficient of these variables is 0.89, suggesting that a relative ranking of firm-level productivity is generally robust to the measurement. From a conceptual point of view, we consider labor productivity to capture knowledge spillovers from FDI to workers' productivity at local firms and TFP to capture the spillover effects on the broad aspect of unobserved firm efficiency. Before proceeding to a productivity comparison, we emphasize that the estimation of TFP involves many issues in practice. Van Biesebroeck (2007) assesses the strengths and weaknesses of alternative estimation methodologies, suggesting that no single estimation method excels in the presence of factor price heterogeneity, measurement errors, and the misspecification of production technology. Therefore, we employ both labor productivity and TFP in the analysis.

To compare productivity between domestic and foreign firms, Table 1 presents the summary statistics of the sample used for regression. As it is often argued that the nationality of foreign investors may have a different impact on local firms, we also disaggregate foreign ownership by foreign country, such as Hong Kong, Macau, and Taiwan (HMT), and others. It is evident that unconditional productivity as measured by labor productivity and TFP is higher for foreign firms than domestic firms in terms of the mean and median. Among foreign investors, the summary statistics indicate that HMT foreign firms are relatively less productive than non-HMT foreign firms.

---Table 1---

To conduct a statistical test, we estimate the following equation for firm i, industry j, and county k:

$$y_{ijk} = \beta_0 + \beta_1 F_i + \delta_j + \delta_k + \varepsilon_{ijk} \quad (2)$$

where y is a measure of firm-level efficiency; F is a dummy variable that takes on unity if firm i is owned by foreign investors, and zero otherwise; δ_j is an industry-fixed effect; δ_k is a county-fixed effect; and ε is an error term. Table 2 presents the estimation results of the equation by OLS. Column (1) shows that labor productivity is on average 7.9% higher for foreign firms than domestic firms. Column (3) also indicates that TFP is on average 8.8% larger for foreign firms. In both cases, the productivity difference is significant at the 1% level. Additionally, columns (2) and (4) show that foreign firms originating from countries except for Hong Kong, Macau, and Taiwan are particularly more productive than domestic firms. Taken together, the results provide the first piece of evidence to motivate our investigation of FDI spillovers in the region.

---Table 2---

2.3. Geographic Distribution of Foreign Firms

We proceed to provide a second piece of evidence on FDI agglomeration to motivate our empirical study. To this end, we focus exclusively on foreign firms in the sample and aggregate the number of foreign firms at the county-level. The total number of foreign firms in each county is then shown in the geographic map of four providences in the Yangtze River Delta. Figure 1 illustrates a geographic distribution of foreign firms, where a darker region exhibits a greater number of foreign firms. It is evident that foreign investors are concentrated more in Shanghai province than in Anhui province, implying a strong agglomeration force for FDI activity toward the coastal locations. Along the coastal regions from Jiangsu province to Zhejiang province, a number of foreign firms exist in clusters. While Coughlin and Segev (2000) find a spatial dependence of FDI inflows in China at the provincial level, our data suggest that such spatial dependence force is likely to be at work across counties within each province.

---Figure 1---

A concern in the above finding is that the number of firms may not necessarily represent the economic size of foreign-firm activities across regions. To address this concern, we also create a county-level measure of FDI activity with the total number of workers employed by foreign firms and the total volume of their valued added. Then, these measures are illustrated in the same geographic map as in Figure 1. While these maps are not shown here to save space, we find that FDI activities measured by employment and value added are also concentrated in the coastal regions, which are pronounced more toward Shanghai province and less toward Anhui province. Taken together, we show a spatial concentration of FDI activities in the region to motivate the empirical investigation of the effects of FDI agglomeration.

3. Empirical Framework

This section shows the empirical framework to investigate the spatial impact of FDI clusters on domestically owned firms. We first explain an empirical strategy to identify the causal impact of foreign firms on domestic firms in the same county and similar industry, which are referred to as *local spillovers* from FDI. Then, we specify a spatial model to estimate the spatial effects of local FDI spillovers, which are referred to as *spatial spillovers* from FDI.

3.1. Local Spillovers from FDI

We first address the question of whether local firms in one region are *on average* more productive than those in another for knowledge spillovers from FDI. We focus on regional variations because policy initiatives for FDI in China have been made by a local government at the county-level (Ding, 2010). From a policymaker's point of view, it is relevant to examine a regional difference in firm performance compared with a firm-level difference within the same location. Thus, we exploit a variation in the regional *average* of firm productivity in a given industry to identify local spillovers from FDI clusters.

Using the sample of domestically owned firms, we compute the regional productivity of local firms for industry j and county k:

$$Y_{jk} = {n_{jk}}^{-1} \sum_{i \in \Omega_{jk}} \frac{q_{ijk}}{\sum_{i \in \Omega_{jk}} q_{ijk}} y_{ijk} \tag{3}$$

where n_{jk} is the number of domestic firms in industry j and county; Ω_{jk} is the set of domestic firms that belong to industry j and county k. Our measure of regional productivity is an average of local-firm productivity weighted by a share of its own value added in the total value added across industry and county. The regional productivity measure, Y_{jk}, is calculated to estimate labor productivity and TFP in each industry and county: $\ln\left(q_{jk}/H_{jk}\right)$ and $\ln\left(TFP_{jk}\right)$. In measuring the regional TFP of domestic firms, we re-estimate a production function for the sample of domestic firms in each sector by OLS and use the residuals as a proxy for firm-level TFP. This approach allows for domestic firms to have different estimates for the elasticity of capital and efficient labor with respect to value added, compared with foreign firms.

To estimate local spillovers from FDI, regional productivity is related to the agglomeration of FDI activities and other relevant determinants for industry j and county k:

$$Y_{jk} = \gamma_0 + \gamma_1 \ln FA_{jk} + \gamma_2 \ln P_k + \gamma_3 \ln UPS_k + \gamma_3 \ln EX_{jk} + \delta_j + \sum_r \delta_r D_r + e_{jk} \qquad (4)$$

where FA is the size of FDI agglomeration measured by the number of foreign firms; P is total population; UPS is urban population as a share of total population; EX is the volume of exports by domestic firms; δ_j is an industry-fixed effect; D is a dummy variable that takes on unity when county k belongs to prefecture r; and e is an error term. As will be discussed below, we include a prefecture (not county) dummy variable to exploit a county-level variation in the data with the instrumental variables of county characteristics. We include a population variable to control for demand effects. The urban population share serves to control for the net effect of urbanization, including the positive impact of dense interactions between firms and workers and the negative congestion effect in a factor market and in infrastructure (Mitra, 1999; Morikiawa, 2011). The export variable serves to control for the role of exporting in firm performance.

Our key interest is an estimate for the coefficient of FDI agglomeration, γ_1, representing a relationship between the aggregate activities of foreign firms and the average productivity of local firms in a similar industry and location. In our specification, the similarity in industrial and geographic linkages is defined by two-digit sector codes and county boundaries in China. We hypothesize that the agglomeration of foreign firms may yield positive local spillovers for domestic firms in the proximate location, leading to an average improvement in their efficiency as measured by regional variations in labor productivity or TFP. Thus, we predict a positive estimate for the coefficient γ_1.

Our hypothesis is based on alternative explanations for FDI spillovers in the previous literature. While a comprehensive review of various channels should be referred to prior work such as Görg and Greenaway (2004) and Smeets (2008), here we highlight the role of labor and input markets in accounting for positive FDI spillovers. In the labor market, labor mobility between foreign and domestic firms can be a channel of positive spillovers. It is often argued that skilled workers receiving investment in their training at a foreign firm move to work for a local firm, and bring it with a tacit form of superior management and production technology embodied in the workers. Consequently, the local firm that benefits from knowledge transfers from FDI via labor mobility is likely to improve its own efficiency. The labor-mobility hypothesis has received supporting evidence in empirical studies such as Görg and Strobl (2005) and Balsvik (2011).

In the input market, a supplier-buyer relationship between foreign and domestic firms may be a channel of positive spillovers. When a local firm supplies intermediate inputs to a foreign firm, it must meet a high requirement regarding product quality and delivery schedule. As a defection in the inputs supplied reduces the production efficiency of users, the foreign firm has an incentive to provide technical and managerial advice to the local supplier and to improve the quality of the purchased inputs. In this way, directed knowledge transfers from a downstream foreign firm to an upstream local firm can generate productivity improvements for domestic suppliers in a proximate upstream sector. A backward linkage in intermediate inputs between foreign and local firms has received supporting evidence in studies such as Javorcik (2004). Additionally, when a foreign firm supplies intermediate inputs to a local firm, similar knowledge transfers could occur through a forward linkage. In contrast with a backward linkage, empirical evidence for the forward spillovers tends to be mixed, possibly suggesting a weaker incentive for the foreign firm to improve for its own customer in a downstream sector.

We must emphasize that the estimated coefficient of the FA variable should pick up a *net* effect of FDI clusters due to a wide variety of linkages between foreign and domestic firms. Especially, we do not attempt to clearly distinguish between horizontal and vertical spillovers from FDI; horizontal spillovers occur between foreign and local firms within the same sector, whereas vertical spillovers do across different sectors.[5] Instead, we aim to estimate aggregate horizontal and vertical spillovers from FDI clusters that occur locally in a given region for a set of broadly similar sectors at two-digit industry classification.[6] This definition allows us to analyze an interaction between foreign and local firms in a small range of narrowly different industries at the four-digit level.

Endogeneity issues

[5] In urban economics literature, agglomeration externalities within the same industries are referred to as *localization economies* whereas those across industries are called *urbanization economies* (Rosenthal and Strange, 2004).

[6] A standard practice in literature is to use a national input-output table to measure horizontal and vertical linkages between foreign and domestic firms. As discussed in Barrios et al. (2011), such an approach must assume that foreign firms in a local market follow the same sourcing behavior as other domestic firms. However, it is well known that multinational firms in the Chinese coastal regions engage extensively in input-processing trade to import intermediate inputs and export assembled final goods (Greaney and Li, 2009). Thus, a lack of transaction-level data on foreign firms in China makes it difficult to precisely disentangle vertical spillovers from horizontal ones.

We seek to interpret a regression coefficient of FDI agglomeration, γ_1, as representing a causal effect of local spillovers from FDI clusters on the regional productivity of local firms. Such a causal interpretation of the regression estimates requires a conditional independence assumption (Angrist and Pischke, 2009). However, this assumption is clearly violated for the potential endogeneity of the FDI variable, making it difficult to interpret that the agglomeration economies of foreign firms enhance regional productivity. As is shown in Baldwin and Okubo (2006), highly productive firms in a local market may be more likely than less productive firms to locate themselves in more agglomerated areas, where local firms with more advanced production technology could reap larger profits from economic transactions with foreign firms. On the other hand, foreign firms may also choose to locate themselves in more productive regions where they can enjoy a better match with highly productive local firms. Together, the spatial selection effects should be already embodied in the observed variables of regional productivity and agglomeration, suggesting that there may be potential upward bias in the estimate of FDI agglomeration.

To address the spatial selection bias in agglomeration economies, we exploit a method of instrumental variables with the following first-stage equation:

$$\ln FA_{jk} = \omega_0 + \omega_1 \ln D_k + \omega_2 \ln A_k + \sum_m \psi_m z_m + u_{jk} \quad (5)$$

where D is the geographic distance between the county of each industry and the major marine port of Shanghai, A is an area of county in square kilometers, and z is a set of other exogenous explanatory variables. We estimate the first-stage equation to purge out an endogenous component of the FA variable, and then estimate our main equation using an exogenous component of the FA variable that is quasi-experimentally generated by the instruments.

Our choice of valid instruments relies on the well-known fact that many foreign firms investing in the Chinese coastal regions were seeking to assemble imported intermediate inputs with low labor costs. They further export final products to foreign markets such as the U.S. and Europe by ocean shipping. To engage in the processing trade, they must transport a wide variety of goods between a marine port and their factory. An incentive to economize on inland transport costs induces foreign investors to locate closer to the central marine port in this region. As shown in Figure 1, this hypothesis is consistent with the clear spatial concentration of foreign firms toward Shanghai province. On the other hand, it is a reasonable assumption that the average regional productivity of local firms should not have a strong association with a geographic distance between the corresponding region and the Shanghai marine port. Additionally, we include another instrument variable of county-level geographic areas.

Foreign firms may be seeking larger county for lower land costs, but the size of the county by itself does not have direct influence on local firms' productivity. Together, these instruments allow us to test an exclusion-restriction assumption of the instruments.

3.2. Spatial Spillovers from FDI

Having established that FDI spillovers occur locally in space and among similar industries, we then ask whether such local spillovers will extend to neighboring regions. Specifically, we hypothesize that the spatial concentration of FDI activity first generates knowledge spillovers for local firms that are closely related with foreign firms in terms of geographic proximity and industrial production. Next, the local knowledge spillovers would spread into other local firms in neighboring locations for interactions among local firms through labor mobility, intermediate transactions, imitation, and so on. These interactions should be more intense among local firms in nearby areas whereas spatial diffusion effects are stronger between nearby locations than distant locations. As local knowledge spillovers simultaneously occur in other locations, there are similar spatial diffusion processes due to FDI agglomeration elsewhere. Thus, a spatial concentration of FDI activity could generate a mutually reinforcing interaction of knowledge spillovers among local firms over space.

In the second step of the empirical strategy, we estimate spatial externalities from FDI. For this task, we need to explicitly consider the spatial dependence of the regional productivity of local firms. For the number of observations in our sample (n = 1,…, N), we specify a spatial-autoregressive model as:

$$\mathbf{Y} = \lambda\mathbf{WY} + \mathbf{X\gamma} + \boldsymbol{\varepsilon} \tag{6}$$

where $\mathbf{Y}$ is an N × 1 vector of observations on the dependent variable of regional productivity across industries; $\mathbf{WY}$ is an N × 1 vector referred to as a spatial lag of the dependent variable with elements $\sum_{\mathrm{p}} \mathrm{w}_{np}\mathrm{Y}_p$ for $p \neq n$; λ is a spatial-autoregressive parameter; $\mathbf{X}$ is an N × M matrix of observations on M explanatory variables as in equation (4); $\boldsymbol{\gamma}$ is an N × 1 vector of corresponding parameters; and $\boldsymbol{\varepsilon}$ is an N × 1 vector of random error terms.[7]

A spatial-weighting matrix, $\mathbf{W}$, consists of weights that are inversely related to the distances between the observational units, $\mathrm{w}_{np} = 1/\mathrm{d}_{np}$, with zero diagonal elements. More weights are placed on nearby observations than distant observations. The distances between counties are computed from the geographic coordinate variables that include latitudes and longitudes on the central point of each county. Note that our

[7] In the estimation, N (= 4,366) is the total number of the sample industry and county.

observational units are defined at the county and industry level in order to capture a net spatial effect of within-industry and across-industry spillovers from FDI. By exploiting only the distances between counties, we consequently need to assume that the sample industries belonging to the same county are located at the exactly same area. However, this assumption is conceptually difficult to hold for manufacturing activities in China and practically implausible to compute the inverse distances. To address this issue in a practical, but imperfect way, we assume that the industries in each county are randomly scattered around the central point within the county.[8]

A structural form of our spatial model is written in a reduced form:

$$\mathbf{Y} = (\mathbf{I} - \lambda\mathbf{W})^{-1}\mathbf{X}\boldsymbol{\gamma} + (\mathbf{I} - \lambda\mathbf{W})^{-1}\boldsymbol{\varepsilon} \tag{7}$$

where $(\mathbf{I} - \lambda\mathbf{W})^{-1}$ is a spatial multiplier effect through which the explanatory variables and the error term affect the dependent variable (Anselin, 2003). For $|\lambda| < 1$, all zero diagonal elements of $\mathbf{W}$, and the nonsingularity of $(\mathbf{I} - \lambda\mathbf{W})$, we express a "Leontief expansion" of the inverse matrix to facilitate an interpretation of equation (7):

$$(\mathbf{I} - \lambda\mathbf{W})^{-1} = \mathbf{I} + \lambda\mathbf{W} + \lambda^{2}\mathbf{W}^{2} + \cdots + \lambda^{\mathbf{m}}\mathbf{W}^{\mathbf{m}} \tag{8}$$

where $m \to \infty$. Taking into account equation (8), we can interpret equation (7) as showing that the regional productivity of local firms in each industry and county is related to the explanatory variables, such as FDI agglomeration in the corresponding industry and county, $\mathbf{X}\boldsymbol{\gamma}$, a first-order spatial linkage, $\lambda\mathbf{W}\mathbf{X}\boldsymbol{\gamma}$, a second-order spatial linkage, $\lambda^{2}\mathbf{W}^{2}\mathbf{X}\boldsymbol{\gamma}$, and so on. In this spatial multiplier process, the spatial spillover is stronger for nearby FDI agglomeration than it is for distant FDI agglomeration. Note that similar spatial multiplier processes are applied to unobserved shocks to regional productivity. Additionally, the higher-order spatial linkages with FDI agglomeration decline in importance by a discounted rate of λ.

A traditional method of estimating the parameters of equation (6) is maximum likelihood. A consistency of the maximum likelihood estimator is based on the assumption that the error term is homoskedastic (Lee, 2004). However, the sample counties differ in size and other county-level characteristics, suggesting that the error term is likely to be heteroskedastic. If the homoskedasticity assumption is violated, the

---

[8] For a weighting matrix, we define a distance between any two units, n_1 and n_2, as the Euclidean distance between them, which have coordinates, (x'_1, y'_1) and (x'_2, y'_2), respectively. Specifically, we denote the Euclidean distance as:

$$d(n_1, n_2) = \left[(x'_1 - x'_2)^2 + \left(y'_1 - y'_2\right)^2\right]^{1/2}$$

where $x'_1 = x_1 + \Delta x_{1j}$, $x'_2 = x_2 + \Delta x_{2j}$, $y'_1 = y_1 + \Delta y_{1j}$, and $y'_2 = y_2 + \Delta y_{2j}$. For each industry j, (x_1, y_1) and (x_2, y_2) indicate the coordinates of the county to which the industry belongs. Δx and Δy are randomly assigned values to each industry to ensure that the industries are scattered around the central point of their own county, but within the county's boundary.

maximum likelihood estimator is inconsistent. To address this issue, Kelejian and Prucha (2010) developed an estimation method to allow for the presence of heteroskedasticity in the error term. They introduce a generalized-moments estimator and showed its consistency under reasonably general assumptions. As explained in Arraiz et al. (2008), an ordinary-least-squares estimator is inconsistent for the spatial lag of the dependent variable in equation (6). Then, we employ an instrumental-variable estimator with the instrument matrix $\mathbf{H}$ defined as a set of linearly independent columns of $\{\mathbf{X}, \mathbf{WX}, \mathbf{W}^2\mathbf{X}\}$, as suggested by Kelejian and Prucha (2010). In the estimation, we allow the error term to be heteroskedastic of unknown form.

4. Estimation Results

This section first presents the estimation results of local spillovers from FDI agglomeration and then the results of a spatial-lag model to estimate spatial spillovers. Finally, spatial multiplier effects are shown to examine a spatial variation of local spillovers.

4.1. Local Spillovers

Table 3 shows the summary statistics of the county-level sample used in the analysis. All variables are defined in the log except for the variable of urban population share. The maximum number of observations is 6,467 (= 29 industries × 223 counties), but there are 4,366 observations in the sample used. The difference is due to the fact that domestic firms do not exist in some industries and counties, making it infeasible to compute regional productivity in those industries and counties.

---Table 3---

Using the sample, we estimate equation (4) by OLS and IV, with the three alternative measures of FDI agglomeration: foreign firms' number, employment, and value added. Table 4 shows the estimation results for regional labor productivity. Columns (1) and (2) use the number of foreign firms as the dependent variable. The OLS estimate of the FA variable is significantly positive at the 1% level, with the coefficient of 0.109. This suggests that a 10% increase in the number of foreign firms in a given sector and county is associated with a 1.1% increase in the regional labor productivity of domestic firms.

---Table 4---

While the OLS result provides evidence of local spillovers from FDI, a potential endogeneity bias does not allow for causal inference. To address this issue, column (2) shows the IV result of the same specification. Consistent with the OLS result, the IV estimate is significantly positive. In a first-stage regression, the F statistic for excluded instruments is 141.3, with a p-value of 0.00, implying that our instruments are strongly correlated with the endogenous variable of FDI agglomeration. In addition, the Hansen statistic for over-identifying restrictions is 0.55, with a p-value of 0.46, thereby we fail to reject the hypothesis that the excluded instruments are not correlated with an error term. These statistical tests support the validity of our instruments, allowing us to interpret that FDI clusters have a causal impact on the regional labor productivity of domestic firms. The IV estimate implies that a 10% increase in the number of foreign firms in a given sector and county improves the regional labor productivity of domestic firms by 2.2%.

Columns (3)–(6) present the results using foreign firms' employment and value added as the dependent variable. Consistent with the prior results, the regional labor productivity of domestic firms is positively associated with the FA variable. The statistical tests for the instruments' validity also lend support to the causal inference. Moreover, the IV estimates are systematically larger in magnitude than the OLS estimates in the corresponding specification, possibly suggesting that the endogeneity bias is *downward*. The IV estimations suggest that a 10% increase in foreign firms' employment raises regional labor productivity by 0.8% whereas a 10% increase in their value added leads to a 0.5% increase in regional labor productivity.

An interesting difference between the OLS and IV estimates is that the FA variable has the larger positive coefficient in the IV estimation. Our prior concern was that an impact of FDI agglomeration would be overestimated possibly because more productive local firms and foreign firms tend to cluster together. However, our estimation results show the opposite direction of an endogeneity bias. Intuitively, less productive domestic firms might tend to coexist with a greater number of foreign firms in a given industry and county, which account in part for a downward bias in the coefficient of FDI agglomeration in the OLS estimation. This result is in stark contrast with the theoretical implication by Baldwin and Okubo (2006); more productive firms are attracted to the agglomerated region. While it is beyond the scope of this paper to provide a convincing account of our result, a plausible explanation is that the presence of foreign firms may reduce the entry barrier to domestic firms in an area, where they can engage in some stages of the global value chains by multinational firms. Specialization in the specific tasks of the value chains might allow less productive local firms to cluster with other foreign firms.

While we demonstrate that domestic firms improve their labor productivity due to FDI spillovers, knowledge flows from foreign firms may reach other aspects of firm-level efficiency, including managerial know-how and marketing, and so on. To examine a broader aspect of firm productivity, we present the estimation results of local spillovers to regional TFP. The results in Table 5 show that the coefficients of the FA variable are significantly positive for alternative measures of FDI agglomeration in both OLS and IV estimations. Thus, we can reach the similar conclusion that domestic firms improve their productivity for local spillover effects of FDI clusters in a similar industry and county.

---Table 5---

While the IV estimate would pick up a net effect of local spillovers from foreign to domestic firms, the local spillovers occur through variable channels as discussed previously. We must caution that this paper does not identify the distinctive spillover linkages by making the channels as a black box. To shed light on this issue, an insightful finding is reported by Yong (2011). His study presents a firm-level survey in Kunshan of Jiangsu province, which is close to Shanghai. While the survey sample is limited, he shows some evidence that local subcontractors with foreign firms have improved their productivity and production technology. Specifically, a productivity improvement was associated positively with foreign firms' guidance regarding the purchase of manufacturing equipment and technological cooperation with other firms. This suggests that local firms receive a transfer of tacit knowledge such as management know-how, marketing techniques, and purchasing skills.

For further robustness checks, we measure FDI agglomeration by the share of foreign firms in each industry and county in terms of the number, employment, and value added. The share form of measurement has been often used in literature on FDI spillovers. While we do not show the results to save space, we find that the share of foreign firms has a significantly positive impact on the regional labor productivity and TFP of domestic firms in the corresponding industry and county. Additionally, we separately measure FDI agglomeration for foreign firms originating from (1) Hong Kong, Macau, and Taiwan, and (2) other foreign countries. This practice serves to check the argument that the nationality of foreign investors affects local spillovers (Javorcik and Spatareanu, 2011; Lin et al., 2009). With these measures, we estimate the same specifications as in Tables 4 and 5. While the results are not shown here, both measures are significantly and positively associated with regional productivity. However, we find little evidence of the varying impact of nationality.

4.2. Spatial Spillovers

Having established that FDI clusters yield positive local spillovers to domestic firms, we proceed to investigate spatial spillovers from FDI. Table 6 shows the estimation results for regional labor productivity. A spatial lag of the dependent variable has the significantly positive coefficient across alternative specifications in columns (1)–(3). This implies that the labor productivity of domestic firms is positively related to each other over space. Intuitively, domestic firms exhibit higher labor productivity in the location where other domestic firms nearby also have relatively high labor productivity.

---Table 6---

Consistent with the previous section, the FA variable has the significantly positive coefficient for all the measures of FDI agglomeration. Even after accounting for spatial linkages of regional labor productivity, domestic firms tend to have higher labor productivity in the county and industry with greater FDI agglomeration. Compared with the linear regressions in the previous section, the estimated coefficients of the FA variables tend to be smaller in magnitude, but statistically significant. This implies that local spillover effects are robust to the inclusion of the spatial lag. Additionally, regional labor productivity is positively associated with the aggregate exports of domestic firms, but has an insignificant association with the population size and the share of urban population in each county.

We also estimate equation (6) for the regional TFP of domestic firms. The results in Table 6 show that regional TFP is significantly and positively associated with FDI agglomeration as measured by foreign firms' number, employment, and value added. This finding implies that the estimated impact of spatial spillovers is robust to the measurement of the productivity of domestic firms. As compared with the linear regressions, the size of the coefficients is systematically lower in the spatial regressions.

A possible concern in the spatial regressions is an endogeneity bias in the FA variable. While the linear regressions may not be strictly comparable to the spatial regressions, our findings have indicated that the endogeneity bias of the FA variable is downward toward zero. As the coefficients of the FA variable are significantly positive across the specifications, our estimates from the spatial model are likely to be underestimated and taken as a lower bound of the impact of FDI agglomeration. In other words, Table 6 reports a conservative set of estimated coefficients for the impact of FDI agglomeration on the regional productivity of domestic firms.

As a robustness check, we examine whether local firms are influenced by FDI agglomeration in *other* regions. For this task, we include a spatial lag of FDI agglomeration together with the FA variable in equation (6) and estimate the modified model for alternative measures of FDI agglomeration and local firms' productivity. While we do not report the results to save space, the coefficients of the spatial lag of FDI agglomeration are mostly insignificant in alternative specifications. We conclude that FDI clusters in neighboring regions have little influence on the productivity of local firms. Indeed, this result is consistent with prior study such as Halpern and Muraközy (2007); domestic firms in Hungary receive spillover effects from foreign firms in nearby regions, but not from those in distant regions.

Spatial Multiplier Effects

We proceed to examine the economic magnitude of spatial spillovers from FDI clusters. In a spatial model, the measurement of marginal effects needs to take into account the fact that a change in FDI activity for a given sector and county will affect the regional productivity of domestic firms in the same sector and county as well as in other sectors and counties, with the latter influence coming from spatial diffusion processes.

For this task, we employ a reduced form of an unbiased spatial predictor based on the information set $\{\mathbf{X}, \mathbf{W}\}$ (Kelejian and Prucha, 2007). We denote this predictor by $\hat{\mathbf{Y}} = \left(\mathbf{I} - \hat{\lambda}\mathbf{W}\right)^{-1}\mathbf{X}\hat{\boldsymbol{\gamma}}$. In addition, let us denote the vector of sample observations on FDI agglomeration in industry j and county k:

$$\mathbf{FA} = \left[\mathrm{FA}_{1,1}, \ldots, \mathrm{FA}_{j,k}\right]'. \quad (9)$$

This allows us to denote the predictor for regional productivity of domestic firms in industry j and county k in terms of FDI agglomeration in the sample:

$$\hat{\mathbf{Y}}(\mathbf{FA}, \tilde{\mathbf{X}}) = \left[\hat{\mathrm{Y}}_{1,1}(\mathbf{FA}, \tilde{\mathbf{X}}), \ldots, \hat{\mathrm{Y}}_{j,k}(\mathbf{FA}, \tilde{\mathbf{X}})\right]' \quad (10)$$

where $\tilde{\mathbf{X}}$ is an N × (M-1) matrix of observations on M explanatory variables excluding the FA variable. Denoting a change in the vector of sample observations on FDI clusters by $\Delta\mathbf{FA}$, we can express the marginal effect of FDI agglomeration on the values of regional productivity for all the sample units as:

$$\widehat{\mathbf{Y}}(\mathbf{FA}, \widetilde{\mathbf{X}}) - \widehat{\mathbf{Y}}(\mathbf{FA} + \Delta\mathbf{FA}, \widetilde{\mathbf{X}}). \tag{11}$$

Equation (11) shows that the impact on the regional productivity of domestic firms due to an increase in FDI activity in a given sector and county is computed from a difference in the values of the spatial predictors between the sample and new values of the FA variable.

To illustrate a spatial distribution of marginal effects, we consider a hypothetical scenario in which the number of foreign firms increases by five in all the sample industries and counties solely for one of the four sample provinces: Shanghai, Zhejiang, Jiangsu, and Anhui, respectively. For example, we increase the number of foreign firms only in the sample industries and counties that belong to Shanghai province. Based on the estimation result in column (1) of Table 6, we then compute a marginal effect on the regional labor productivity of domestic firms across industries and counties. To map out the extent of marginal effect, we take an average of the changes in the regional labor productivity for each county. Finally, we repeat the same procedure for the other three provinces and create a corresponding map of spatial multiplier effects.

Figure 2 shows a geographic variation of the impact on the regional labor productivity of increased foreign firms only in Shanghai. As a darker area indicates a larger impact, all the counties within Shanghai receive a stronger effect from increased FDI in the same region. This finding is consistent with the previous work that FDI spillovers tend to be localized. By contrast, our finding is distinctive in that the neighboring regions also benefit from FDI activity, as shown by the less dark regions that surround Shanghai province.

Figures 3 and 4 present the spatial multiplier effects from an increase in foreign firms in Zhejiang and Jiangsu, respectively. As compared with Shanghai, there were also a larger number of foreign firms in Zhejiang and Jiangsu. A notable difference is the spatial concentration of foreign firms across counties within these provinces, as is evident in Figure 1. While the extent of FDI activity is different, a geographic variation in the magnitude of marginal effects is generally consistent with the findings in the case of Shanghai. The spatial multiplier effects are stronger within the corresponding province and become weaker over space away from the corresponding province. Interestingly, the spatial spillovers extend to all the sample provinces, which would reflect the fact that Zhejiang and Jiangsu have a larger province size than Shanghai does.

Finally, Figure 5 presents the spatial multiplier effect from increased FDI activity in Anhui. As compared with the other provinces, there were a smaller number of foreign firms. The result shows that the spatial spillovers are stronger within Anhui province and decay over distance toward the other provinces. Generally, this finding is consistent with the spatial multiplier effects in the other provinces. Even in the less agglomerated areas, spillover effects from FDI clusters are stronger within the same area.

While the spatial multiplier effect does not identify a distinctive channel of FDI spillovers, our simulation exercises here show evidence that FDI spillovers can diffuse over space. This suggests that knowledge flows from FDI to local firms decay over space, causing other domestic firms in distant regions difficulty in benefiting from FDI agglomeration. In addition, we find that the spatial spillovers do not reach distant areas from Shanghai, which is relatively smaller than other provinces. For the FDI spillovers to diffuse over distant areas, the size of FDI agglomeration matters. In this respect, the spatial multiplier effect found in this practice is also consistent with the literature that knowledge spillovers tend to be local over space (Audretsch and Feldman, 2004).

5. Conclusion

This paper has quantified spatial externality from FDI agglomeration on domestic firms. Using Chinese firm-level data in 2004, we find that a spatial concentration of foreign firms generates a significantly positive spillover to the regional productivity of domestic firms in the Yangtze River Delta. For example, a 10% increase in the number of foreign firms could improve the average productivity of domestic firms in a similar industry and the same county by 1.5%. Furthermore, such a local spillover can be transmitted to other domestic firms in other industries and counties through a spatial multiplier process. As knowledge flows tend to decay over distance, a spatial spillover from FDI agglomeration is stronger for domestic firms in nearby locations than in distant locations.

These findings provide implications for an industrial policy in the Chinese coastal regions. As discussed by Ding (2010), local governments have played an active role in regional industrial development since the mid-1990s. Specifically, the county-level governments have established an industrial zone in the area under their jurisdiction and attempted to improve the investment environment for industrial activities. They provide a generous investment incentive for foreign investors and promote their export processing activities within the industrial zone. In addition to fiscal incentives and infrastructure development, the local governments have also taken an active role in streamlining customs procedures for exports/imports and in promoting matching processes between foreign firms and local suppliers.

While these industrial policies toward foreign investors could be criticized as a preferential treatment of foreign firms against domestic firms, the formal evidence on positive spillovers from FDI justifies the FDI-target policy. Intuitively, preferential incentives for foreign firms could contribute to creating the industrial agglomeration of highly productive firms so that agglomeration externalities benefit other firms. Through spatial spillover processes, domestic firms are likely to benefit from the industrial policy in favor of foreign firms. On the other hand, our analysis implies a possible improvement for the industrial policy in the Chinese coastal regions, which has been implemented independently at the county-level because local governments have competed with each other to develop their own industry. As positive spillovers from FDI agglomeration in one county can easily transfer to nearby counties, our findings point to further gains from regional policy coordination to attract foreign investment.

References

Angrist, J.D., Pischke, J.-S., 2009. *Mostly harmless econometrics: an empiricist's companion*. Princeton, Princeton University Press.

Anselin, L., 2003. Spatial externalities, spatial multipliers, and spatial econometrics. International Regional Science Review 26(2), 153-166.

Arraiz, I., Drukker, D.M., Kelejian, H.H., Prucha, I.R., 2008. A spatial Cliff-ord-type model with heteroskedastic innovations: small and large sample results. CESifo working paper No. 2485.

Audretsch, D., Feldman, M., 2004. Knowledge spillovers and the geography of innovation. In Henderson, V. and Thisse, J.F. (eds), *Handbook of Regional and Urban Economics, Vol. 4: Cities and Geography*, Amsterdam: 2713-2739.

Baldwin, R., Okubo, T., 2006. Heterogeneous firms, agglomeration and economic geography: spatial selection and sorting. Journal of Economic Geography 6(3), 323-346.

Balsvik, R., 2011. Is labor mobility a channel for spillovers from multinationals? Evidence from Norwegian manufacturing. Review of Economics and Statistics 93(1), 285-297.

Barrios, S., Bertinelli, L., Strobl, E., 2006. Coagglomeration and spillovers. Regional Science and Urban Economics 36(4), 467-481.

Barrios, S., Görg, H., Strobl, E., 2011. Spillovers through backward linkages from multinationals: Measurement matters! European Economic Review 55(6), 862-875.

Brandt, L., Van Biesebroeck, J., Zhang, Y., 2012. Creative accounting or creative destruction? Firm-level productivity growth in Chinese manufacturing. Journal of Development Economics 97(2), 339-351.

Coughlin, C., Segev, E., 2000. Foreign direct investment in China: a spatial econometric study. The World Economy 23(1), 1-23.

Ding, K., 2010. Regional economic development in China and the role of local government. In Sasaki, N. (eds), *A Current Stage in Building the Chinese Harmonized Society*, Chiba: 43-76.

Girma, S., Wakelin, K., 2007. Local productivity spillovers from foreign direct investment in the U.K. electronics industry. Regional Science and Urban Economies 37(3), 399-412.

Görg, H., Greenaway, D., 2004. Much ado about nothing? Do domestic firms really benefit from foreign direct investment? World Bank Research Observer 19, 171-197.

Görg, H., Strobl, E., 2005. Spillovers from foreign firms through worker mobility: an empirical investigation. Scandinavian Journal of Economics 107(4), 693-709.

Greaney, M.T., Li, Y., 2009. Assessing foreign direct investment relationships between China, Japan, and the United States. Journal of Asian Economics 20(6), 611-625.

Halpern, L., Muraközy, B., 2007. Does distance matter in spillover? Economics of Transition 15(4), 781-805.

Hashiguchi, Y., Chen, K.-H., 2012. Assessing agglomeration economies in the Yangzi River Delta, China: a Bayesian spatial econometric approach. IDE Discussion Paper No. 339.

Havranek, T., Irsova, Z., 2011. Estimating vertical spillovers from FDI: Why results vary and what the true effect is. Journal of International Economics 85(2), 234-244.

Jaffe, A.B., Trajtenberg, M., Henderson, R., 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. Quarterly Journal of Economics 108, 577-598

Javorcik, B.S., 2004. Does foreign direct investment increase the productivity of domestic firms? In search of spillovers through backward linkages. American Economic Review 94(3), 605-627.

Javorcik, B.S., Spatareanu, M., 2011. Does it matter where you come from? Vertical spillovers from foreign direct investment and the origin of investors. Journal of Development Economics 96(1), 126-138.

Ke, S., 2010. Agglomeration, productivity, and spatial spillovers across Chinese cities. The Annals of Regional Science 45(1), 157-179.

Kelejian, H.H., Prucha, I.R., 2007. The relative efficiencies of various predictors in spatial econometric models containing spatial lags. Regional Science and Urban Economies 37(3), 363-374.

Kelejian, H.H., Prucha, I.R., 2010. Specification and estimation of spatial autoregressive models with autoregressive and heteroskedastic disturbances. Journal of Econometrics 157(1), 53-67.

Keller, W., 2002. Geographic localization of international technology diffusion. American Economic Review 92(1), 120-142.

Lee, L.-F., 2004. Asymptotic distributions of maximum likelihood estimators for spatial autoregressive models. Econometrica 72(6), 1899-1925.

Levinsohn, J., Petrin, A., 2003. Estimating production functions using inputs to control for unobservables. Review of Economic Studies 70(2), 317-341.

Lin, P., Liu, Z., Zhang, Y., 2009. Do Chinese domestic firms benefit from FDI inflow? Evidence of horizontal and vertical spillovers. China Economic Review 20(4), 677-691.

Martin, P., Mayer, T., Mayneris, F., 2011. Spatial concentration and plant-level productivity in France. Journal of Urban Economics 69(2), 182-195.

Markusen, J.R., 2002. *Multinational firms and the theory of international trade*. Cambridge, Mass.: MIT Press.

Mitra, A., 1999. Agglomeration economies as manifested by technical efficiency at the firm level. Journal of Urban Economics 45(3), 490-500.

Morikawa, M., 2011. Economies of density and productivity in service industries: an analysis of personal service industries based on establishment-level data. Review of Economics and Statistics 93(1), 179-192.

Nicolini, M., Resmini, L., 2007. Productivity spillovers and multinational enterprises: in search of a spatial dimension. DYNREG Working Paper.

Olley, G.S., Pakes, A., 1996. The dynamics of productivity in the telecommunications equipment industry. Econometrica 64(6), 1263-1297.

Psacharopoulos, G., Patrinos, H.A., 2004. Returns to investment in education: a further update. Education Economics 12(2), 111-134.

Rosenthal, S.S., Strange, W.C., 2004. Evidence on the nature and sources of agglomeration economies. In Henderson, V. and Thisse, J.F. (eds), *Handbook of Regional and Urban Economics, Vol. 4: Cities and Geography*, Amsterdam. 2119-2171

Smeets, R., 2008. Collecting the pieces of the FDI knowledge spillovers puzzle. World Bank Research Observer 23(2), 107-138.

Van Biesebroeck, J., 2007. Robustness of productivity estimates. Journal of Industrial Economics 55(3), 529-569.

Xu, X., Sheng, Y., 2012. Are FDI spillovers regional? Firm-level evidence from China. Journal of Asian Economics 23, 244-258.

Yong, F., 2011. “Learning-by-subcontracting” or “self-selection as a TNCs’ local subcontractor: micro-level evidence from China. V.R.F. Series No. 468, Institute of Developing Economies.

Figure 1. Geographic distribution of foreign firms by number

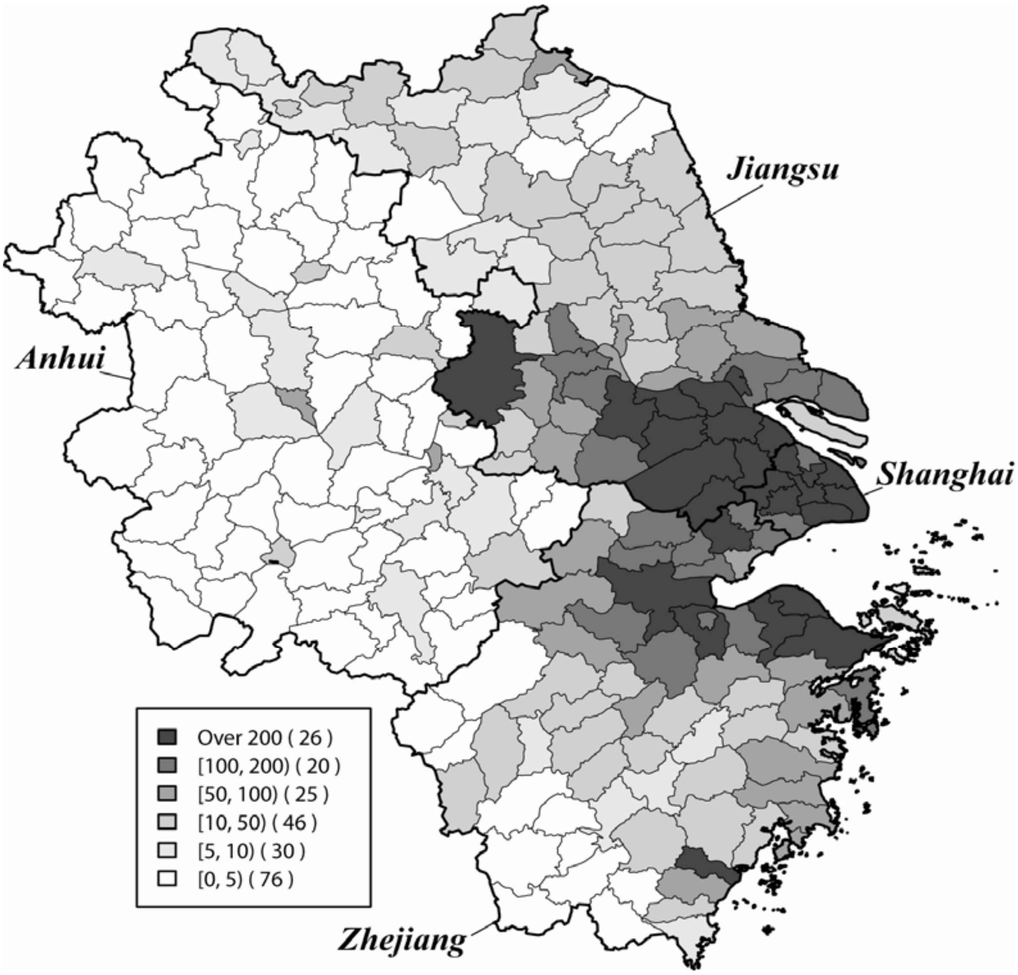

Figure 2. Impact on regional productivity of increased foreign firms in Shanghai

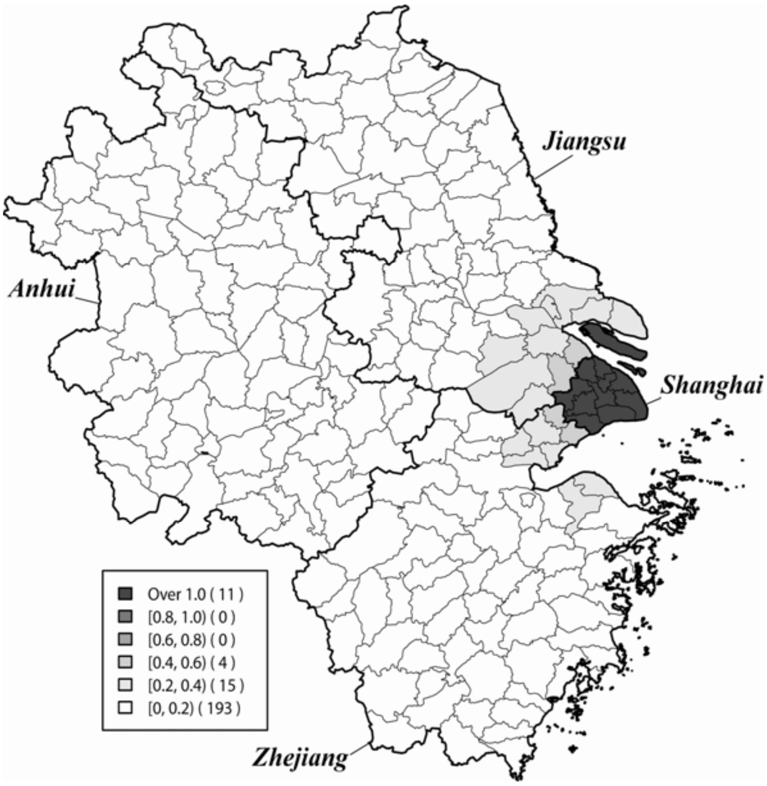

Figure 3. Impact on regional productivity of increased foreign firms in Zhejiang

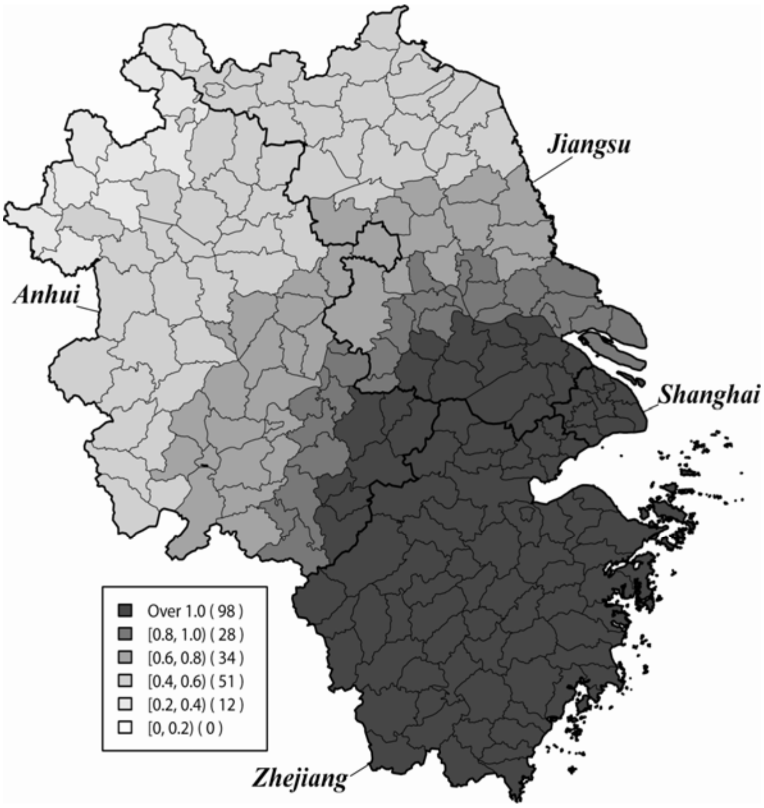

Figure 4. Impact on regional productivity of increased foreign firms in Jiangsu

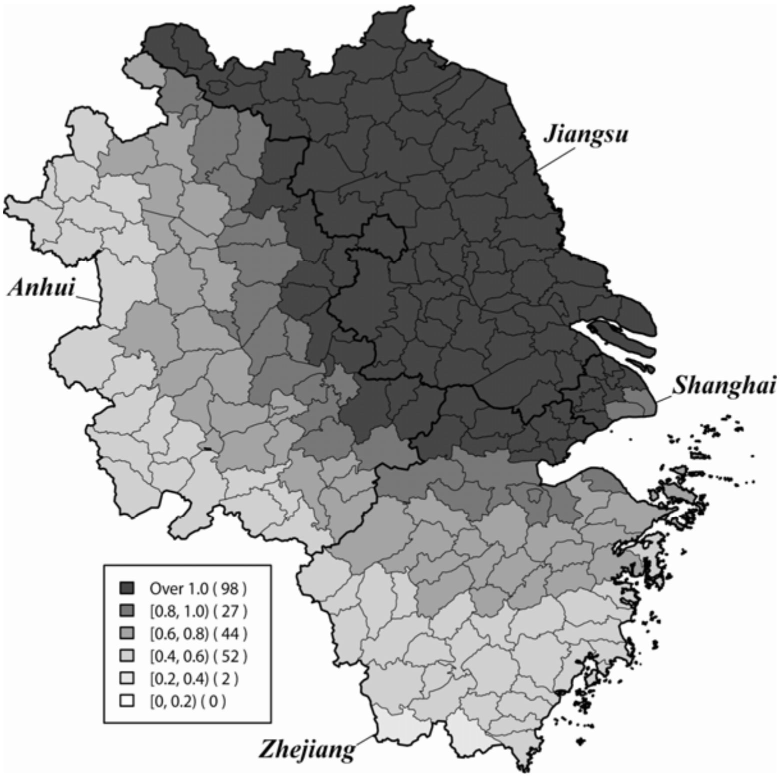

Figure 5. Impact on regional productivity of increased foreign firms in Anhui

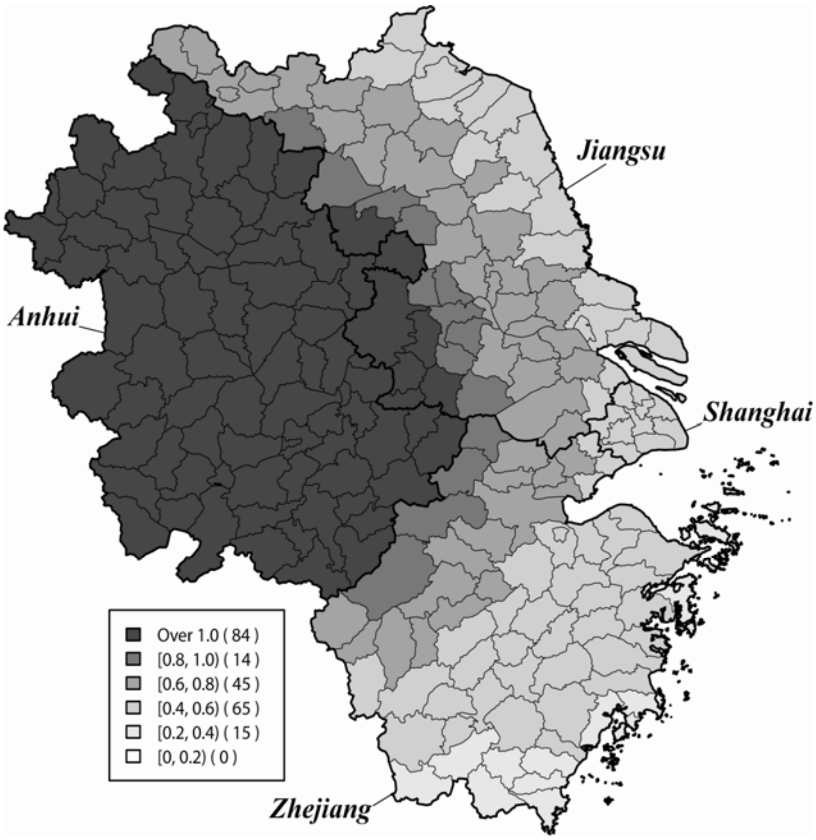

Table 1. Productivity levels by ownership status

	Domestic	Foreign		
		All	HMT	Other
Log of labor productivity				
Mean	2.06	2.10	2.03	2.16
Median	1.99	2.07	2.00	2.13
S.D.	0.87	1.03	0.98	1.07
No. of obs.	76,881	21,066	9,246	11,820
Log of total factor productivity				
Mean	-0.02	0.08	0.02	0.13
Median	-0.06	0.09	0.02	0.15
S.D.	0.77	0.94	0.90	0.97
No. of obs.	76,881	21,066	9,246	11,820

Note: HMT indicates the firms from Hong Kong, Macau, and Taiwan.

Table 2. Productivity difference between domestic and foreign firms

	(1)	(2)	(3)	(4)
Dependent	Labor productivity		Total factor productivity	
Foreign firm	0.079*		0.088*	
	(0.028)		(0.016)	
HMT firm		0.007		0.035
		(0.027)		(0.024)
Other foreign firm		0.137*		0.130*
		(0.034)		(0.019)
Two-digit industry dummy	Yes	Yes	Yes	Yes
County dummy	Yes	Yes	Yes	Yes
No. of observations	97947	97947	97947	97947
R^2	0.129	0.130	0.053	0.053

Notes: Parentheses report standard errors corrected for clustering for two-digit industries; * denotes significance at the 1% level.

Table 3. Summary statistics of county-level samples

Variable	No. of Obs.	Mean	Std. Dev.	Min	Max
Labor productivity	4366	2.37	0.89	-3.34	5.84
Total factor productivity	4366	0.36	0.77	-5.13	4.06
Number of foreign firms	4366	0.66	1.10	0.0	5.63
Employment of foreign firms	4366	3.18	3.40	0.0	12.3
Value added of foreign firms	4366	5.23	5.44	0.0	17.2
Population	4366	13.5	0.65	11.4	15.8
Urban population share	4366	0.51	0.01	0.46	0.54
Domestic firms' exports	4366	5.90	5.38	0.0	16.5
Distance from Shanghai port	4366	-2.13	0.66	-4.61	-0.80
Land area	4366	5.37	0.83	1.01	6.43

Note: All variables are defined in logs except for urban population share.

Table 4. Estimation results for local spillovers to regional labor productivity

	(1)	(2)	(3)	(4)	(5)	(6)
Estimation	OLS	IV	OLS	IV	OLS	IV
Number of foreign firms	0.109*	0.224*				
	(0.011)	(0.040)				
Employment of foreign firms			0.031*	0.084*		
			(0.004)	(0.015)		
Value added of foreign firms					0.020*	0.054*
					(0.003)	(0.010)
Population	0.061*	0.025	0.070*	0.026	0.070*	0.027
	(0.020)	(0.024)	(0.020)	(0.023)	(0.020)	(0.023)
Urban population share	-6.416*	-5.447*	-6.187*	-4.204*	-6.046*	-3.902*
	(0.992)	(1.055)	(1.002)	(1.152)	(1.002)	(1.181)
Domestic firms' exports	0.024*	0.016*	0.025*	0.013*	0.025*	0.013*
	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)
Two-digit industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture dummy	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	4366	4366	4366	4366	4366	4366
R^2	0.307	0.296	0.305	0.282	0.306	0.282
First-stage F statistic for excluded instruments		141.3		128.3		122.2
(P-value)		0.000		0.000		0.000
Hansen statistic for Over-identification test		0.553		0.737		1.219
(P-value)		0.457		0.391		0.270

Notes: Parentheses report robust standard errors; all variables are defined in logs except for urban population share; constant is not reported; instruments used in IV estimation include the log of distance from Shanghai port and land area; * denotes significance at the 1% level.

Table 5. Estimation results for local spillovers to regional total factor productivity

	(1) OLS	(2) IV	(3) OLS	(4) IV	(5) OLS	(6) IV
Number of foreign firms	0.091*	0.151*				
	(0.011)	(0.036)				
Employment of foreign firms			0.030*	0.062*		
			(0.004)	(0.014)		
Value added of foreign firms					0.019*	0.041*
					(0.002)	(0.009)
Population	0.075*	0.057*	0.080*	0.053[a]	0.080*	0.053[a]
	(0.019)	(0.022)	(0.019)	(0.021)	(0.019)	(0.021)
Urban population share	-4.438*	-3.929*	-4.106*	-2.888*	-3.988*	-2.628 [a]
	(0.922)	(0.973)	(0.927)	(1.054)	(0.927)	(1.080)
Domestic firms' exports	0.034*	0.030*	0.034*	0.027*	0.034*	0.027*
	(0.002)	(0.003)	(0.002)	(0.004)	(0.002)	(0.004)
Two-digit industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture dummy	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	4366	4366	4366	4366	4366	4366
R^2	0.213	0.209	0.213	0.201	0.214	0.201
First-stage F statistic for excluded instruments		141.4		128.3		122.2
(P-value)		0.000		0.000		0.000
Hansen statistic for over-identification test		3.755		0.433		0.202
(P-value)		0.053		0.511		0.653

Notes: Parentheses report robust standard errors; all variables are defined in logs except for urban population share; constant is not reported; instruments used in IV estimation include the log of distance from Shanghai port and land area; * ([a]) denotes significance at the 1% (5%) level.

Table 6. Estimation results for spatial spillovers to regional productivity

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable		Labor productivity			Total factor productivity	
Spatial lag	0.864*	0.902*	0.890*	0.893*	0.899*	0.891*
	(0.095)	(0.092)	(0.091)	(0.096)	(0.094)	(0.094)
Number of foreign firms	0.055*			0.047*		
	(0.012)			(0.011)		
Employment of foreign firms		0.014*			0.015*	
		(0.004)			(0.004)	
Value added of foreign firms			0.010*			0.010*
			(0.003)			(0.003)
Population	0.028	0.031	0.031	0.023	0.025	0.025
	(0.021)	(0.021)	(0.021)	(0.020)	(0.020)	(0.020)
Urban population share	-1.689	-1.390	-1.350	-0.390	-0.185	-0.141
	(1.094)	(1.092)	(1.089)	(0.970)	(0.968)	(0.966)
Domestic firms' exports	0.019*	0.020*	0.019*	0.029*	0.029*	0.029*
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Two-digit industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture dummy	Yes	Yes	Yes	Yes	Yes	Yes
No. of observations	4366	4366	4366	4366	4366	4366

Notes: Parentheses report robust standard errors; all variables are defined in logs except for urban population share; * denotes significance at the 1% level.