Does Foreign Direct Investment Lead to Industrial Agglomeration?

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Abstract

This paper studies the effect of foreign direct investment (FDI) on industrial agglomeration. Using the differential effects of FDI deregulation in 2002 in China on different industries, and using the Ellison-Glaeser index as the measure of industrial agglomeration, we find that FDI actually affects agglomeration *negatively*. This result is somewhat counter-intuitive, as the conventional wisdom tends to think that FDI influx promotes agglomeration. To reconcile our empirical findings and the conventional wisdom, we develop a theory of FDI and agglomeration based on interplay between technology diffusion and pro-competitive effect. Our theory indicates that which force dominates depends on the scale of the economy. When the scale of the economy is small, FDI promotes agglomeration because competition is not fierce (and technology gap is large); otherwise, FDI promotes dispersion. Our evidence also shows that the FDI deregulation also leads to lower markups, sales, and profits of firms, consistenet with the mechanism of the theory. We also show that both FDI and industrial agglomeration increase industrial growth rate, and the dispersion caused by FDI deregulation accounts for 17% loss in industrial growth rate.

Keywords: industrial agglomeration, Ellison-Glaeser index, pro-competitive effect, FDI deregulation, WTO, industrial growth

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1 Introduction

In the theories of economic growth and development, two salient mechanisms are agglomeration of economic activities and technology diffusion across countries, the latter of which is particularly important for developing countries. First, industrialization and urbanization are closely closely intertwined in the development process (Henderson 2004; Michaels, Rauch, and Redding 2012), and various positive externalities that are best internalized at an aggregate level when firms and people are in close proximity geographically are believed to be engines of growth (Jacobs 1969; Lucas 1988; Krugman 1991).[1] Second, technology diffusion is one key mechanism behind the the convergence hypothesis in the growth theory.

Take the story of Shenzhen, for an example. Before the *opening-up* in 1979, Shenzhen was merely an ordinary countryside with mainly farming and fishing activities. It was chosen as the first special economic zone (SEZ), which was established in 1980, because it was right next to Hong Kong, and the purposes of special economic zones were mainly for attracting foreign direct investment (FDI) and fostering agglomeration (for both foreign and domestic firms). At 2017, Shenzhen is already one of the four top-tier cities in China, alongside with Shanghai, Beijing, and Guangzhou, with a urban population of more than 10 millions at 2010 and being a major manufacturing hub of the world.[2]

Presumbly both technology diffusion and agglomeration play a role in the growth stories such as Shenzhen and elsewhere.[3] Nevertheless, these two mechanisms are *not orthogonal*. Open and FDI-friendly policies and environment attract both foreign firms and domestic firms, and their complex interactions are what drive technology diffusion. When these firms cluster, various agglomeration economies[4] tend to reinforce both tech-

[1]See Marshall (1920) for initial ideas on agglomeration. For modern development of related literature, see Duranton and Puga (2004) for a survey on the theoretical literature, and Rothenthal and Strange (2004) on the empirical counterpart.

[2]The special economic zone of Shenzhen was considered as a testing ground for trade and FDI liberalization and tax reforms. To attract foreign investment, the government provided preferential policies for foreign investors, for example, reductions in corporate income tax and land use fees. After 20 years of the establishment of the Shenzhen SEZ, foreign investors from 60 countries set up enterprises and establishments in the zone. The total number of foreign investment projects reached about 23.6 thousands, and the realized foreign direct investment in the zone achieved 20.05 billion U.S. dollars. The annual growth rate in GDP in Shenzhen averaged 29.5 percent between 1980 and 2001. The corresponding number for gross industrial output and total exports was 46.4 percent and 39.4 percent, respectively.

[3]Iskandar Malaysia is another story that bears some similarity to Shenzhen's. The Malaysian government established the special economic zone of Iskandar Malaysia in November 2006. After a decade of the establishment, the zone has created about 700 thousand employment opportunities and the committed cumulative investments reached 52.99 billion US dollars in 2016. The region's GDP grew annually at 4.1 percent from 2006 to 2010, and at about 7 percent after 2011 (Iskandar Regional Development Authority, 2016).

[4]In addition to the knowlege spillover emphasized by Lucas (1988, 2001) and Lucas and Rossi-Hansberg

nology diffusion and the agglomeration itself, setting up a rapid growth process. In other words, FDI can actually act as sparks that ignite clustering of firms. For these reasons, one may naturally conjecture that FDI tends to foster agglomeration.

Aggregating firm-level data to the industry level, this paper aims to study the interactions between FDI and industrial agglomeration, as well as their implications on economic growth. Our first task is to test the above-mentioned conjecture: do we actually see larger industrial agglomeration when there is more influx of foreign investment? For this purpose, we explore a particular historical event to empirically examine the effect FDI deregulation on industrial agglomeration. China entered the World Trade Organization (WTO) in the end of 2001. As a condition of accession, China was required to relax its controls on FDI entry, and the extent of deregulation differed across industries. Specifically, China encouraged FDI entries in around one quarter of its manufacturing industries, with the rest remaining mostly status quo. Our data shows that such deregulation increases both the foreign equity share and the share of foreign numbers in the de-regulated industries much faster than the status-quo ones.

These variations in FDI deregulation across industries and time allow us to use a *difference-in-differences* (DD) estimation approach. Specifically, we compare the degree of industrial agglomeration the FDI deregulated industries with that in status quo industries before and after the deregulation, which occurred soon after the accession on April 1, 2002. We use Ellison-Glaeser (EG) index (Ellison and Glaeser 1997) to measure industrial agglomeration. Consistently, we find a significant and *negative* effect of FDI deregulation on industrial agglomeration. These results are robust to a battery of robustness checks on the DD identifying assumption, including the checks on the pre-treatment trends between treatment and control groups, controlling for the nonrandom selection of deregulated industries, and controlling for other concurrent policy reforms.

The results surprised us, as they are contrary to the above-mentioned conjecture. To solve the puzzle and reconcile the empirical finding and the conventional wisdom behind the conjecture, we develop a theory of FDI and industrial agglomeration based on two counter-veiling forces. On the one hand, FDI brings in foreign firms that are more productive than domestic firms. If domestic firms are located in the same region as the foreign firms, they may receive technological spillover and thus have higher productivities on average than the domestic firms that stay in the other region with less or no foreign firms. On the other hand, the existence of transport cost between regions make the

(2002), agglomeration economies also include labor pooling, input-output linkages (Krugman 1991; Krugman and Venables 1995), and many others. See Marshall (1920) for initial ideas on agglomeration. For modern development of related literature, see Duranton and Puga (2004) for a survey on the theoretical literature, and Rothenthal and Strange (2004) on the empirical counterpart.

region with more firms more competitive, which means that the firms there enjoy lesser markups, sales, and profits for the same given productivity. Therefore, FDI deregulation may increase the competition pressure in the location where the foreign firms agglomerate, and this competition pressure may discourage firms from locating there.

Our theory predicts a hump shape in the relation of industrial agglomeration with foreign capital. When the economy or the size of total foreign capital is small, technology diffusion attracts domestic firms to where the foreign capital is located. At this stage, competition pressure is small, and thus the pro-competitive effects are dominated by the force via technology diffusion. When the economy or the size of total foreign capital becomes large, competition pressure also grows large, and the productivity gaps may have become small due to large technology diffusion that has already occurred. In this case, a further influx of foreign capital induces dispersion rather than agglomeration. The former case is fitting to the stories of Shenzhen, whereas the latter case explains our empirical results. In sum, our theory adds in pro-competitive effects to a standard story of technology diffusion of FDI to reconcile the conventional wisdom and our empirical finding. To lend support to our theory, we empirically estimate the effect of FDI deregulation on markups, sales, and profits of firms. We do find that after 2002 the markups, sales, and profits of firms in the deregulated industries are significantly lower than the counterparts in the status quo industries.

Our last part of empirical analysis focuses on the effects of FDI deregulation on industrial growth (in terms of growth rate in value added) and the role of industrial agglomeration. We find a significant and positive effect of FDI deregulation on industrial growth rate, but when the degree of industrial agglomeration (measured by the EG index) is controlled, the effect of FDI deregulation on industrial growth rate is increased. As FDI deregulation causes lesser degrees of industrial agglomeration, the above result implies that industrial agglomeration is also conducive to industrial growth. We find that about 17% of the growth rate is lost due to the dispersion caused by FDI deregulation. Taken together, as both FDI and industrial agglomeration are conducive to industrial growth while FDI discourages industrial agglomeration, these seem to rationalize place-based polices (such as SEZs) that encourge FDI and give additional incentive to industrial agglomeration.

Our literature review starts with the role of openness on agglomeration. Compared with the vast literature of agglomeration economies, the role of international trade and FDI on regional/industrial agglomeration is less studied. Recent studies point to the positive role of international trade on the agglomeration of economic activities within a country (see, e.g., Rauch 1991; Fajgelbaum and Redding 2014; Tombe and Zhu 2015;

Redding 2016), but few is done on the role of FDI. A recent empirical study by Alfaro and Chen (2014) finds that multinational firms tend to agglomerate spatially, and technology diffusion is one factor that drives their agglomeration patterns different from domestic firms. Yet, their study does not empirically examine how FDI affects overall patterns of industrial agglomeration in a country.

Compared with the theory of agglomeration, we note that our work is specifically on "industrial agglomeration", instead of "agglomeration". The canonical theories of agglomeration typically model situations when two sides of the markets (buyers and sellers) are both mobile; e.g., when firms and people cluster together to form large regions or cities. See, for examples, Krugman (1991), Helpman (1998), Ottaviano, Tabuchi, and Thisse (2002). However, our focus here, as fitting to our regression specification and results, is on the location pattern of firms in an industry. Thus, we use a partial-equilibrium framework in Melitz and Ottaviano (2008) and allow only the firms to be mobile, i.e., we assume workers/consumers are immobile. After all, the location pattern of an industry is unlikely to affect the location pattern of the overall economy. Our theoretical approach is also fitting to our empirical measure in the EG index, which takes the spatial distribution of overall economic activities as given. To the best of our knowledge, our theory is the first on how FDI affects industrial agglomeration.

A related point is on the role of pro-competitive effects. In the theories of "agglomeration", pro-competitive effects may be conducive to agglomeration because consumers enjoy lower prices (e.g., Ottaviano, Tabuchi, and Thisse 2002). But under our setup to study the location pattern of an industry, pro-competitive effects simply discourages agglomeration of firms. Also related is the study by Behrens, Gaigne, Ottaviano, and Thisse (2007) who show geographic dispersion of the industry when trade becomes more open. Our theory differs from theirs as we focus on FDI and incorporate technology diffusion.

The rest of the paper is organized as follows. Section 2 details the background of deregulation on FDI into China, the data, and the estimation strategy. Section 3 presents the empirical results. Section 4 provides a theoretical explanation to the negative scale effect. This section also includes a mechanism test. Section 5 concludes.

2 Background and Data

2.1 Regulations of FDI in China

In December 1978, the then leader of China, Deng Xiaoping, initiated an open door policy to promote foreign trade and investment. The policy changed dramatically the situation of China under rigid central planning before 1978, with almost complete absence of foreign-invested enterprises (FIEs). From the late 1970s to the early 1990s, a series of laws on FDI and implementation measures were further introduced and revised.

- In July 1979, a "Law on Sino–Foreign Equity Joint Ventures" was passed to attract foreign direct investment.
- In September 1983, the "Regulations for the Implementation of the Law on Sino–Foreign Equity Joint Ventures" was issued by the State Council of China; it was revised in January 1986, December 1987, and April 1990.
- In April 1986, the "Law on Foreign Capital Enterprises" was enacted.
- In October 1986, "Policies on Encouragement of Foreign Investment" was issued by the State Council of China.

FIEs enjoy preferential policies on taxes, land usage, and other matters, often in the form of policies for special economic zones, which were expected to bring advanced technologies and management know-how to China and to promote China's integration into the world economy. As a result of these laws and implementation measures, China experienced a rapid growth in FDI inflows from 1979 to 1991. After Deng Xiaoping took a tour of Southern China in the spring of 1992 to revive a slowing economy, the FDI inflows to China grew even faster, reaching US$ 27.52 billion in 1993.

Most significantly, there were policies designating which industries were permitted to accept foreign direct investment. In June 1995, the central government of China promulgated "the Catalogue for the Guidance of Foreign Investment Industries" (henceforth, the Catalogue), which, together with the modifications made in 1997, became the government guidelines for regulating the inflows of FDI. Specifically, the Catalogue classified products into four categories: (i) FDI was supported, (ii) FDI was permitted, (iii) FDI was restricted, and finally, (iv) FDI was prohibited.

After China's entry into the World Trade Organization (WTO) in November 2001, its central government substantially revised the Catalogue in March 2002, and made minor revisions in November 2004.[5] In this study, we use the plausibly exogenous relaxation of FDI regulations upon China's WTO accession at the end of 2001 to identify the effect of FDI on industrial agglomeration.

[5]The National Development and Reform Commission and the Ministry of Commerce jointly issued the fifth and sixth revised versions of the Catalogue in October 2007 and December 2011, which are out of our sample period.

2.2 Data

Panel Data on Industrial Firms.—The main data used in this study are from the Annual Surveys of Industrial Firms (ASIF), conducted by the National Bureau of Statistics of China for the 1998–2007 period.[6] These surveys cover all of the state-owned enterprises (SOEs) and all of the non-SOEs firms with annual sales over 5 million Chinese yuan (about US$827,000). The number of firms covered in the surveys varies from approximately 162,000 to approximately 270,000. The dataset has more than 100 variables, including the basic information for each surveyed firm, such as its identification number, location code, and industry affiliation, and the financial and operational information extracted from accounting statements, such as sales, employment, materials, fixed assets, and total wage bill.

For our study, we need precise industry and location information about our sample firms. In 2003, a new classification system for industry codes (GB/T 4754-2002) was adopted in China to replace the old classification system (GB/T 4754-1994) that had been used from 1995 to 2002. To achieve consistency in the industry codes over our entire sample period (1998–2007), we use the concordance table constructed by Brandt, Van Biesebroeck, and Zhang (2012).[7] Meanwhile, during our sample period, there were several changes in the county or prefecture codes in our data set, due to the changes in China's administrative boundaries.[8] Using the 1999 National Standard (promulgated at the end of 1998 and called GB/T 2260-1999) as the benchmark codes, we convert the regional codes of all the firms to these benchmark codes to achieve consistency in the regional codes throughout the whole sample period.

Our outcome variable, the degree of industrial agglomeration, is measured by following the method of Ellison and Glaeser (1997). Ellison and Glaeser's index (henceforth, the EG index) is constructed as follows:

[6]These data have been widely used by economic researchers in recent years, e.g., Lu, Lu, and Tao (2010), Brandt, Van Biesebroeck, and Zhang (2012), and Lu and Yu (2015).

[7]One potential problem with the ASIF data is that, for firms with multiple plants located in regions other than their domiciles, the information about the satellite plants might be aggregated to that of the domicle-based plants. According to Article 14 of the Company Law of the People's Republic of China, however, for a company to set up a plant in a region other than its domicile, "it shall file a registration application with the company registration authority, and obtain the business license." For example, Beijing Huiyuan Beverage and Food Group Co., Ltd. has six plants, located in Jizhong (Hebei Province), Youyu (Shanxi Province), Luzhong (Shandong Province), Qiqihar (Heilongjiang Province), Chengdu (Sichuan Province), and Yanbian (Jilin Province). Our data set accordingly counts them as six different observations belonging to six different regions. Thus a firm in our data is essentially a plant.

[8]For example, new counties were established, while existing counties were combined into larger ones or even elevated to prefectures.

$$EG_i \equiv \frac{G_i - (1 - \sum_r x_r^2) H_i}{(1 - \sum_r x_r^2)(1 - H_i)},$$

where $G_i \equiv \sum_r (x_r - s_r^i)^2$ with x_r the share of total output of all industries in region r, and s_r^i the share of output of region r in industry i; and $H_i \equiv \sum_j h_j^2$ is the Herfindahl index of industry i, with h_j the output share of a particular firm j in industry i.[9]

For a given industry, the EG index measures the degree of spatial concentration relative to the case where the firms in this industry are randomly assigned to locations (as metaphored as a dartboard approach). In the main analysis, we measure the EG index by using the prefecture (around 380 prefectures in China) as the geographic unit. To check whether our findings are sensitive to the selection of geographic unit in constructing the measure of industrial agglomeration (or so-called modifiable area unit problem), we also measure the EG index using the county (around 2,800 counties in China) as the geographic unit.

Data on China's FDI Regulations.—To obtain information about changes in FDI regulations upon China's accession to the WTO, we follow Lu, Tao, and Zhu (2017) by comparing the 1997 and 2002 versions of *the Catalogue for the Guidance of Foreign Investment Industries* and matching the product level in the Catalogue to the ASIF industry level.

In the Catalogue, products were classified into four categories: (i) products where foreign direct investment was supported (the supported category), (ii) products (not listed in the Catalogue) where foreign direct investment was permitted (the permitted category), (iii) products where foreign direct investment was restricted (the restricted category), and finally, (iv) products where foreign direct investment was prohibited (the prohibited category).

Then, we compare the 1997 and 2002 versions of the Catalogue, and identify, for each product in the Catalogue, whether there was a change in the FDI regulations upon China's accession to the WTO. We then assign each product to one of three possible outcomes: (i) FDI became more welcome (henceforth, such products are referred to as (FDI) encouraged products), (ii) FDI became less welcome (henceforth, such products are referred to as (FDI) discouraged products), (iii) No change in FDI regulations between 1997 and 2002.[10]

[9]Duranton and Overman (2005) develops a distance-based approach to study the location patterns of industries. Duranton and Overman's index (henceforth, the DO index) requires precise information on firm's geocoding data, i.e., firm's spatial coordinates. The Chinese firm-level data from 1998 to 2003 do not contain accurate information on firm's addresses. This restricts us to measure the DO index for our analysis.

[10]In the appendix, we discuss in details how we make comparison between Catalogue 1997 and 2002 and match Catalogue product level to the ASIF industry level.

Finally, we aggregate the changes in FDI regulations from the Catalogue product level to the ASIF industry level. The aggregation process leads to four possible scenarios:

1. (FDI) Encouraged Industries: For all of the possible Catalogue products in a 4-digit CIC industry, there was either an improvement in FDI regulations or no change in FDI regulations.

2. (FDI) Discouraged Industries: For all of the possible Catalogue products in a 4-digit CIC industry, there was either a deterioration in FDI regulations or no change in FDI regulations.

3. No-Change Industries: There was no change in FDI regulations for any of the possible Catalogue products under a 4-digit CIC industry.

4. Mixed Industries: Some of the possible Catalogue products in a 4-digit CIC industry experienced an improvement in FDI regulations, but some had worsening FDI regulations.

Among the 424 4-digit CIC industries, 112 are (FDI) *encouraged industries* (which is the treatment group in our regression analysis), 300 are *no-change industries* (which serves as the control group in our regression analysis), 7 are (FDI) *discouraged industries* and 5 industries are *mixed industries*; the latter two groups are excluded from the analysis.[11]

Descriptive Statistics.—Table 1 reports the EG index calculated at the prefecture level across the 2-digit industries over the entire sample period (1998–2007), the pre-WTO period (1998–2001), and the post-WTO period (2002–2007). The three most geographically concentrated industries in the 1998–2007 period are Smelting & Pressing of Nonferrous Metals, Leather, Furs, Down & Related Products, and Food Processing. The industries with the lowest degree of agglomeration are Tobacco Processing, Printing Industry, and Medical & Pharmaceutical Products.

[Insert Table 1 here]

From the pre-WTO period to the post-WTO period, there were substantial changes in the degree of agglomeration across these industries in China. Specifically, Chemical

[11] The results (available upon request) remain robust when we include the *discouraged industries* in the analysis.

Fiber industry witnessed the fastest growth rate in agglomeration, followed by Instruments, Meters, Cultural & Office Equipment, and then Transport Equipment, while Tobacco Processing, Petroleum Processing & Coking, and Medical & Pharmaceutical Products industries experienced decreases in the degrees of agglomeration.

Table 2 compares the changes in foreign equity share, in Panel A and the changes in the share of number of foreign firms, in Panel B before and after the WTO accession for the treatment and control groups, respectively. There were significant increases in both the foreign equity share and the share of number of foreign firms for the treatment industries (i.e., industries in which FDI was encouraged) than for the control industries (i.e., industries without any changes in FDI entry regulation).

[Insert Table 2 here]

3 Estimation Strategy

3.1 Specification

To identify the effect of FDI regulation changes on industrial agglomeration, we use variations across industries in the changes in FDI regulations upon China's WTO accession; an DD estimation framework. Specifically, we compare the degree of agglomeration in our treatment group (i.e., the encouraged industries) with that in our control group (i.e., the no-change industries) before and after China's WTO accession at the end of 2001.

The specification for our DD estimation is:

$$y_{it} = \alpha_i + \beta Treatment_i \times Post02_t + \mathbf{X}_{it}^{'}\boldsymbol{\lambda} + \gamma_t + \varepsilon_{it}, \tag{1}$$

where i, and t denote the 4-digit industry, and year, respectively; y_{it} measures the agglomeration (e.g., EG index) of industry i in year t; α_i and γ_t are industry and year fixed effects, respectively; and ε_{it} is the error term. To address the potential serial correlation and heteroskedasticity issues, we calculate the standard errors clustered at the industry level (see Bertrand, Duflo, and Mullainathan, 2004).

$Treatment_i \times Post02_t$ is our regressor of interest, capturing the FDI regulation changes in industry i and year t, where $Treatment_i$ indicates whether industry i belongs to the *encouraged industries*; and $Post02_t$ is a dummy indicating the post-WTO period, i.e., $Post02_t = 1$ if $t \geq 2002$, and 0 if $t < 2002$. To isolate the effect of FDI regulation changes, we control for a vector of time-varying industry characteristics $\mathbf{X}_{it}$ (to be explained later) that may be correlated with $Treatment_i \times Post02_t$.

3.2 Identifying Assumption and Checks

The identifying assumption of the DD estimation specification (1) is that conditional on a list of controls, our regressor of interest ($Treatment_i \times Post02_t$) is uncorrelated with the error term (ε_{it}), i.e., $cov\left(Treatment_i \times Post02_t, \varepsilon_{it}|\mathbf{W}_{it}\right) = 0$, where $\mathbf{W}_{it}$ summates all of the controls (α_i, $\mathbf{X}_{it}$, γ_t). There are only two possible sources of violation of this identifying assumption; that is, $cov\left(Post02_t, \varepsilon_{it}|\mathbf{W}_{it}\right) \neq 0$ and $cov\left(Treatment_i, \varepsilon_{it}|\mathbf{W}_{it}\right) \neq 0$. We discuss these possible estimation biases in sequence, and also our checks.

Nonrandom timing of treatment. $cov\left(Post02_t, \varepsilon_{it}|\mathbf{W}_{it}\right) \neq 0$ indicates that the timing of the FDI deregulation was nonrandom. Note that we have included year fixed effects in all the analyses, which removes all the common differences across years. Hence, this nonrandom selection of treatment timing would have biased our estimates if the Chinese government had chosen to change the FDI regulations in 2002 knowing that treatment and control industries would become different at that moment.

As discussed in the previous subsection, however, the FDI deregulation in 2002 was part of the requirements of China's WTO accession, the negotiation of which was very lengthy and rather uncertain prior to 2001. First, it took more than 15 years of exhaustive negotiations with the 150 WTO member countries for China to join the WTO. Second, although China signed a breakthrough agreement with the United States in November 1999 and an agreement with the European Union in May 2000, several remaining issues, such as farm subsidies, were still unresolved in mid-2001. To provide quantitative evidence that there was no anticipation of China's WTO accession by the end of 2001, we conduct a robustness check following Jensen and Oster (2009). Specifically, we include an additional control in the regression, $Treatment_i \times One\,Year\,Before\,WTO\,Accession_t$; any significant coefficient of this additional control variable would indicate possible expectation effects.

Another potential bias arising from the treatment timing is that other on-going policy reforms at the time of China's WTO accession might affect industrial agglomeration, thereby confounding the effect of FDI on industrial agglomeration. At the time of China's WTO accession, there were substantial tariff reductions by China and its trading partners, which affected the use of imported inputs and access to export markets. To condition out the tariff reduction effects, we include the interactions between year dummies and various tariffs (specifically, China's output and input tariffs, and its export tariffs) in 2001 in $\mathbf{X}_{it}$.[12] Another important policy reform in the early 2000s was the restructuring and

[12]The tariff data for HS-6 products are obtained from the World Integrated Trade Solution (WITS). By

privatization of SOEs. To control for the possibility that the extent of SOE restructuring and privatization differed across industries and affected our outcomes, we add the interaction between year dummies and industry-level SOE share in 2001 in $\mathbf{X}_{it}$. China has set up special economic zones to attract foreign direct investments, and to alleviate this concern, we include an additional control, the interaction between year dummies and the share of industry output from the special economic zones in 2001.

Nonrandom selection of treatment group. $cov\left(Treatment_i, \varepsilon_{it}|\mathbf{W}_{it}\right) \neq 0$ challenges the comparability of our treatment and control groups. Specifically, the selection of which industries to open up to FDI upon the WTO accession was not random; hence, the *encouraged industries* and the *no-change industries* could have been experiencing different trends before the WTO accession and these differences might have generated differential trends in our outcomes across industries in the post-WTO period.

To alleviate the identification concern due to the nonrandom selection of treatment industries, we follow the approach proposed by Gentzkow (2006). First, we carefully characterize the important determinants of the changes in FDI regulations upon the WTO accession. As discussed in Lu, Tao, and Zhu (2017), four determinants are identified at the four-digit industry level: new product intensity, export intensity, number of firms, and average age of firms in the industry.[13] Let these variables measured in 2001 be denoted as Z_{i2001}. We then add interactions between the four determinants measured in 2001 and year dummies ($Z_{i2001} \times \gamma_t$) in $\mathbf{X}_{it}$ to control flexibly for post-WTO differences in the time path of the outcomes that are caused by the endogenous selection of industries for changes in FDI regulations. Furthermore, we control for time-varying industrial characteristics to balance different industries. Specifically, we include in $\mathbf{X}_{it}$ that may affect industrial agglomeration, such as knowledge spillovers (measured by industrial productivity), input sharing (measured by share of intermediate inputs to output), labor market pooling (measured by wage premium), scale economies (measured by average firm size), and geographic factor (measured by employment in the coastal area). **We further control for the channel of vertical FDI (i.e., backward and forward FDI), which may affect industrial agglomeration.**[14]

mapping HS-6 products to ASIF 4-digit industries through the concordance table from the National Bureau of Statistics of China, we can calculate simple average output tariff at the industry level. The input tariff is constructed as a weighted average of the output tariff, using as the weight share of the inputs in the output value from the 2002 China's Input-Output Table. The export tariff is measured as a weighted average of the destination country's tariffs on China's imports, using China's imports by each destination country as the weight.

[13] New product intensity is measured as the ratio of new products output to total output. Export intensity is measured as the ratio of total exports to total output.

[14] Following Javorcik (2004), we measure backward and forward FDI as $\sum_{k \text{ if } k \neq i} \alpha_{ik} \times Treatment_k \times \gamma_t$,

A placebo test. We formalize the identification issues and carry out a placebo test with randomly assigned reform status (for similar exercises, see, for example, Chetty, Looney, and Kroft, 2009; La Ferrara, Chong, and Duryea, 2012). We decompose the error term into two parts: $\varepsilon_{it} = \delta\omega_{it} + \tilde{\varepsilon}_{it}$, such that

$$\begin{aligned} cov\left(Treatment_i \times Post02_t, \omega_{it}|\mathbf{W}_{it}\right) &\neq 0, \\ \text{and } cov\left(Treatment_i \times Post02_t, \tilde{\varepsilon}_{it}|\mathbf{W}_{it}\right) &= 0. \end{aligned}$$

In other words, all of the identification issues come from the omitted variable ω_{it}. Hence, our estimator $\hat{\beta}$ is such that

$$plim\hat{\beta} = \beta + \delta\kappa, \tag{2}$$

where $\kappa \equiv \frac{cov(Treatment_i \times Post02_t, \omega_{it}|\mathbf{W}_{it})}{var(Treatment_i \times Post02_t|\mathbf{W}_{it})}$. And $\hat{\beta} \neq \beta$ if $\delta\kappa \neq 0$. To check whether our results are biased due to the omitted variable ω_{it}, we conduct a placebo test by randomly generating the industry and time variations in the changes in FDI entry regulations. Specifically, we first randomly select 112 industries from the total 412 industries in the regression sample and assign them to the category of *(FDI) encouraged industries*; then, we randomly choose a year from 1999 to 2006 (to make sure we have at least one year before the treatment and one year after the treatment for our DD analysis) as the year of the WTO accession; finally, we construct a *false* instrumental variable from these two randomizations, i.e., $Treatment_i^{false} \times Post_t^{false}$. The randomization ensures that $Treatment_i^{false} \times Post_t^{false}$ should have no effect on FDI inflows (i.e., $\beta^{false} = 0$) and hence the regression of our outcome directly on $Treatment_i^{false} \times Post_t^{false}$ should produce zero effect; otherwise, it indicates the existence of the omitted variable ω_{it}.We conduct this random data generating process 500 times to avoid contamination by any rare events and to improve the power of the test.[15]

and $\sum_{m \text{ if } m \neq i} \beta_{im} \times Treatment_m \times \gamma_t$, respectively. Here, α_{ik} is the ratio of industry i's output supplied to sector k, and β_{im} is the ratio of inputs purchased by industry i from industry m. Information on α_{ik} and β_{im} is compiled from China's 2002 Input–Output Table.

[15]To be specific, we conduct the placebo test by estimating the following equation: $y_{it} = +\beta^{false} Treatment_i^{false} \times Post_t^{false} + \mathbf{X}_{it}^{'}\boldsymbol{\lambda} + \gamma_t + \nu_{it}$. The controls $(\alpha_i, \mathbf{X}_{it}^{'}, \gamma_t)$ are the same as those in the benchmark estimation in (1).

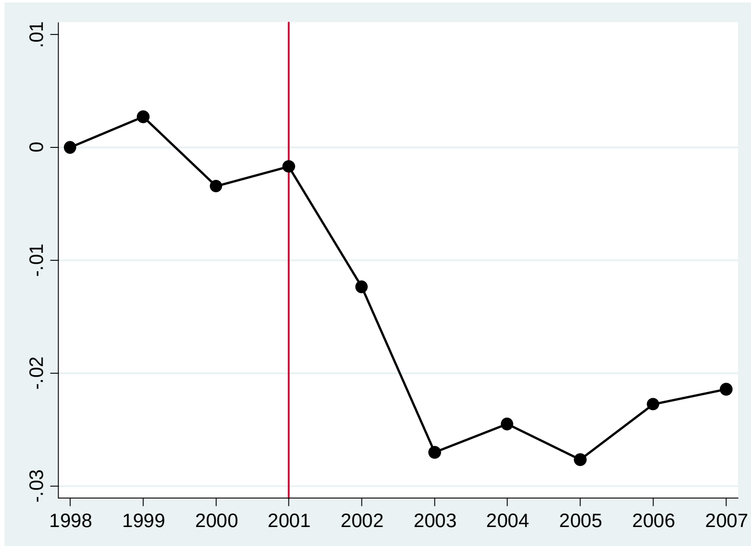

Figure 1: Effects of FDI regulation changes on industrial agglomeration

4 Empirical Findings

4.1 Graphical Results

To illustrate the validity of our identification strategy, we plot, in Figure 1, time trends of the difference in industrial agglomeration (measured by the EG index) between *encouraged industries* and *no-change industries*, conditional on a set of controls in equation (1). It is clear that in the pre-treatment period, treatment and control groups show quite similar trends. This alleviates the concern that our treatment and control groups are systematically different *ex ante*, which lends support to the satisfaction of our DD identifying assumption.

Meanwhile, in the post-treatment period, the treatment group experienced a significant decline in the degree of agglomeration compared with the control group, indicating that the relaxation of FDI regulations had a negative effect on industrial agglomeration.

4.2 Main Results

The DD estimation results are reported in Table 3. We start with a DD specification that includes only industry and year fixed effects in column 1. Then, we stepwisely include a set of controls as elaborated in the previous section. The inclusion of these additional controls allows us to isolate the effect of FDI from other confounding factors such as the endogenous selection of industries for changes in FDI regulations upon the WTO accession and other on-going policy reforms (tariff reductions, SOE reform, and special economic zones) occurring at around the same period. Specifically, interactions between year dummies and potential determinants of changes in FDI regulations are reported in column 2. Interactions between year dummies and tariff reductions, and between year dummies and SOE share are included in columns 3-4, respectively. Column 5 adds the interaction between between year dummies and the share of industry output from the special economic zones in 2001. Time-varying industry characteristics are added in column 6. The extent of backward and forward FDI is controlled in column 7.

We consistently find that our regressor of interest, $Treatment_i \times Post02_t$, is statistically significant and negative, which **echos** the message in Figure 1. Meanwhile, as presented in Table 2, there were substantial increases in both the share of foreign equity and the share of number of foreign firms in industries that experienced FDI liberalization than in industries that did not. Given that there were larger FDI inflows into industries that became more encouraged for FDI after 2002, these results imply that FDI liberalization has a negative effect on industrial agglomeration.[16]

[Insert Table 3 here]

4.3 Economic Magnitude

To calculate the magnitude of the effect, we rely on the estimate in column 7 of Table 3. We find that the adoption of FDI regulation decreases the degree of industrial agglomeration by 0.022 on average. As the FDI reform started in 2002 and our sample period is from 1998 to 2007, the DD estimate captures the average treatment effect over six year. Thus, the 0.022 drop of EG index can be translated into 0.004 drop annually.

4.4 Robustness Checks

Randomly Assigned Policy Reform.—As discussed in the previous section, we conduct a placebo test by randomly generating the industry and time variations in the changes in FDI entry regulations. Figure 2 shows the distribution of the estimates from the 500 randomized assignments. We find that the distribution of these estimates is centered around

[16]One alternative explanation is that the changes in FDI regulations upon China's WTO accession is associated with the relaxation of FDI entries in regions, subsequently affecting the geographic distribution of economic activities. However, after carefully examined the 2002 Catalogue as well as other policies related to FDI issued in 2002, we did not find any changes regarding the regional aspects of FDI entry regulations. Actually, on May 4, 1997, the State Council issued "the Termination of Unauthorized Local Examination and Approval of Commercial Enterprises with Foreign Investment", which forbid the location discretions in FDI entry regulations.

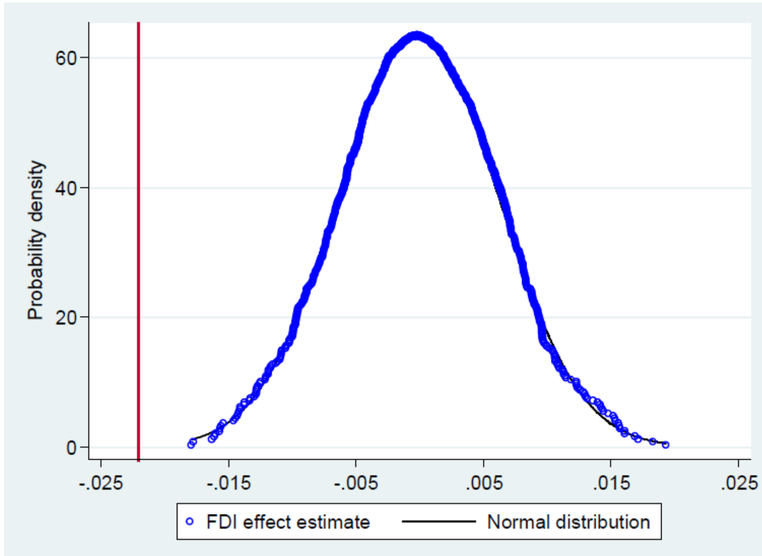

Figure 2: Distribution of estimated coefficients of placebo test

zero (mean value of -0.00008), with a standard deviation of 0.006. In addition, our true estimate (i.e., -0.022) lies beyond the 95 percentile of the 500 estimates. Combined, these observations suggest that the negative and significant effect of FDI on industrial agglomeration is unlikely to be driven by unobserved factors.

Alternative Measures of Agglomeration.—In column 1 of Table 4, we repeat our analysis using an alternative measures of agglomeration: EG index measured using county as the geographic unit. Consistently, we find that $Treatment_i \times Post02_t$ is negative and statistically significant, implying that our aforementioned results are not driven by the specific measure of industrial agglomeration.

[Insert Table 4 here]

Expectation Effect.—In columns 2-3 of Table 4, we add to the regression an additional control, $Treatment_i \times One\ Year\ Before\ WTO\ Accession$, to check whether the degree of industrial agglomeration changes in anticipation of the FDI regulation changes upon WTO accession. We find that our regressor of interest remains negative and statistically significant, while the coefficient of $Treatment_i \times One\ Year\ Before\ WTO\ Accession$ is statistically insignificant and with magnitude close to 0. These results indicate that the treatment and control groups are comparable in the pre-treatment periods and there is no expectation effect.

5 A Theory of Foreign Direct Investment and Industrial Agglomeration

This section provides a theory to comprehend our empirical results. As mentioned in the introduction, the conventional wisdom on the positive relation of FDI and industrial agglomeration is intimately linked with the ideas surrounding technological spillovers and various examples of successful SEZ stories such as Shenzhen and **Iskandar**. To reconcile such conventional wisdom and our empirical results, we develop a theory that is based on the interplay between technology diffusion and competition.

Note first that technology diffusion here can be interpreted more generally. There are various benefits that domestic firms can receive from the presence of foreign firms, say, via technological spillovers, input-output links, and labor pooling. We take a simple approach to model these various benefits to domestic firms by technology diffusion, i.e., the domestic firms become more productive when locating near foreign firms. On the other hand, whereas FDI deregulation implies more FDI inflows, the number of firms increases, and this brings fiercer competition which also affects firms' location choices.

The main idea is that when the scale of the industry/economy is small, which is often the case for developing countries in their early developing stage, firm productivities tend to be low and competition is not fierce. In this case, domestic firms can benefit tremendously from FDI firms, and thus FDI deregulation fosters industrial agglomeration. However, if the industry/economy has grown sufficiently large, then the productivity gap is already smaller and competition has become fierce. In this case, the benefits that domestic firms receive from the foreign firms have become small, while the already fierce competition will encourage dispersion of firms in the face of more influx of foreign capital.

As fitting to our empirical results from industry-level regressions, labor is assumed to be immobile as each particular industry has only small influence on the overall distribution of labor force or population. We thus focus on "industrial agglomeration" rather than "agglomeration" of both population and firms. As the model features pro-competitive effects, one departure of our theory from the literature is that without mobility of workers/consumers, pro-competitive effects are negative incentives for firms' location choices, as firms would typically choose to go to places with less fierce competition.[17]

[17] When labor is mobile, pro-competitive effects can be an agglomeration forces, as more firms in a location can lower product prices and thus attract consumers/workers to move to that location, too. See, e.g., Ottaviano, Tabuchi, and Thisse (2002).

5.1 Model

To incorporate pro-competitive effects in an analytically tractable way, our model builds on Melitz and Ottaviano's (2008) model of heterogeneous firms and variable markups. Consider a country with two regions, indexed by $i = 1, 2$. There are a mass of immobile workers $\bar{L}_i$ living and working in each region i such that $\bar{L}_1 + \bar{L}_2 = \bar{L}$.

5.1.1 Consumption

For any worker living in region i, she consumes a set of differentiated products indexed by ω and a homogeneous good, which is set to be the numeraire. She solves the following utility maximization problem:

$$\max_{q_0, q_{ji}(\omega)} U_i = q_0 + \alpha \sum_j \int_{\omega \in \Omega_j} q_{ji}(\omega) d\omega - \frac{\gamma}{2} \sum_j \int_{\omega \in \Omega_j} q_{ji}^2(\omega) d\omega - \frac{\eta}{2} \left(\sum_j \int_{\omega \in \Omega_j} q_{ji}(\omega) d\omega \right)^2$$

$$s.t.\ q_0 + \sum_j \int_{\omega \in \Omega_j} p_{ji}(\omega) q_{ji}(\omega) d\omega = y_i + \bar{q}_0,$$

where Ω_j is the set of differentiated products produced in region j, $q_{ji}(\omega)$ is her demand for the goods produced in region j with price $p_{ji}(\omega)$, q_0 is the amount of of the numeraire good consumed, and $\bar{q}_0$ is the per person endowment of the numeraire good. The positive parameters α and η capture the substitution between the differentiated products and the numeraire: A larger α or a smaller η indicates larger willingness to pay for any differentiated product in terms of the numeraire. The parameter $\gamma > 0$ captures the degree of product differentiation between the varieties: the larger γ, the more differentiated the products are. When $\gamma = 0$, they are perfect substitutes.

Each worker is endowed with a unit of labor, which is supplied inelastically to the firms in the region where she resides. Assume $\bar{q}_0$ is sufficiently large so that the consumption q_0 is always positive. Each worker also owns an equal share of total domestic capital K^H (H stands for home). Thus, her total income is $y_i = w_i + \frac{K^H}{\bar{L}} r_i$, where r_i is rental rate of capital in region i and endogenously determined.

As shown in Melitz and Ottaviano (2008), there exist choke prices p_i^m such that the individual demand is as follows

$$q_{ji}^c = \begin{cases} \frac{1}{\gamma}\left(p_i^m - p_{ji}\right) & p_{ji} \le p_i^m \\ 0 & p_{ji} > p_i^m \end{cases} . \tag{3}$$

Following similar procedure in Melitz and Ottaviano (2008), the choke price is given by

$$p_i^m = \frac{\gamma\alpha + \eta P_i}{\gamma + \eta N_i},$$

where

$$P_i \equiv \sum_j \int_{\omega \in \Omega_{ji}^c} p_{ji}(\omega) d\omega. \tag{4}$$

The price elasticity of demand for positive q_{ji}^c is $\varepsilon_{ji} = -\frac{\partial q_{ji}^c}{\partial p_{ji}} \frac{p_{ji}}{q_{ji}^c} = \left(\frac{p_i^m}{p_{ji}} - 1\right)^{-1}$. For a given price p_{ji}, a larger number of competing firms N_i lowers the choke price and induce an increase in ε_{ji}, characterizing a fiercer competition.

5.1.2 Production

The numeraire goods q_0 are produced using one-to-one constant-returns technology, and freely traded between the two regions. Thus $w_1 = w_2 = 1$. For the differentiated sector, ϕ units of capital is required to set up a firm in any region. Upon hiring ϕ units of capital to set up, each entrant in region i obtains a distinct product and draws its unit labor requirement c (i.e., marginal cost or the inverse of productivity) from a given distribution $G_i^s(c)$, $s = H, F$. As in Melitz and Ottaviano (2008), choke price in a region i determines the selection cutoff c_i such that entrants in i with $c > c_i$ will exit.

The standard iceberg trade cost assumption is also made: for each good ω, τ_{ji} units need to be shipped in order to deliver 1 unit to region i from region j. For simplicity, we assume symmetric trade cost, and trading locally is free. Thus, $\tau_{ji} = \tau > 1$ if $j \neq i$, and $\tau_{ji} = 1$ if $j = i$.

The total capital $\bar{K}$ in this country consists of domestic capital K^H and foreign capital (FDI) K^F. For our purpose of highlighting the tradeoff between technology diffusion and pro-competitive effects, we assume that foreign firms can only be located in one of the two regions, i.e., only domestic firms are freely mobile. This can be interpreted as SEZs or any broader policy restrictions or incentives targeting foreign firms. This assumption simplifies the analysis and makes the result more stark. Moreover, as various empirical evidence shows, foreign firms do have a strong tendency in locating near other foreign firms and in a more open and developed region. For China, this is the east coastal area.[18]

[18]When the foreign firms are allowed to be mobile, the resulting equilibrium will be one in which the numbers of foreign and domestic firms are proportional to population distribution. This is because the model does not build in an innate agglomeration force. Nevertheless, one can easily incorporate a standard agglomeration economies to generate an innate agglomeration, and therefore all of our results still hold because an uneven distribution of foreign firms entails larger technology diffusion in region 1, and the tradeoff that we will illustrate still works.

Denote the number of entrant firms in region i is N_i^E. The total number of entrants in this country is $\bar{N}^E \equiv N_1^E + N_2^E = \frac{K^F+K_1^H}{\phi} + \frac{K_2^H}{\phi} = \frac{\bar{K}}{\phi}$. By choosing units for capital, we can normalize ϕ to 1. Define the fraction of surviving firms in region 1 as

$$f \equiv \frac{K^F G_1^F\left(c_1^D\right) + K_1^H G_1^H\left(c_1^D\right)}{K^F G_1^F\left(c_1^D\right) + K_1^H G_1^H\left(c_1^D\right) + K_2^H G_2^H\left(c_2^D\right)}.$$

It is actually easier to work with the ratio of surviving firms between the two regions:

$$\lambda \equiv \frac{K^F G_1^F\left(c_1^D\right) + K_1^H G_1^H\left(c_1^D\right)}{K_2^H G_2^H\left(c_2^D\right)}, \tag{5}$$

which has a one-to-one mapping with f such that $f = \frac{\lambda}{1+\lambda}$and is increasing λ. We are interested in how FDI will affect the spatial distribution of firms in the two regions, or equivalently, how the equilibrium value of λ, denoted as λ^e, will respond to the change in the amount of capital.

If there is no technology diffusion, then regardless of the locations, a firm in type s draws its cost c from a distribution given by

$$\bar{G}^s(c) = \left(\frac{c}{c^{M,s}}\right)^{\theta}, \ c \in [0, c^{M,s}], \quad s \in \{H, F\}$$

We assume $c^{M,F} \leq c^{M,H}$ to reflect the technological advantage of foreign firms over home firms. With technology diffusion in region 1, the domestic firms in region 1 draws from

$$G_1^H(c) = \left(\frac{c}{c_1^{M,H}}\right)^{\theta}, \ c \in [0, c_1^{M,H}],$$

where

$$c_1^{M,H} = c^{M,F} + e^{-\beta K^F}\left(c^{M,H} - c^{M,F}\right), \ \ \beta > 0.$$

Therefore, if $K^F = 0$, $c_1^{M,H} = c^{M,H}$, and if $K_1^F \to \infty$, $c_1^{M,H} = c^{M,F}$. That is, more FDI will make the productivity of domestic firms in region 1 higher, but still lower than that of the foreign firms. Meanwhile, foreign firms still draw from the distribution with $c^{M,F}$, and the home firms in region 2 draw from the distribution with $c_2^{M,H} = c^{M,H}$.

From the individual demand (3), the aggregate demand (that is, the demand facing a firm) is $q_{ij} \equiv \bar{L}_j q_{ij}^c$. With trade cost $\tau > 1$, firms price-discriminate across regions. Thus, maximizing $\pi_i = \pi_{ii} + \pi_{ij}$ is equivalent to

$$\max_{p_{ij}} \pi_{ij} = \left(p_{ij} - \tau_{ij} c\right) q_{ij} \quad \text{for } j = 1, 2.$$

Therefore,

$$
\begin{aligned}
p_{ij} &= \frac{\varepsilon_{ij}}{\varepsilon_{ij}-1}\tau_{ij}c = \frac{p_{ij}}{2p_{ij}-p_j^m}\tau_{ij}c = \frac{1}{2}\left(p_j^m+\tau_{ij}c\right), \qquad (6)\\
q_{ij} &= \bar{L}_j\left(\frac{p_j^m}{\gamma}-\frac{p_{ij}}{\gamma}\right) = \frac{\bar{L}_j}{2\gamma}\left(p_j^m-\tau_{ij}c\right).
\end{aligned}
$$

Let c_i^D and c_i^X denotes cutoff cost levels in the local market and export market for firms in region i. Note that these cutoffs are independent of firm types $s = H, F$. Then, $c_i^D = p_i^m$; $\tau_{ij}c_i^X = p_j^m$. Hence, we have $c_i^X\tau_{ij} = c_j^D$. Equilibrium profit and revenue for a firm from i with c in market j (if it sells there) is

$$
\begin{aligned}
\pi_{ij} &= \frac{\bar{L}_j}{4\gamma}\left(c_j^D-\tau_{ij}c\right)^2 \qquad (7)\\
s_{ij}(c) &= \frac{\bar{L}_j}{4\gamma}\left(\left(c_j^D\right)^2-\left(\tau_{ij}c\right)^2\right). \qquad (8)
\end{aligned}
$$

Moreover, the firm's mark-up in market j (if at all) is

$$
\mu_{ij}(c) = p_{ij}(c)-\tau_{ij}c = \frac{1}{2}\left(p_j^m-\tau_{ij}c\right). \qquad (9)
$$

5.1.3 Entry

The products available in region i consist of those locally produced and those imported:

$$
\sum_{s\in\{H,F\}} N_i^{E,s}G_i^s\left(c_i^D\right) + \sum_{s\in\{H,F\}} N_j^{E,s}G_j^s\left(c_j^X\right) = N_i \qquad (10)
$$

By (4) and (10), we have

$$
P_i = N_i\frac{2\theta+1}{2(\theta+1)}c_i^D. \qquad (11)
$$

Combining the expression of the choke price and (11), we can solve out the number of products available in region i:

$$
N_i = \frac{2(\theta+1)\gamma}{\eta}\frac{\alpha-c_i^D}{c_i^D}. \qquad (12)
$$

Let $\rho \equiv \tau^{-\theta}$, and thus ρ is a measure of trade openness. Using (10) and (12), the numbers of entrants are

$$N_1^{E,H} = \frac{2(\theta+1)\gamma\left(c_1^{M,H}\right)^\theta}{\eta(1-\rho^2)}\left(\frac{\alpha-c_1^D}{\left(c_1^D\right)^{\theta+1}} - \rho\frac{\alpha-c_2^D}{\left(c_2^D\right)^{\theta+1}}\right) - K^F\left(\frac{c_1^{M,H}}{c^{M,F}}\right)^\theta \quad (13)$$

$$N_2^{E,H} = \frac{2(\theta+1)\gamma\left(c_2^{M,H}\right)^\theta}{\eta(1-\rho^2)}\left(\frac{\alpha-c_2^D}{\left(c_2^D\right)^{\theta+1}} - \rho\frac{\alpha-c_1^D}{\left(c_1^D\right)^{\theta+1}}\right) \quad (14)$$

Together with $c_i^X\tau_{ij} = c_j^D$, each firm's expected profit gross of capital rental is:

$$E(\pi_i^s) = \int_0^{c_i^D}\pi_{ii}^s(c)\,dG_i^s(c) + \int_0^{c_i^X}\pi_{ij}^s(c)\,dG_i^s(c) = \frac{\bar{L}_i\left(c_i^D\right)^{\theta+2} + \rho\bar{L}_j\left(c_j^D\right)^{\theta+2}}{2\gamma(\theta+1)(\theta+2)\left(c_i^{M,s}\right)^\theta} \quad (15)$$

Competition for capital equates the capital rental rate to the above expected profit. That is, $r_i^H = E\left(\pi_i^H\right)$ and $r_1^F = E\left(\pi_1^F\right)$.

5.2 Equilibrium Analysis

5.2.1 Equilibrium with fixed spatial distribution of firms

Before the analysis of equilibrium spatial distribution of firms, we first write down the equilibrium conditions when the spatial distribution is fixed, that is, when λ is fixed. Using (5) and $N_1^{E,H} + N_2^{E,H} = K^H$, we have

$$N_1^{E,H} = \frac{K^H\lambda G_2^H\left(c_2^D\right) - K^F G_1^F\left(c_1^D\right)}{\lambda G_2^H\left(c_2^D\right) + G_1^H\left(c_1^D\right)} = \frac{K^H\lambda\left(\frac{c_2^D}{c_2^{M,H}}\right)^\theta - K^F\left(\frac{c_1^D}{c^{M,F}}\right)^\theta}{\lambda\left(\frac{c_2^D}{c_2^{M,H}}\right)^\theta + \left(\frac{c_1^D}{c_1^{M,H}}\right)^\theta} \quad (16)$$

$$N_2^{E,H} = \frac{K^F G_1^F\left(c_1^D\right) + K^H G_1^H\left(c_1^D\right)}{\lambda G_2^H\left(c_2^D\right) + G_1^H\left(c_1^D\right)} = \frac{K^F\left(\frac{c_1^D}{c^{M,F}}\right)^\theta + K^H\left(\frac{c_1^D}{c_1^{M,H}}\right)^\theta}{\lambda\left(\frac{c_2^D}{c_2^{M,H}}\right)^\theta + \left(\frac{c_1^D}{c_1^{M,H}}\right)^\theta} \quad (17)$$

Equating (13) and (16), as well as (14) and (17), we obtain

$$\frac{\alpha - c_1^D}{\left(c_1^D\right)^{\theta+1}} = \frac{\left[\rho\left(c_1^D\right)^{\theta} + \lambda\left(c_2^D\right)^{\theta}\right]\left[K^F\left(\frac{c_1^{M,H}}{c^{M,F}}\right)^{\theta} + K^H\right]}{\lambda\left(c_2^D c_1^{M,H}\right)^{\theta} + \left(c_1^D c_2^{M,H}\right)^{\theta}} \frac{\eta}{2(\theta+1)\gamma}, \tag{18}$$

$$\frac{\alpha - c_2^D}{\left(c_2^D\right)^{\theta+1}} = \frac{\left[\left(c_1^D\right)^{\theta} + \lambda\rho\left(c_2^D\right)^{\theta}\right]\left[K^F\left(\frac{c_1^{M,H}}{c^{M,F}}\right)^{\theta} + K^H\right]}{\lambda\left(c_2^D c_1^{M,H}\right)^{\theta} + \left(c_1^D c_2^{M,H}\right)^{\theta}} \frac{\eta}{2(\theta+1)\gamma}. \tag{19}$$

For a given λ, the two cutoffs c_1^D and c_2^D are determined by the above two equilibrium conditions.

5.2.2 Equilibrium spatial distribution of firms

Let $\Delta^H(\lambda) \equiv E\left(\pi_1^H(\lambda)\right) - E\left(\pi_2^H(\lambda)\right)$, where $\lambda \in [\underline{\lambda}, \infty)$ with $\underline{\lambda} \equiv \frac{K^F G_1^F\left(c_1^D\right)}{K^H G_2^H\left(c_2^D\right)}$, as the lower and upper ends correspond to the cases where all domestic firms are in region 2 and region 1, respectively.[19] We define equilibria following standard approach (e.g., Krugman 1991; Ottaviano, Tabuchi and Thisse 2002). That is, an interior equilibrium λ, λ^e, must satisfy $\Delta^H(\lambda^e) = 0$. A corner equilibrium $\lambda^e \to \infty$ ($f^e = 1$) exists if $\lim_{\lambda\to\infty}\Delta^H(\lambda) > 0$. Similarly, a corner equilibrium $\lambda^e = \underline{\lambda}$ exists if $\Delta^H(\underline{\lambda}) < 0$.

From (15), we have

$$\Delta^H(\lambda) = \frac{\left[\left(\frac{c_1^{M,H}}{c_2^{M,H}}\right)^{-\theta} - \rho\right]\bar{L}_1\left(c_1^D\right)^{\theta+2} + \left[\left(\frac{c_1^{M,H}}{c_2^{M,H}}\right)^{-\theta}\rho - 1\right]\bar{L}_2\left(c_2^D\right)^{\theta+2}}{2\gamma(\theta+1)(\theta+2)\left(c_2^{M,H}\right)^{\theta}}.$$

First recall that $\frac{c_1^{M,H}}{c_2^{M,H}} < 1$ due to technology diffusion. If $\frac{c_1^{M,H}}{c_2^{M,H}} \leq \rho^{\frac{1}{\theta}}$, then $\left(\frac{c_1^{M,H}}{c_2^{M,H}}\right)^{-\theta}\rho \geq 1$ and $\Delta^H(\lambda) > 0$ for all λ. Hence, full agglomeration ($f^e = 1$) occurs when $\frac{c_1^{M,H}}{c_2^{M,H}} \leq \rho^{\frac{1}{\theta}}$. Any

[19] When all domestic firms are in region 2, the levels of c_1^D and c_2^D are determined by

$$\frac{2(\theta+1)\gamma\left(c_1^{M,H}\right)^{\theta}}{\eta(1-\rho^2)}\left(\frac{\alpha - c_1^D}{\left(c_1^D\right)^{\theta+1}} - \rho\frac{\alpha - c_2^D}{\left(c_2^D\right)^{\theta+1}}\right) - K^F\left(\frac{c_1^{M,H}}{c^{M,F}}\right)^{\theta} = 0$$

$$\frac{2(\theta+1)\gamma\left(c_2^{M,H}\right)^{\theta}}{\eta(1-\rho^2)}\left(\frac{\alpha - c_2^D}{\left(c_2^D\right)^{\theta+1}} - \rho\frac{\alpha - c_1^D}{\left(c_1^D\right)^{\theta+1}}\right) = K^H,$$

which are derived from (13) and (14). It can be shown that this will occur when $\bar{L}_1/\bar{L}_2$ is below a certain level, causing $\Delta^H(\lambda) < 0$.

interior equilibrium λ^e must satisfy $\Delta^H(\lambda^e) = 0$. Note that this also implies equal rental rate of domestic capital: $r_1^H = r_2^H \equiv r^H$. The condition $\Delta^H = 0$ implies that

$$\frac{c_2^D}{c_1^D} = \left(\frac{\left(c_2^{M,H}\right)^\theta - \rho \left(c_1^{M,H}\right)^\theta}{\left(c_1^{M,H}\right)^\theta - \rho \left(c_2^{M,H}\right)^\theta} \frac{\bar{L}_1}{\bar{L}_2} \right)^{\frac{1}{\theta+2}} \equiv h > \left(\frac{\bar{L}_1}{\bar{L}_2} \right)^{\frac{1}{\theta+2}}. \tag{20}$$

Note that for a given K^F, h is exogenously determined. Suppose the population sizes are the same in the two regions. Then, (20) implies that $c_2^D > c_1^D$. Because foreign firms are more productive, the domestic firms in region 1 are also more productive due to technology diffusion. Together with positive trade cost ($\tau > 1$; $\rho < 1$), firms in region 1 being more productive ensures the competition and selection are both more fierce in region 1, resulting in $c_1^D < c_2^D$. Observe that h is strictly decreasing in $c_1^{M,H}$, which is strictly decreasing in K^F; so h is strictly increasing K^F. FDI deregulation (an increase in K^F) therefore widens the difference of the two selection cutoffs, as the market in region 1 becomes more competitive. When the population sizes are different, the larger the population ratio $\bar{L}_1/\bar{L}_2$, the larger the gap between the two cutoffs. Also, the larger the technology diffusion, the larger the gap.

Letting $\bar{\ell} \equiv \frac{\bar{L}_2}{\bar{L}_1}$, and using $N_1^{E,H} + N_2^{E,H} = K^H$, (13), (14), and (20), we have

$$\frac{\alpha\left(1+\bar{\ell}h\right) - c_1^D\left(1+\bar{\ell}h^2\right)}{\left(c_1^D\right)^{\theta+1}} = \frac{\left(1-\rho^2\right)}{\left(c_1^{M,H}\right)^\theta - \rho\left(c_2^{M,H}\right)^\theta} \frac{\eta\left[K^H + K^F\left(\frac{c_1^{M,H}}{c^{M,F}}\right)^\theta\right]}{2\left(\theta+1\right)\gamma}. \tag{21}$$

The selection cutoff c_1^D is the only endogenous variable in (21), which allows the following characterization.

Proposition 1. *When $\frac{c_1^{M,H}}{c_2^{M,H}} \leq \rho^{\frac{1}{\theta}}$, the equilibrium where all firms agglomerate at region 1 ($f^e = 1$) is the only equilibrium. Let h be defined by (20). When $\rho^{\frac{1}{\theta}} < \frac{c_1^{M,H}}{c_2^{M,H}} < 1$ and*

$$\frac{K^H + K^F\left(\frac{c_1^{M,H}}{c^{M,F}}\right)^\theta}{\left(c_1^{M,H}\right)^\theta - \rho\left(c_2^{M,H}\right)^\theta} \frac{\eta\left(1-\rho^2\right)}{2\left(\theta+1\right)\gamma} > \frac{\left(h-1\right)h^\theta}{\alpha^\theta}, \tag{22}$$

there exists a unique interior equilibrium. Moreover, $f^e \geq 1/2$ if and only if $h \geq 1$.

Proof. The claim on the full-agglomeration case is already proved. Define $F(c) \equiv \frac{\alpha\left(1+\bar{\ell}h\right) - c\left(1+\bar{\ell}h^2\right)}{c^{\theta+1}}$, where $c \in \left(0, \frac{\alpha}{h}\right)$. The domain is $\left(0, \frac{\alpha}{h}\right)$ because $0 < c_1^D < \alpha$ and $c_2^D = hc_1^D < \alpha$. It can be shown that $F(c)$ is strictly decreasing on $\left(0, \frac{\alpha}{h}\right)$. Thus, the left-hand side of (21) strictly decreases from infinity to $\frac{(h-1)h^{\theta}}{\alpha^{\theta}} > 0$. Observe that $\left(c_1^{M,H}\right)^{\theta} - \rho\left(c_2^{M,H}\right)^{\theta} > 0$ if and only if $\frac{c_1^{M,H}}{c_2^{M,H}} > \rho^{\frac{1}{\theta}}$. Thus, if $\frac{c_1^{M,H}}{c_2^{M,H}} > \rho^{\frac{1}{\theta}}$ and (22) holds, then there exists a unique equilibrium c_1^D that satisfies (21), which is a condition for interior equilibrium. If $\frac{c_1^{M,H}}{c_2^{M,H}} > \rho^{\frac{1}{\theta}}$ but (22) fails, then an interior equilibrium does not exists. Observe that

$$\begin{aligned}
\lambda^e &= \frac{K^F G_1^F\left(c_1^D\right) + N_1^{E,H} G_1^H\left(c_1^D\right)}{N_2^{E,H} G_2^H\left(c_2^D\right)} = \frac{\frac{\alpha-c_1^D}{\left(c_1^D\right)^{\theta+1}} - \rho\frac{\alpha-c_2^D}{\left(c_2^D\right)^{\theta+1}}}{\frac{\alpha-c_2^D}{\left(c_2^D\right)^{\theta+1}} - \rho\frac{\alpha-c_1^D}{\left(c_1^D\right)^{\theta+1}}} h^{-\theta} \\
&= \left(\frac{\left(1-\rho^2\right)}{\frac{\alpha-c_2^D}{\alpha-c_1^D}h^{-\theta-1} - \rho} - \rho\right) h^{-\theta} = \frac{\left(1-\rho^2\right)h}{\frac{\alpha-h\alpha}{\alpha-c_1^D} + h - \rho h^{\theta+1}} - \rho\left(\frac{1}{h}\right)^{\theta} \qquad (23)
\end{aligned}$$

We know that $c_1^D < \alpha$ and $c_2^D = hc_1^D < \alpha$, and thus, $c_1^D < \min\{\alpha, \frac{\alpha}{h}\}$.If $h > 1$,

$$\lambda^e = \left(\frac{1-\rho^2}{\left(\frac{1}{h}\right)^{\theta+1}\frac{\alpha-c_2^D}{\alpha-c_1^D} - \rho} - \rho\right) h^{-\theta} > \frac{\left(1-\rho^2\right)}{h^{-1} - \rho h^{\theta}} - h^{-\theta}\rho \equiv H(h),$$

where the inequality follows from the fact that $c_1^D < c_2^D < \alpha$ in equilibrium and that $H(h)$ is increasing in h on the domain $\left(1, \rho^{-\frac{1}{\theta+1}}\right)$. Note here that $h \geq \rho^{-\frac{1}{\theta+1}}$ is not permissible because the term $\left(\frac{1}{h}\right)^{\theta+1}\frac{\left(\alpha-c_2^D\right)}{\left(\alpha-c_1^D\right)} - \rho$ in (23) must be positive, and $c_1^D < c_2^D$ when $h > 1$. Hence, $\lambda^e > H(1) = 1$ and $f^e = \frac{\lambda^e}{1+\lambda^e} > \frac{1}{2}$. Similarly, if $h < 1$, we have $c_1^D > c_2^D$, and thus $\lambda^e = \left(\frac{1-\rho^2}{\left(\frac{1}{h}\right)^{\theta+1}\frac{\alpha-c_2^D}{\alpha-c_1^D} - \rho} - \rho\right)\left(\frac{1}{h}\right)^{\theta} < \left(\frac{\left(1-\rho^2\right)}{\left(\frac{1}{h}\right)^{\theta+1} - \rho} - \rho\right)\left(\frac{1}{h}\right)^{\theta} \equiv H(h)$, which is increasing in $(0,1)$, and thus $\lambda^e < H(1) = 1$ and $f^e = \frac{\lambda^e}{1+\lambda^e} < \frac{1}{2}$. Also, if $h = 1$, then $\lambda^e = 1$ and $f^e = 1/2$. ■

Note that the condition (22) serves as a regularity condition that guarantees the existence of an interior equilibrium. Two key observations are in order. First, the ratio $\frac{c_1^{M,H}}{c_2^{M,H}}$ inversely measures technology diffusion as it is negatively affected by K^F. Thus, given $\rho \in (0,1)$, for an initial K^F such that $\rho^{\frac{1}{\theta}} < \frac{c_1^{M,H}}{c_2^{M,H}}$, keeping increasing K^F from the initial level will eventually make $\frac{c_1^{M,H}}{c_2^{M,H}}$ switch from larger than $\rho^{\frac{1}{\theta}}$ to smaller than $\rho^{\frac{1}{\theta}}$, and hence switching the equilibrium from a partial agglomeration to a full one. This demonstrates that FDI can encourage agglomeration by attracting domestic firms to region 1.

Second, if $\rho = 1$ ($\tau = 1$), competition pressure facing a firm is the same regardless where the firm is located. Thus, transport cost τ measures the degree in which locations

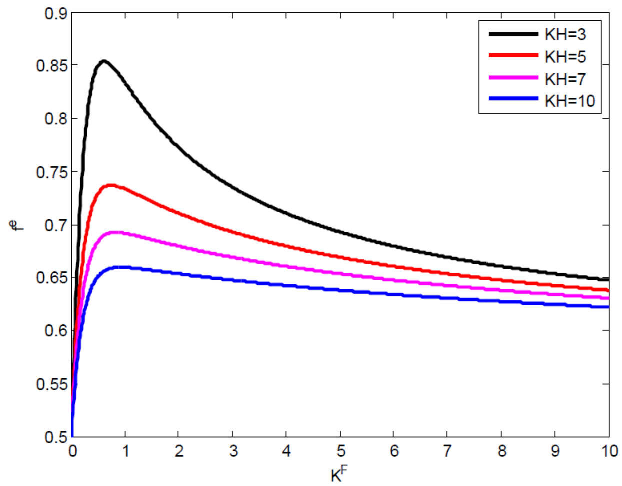

Figure 3: Comparative statics of K^F on f^e

matter in terms of competition pressure. Given K^F (hence given $\frac{c_1^{M,H}}{c_2^{M,H}}$), increasing the transport cost between the two regions (reducing ρ) may switch the equilibrium from a full agglomeration one to a partial one. When τ is high, locations matters much for competition pressure, and firms tend to spread themselves over locations.

Even though Proposition 1 show the importance of the composite parameter h in determines the location pattern f^e, we still lack an analysis on the comparative statics of K^F on f^e in a continuous range, say, when $h > 1$. Due to the complexity of the model, analytical results on this are not available. We thus resort to numerical analysis for such a comparative statics.

We consider three cases based on the relative size of foreign capital to home capital. In all the cases, we let $\bar{L}_1 = \bar{L}_2$.

1. Hold K^H fixed and increase K^F only. This is numerical comparative statics of influx of foreign capital (Shenzhen and **Iskandar** vs 2002 FDI deregulation).

2. Increase K^H and K^F at the same rate. This is numerical comparative statics of the overall scale of the industry.

3. Increase K^H faster than K^F. Numerical comparative statics of the overall scale of the industry when the domestic capital increases faster than the foreign capital.

Figure 3 shows that f^e first increases in K^F and then decreases, and this is true for dif-

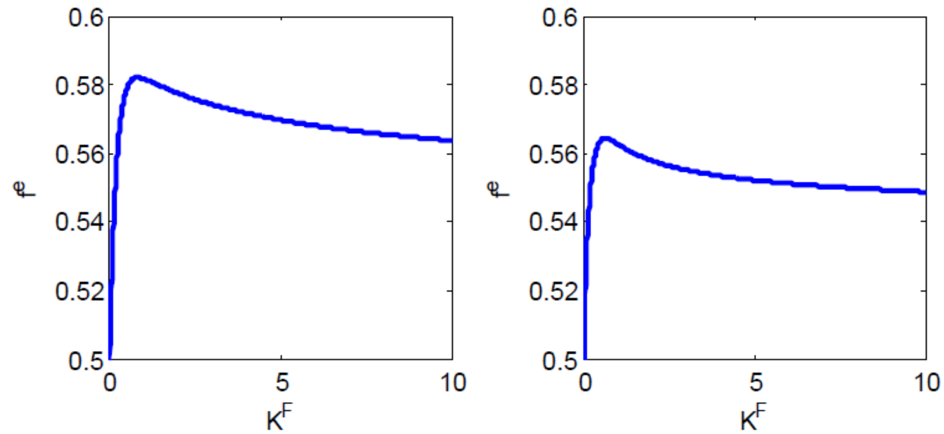

Figure 4: Comparative statics on f^e when K^F and K^H both grow

ferent levels of K^H.[20] Such non-monotonic pattern shows out key intuition: the increasing part corresponds the case where K^F is small but its increase promotes agglomeration sharply because of sharp technology diffusion. The decreasing part shows up eventually when K^F becomes even larger as the competition becomes fiercer and there is a diminishing returns in technology diffusion. The curves with small K^H can be thought of as mimicking the case where the economy is small overall (**for example,** when Shenzhen is a small fishing village in 1979). In such a case, the slope of the increasing part is particularly steep as technology diffusion plays a large role. The curves with large K^H can be thought of as mimicking the case where the overall scale of the economy has grown large. In such a case when K^F is also large, we still see a negative effect of FDI on agglomeration of firms even when the slope is flatter than the cases where K^H is small. This corresponds to our empirical findings.

The left/right panel of Figure 4 plots the second/third case.[21] We plot these in order to show what would occur if the effect of FDI deregulation is to increase not only the foreign firms but also the domestic firms (through various complementary channels). The pattern found in Figure 4 remain robust here. Note also that the reactions are smaller than the left panel because the amount of foreign capital is relatively less in the right panel, mitigating

[20]The parameters used for plotting Figure 4 are $L_1 = L_2 = 1$, $\theta = 5$, $\alpha = 2$, $\beta = 5$, $\eta = 10$, $\gamma = 1$, $\tau = 2.2$, $c^{M,H} = 2$, $c^{M,F} = 1.75$. Here, K^F increases from 0 to 10, and there are four values of K^H: $3, 5, 7$ and 10.

[21]Except for the amount of capital, the parameters used in both panels are same: $\bar{L}_1 = \bar{L}_2 = 1$, $\theta = 5$, $\alpha = 2$, $\beta = 5$, $\eta = 10$, $\gamma = 1$, $\tau = 2.2$, $c^{M,H} = 2$, $c^{M,F} = 1.75$. Initial home capital $K_0^H = 5$ and initial foreign capital $K_0^F = 0$ in both panels. In the left panel, home and foreign capital increase at the same rate, that is: $K_t^s = K_0^s + t$, where $s \in \{H, F\}$, and time $t \in (0, 10)$. In the right panel, home capital increases faster than foreign capital: $K_t^F = K_0^F + t$, and $K_t^H = K_0^H + 20t$ with time $t \in (0, 10)$.

the effect of technology diffusion.

In all of our numerical comparative statics, c_1^D and c_2^D both decrease in response to FDI deregulation (increase in K^F). Consequently, according to (7), (8), and (9) it's obvious to see that firms' mark-ups, revenues and profits decrease in both regions and for both types of firms. These are natural reflections of increased competition pressure.

6 Empirical Evidence on Competition and Industrial Growth

In this section, we examine empirical evidence on pro-competitive effects, the main mechanism of our theory. We also examine how FDI and industrial agglomeration affect industrial growth, which responds to the first-order question mentioned in the introduction.

6.1 Evidence on Pro-competitive Effects

As mentioned above, a crucial element in our model is that the increased scale generates pro-competitive effects, which reduce firm markups, profits, and sales. These pro-competitive effects thus constitute a force for dispersion. To lend support to our theoretical model, we empirically test whether there are negative scale effects on an array of firm performance measures, including markups, profits, and sales.

Firm sales and profits can be directly taken from the data, while we estimate firm markups using the methodology developed by De Loecker and Warzynski (2012).[22] The estimation uses the following DD specification:

$$y_{fit} = \alpha_f + \beta Treatment_i \times Post02_t + \mathbf{X}_{it}^{'}\boldsymbol{\theta} + \boldsymbol{\Psi}_{ft}^{'}\boldsymbol{\phi} + \gamma_t + \varepsilon_{fit}, \tag{24}$$

where f, i, and t denote the firm, 4-digit industry, and year, respectively; y_{fit} measures the performance (e.g., markups, profits, and sales) of firm f in industry i in year t; α_f and γ_t are firm and year fixed effects, respectively; and ε_{fit} is the error term. We control for the time-varying industry characteristics, X_{it} as in the benchmark estimation in (1) and a vector of time-varying firm characteristics, Ψ_{ft} including firm size (measured by firm employment), capital intensity (measured by the ratio of capital to labor), intermediate inputs, and firm ownership (measured by a state-owned enterprise dummy and a foreign-invested enterprise dummy). To address the potential serial correlation and heteroskedasticity, we cluster the standard errors at the industry level.

The estimation results are presented in Table 5, with Panel A for the sample of all

[22] See the appendix for details of firm markup estimation.

firms and Panel B for the sample of domestic firms only.[23] Consistently, we find that FDI deregulation has negative and statistically significant effects on firm markups, profits, and sales. These results are consistent with our model predictions, lending strong empirical support to our theoretical model.

[Insert Table 5 here]

6.2 The Effect of FDI and Industrial Agglomeration on Industrial Growth

Our aforementioned analyses show a significant negative effect of FDI deregulation on industrial agglomeration. As mentioned in the introduction, one fundamental reason of investigating FDI and industrial agglomeration is about their implications on economic growth. Thus, we are interested in knowing industrial growth rate is affected by these two factors, which, as we have shown, are not orthogonal. In particular, the technology diffusion channel of FDI implies that FDI is conducive to industrial growth. The deregulated industries may also grow faster because the deregulation allows more foreign capital to enter, which may also attract domestic capital to accumulate. Moreover, even though the competition channel causes firms to disperse spatially, the induced stronger selection implies higher average productivity, which is also conducive to industrial agglomeration. The nature of various agglomeration economies (even though they are not explicitly modeled here) are positive externalities, and thus by definition, these are conducive to industrial growth, too. We therefore expect that both FDI and industrial agglomeration should enhance industrial growth.

We again approach this problem by the FDI deregulation event. We provide a decomposition framework in the spirit of Heckman, Pinto, and Savelyev (2013). The decomposition exercise is conducted in three steps. First, we regress the industrial growth (measured by the growth rate of industry value-added, i.e., the difference in the logarithm of value-added between t and $t-1$ for one-year growth rate, and the difference in value-added between t and $t-3$ for three-year growth rate) on the FDI regulation changes using the same specification as in our baseline estimation in (1). From this regression we retain the estimated coefficients for the total FDI regulation change, $\hat{\beta}^{total}$. In the second step, we include industrial agglomeration (measured by the EG index) in the previous regression, from which we obtain the total FDI effect net of the changes in economic growth induced by FDI regulation policy via industrial agglomeration, $\hat{\beta}^{net}$. Lastly, we calculate the rela-

[23]Similar to the empirical literature of FDI, we also look at the impacts of FDI on domestic firms. In addition, competition may have a stronger impact on domestic firms than foreign firms because domestic firms are more mobile within China.

tive contribution of the industrial agglomeration to the total effect of FDI deregulation on economic growth as $\left|\frac{\hat{\beta}^{total}-\hat{\beta}^{net}}{\hat{\beta}^{total}}\right| \times 100$ percent.

Table 6 presents the estimation results. First, the fact that the estimated coefficients of $Treatment_i \times Post02_t$ are positive and signifiant indicate that FDI does promote industrial growth. The decompostion further indicates that the effect of FDI deregulation policy on industrial agglomeration can explain about 16 to 18 percent of the policy impact on industrial's value added. Given the significant negative effect of FDI deregulation on industrial agglomeration, this effect could translate into roughly $16\%-18\%$ loss in industrial growth due to dispersion. We discuss related policy implications in the conclusion.

[Insert Table 6 here]

7 Conclusion

FDI is often thought of as having technology spillover effect to domestic firms, and this should foster agglomeration of firms. Our study reveals that whether this is true depends on the stage of development. It may likely to be true in early stages of development, but it turns out to be the opposite for China during the period of our study. By using a DD estimation, this paper finds that the FDI deregulation in 2002 in China on average causes geographic dispersion of industries. We propose a theory based on the interaction of technology diffusion and pro-competitive effect to explain when such a finding may arise and also the situation when the influx of foreign capital can encourage agglomeration. Empirical evidence supports the mechanism in the theory.

As mentioned, the main reason of investigating FDI and industrial agglomeration industrial growth is about their implications on growth. Our results show that both FDI and industrial agglomeration do promote industrial growth. Moreover, about 17% of industrial growth rate is lost due to the de-agglomeration caused by FDI deregulation. As Chinese officials are quite growth-wary, these rationalize FDI-promoting and agglomeration-promoting policies, of which the combinations are special economic zones.

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Appendix

Data on FDI Regulations in China

In the appendix, we discuss in details how we make comparison between 1997 and 2002 versions of the Catalogue and match the product level in the Catalogue to the ASIF industry level.

To obtain information about changes in FDI regulations upon China's accession to the WTO, we compare the 1997 and 2002 versions of the Catalogue for the Guidance of Foreign Investment Industries. We focus on the 2002 version rather than the 2004/2007/2011 versions for three reasons. First, the revision to China's FDI regulations contained in the 2002 version of the Catalogue was substantial and in strict accordance with the commitments made by China's central government in its negotiations with the existing member countries of the WTO before its WTO accession. Second, there were very few changes in the 2004 revision of the Catalogue. Finally, the 2007 and 2011 modifications were not applicable to our sample period, which is from 1998 to 2007.

In the Catalogue, products were classified into four categories: (i) products where foreign direct investment was supported (the supported category), (ii) products (not listed in the Catalogue) where foreign direct investment was permitted (the permitted category), (iii) products where foreign direct investment was restricted (the restricted category), and finally, (iv) products where foreign direct investment was prohibited (the prohibited category).

Next, by comparing the 1997 and 2002 versions of the Catalogue, we can identify, for each product in the Catalogue, whether there was a change in the FDI regulations upon China's accession to the WTO. We then assign each product to one of three possible outcomes:

- FDI became more welcome (henceforth, such products are referred to as (FDI) encouraged products). For example, "dairy products" was listed in the supported category in the 2002 Catalogue, but listed in the permitted category in the 1997 Catalogue. We thus designate "dairy products" as (FDI) encouraged products.

- FDI became less welcome (henceforth, such products are referred to as (FDI) discouraged products). For example, "ethylene propylene rubber" was listed in the supported category in the 1997 Catalogue, but listed in the permitted category in the 2002 Catalogue. We thus designate "ethylene propylene rubber" as (FDI) discouraged products.

- No change in FDI regulations between 1997 and 2002. For example, “Casting and forging roughcasts for automobiles and motorcycles” was listed in the supported category in both the 1997 and 2002 Catalogues. We designate such products as no-change products.

Table A1 lists a matrix of all of the possible changes in product categories (supported, restricted, prohibited, and permitted) between 1997 and 2002 with the corresponding classifications in the changes in FDI regulations (encouraged, discouraged, or no change).

Then, we aggregate the changes in FDI regulations from the Catalogue product level to the ASIF industry level. As the product classifications used by the Catalogue are different from the industry classifications used in the ASIF data, we convert the product classifications of the Catalogue for the Guidance of Foreign Investment Industries into the 4-digit Chinese Industry Classification (CIC) of 2003 using the Industrial Product Catalogue from the National Bureau of Statistics of China.[24] As the Chinese industry classification was revised in 2003, we use a concordance table from Brandt, Van Biesebroeck, and Zhang (2012) to create a harmonized Chinese Industry Classification that is consistent for the entire 1998-2007 period. As the product classifications of the Catalogue are generally more disaggregated than the 4-digit Chinese Industry Classifications of the ASIF, it is possible that two or more products from the Catalogue are sorted into the same 4-digit CIC industry of the ASIF. The aggregation process leads to four possible scenarios:

1. (FDI) Encouraged Industries: For all of the possible Catalogue products in a 4-digit CIC industry, there was either an improvement in FDI regulations or no change in FDI regulations. For example, four sub-categories under “Synthetic Fiber Monomer (Polymerization)” (CIC code: 2653) experienced improvements in FDI regulations (listed in the restricted category in the 1997 Catalogue, but the supported category in the 2002 Catalogue): “Pure Terephthalic Acid (PTA)” (CIC sub-code: 26530101), “Acrylonitrile” (26530103), “Caprolactam” (26530104), and “Nylon 66 Salt” (26530299); and there was no change in FDI regulations for the other sub-categories. We thus designate “synthetic fiber monomer (polymerization)” as an (FDI) encouraged industry.

2. (FDI) Discouraged Industries: For all of the possible Catalogue products in a 4-digit CIC industry, there was either a deterioration in FDI regulations or no change in FDI regulations. For example, one sub-category in “Food Additives” (CIC code: 1494) experienced a deterioration in FDI regulations (listed in the permitted category in

[24] The Industrial Product Catalogue lists each CIC 4-digit industry and its sub-categories at the 8-digit disaggregated product level.

the 1997 Catalogue but listed in the restricted category in the 2002 Catalogue): "Synthetic Sweeteners" (CIC sub-code: 14940103); and there were no changes in FDI regulations for the other sub-categories. We thus designate "Food Additives" as an (FDI) discouraged industry.

3. No-Change Industries: There was no change in FDI regulations for any of the possible Catalogue products under a 4-digit CIC industry. For example, in "Edible Vegetable Oil" (CIC code: 1331), all of the sub-categories were permitted in both the 1997 Catalogue and the 2002 Catalogue. We thus designate "Edible Vegetable Oil" as a no-change industry.

4. Mixed Industries: Some of the possible Catalogue products in a 4-digit CIC industry experienced an improvement in FDI regulations, but some had worsening FDI regulations. For example, under "Crude Chemical Medicine" (CIC code: 2710), the FDI regulations for one sub-category ("Vitamin B6" (CIC sub-code: 27100404)) improved (listed in the restricted category in the 1997 Catalogue, but the permitted category in the 2002 Catalogue), but the FDI regulations for one sub-category ("Vitamin E" (CIC sub-code: 27100408)) deteriorated (listed in the permitted category in the 1997 Catalogue, but in the restricted category in the 2002 Catalogue). We thus designate "Crude Chemical Medicine"as a mixed industry.

Table 1: Summary Statistics

	(1)	(2)	(3)
Industry	1998−2007	1998−2001	2002−2007
Food processing	0.0506	0.0531	0.0490
Food manufacturing	0.0186	0.0181	0.0189
Beverage manufacturing	0.0396	0.0428	0.0375
Tobacco processing	−0.0001	0.0007	−0.0006
Textile industry	0.0476	0.0392	0.0532
Garments & other fiber products	0.0136	0.0109	0.0154
Leather, furs, down & related products	0.0640	0.0427	0.0781
Timber processing, bamboo, cane, palm fiber & straw products	0.0235	0.0229	0.0239
Furniture manufacturing	0.0122	0.0084	0.0145
Papermaking & paper products	0.0499	0.0989	0.0173
Printing industry	0.0145	0.0205	0.0105
Cultural, educational & sports goods	0.0211	0.0153	0.0249
Petroleum processing & coking	0.0065	−0.0113	0.0184
Raw chemical materials & chemical products	0.0348	0.0294	0.0384
Medical & pharmaceutical products	0.0069	0.0050	0.0081
Chemical fiber	0.0220	−0.0044	0.0396
Rubber products	0.0147	0.0073	0.0195
Plastic products	0.0294	0.0230	0.0336
Nonmetal mineral products	0.0403	0.0297	0.0473
Smelting & pressing of ferrous metals	0.0157	0.0122	0.0181
Smelting & pressing of nonferrous metals	0.0654	0.0551	0.0723
Metal products	0.0347	0.0288	0.0387
Ordinary machinery	0.0122	0.0099	0.0137
Special purpose equipment	0.0220	0.0009	0.0360
Transport equipment	0.0316	0.0126	0.0434
Electric equipment & machinery	0.0271	0.0195	0.0321
Electronic & telecommunications equipment	0.0417	0.0234	0.0528
Instruments, meters, cultural & office equipment	0.0259	0.0197	0.0300

Note: EG index in each 2-digit industry is calculated over the 1998-2007 period, the pre-WTO 1998-2001 period, and the post-WTO 2002-2007 period, respectively.

Table 2: FDI Inflows Before and After WTO Accession

	(1)	(2)	(3)
	1998−2001	2002−2007	Percentage change (%)
Panel A. Foreign equity share for the treatment and control groups			
Treatment	0.244	0.312	27.99
Control	0.217	0.250	15.46
Panel B. Share of number of foreign firms for the treatment and control groups			
Treatment	0.131	0.161	22.78
Control	0.192	0.208	8.48

Note: Foreign equity share in Panel A and share of foreign firms in Panel B, in the treatment and control groups, calculated over the pre-WTO 1998–2001 period, the post-WTO 2002–2007 period, and their percentage changes, respectively.

Table 3: Main Results

	Dependent variable: industrial agglomeration (EG index, prefecture level)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment × Post02	−0.020**	−0.018**	−0.019**	−0.020**	−0.020**	−0.022***	−0.022***
	(0.008)	(0.009)	(0.008)	(0.008)	(0.009)	(0.008)	(0.008)
Observations	4,076	4,076	4,076	4,076	4,076	4,076	4,076
Additional controls:							
Industry fixed effects	yes	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes	yes	yes
Control for determinants of FDI regulation changes	no	yes	yes	yes	yes	yes	yes
Control for tariff reductions	no	no	yes	yes	yes	yes	yes
Control for SOE reforms	no	no	no	yes	yes	yes	yes
Special economic zones control	no	no	no	no	yes	yes	yes
Control for time-varying industry characteristics	no	no	no	no	no	yes	yes
Control for vertical FDI	no	no	no	no	no	no	yes

Note: Standard errors are clustered at the industry level in parentheses. Determinants of FDI regulation changes include interactions of year dummies and new product intensity, export intensity, number of firms, and industry age. Tariff reductions include interactions of year dummies and output tariff, input tariff, and export tariff. SOE reforms include interactions of year dummies and the ratio of state-owned enterprises in the total number of firms. Special economic zones include interactions of year dummies and the ratio of firms in the SEZs in the total number of firms. Time-varying industry characteristics include industrial productivity, ratio of intermediate inputs to output, wage premium, average firm size, and employment ratio in coastal areas. Vertical FDI include backward and forward FDI. ***, ** and * denote significance at the 1, 5 and 10% level respectively.

Table 4: Robustness Checks

	Dependent variable: industrial agglomeration		
	EG index (county level)	EG index (prefecture level)	EG index (county level)
	(1)	(2)	(3)
Treatment × Post02	−0.014**	−0.022***	−0.014**
	(0.006)	(0.008)	(0.006)
Treatment × One Year Before WTO Accession		−0.001	0.001
		(0.005)	(0.004)
Observations	4,076	4,076	4,076
Additional controls:			
Industry fixed effects	yes	yes	yes
Year fixed effects	yes	yes	yes
Control for determinants of FDI regulation changes	yes	yes	yes
Control for tariff reductions	yes	yes	yes
Control for SOE reforms	yes	yes	yes
Special economic zones control	yes	yes	yes
Control for time-varying industry characteristics	yes	yes	yes
Control for vertical FDI	yes	yes	yes

Note: Standard errors are clustered at the industry level in parentheses. Determinants of FDI regulation changes include interactions of year dummies and new product intensity, export intensity, number of firms, and industry age. Tariff reductions include interactions of year dummies and output tariff, input tariff, and export tariff. SOE reforms include interactions of year dummies and the ratio of state-owned enterprises in the total number of firms. Special economic zones include interactions of year dummies and the ratio of firms in the SEZs in the total number of firms. Time-varying industry characteristics include industrial productivity, ratio of intermediate inputs to output, wage premium, average firm size, and employment ratio in coastal areas. Vertical FDI include backward and forward FDI. ***, ** and * denote significance at the 1, 5 and 10% level respectively.

Table 5: Mechanism

	(1)	(2)	(3)
Dependent variable:	Log markups	Log profits	Log sales
Panel A. Full sample			
Treatment × Post02	−0.041***	−0.034***	−0.023***
	(0.014)	(0.012)	(0.006)
Observations	1,724,823	1,429,489	1,761,629
Panel B. Domestic firms sample			
Treatment × Post02	−0.037***	−0.035***	−0.025***
	(0.013)	(0.012)	(0.006)
Observations	1,363,524	1,152,490	1,395,898
Additional controls:			
Firm fixed effects	yes	yes	yes
Year fixed effects	yes	yes	yes
Control for determinants of FDI regulation changes	yes	yes	yes
Control for tariff reductions	yes	yes	yes
Control for SOE reforms	yes	yes	yes
Special economic zones control	yes	yes	yes
Control for time-varying industry characteristics	yes	yes	yes
Control for vertical FDI	yes	yes	yes
Control for time-varying firm characteristics	yes	yes	yes

Note: Standard errors are clustered at the industry level in parentheses. Determinants of FDI regulation changes include interactions of year dummies and new product intensity, export intensity, number of firms, and industry age. Tariff reductions include interactions of year dummies and output tariff, input tariff, and export tariff. SOE reforms include interactions of year dummies and the ratio of state-owned enterprises in the total number of firms. Special economic zones include interactions of year dummies and the ratio of firms in the SEZs in the total number of firms. Time-varying industry characteristics include industrial productivity, ratio of intermediate inputs to output, wage premium, average firm size, and employment ratio in coastal areas. Vertical FDI include backward and forward FDI. Time-varying firm characteristics include firm size, capital-labor ratio, intermediate inputs, a state-owned enterprise dummy, and a foreign-invested enterprise dummy. ***, ** and * denote significance at the 1, 5 and 10% level respectively.

Table 6: Role of Industrial Agglomeration in Industrial Growth

	Estimated coefficient of *Treatment* × *Post02*		Implied relative contribution
	EG index not included	EG index included	
Dependent variable:			
Growth rate of industry value-added	0.045**	0.053**	17.77%
(difference in the logarithm of value-added between *t* and *t-1*)	(0.021)	(0.022)	
Growth rate of industry value-added	0.108*	0.126**	16.36%
(difference in the logarithm of value-added between *t* and *t-3*)	(0.056)	(0.058)	
Additional controls:			
Industry fixed effects	yes	yes	−
Year fixed effects	yes	yes	−
Control for determinants of FDI regulation changes	yes	yes	−
Control for tariff reductions	yes	yes	−
Control for SOE reforms	yes	yes	−
Special economic zones control	yes	yes	−
Control for time-varying industry characteristics	yes	yes	−
Control for vertical FDI	yes	yes	−

Note: Standard errors are clustered at the industry level in parentheses. The implied relative contribution is the relative contribution of the industrial agglomeration to the total effect of FDI deregulation on industrial growth. Determinants of FDI regulation changes include interactions of year dummies and new product intensity, export intensity, number of firms, and industry age. Tariff reductions include interactions of year dummies and output tariff, input tariff, and export tariff. SOE reforms include interactions of year dummies and the ratio of state-owned enterprises in the total number of firms. Special economic zones include interactions of year dummies and the ratio of firms in the SEZs in the total number of firms. Time-varying industry characteristics include industrial productivity, ratio of intermediate inputs to output, wage premium, average firm size, and employment ratio in coastal areas. Vertical FDI include backward and forward FDI. ***, ** and * denote significance at the 1, 5 and 10% level respectively.