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Firm Agglomeration and Aggregate Fluctuations

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May 2020

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This study uses Indonesian plant-level manufacturing data from 2000 to 2014 to examine the role of individual firms located in agglomeration areas in generating aggregate fluctuations. While previous studies have used a method to decompose aggregate fluctuations into macroeconomic (sectoral) and firm-specific components, this paper illustrates an approach to further decompose the firm-specific component into higher and lower agglomeration groups. Our results suggest that plant-specific fluctuations in higher agglomeration areas have a greater impact on aggregate fluctuations than those in lower agglomeration areas, and the interaction or co-movements of plants in higher agglomerations areas have a significant role to drive aggregate fluctuations.

Keywords: Aggregate fluctuation, firm agglomeration, plant-level data, Indonesia

JEL classification: E23, E32, R11, R12

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May 7, 2020

Abstract

This study uses Indonesian plant-level manufacturing data from 2000 to 2014 to examine the role of individual firms located in agglomeration areas in generating aggregate fluctuations. While previous studies have used a method to decompose aggregate fluctuations into macroeconomic (sectoral) and firm-specific components, this paper illustrates an approach to further decompose the firm-specific component into higher and lower agglomeration groups. Our results suggest that plant-specific fluctuations in higher agglomeration areas have a greater impact on aggregate fluctuations than those in lower agglomeration areas, and the interaction or co-movements of plants in higher agglomerations areas have a significant role to drive aggregate fluctuations.

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1 Introduction

Understanding how a small shock that affects only a specific firm or technology can propagate throughout the economy to cause sizable aggregate fluctuations is a central issue in macroeconomics. Recent studies have argued that the firm size distribution and the linkages or interactions among firms are key to understanding the propagation mechanism. A seminal paper by Gabaix (2011) showed that when the firm-size distribution has extremely fat tails, micro economic shocks to individual firms do not average out but rather bring about aggregate fluctuations. Acemoglu, Carvalho, Ozdaglar, and Tahbaz-Salehi (2012), Acemoglu, Ozdaglar, and Tahbaz-Salehi (2017) and Carvalho (2014) developed a variant of the multi-sector model of Long and Plosser (1983) and showed that the production network or input-output linkages is

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key whether and how a small shock is amplified and leads to aggregate fluctuations. Di Giovanni, Levchenko, and Mejean (2014) used French firm-level data and found that firm-to-firm linkages have a significant role in explaining the movements of aggregate fluctuations.

On the other hand, in the literature of urban economics, firms and workers are likely to be spatially concentrated to benefit from agglomeration externalities generated by more efficient sharing of local suppliers, better matching between employers and workers, and knowledge spillovers among firms (Combes and Gobillon, 2015; Duranton and Puga, 2004). A spatial concentration of economic activities increases interaction among firms and, consequently, may intensify aggregate fluctuations. However, as Overman and Puga (2010) point out, large agglomerations may iron out a firm-specific shock. Does firm agglomeration contribute to increasing aggregate fluctuations? Despite the fact that both firm agglomeration and aggregate fluctuations have significant implications for macroeconomic performance, little research has been done to explore their relationship.

This study uses Indonesian manufacturing plant-level panel data to examine the role of individual firms located in agglomeration areas in generating aggregate fluctuations. We have used two sets of balanced panel data: (1) the balanced panel from 2000 to 2014 and (2) the balanced panel from 2006 to 2014. The methodology is based on the decomposition method proposed by Di Giovanni, Levchenko, and Mejean (2014), which enables us to decompose aggregate fluctuations into (sector-level) macroeconomic shocks and firm-level shocks. This study extends their methodology and develops an approach to further decompose the firm-level shocks into higher and lower agglomeration groups.

Our main findings are as follows. First, as like Di Giovanni, Levchenko, and Mejean's (2014) empirical results, plant-level shocks mainly contribute to aggregate fluctuations, instead of sector-level macroeconomic shocks. Plant-specific shocks contribute more than 80% to the aggregate fluctuations. Second, plant-to-plant linkages play an important role to explain the magnitude of plant-specific shock. The covariance of shocks among plant (labeled LINK) is much greater than the variance of individual shocks (labeled DIRECT). Third, we decompose the effect of plant-specific shock into two groups: (1) plants located in higher agglomeration areas and (2) plants in lower agglomeration areas. We found that plants in higher agglomeration area have greater plant-specific fluctuations. Fourth, comparing the DIRECT and LINK effects, the relatively large difference between higher and lower agglomeration groups lies in the LINK effect. Therefore, aggregate fluctuations in the Indonesian manufacturing sector are mainly caused by fluctuations of plants located in higher agglomeration area. In particular, the comovement among those plants is a key driver of aggregate fluctuations.

The rest of this paper is structured as follows. Section 2 describes our empirical approach; Section 3 presents the data sources; and Section 4 reports our empirical findings. Section 5 concludes the paper.

2 Conceptual framework

We consider the Indonesian manufacturing sector with N plants. Total value-added of all those plants is defined as $X_t = \sum_f^N x_{ft}$, where t and f denote year and plant, and x_{ft} represents value-added by plant f in year t. The growth rate of the total value-added $\gamma_{A,t}$ is obtained

$$\begin{aligned}\gamma_{A,t} &= \frac{X_t}{X_{t-1}} - 1 \\ &= \frac{\sum_f^N x_{ft}}{\sum_f^N x_{f,t-1}} - 1 \\ &= \sum_f^N w_{f,t-1}\gamma_{ft}\end{aligned} \tag{1}$$

where γ_{ft} is value-added growth rate of plant f, and $w_{f,t-1} = x_{f,t-1}/\sum_f^N x_{f,t-1}$ represents the share of value-added by plant f in year $t-1$.

Following the model of Di Giovanni, Levchenko, and Mejean (2014), we assume that the plant-level value-added x_{ft} is multiplicative in the subsectoral and plant-specific components, and that the growth rate of x_{ft} between t and $t-1$ can be approximated by the first difference of $\log x_{ft}$. The plant value-added growth can then be decomposed into a subsector-specific shock and a firm-specific shock. We introduce the following two models which differ in the elasticity of the plant value-added growth with respect to sectoral shocks:

$$\begin{aligned}&\text{(Model 1)} \quad \mathit{\Delta} \log x_{tf} = \delta_{it} + \varepsilon_{ft} \\ &\text{(Model 2)} \quad \mathit{\Delta} \log x_{tf} = \delta_{it} + \delta_{it} \times \mathbf{Z}_{ft} + \mathbf{Z}_{ft}\boldsymbol{\beta} + \epsilon_{ft} \\ &\qquad\qquad\qquad\qquad = \tilde{\delta}_{ft} + \tilde{\varepsilon}_{ft}\end{aligned} \tag{2}$$

where $i = 1, 2, ..., M$ denotes a subsector of manufacturing in which plant f belongs, δ_{it} are a subsector $\times$ year effect, ε_{ft} and $\tilde{\varepsilon}_{ft}$ are a firm-specific shock, and $\mathbf{Z}_{ft}$ is a vector of observable firm characteristics. The term $\tilde{\delta}_{ft}$ is defined as $\tilde{\delta}_{ft} \equiv \delta_{it} + \delta_{it} \times \mathbf{Z}_{ft} + \mathbf{Z}_{ft}\boldsymbol{\beta}$. In Model 1, the elasticity of plant value-added growth with respect to sectoral shocks is the same across plants, while in Model 2 the term $\tilde{\delta}_{ft}$ takes into account the effect of plant characteristics on the plant value-added growth, and then its firm-specific shock $\tilde{\varepsilon}_{ft}$ is normalized by the observable plant characteristics. Plant characteristics used in this paper are firm size, the degree of access to international trade, and the degree of agglomeration faced by each firm. The model 2 is more general specification which allows firms to react heterogeneously to sectoral shocks. When the case of model 2 is more realistic, the firm-specific effect $\tilde{\varepsilon}_{ft}$ of model 1 would capture not only plant-level idiosyncratic shocks, but also the heterogeneous response of the plant to sectoral shocks. When this is the case, model 1 could overestimate the firm-specific effect on the aggregate fluctuation.

The purpose of this paper is to investigate the impact of firm-specific shocks (ε_{ft} and ϵ_{ft}) on the fluctuations of aggregate value-added growth, and to examine the role of individual plants located in agglomeration areas in generating the aggregate fluctuations. To that end, the variance of γ_{At} is defined as aggregate fluctuations of value-added growth. Assuming $\gamma_{ft} = \mathit{\Delta} \log x_{ft}$ and substituting Equation (2) into Equation (1), we have

$$\begin{aligned} &\text{(Model 1)} \quad \gamma_{A,t} = \sum_{i}^{M} w_{i,t-1}\delta_{it} + \sum_{f}^{N} w_{f,t-1}\varepsilon_{ft} \\ &\text{(Model 2)} \quad \gamma_{A,t} = \sum_{f}^{N} w_{f,t-1}\tilde{\delta}_{ft} + \sum_{f}^{N} w_{f,t-1}\tilde{\varepsilon}_{ft}, \end{aligned} \tag{3}$$

where $w_{i,t-1}$ is the share of sector i's total value-added at year $t-1$, that is $w_{i,t-1} = \sum_{f\in i} \frac{x_{f,t-1}}{\sum_{g}^{N} x_{g,t-1}}$.

To calculate the variance of Equation (3), the weights $(w_{i,t-1}, w_{f,t-1})$ are replaced with $w_{i,\tau-1}$ and $w_{f,\tau-1}$, respectively, and for a given τ these weights are fixed over time at their $\tau-1$ in a stochastic process of $\gamma_{At|\tau}$. Then, the variance of $\gamma_{At|\tau}$ is written as

$$\text{(Model 1)} \quad \sigma^2_{A\tau} = \sigma^2_{I\tau} + \sigma^2_{F\tau} + \text{COV}_\tau \tag{4}$$

where $\text{Var}(\gamma_{At|\tau}) = \sigma^2_{A\tau}$ is the variance of $\gamma_{At|\tau}$, and

$$\sigma^2_{I\tau} = \text{Var}\left(\sum_{i}^{N} w_{i,\tau-1}\delta_{it}\right),\ \sigma^2_{F\tau} = \text{Var}\left(\sum_{f}^{N} w_{f,\tau-1}\varepsilon_{ft}\right),\ \text{COV}_\tau = \text{Cov}\left(\sum_{i}^{N} w_{i,\tau-1}\delta_{it}, \sum_{f}^{N} w_{f,\tau-1}\varepsilon_{ft}\right).$$

Since Model 2 can be written in the same way as Model 1, we only describe Model 1 below. The terms $\sigma^2_{I\tau}$ and $\sigma^2_{F\tau}$ indicate the contribution of subsectoral fluctuations and plant-specific fluctuations to movements of aggregate fluctuations ($\sigma^2_{A\tau}$). As is demonstrated in Di Giovanni, Levchenko, and Mejean (2014), $\sigma^2_{F\tau}$ can be decomposed into the variance of individual plants (labeled DIRECT) and the covariance across plants (labeled LINK) as follows.

$$\sigma^2_{F\tau} = \underbrace{\sum_{f}^{N} w^2_{f,\tau-1}\text{Var}\left(\varepsilon_{ft}\right)}_{\text{DIRECT}_\tau} + \underbrace{\sum_{g\neq f}^{N}\sum_{f\neq g}^{N} w_{g,\tau-1}w_{f,\tau-1}\text{Cov}\left(\varepsilon_{gt}, \varepsilon_{ft}\right)}_{\text{LINK}_\tau} \tag{5}$$

Di Giovanni, Levchenko, and Mejean (2014) used French firm-level data and found that (1) the component of firm-specific fluctuation ($\sigma^2_{F\tau}$) plays a significant role to explain the movements of aggregate fluctuations ($\sigma^2_{F\tau}$) and (2) the LINK component explains more than 90% of firm-specific fluctuations, indicating that firm-to-firm linkages or interactions have a significant impact on aggregate fluctuations.

In this paper, we take more steps forward from Di Giovanni, Levchenko, and Mejean (2014). The effect of plant-specific fluctuations is decomposed into two groups: (1) firms located in higher agglomeration areas and (2) firms in lower agglomeration areas. Then we have

$$
\begin{aligned}
\sigma^2_{F\tau} &= \sigma^2_{F,H,\tau} + \sigma^2_{F,L,\tau} + \mathrm{COV}_{F,H,L,\tau} \\
&= \underbrace{\sum_{f\in\mathcal{H}} w^2_{f,\tau-1}\mathrm{Var}\left(\varepsilon_{ft}\right)}_{\mathrm{DIRECT}_{H,\tau}} + \underbrace{\sum_{g\neq f,(f,g)\in\mathcal{H}}\ \sum^{N}_{f\neq g,(f,g)\in\mathcal{H}} w_{g,\tau-1}w_{f,\tau-1}\mathrm{Cov}\left(\varepsilon_{gt},\varepsilon_{ft}\right)}_{\mathrm{LINK}_{H,\tau}} \\
&+ \underbrace{\sum_{f\in\mathcal{L}} w^2_{f,\tau-1}\mathrm{Var}\left(\varepsilon_{ft}\right)}_{\mathrm{DIRECT}_{L,\tau}} + \underbrace{\sum_{g\neq f,(f,g)\in\mathcal{L}}\ \sum^{N}_{f\neq g,(f,g)\in\mathcal{L}} w_{g,\tau-1}w_{f,\tau-1}\mathrm{Cov}\left(\varepsilon_{gt},\varepsilon_{ft}\right)}_{\mathrm{LINK}_{L,\tau}} \\
&+ \underbrace{\sum_{g\neq f,(f,g)\in\mathcal{H}}\ \sum_{f\neq g,(f,g)\in\mathcal{L}} w_{g,\tau-1}w_{f,\tau-1}\mathrm{Cov}\left(\varepsilon_{gt},\varepsilon_{ft}\right)}_{\mathrm{COV}_{F,H,L,\tau}}
\end{aligned}
\tag{6}
$$

where $\mathcal{H}$ and $\mathcal{L}$ denote the sets of firms located in higher and lower agglomeration areas, respectively. The terms $\mathrm{DIRECT}_{H,\tau}$ and $\mathrm{LINK}_{H,\tau}$ represent the variance and covariance of firms located in higher agglomeration areas, and $\mathrm{DIRECT}_{L,\tau}$ and $\mathrm{LINK}_{L,\tau}$ represent the variance and covariance of firms located in lower agglomeration areas. $\mathrm{COV}_{F,H,L,\tau}$ denotes the covariance between firms in higher and lower agglomeration areas. Using this decomposition, we investigate which components are more important to explain aggregate fluctuations and whether fluctuations of firms located in agglomeration areas contribute to increasing aggregate fluctuations.

3 Data description

This study uses two balanced panel data sets of Indonesian manufacturing plants: the panel data from 2000 to 2014, and those from 2006 to 2014. The plant-level data are obtained from the annual survey of medium and large manufacturing establishments (IBS) conducted by Statistics Indonesia (Badan Pusat Statistik: BPS). The 2000–2014 panel data used in this study is constructed by plants existing in 1996 because the 1996 IBS survey includes information of administrative community-level locations, which is the lowest administrative unit.[1] The 2000 IBS survey, however, does not have the community-level location information. This location information is crucial for our study to measure the degree of spatial concentration of economic activities. In addition, although we have the plant-level data from 1996 to 1999, we do not use it for the main empirical analysis because we cannot confirm the consistency between the sum of plant-level value-added (at 2000 price) and the official statistics of Indonesian GDP from 1996 to 1999. More specifically, the official GDP data is more volatile and captures the sharp decline of the value-added due to the Asian financial crisis, while the sum of plant-level value-added does not show such decline during the period 1996–1999. After 2000, the time series behavior of the sum of plant-level data is consistent with the macroeconomic index. Hence, we employ the 2000-2014 plant-level panel data, based on plants existing in 1996. On the other hand, the

[1]Indonesia's administrative divisions are classified as follows: province (*provinsi*), regency/city (*kabupaten/kota*), district (*kecamatan*), and community (*desa/kelurahan*).

2006-2014 panel data is constructed by plants in 2006. As in the 1996 survey, the 2006 IBS survey also includes the community-level location information, which is required to calculate the degree of agglomeration faced by each plant.[2]

The manufacturing plants are classified into two groups based on their locations: plants located in higher agglomeration and those in lower agglomeration areas. The degree of agglomeration for each community (agg_l) is measured as follows.

$$agg_l = \frac{1}{2}\left[\sum_{m}^{M} \frac{Labor_{m,1996}}{d_{lm}^2} + \sum_{m}^{M} \frac{Labor_{m,2006}}{d_{lm}^2}\right] \tag{7}$$

where d_{lm} is the great circle distance between communities l and m, $d_{lm} = 1$ if $l = m$, $Labor_{m,1996}$ and $Labor_{m,2006}$ denote the total number of workers in community m which are calculated using the manufacturing plant-level data (IBS) for 1996 and 2006, respectively. The distance between communities is computed using the community-level map information of the 2012 *Peta Digital* database in the *shapefile* format. The map data are merged with the 2000 and 2006 plant-level data by using information about community-level administrative codes and the historical transition of administrative communities from 1996 to 2013. The quintile of agg_l is used for the threshold to classify higher and lower agglomeration groups.

The quintile dummy of agg_l is also used in a variable in plant characteristics $\mathbf{Z}_{ft}$. Other plant characteristics used in $\mathbf{Z}_{ft}$ are firm size and the degree of access to international trade. The firm size is a dummy variable which is equal to 1 if its plant's gross output is greater than the quintile of gross outputs. The degree of access to international trade is a dummy variable equal to 1 if plant f engages in exporting products to foreign market and/or importing materials from foreign countries.

[– Table 1 –]

Table 1 presents the summary statistics of the sample used. After dropping outliers,[3] we have 8,168 and 15,428 plants for the 2000 and 2006 balanced panel data, respectively. As shown in Table 1, the average of value-added per worker in the agglomeration area is much greater than those in the non-agglomeration area, implying the existence of positive agglomeration externalities.

[– Table 2 –]

Table 2 reports the number of sample plants across higher and lower agglomeration areas. This shows that large, exporting, and/or importing plants are likely to locate in higher agglomeration areas. Furthermore, Tables 3 and 4 present the number of sample plants by province for the 2000 and 2006 panels. Plants in higher agglomeration areas spatially concentrated on the

[2] Since both 1996 and 2006 are Indonesian economic census years, these IBS databases contain more information about plants than those for the other years.

[3] We have removed the following types of plants: 1) plants with non-positive value of wages, number of workers, value added, or output values; and 2) plants whose annual growth rate of either gross output, value added or the number of workers is more than 100 times or less than 0.01 .

island of Java, while plants in lower agglomeration areas are more uniformly distributed across provinces.

[– Table 3 –]

[– Table 4 –]

4 Empirical results

Figure 1 presents the estimates of aggregate fluctuations ($\sigma^2_{A\tau}$), plant-specific ($\tilde{\sigma}^2_{F\tau}$), and sectoral fluctuations ($\sigma^2_{I\tau}$) from $\tau = 2000$ to $\tau = 2013$, based on Model 2 and the 2000 panel data.[4] Table 5 reports the averages of these estimates over time and these ratios. As shown in Figure 1 and Table 5, the aggregate fluctuations are mainly driven by firm-specific fluctuations. On average, the firm-specific component contributes more than 80% to the aggregate fluctuations. This finding is consistent with the result of Di Giovanni, Levchenko, and Mejean (2014), which used French firm-level data and found that the contribution of firm-specific component is 86% in the manufacturing sector (see Di Giovanni, Levchenko, and Mejean, 2014, 1324, Table VI, panel D).

[– Figure 1 –]

[– Table 5 –]

Figure 2 and the column (1) of Tables 6 and Tables 7 present the decomposition of the plant-specific component into the variance of individual shocks (DIRECT) and the covariance of shocks among firms (LINK). The results demonstrate that the LINK is greater than the DIRECT component for both Models 1 and 2, and both the 2000 and 2006 panel data sets, indicating that firm-to-firm linkages have an important role to explain the magnitude of firm-specific shock. This finding is also consistent with Di Giovanni, Levchenko, and Mejean (2014) that the LINK component explains more than 90% of total firm-specific volatility in France.

[– Figure 2 –]

[– Tables 6 and 7 –]

Columns (2) to (4) in Tables 6 and 7 present the contribution of plants located in higher and lower agglomeration areas, respectively. In the case of Model 1, shown in Table 6, plant-specific components for higher agglomeration area are 0.437 for the 2000 panel, 1.3392 for the 2006 panel (Model 1), while those for lower agglomeration area are 0.095 and 0.150, respectively. The ratios of higher agglomeration component to plant-specific fluctuations are 0.545 for the 2000 panel and 0.626 for the 2006 panel. Plants in higher agglomeration area have an important

[4] We do not present the plot of Model 1 because the result of Model 1 is similar to those of Model 2.

role in explaining the movement of total plant-specific fluctuations. These results are the same as Model 2.

Comparing the DIRECT and LINK effects, the relatively large difference between higher and lower agglomeration areas lies in the LINK effect, implying that plants in a higher agglomeration area tend to have a stronger interaction of value-added fluctuations across plants. To test whether the differences in contributions between plants in higher and lower agglomeration areas are statistically significant, we conduct a permutation statistical test as follows.

(i) Randomly produce two groups of plants, labeled $\mathcal{A}$ and $\mathcal{B}$.

(ii) For groups $\mathcal{A}$ and $\mathcal{B}$, calculate the components of Equation (6):

- **(1)** Plant-specific effects: $\sigma^2_{F,\mathcal{A},\tau}$, $\sigma^2_{F,\mathcal{B},\tau}$
- **(2)** Direct effects: $\text{DIRECT}_{\mathcal{A},\tau}$, $\text{DIRECT}_{\mathcal{B},\tau}$
- **(3)** Link effects: $\text{LINK}_{\mathcal{A},\tau}$, $\text{LINK}_{\mathcal{B},\tau}$

(iii) Compute the following ratios:

$$x_F \equiv \frac{1/T\sum_\tau^T \sigma^2_{F,\mathcal{A},\tau}}{1/T\sum_\tau^T \sigma^2_{F,\mathcal{B},\tau}},\ x_D \equiv \frac{1/T\sum_\tau^T \text{DIRECT}_{\mathcal{A},\tau}}{1/T\sum_\tau^T \text{DIRECT}_{\mathcal{B},\tau}},\ x_L \equiv \frac{1/T\sum_\tau^T \text{LINK}_{\mathcal{A},\tau}}{1/T\sum_\tau^T \text{LINK}_{\mathcal{B},\tau}} \tag{8}$$

(iv) Repeat the procedure (i)–(iii) 5001 times and obtain random samples for x_F, x_D and x_L.

(v) Calculate the same ratios using plants in higher ($\mathcal{H}$) and lower ($\mathcal{L}$) agglomeration areas:

$$x^*_F \equiv \frac{1/T\sum_\tau^T \sigma^2_{F,\mathcal{H},\tau}}{1/T\sum_\tau^T \sigma^2_{F,\mathcal{L},\tau}},\ x^*_D \equiv \frac{1/T\sum_\tau^T \text{DIRECT}_{\mathcal{H},\tau}}{1/T\sum_\tau^T \text{DIRECT}_{\mathcal{L},\tau}},\ x^*_L \equiv \frac{1/T\sum_\tau^T \text{LINK}_{\mathcal{H},\tau}}{1/T\sum_\tau^T \text{LINK}_{\mathcal{L},\tau}} \tag{9}$$

Using empirical distributions of random samples x_F, x_D and x_L, we can calculate the probability (i.e., p-value) of $x_F > x^*_F$, $x_D > x^*_D$, and $x_L > x^*_L$, respectively. Figures 3 and 4 demonstrate these empirical distributions for the 2000 and 2006 panel data sets. The dashed lines indicate test statistics (x^*_F, x^*_D, and x^*_L). Table 8 reports these test statistics and the (upper-side) p values. It is found that the DIRECT cannot reject the random hypothesis at 1% significance level, while the LINK can reject it at 1% significance level. Therefore, plant-specific fluctuations in higher agglomeration areas are much greater than those in lower agglomeration areas, and this difference is attributable mainly to the significant difference in the LINK effects.

It is possible that the variance ratios in Table 8 are driven not by the difference in agglomeration, but rather by the difference in plant characteristics such as access to international markets or plant size. To control for the effect of plant characteristics, we separate sample plants with the degree of access to international markets and of plants size, and conduct the permutation tests described above for each sub-sample. Table 9 shows the results of the permutation tests controlling for plant characteristics, using the panel data from 2000 to 2014 and from 2006 to 2014. The p values of the LINK effects for international plants (Column 1) and large plants (Column 3) are smaller than 1% or 5% significant levels and can reject the null hypothesis. On the other hand, the p values for non-international plants (Column 2) and small plants (Column

4) cannot reject the null. These results indicate that, for samples of international plants or large plants, the LINK effects in higher agglomeration areas are significantly greater than those in lower agglomeration areas; however, such differences in the LINK effects disappear for samples of domestic or smaller plants. It seems natural to conclude that agglomeration tends to intensify the amplification effect of micro-shocks through the interaction among international plants or large plants.

[– Table 8 –]

[– Figures 3 and 4 –]

[– Table 9 –]

5 Concluding remarks

Recent findings in macroeconomics have been that firm-specific micro shocks can be amplified and propagated throughout the economy to cause sizable aggregate fluctuations and that the linkages or interactions among firms play a significant role in explaining the movements of aggregate fluctuations. Based on this argument, agglomeration of economic activities may intensify the amplification effect of micro-shocks because agglomeration can increase interaction among firms. However, as Overman and Puga (2010) point out, large agglomeration has an effect of ironing out a firm-specific shock.

In this paper, we investigate the role of firms in agglomeration area to drive aggregate fluctuations. While Di Giovanni, Levchenko, and Mejean (2014) developed the decomposition method of aggregate fluctuations into sectoral and firm-specific components, we take steps forward from their approach and develop an approach to further decompose the firm-specific component into higher and lower agglomeration groups. Using Indonesian manufacturing plant-level panel data, we examine how plant-specific fluctuations in higher and lower agglomeration areas affect aggregate fluctuations.

Our main findings are as follows. First, the aggregate fluctuations are mainly driven by firm-specific fluctuations. On average, the firm-specific component contributes more than 80% to the aggregate fluctuations. Second, we further decompose the plant-specific component into the variance of individual shocks and the covariance of shocks among plants and, as a result, the covariance is much greater than the variance of individual shocks, indicating that firm-to-firm linkages have an important role to explain the magnitude of firm-specific shock. These two findings are consistent with the empirical results of Di Giovanni, Levchenko, and Mejean (2014). Finally, plant-specific fluctuations in higher agglomeration areas are much greater than those in lower agglomeration areas, and this difference is attributable mainly to the significant difference in the covariance across plants (the LINK effects). The interaction or co-movements of firms located in higher agglomerations areas have a significant role to drive aggregate fluctuations. Furtermore, for samples of international plants or large plants, the LINK effects in higher agglomeration areas are significantly greater than those in lower agglomeration areas;

however, such differences in the LINK effects disappear for samples of domestic or smaller plants. Therefore, firm agglomeration tends to intensiy the firm-specific fluctuations through the interaction among international or large plants.

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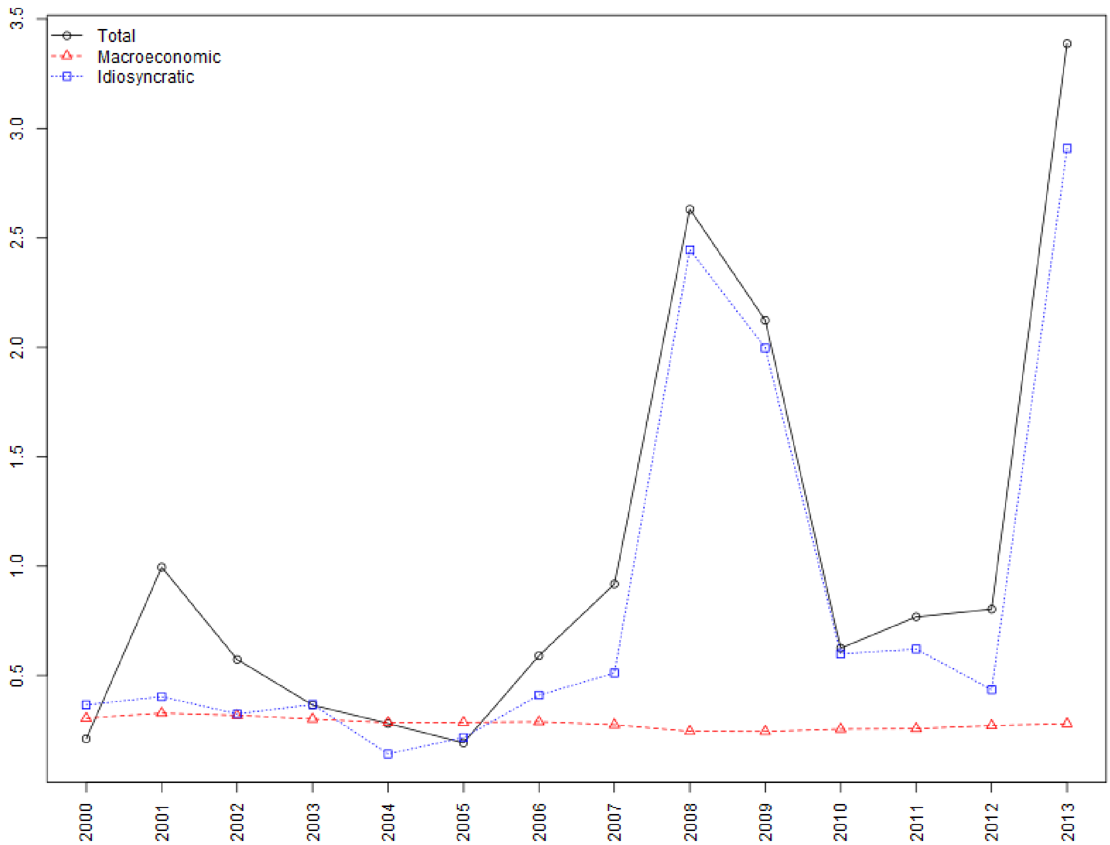

Figure 1: Volatility of Value-added Growth and its Components

Notes: These plots present the aggregate fluctuations (Total), plant-specific shock (Idiosyncratic), and sectoral shock (Macroeconomic), from $\tau = 2000$ to $\tau = 2013$. This result is based on Model 2 and the 2000 balanced panel data.

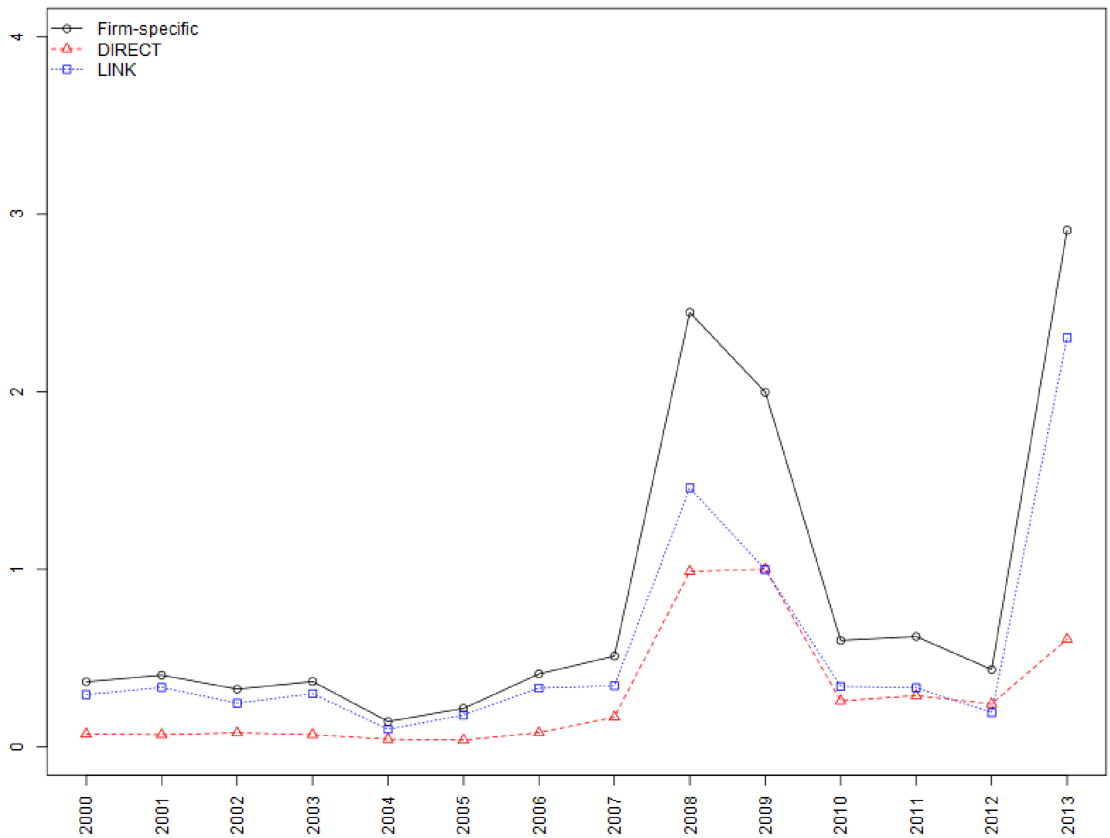

Figure 2: Contribution of individual variance (DIRECT) and covariance (LINK) terms to firm-specific volatility

Notes: This result is based on Model 2 and the 2000 balanced panel data.

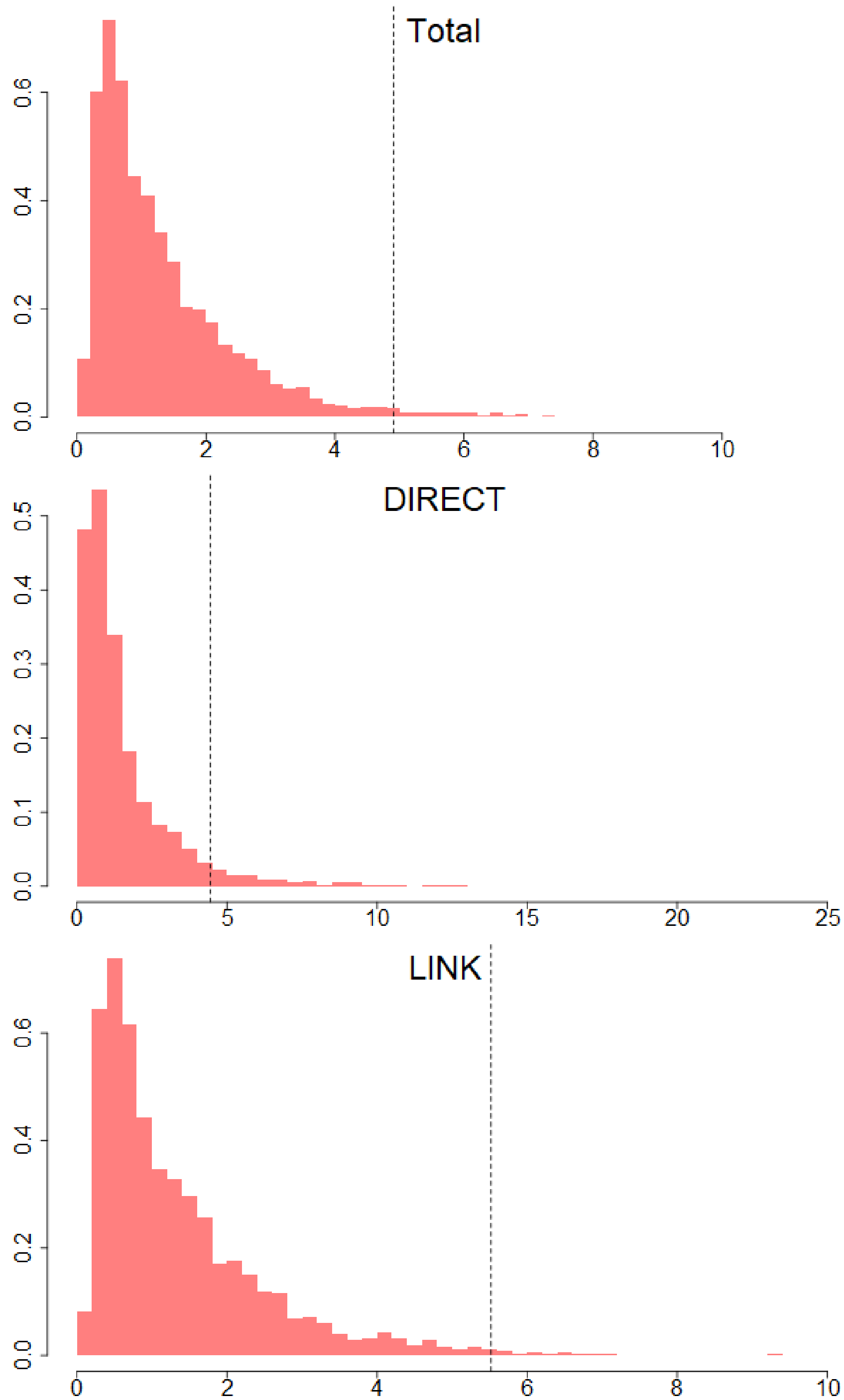

Figure 3: Empirical distribution of permutation test for variance ratios: Balanced panel data from 2000 to 2014

Notes: These figures are based on Model 2, using the balanced panel data from 2000 to 2014. The dashed line indicates a test statistic.

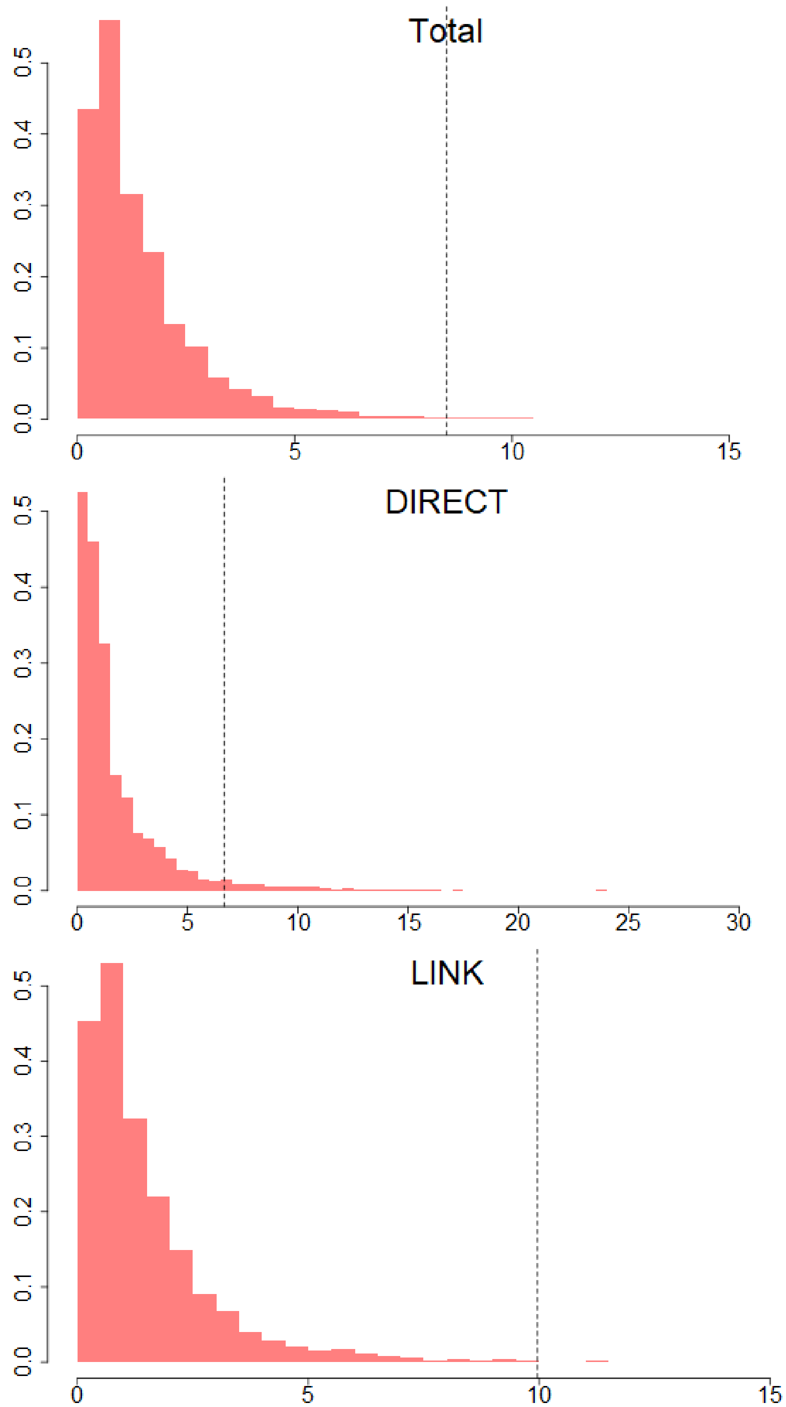

Figure 4: Empirical distribution of permutation test for variance ratios: Balanced panel data from 2006 to 2014

Notes: These figures are based on Model 2, using the balanced panel data from 2006 to 2014. The dashed line indicates a test statistic.

Table 1: Summary statistics

2000 Balanced panel data	Value-added[1)]	Average Number of workers	Value-added per worker
All plants	24,508,580	296	55,429
Export/Import	52,981,401	533	90,710
Non-Export/Import	7,083,236	151	33,8376
Small	499,076	55	11,004
Large	48,518,084	537	99,854
Higher agglomeration area	35,255,296	386	70,127
Lower agglomeration area	13,767,126	207	40,738
Number of firms: 8,168			
Number of years: 15			
2006 Balanced panel data			
All plants	19,697,295	220	58,728
Export/Import	52,107,210	470	110,181
Non-Export/Import	7,542,132	127	39,431
Small	385,017	42	10,710
Large	39,009,573	399	106,747
Higher agglomeration area	29,461,084	305	75,699
Lower agglomeration area	9,933,506	136	41,758
Number of firms: 15,428			
Number of years: 9			

[1)] Constant price at 2000. The unit is 1000 rupiah.

Table 2: Number of sample plants

2000 Balanced panel data	Lower agglomeration	Higher agglomeration
Non-Export/Import plants	2966	2101
Export/Import plants	1119	1982
Small plants	2710	1828
Large plants	1375	2255
2006 Balanced panel data		
Non-Export/Import plants	6443	4777
Export/Import plants	1271	2937
Small plants	4882	2775
Large plants	2832	4939

Note: The quintile dummy of the agglomeration variable agg_l is used to classify plants into agglomeration and non-agglomeration. Export/import plants are defined as plants that engage in exporting products to foreign markets and/or importing materials from foreign countries. Large and small plants are classified based on the quintile of gross output.

Table 3: Number of firms by province: 2000 balanced panel data

Province	Lower agglomeration	Higher agglomeration
Aceh	10	0
Sumatera Utara	395	68
Sumatera Barat	5	0
Riau	25	1
Jambi	20	0
Sumatera Selatan	66	0
Bengkulu	5	0
Lampung	89	2
Jakarta	22	648
Jawa Barat	991	2043
Jawa Tengah	819	327
Yogyakarta	127	0
Jawa Timur	1174	979
Bali	82	0
Nusa Tenggara Barat	26	0
Nusa Tenggara Timur	2	0
Kalimantan Barat	26	0
Kalimantan Tengah	4	0
Kalimantan Selatan	32	6
Kalimantan Timur	47	6
Sulawesi Utara	26	0
Sulawesi Tengah	4	0
Sulawesi Selatan	80	0
Sulawesi Tenggara	3	0
Maluku Utara	5	3

Table 4: Number of firms by province: 2006 balanced panel data

Province	Lower agglomeration	Higher agglomeration
Aceh	25	0
Sumatera Utara	583	161
Sumatera Barat	15	0
Riau	133	1
Jambi	40	0
Sumatera Selatan	84	2
Bengkulu	10	0
Lampung	159	3
Bangka Belitung	29	0
Kepulauan Riau	35	186
Jakarta	4	943
Jawa Barat	1559	2549
Jawa Tengah	1513	913
Yogyakarta	246	16
Jawa Timur	2426	1848
Banten	112	1047
Bali	186	0
Nusa Tenggara Barat	95	0
Nusa Tenggara Timur	11	0
Kalimantan Barat	47	1
Kalimantan Tengah	22	0
Kalimantan Selatan	49	9
Kalimantan Timur	72	10
Sulawesi Utara	36	4
Sulawesi Tengah	14	0
Sulawesi Selatan	143	17
Sulawesi Tenggara	23	0
Gorontalo	12	0
Sulawesi Barat	7	0
Maluku	9	1
Maluku Utara	1	0
Papua Barat	7	3
Papua	7	0

Table 5: The aggregate impact of plant-specific shocks on aggregate volatility

Balanced panel data from 2000 to 2014

	Model 1		Model 2	
	Variance	Relative	Variance	Relative
Aggregate volatility	1.0331	1.0000	1.0331	1.0000
Plant-specific shock	0.8682	0.8404	0.8392	0.8124
Macroeconomic shock	0.1473	0.1426	0.2812	0.2722

Balanced panel data from 2006 to 2014

	Model 1		Model 2	
	Variance	Relative	Variance	Relative
Aggregate volatility	2.1980	1.0000	2.1980	1.0000
Plant-specific shock	2.1385	0.9729	2.0552	0.9350
Macroeconomic shock	0.0940	0.0428	0.1281	0.0583

Note: This table shows the averages of aggregate volatility ($\sigma^2_{A\tau}$), plant-specific shock ($\sigma^2_{F\tau}$), and macroeconomic shock ($\sigma^2_{I\tau}$).

Table 6: Channels for plants' contribution to aggregate volatility: Model 1

Balanced Panel Data from 2000 to 2014

	All plants (1)	Higher Agg. (2)	Lower Agg. (3)	Cov High & Low Agg. (4)
Plant-specific	0.8682	0.4561	0.0992	0.3129
DIRECT	0.2770	0.2234	0.0536	0.0000
LINK	0.5912	0.2327	0.0456	0.3129
			Ratios	
Plant-specific	1.0000	0.5253	0.1143	0.3604
DIRECT	1.0000	0.8065	0.1935	0.0000
LINK	1.0000	0.3936	0.0771	0.5293

Balanced panel data from 2006 to 2014

	All plants (1)	Higher Agg. (2)	Lower Agg. (3)	Cov High & Low Agg. (4)
Plant-specific	2.1385	1.3392	0.1504	0.6488
DIRECT	0.4983	0.4312	0.0672	0.0000
LINK	1.6401	0.9080	0.0832	0.6488
			Ratios	
Plant-specific	1.0000	0.6263	0.0703	0.3034
DIRECT	1.0000	0.8652	0.1348	0.0000
LINK	1.0000	0.5536	0.0508	0.3956

Note: This table shows the averages of plant-specific shock ($\sigma^2_{F\tau}$), the variance of individual shocks (DIRECT), and the covariance of shocks across firms (LINK), based on Model 1. Columns (2) and (3) report plants in higher and lower agglomeration areas, respectively. Column (4) is the covariance between higher and lower agglomeration groups.

Table 7: Channels for plants' contribution to aggregate volatility: Model 2

Balanced panel data from 2000 to 2014

	All plants (1)	Higher Agg. (2)	Lower Agg. (3)	Cov High & Low Agg. (4)
Plant-specific	0.8392	0.4495	0.0916	0.2981
DIRECT	0.2856	0.2332	0.0524	0.0000
LINK	0.5536	0.2163	0.0392	0.2981
			Ratios	
Plant-specific	1.0000	0.5356	0.1092	0.3552
DIRECT	1.0000	0.8165	0.1835	0.0000
LINK	1.0000	0.3907	0.0708	0.5385

Balanced panel data from 2006 to 2014

	All plants (1)	Higher Agg. (2)	Lower Agg. (3)	Cov High & Low Agg. (4)
Plant-specific	2.0552	1.2780	0.1504	0.6268
DIRECT	0.5082	0.4417	0.0665	0.0000
LINK	1.5470	0.8363	0.0839	0.6268
			Ratios	
Plant-specific	1.0000	0.6218	0.0732	0.3050
DIRECT	1.0000	0.8692	0.1308	0.0000
LINK	1.0000	0.5406	0.0543	0.4052

Note: This table shows the averages of plant-specific shock ($\sigma^2_{F\tau}$), the variance of individual shocks (DIRECT), and the covariance of shocks across firms (LINK), based on Model 1. Columns (2) and (3) report plants in higher and lower agglomeration areas, respectively. Column (4) is the covariance between higher and lower agglomeration groups.

Table 8: Results of permutation tests for equality of variances between higher and lower agglomeration areas

Balanced panel data from 2000 to 2014

	Model 1		Model 2	
	Variance ratio	*p* value	Variance ratio	*p* value
Plant-specific	4.5980	0.0240	4.9071	0.0200
DIRECT	4.1675	0.0618	4.4498	0.0534
LINK	5.1040	0.0110	5.5186	0.0096

Balanced panel data from 2006 to 2014

	Model 1		Model 2	
	Variance ratio	*p* value	Variance ratio	*p* value
Plant-specific	8.9044	0.0020	8.4977	0.0068
DIRECT	6.4205	0.0270	6.6471	0.0426
LINK	10.9083	0.0000	9.9627	0.0020

Note: These variance ratios present the ratios of variances of plants in higher and lower agglomeration areas (x_F^*, x_D^*, and x_L^*). The p values are calculated using the permutation sampling distribution under the hypothesis of equality of variances between agglomeration and non-agglomeration areas.

Table 9: Comparing P values of the permutation tests by plant characteristics

Balanced panel data from 2000 to 2014

	Access to international markets		Plant size	
	Export/Import plants (1)	Non-Export/Import plants (2)	Large plants (3)	Small plants (4)
Plant-specific	0.0510	0.2959	0.0258	0.6099
DIRECT	0.1262	0.2517	0.0616	0.7952
LINK	0.0016	0.3237	0.0136	0.2605
Number of plants	3101	5067	3630	4538

Balanced panel data from 2006 to 2014

	Access to international markets		Plant size	
	Export/Import plants (1)	Non-Export/Import plants (2)	Large plants (3)	Small plants (4)
Plant-specific	0.0206	0.2286	0.0062	0.6213
DIRECT	0.0952	0.1102	0.0498	0.5915
LINK	0.0002	0.2603	0.0004	0.6425
Number of plants	4208	11220	7771	7657

Note: This table is based on Model 2. The p values are separately calculated by sub samples (export/import plants, non-export/import plants, large and small plants), by using the permutation sampling distribution under the hypothesis of equality of variances between higher agglomeration and lower agglomeration areas.

Table A1: Number of firms by sector: 2000 balanced panel data

Industrial sector	Lower agglomeration	Higher agglomeration
15 Food and drink	1370	507
16 Tobacco	156	52
17 Textiles	241	579
18 Clothes so	343	345
19 Leather and leather goods	59	154
20 Wood, articles of wood, and wicker	204	131
21 Paper and paper products	64	145
22 Publishing, printing and reproduction	74	116
23 Coal, oil and natural gas, and nuclear fuel	11	10
24 Chemical and goods from chemicals	190	365
25 Rubber and plastic goods	301	448
26 non metallic mineral goods	474	143
27 Base metals	29	98
28 Goods of metal and crockery	111	263
29 Machines and equipment	41	114
31 other electric machines and equipment	22	117
32 Radio, television and communication equipment	10	48
33 medical devices, measuring instruments, navigation, optical and hour	7	23
34 Motor vehicles	36	94
35 other transport equipment	46	72
36 Furniture and other processing industries	286	244
37 Recycling	10	13

Table A2: Number of firms by sector: 2006 balanced panel data

Industrial sector	Lower agglomeration	Higher Agglomeration
10 Food	2565	904
11 Drinks	135	73
12 Tobacco Processing	352	126
13 Textiles	628	973
14 Garment	575	832
15 Leather, leather goods and Footwear	157	306
16 Wood, Cork (Excluding Furniture) and woven from bamboo, rattan parr	392	257
17 Paper and Articles of Paper	101	243
18 Printing and Reproduction of Recorded Media	101	244
19 Products of Coal and Petroleum Refinery	26	16
20 Chemicals and Manufactures of Chemicals	177	426
21 Pharmaceutical, Chemical Medicinal Products and Traditional Medicine	53	134
22 Rubber, Articles of Rubber and Plastics	393	806
23 Item Non Metallic Minerals	832	317
24 Base Metals	47	135
25 Metal Goods, Not Machines and Fittings	166	493
26 Computers, Consumer Electronics and Optics	23	188
27 Electrical Equipment	26	208
28 Machines and Supplies ytdl	56	164
29 Motor Vehicles, Trailers and Semi-Trailers	56	170
30 Other Transport Equipment	38	123
31 Furniture	545	359
32 Other Processing	240	185
33 Repair and Installation of Machinery and Equipment	30	32