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Does the crisis change the nature of agglomeration economies in Indonesia? A productivity analysis of pre-post 1997-1998 financial crisis

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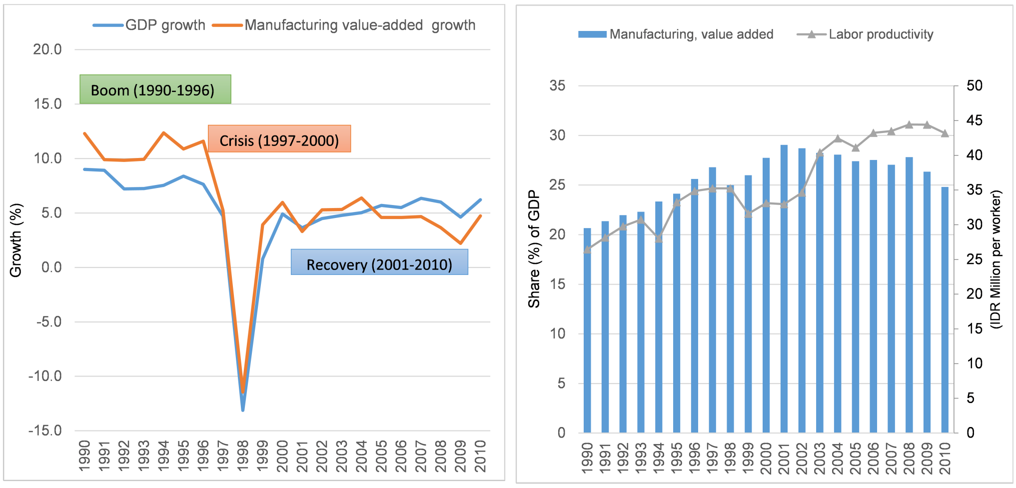
Abstract. By examining their source and magnitude, this paper looked at the changes in the nature of Indonesia's agglomeration economies over two distinct successive periods: the pre-crisis (1990–1998) and the post-crisis (1999-2010). We found that economies of localisation and urbanisation are both present in the post-crisis period, with the former generating a more substantial effect than the latter, though there has been a growing role of urbanisation in recent years. There is relatively strong evidence of plant size and sectoral heterogeneity with respect to types of agglomeration externalities. These factors shed some light on the nature of agglomeration economies and how the agglomeration sources after the crisis period have been visibly in favour of localisation economies. It confirms that the plants have been improved to benefit from the external environment given the policy in place. The results also demonstrate the firm and sectoral life cycle at work, as evidenced by the changing industry structure during the post-crisis period.

JEL classification: R11, R12, R30, L25, L60

Key words: Industry, agglomeration economies, economic cycles, financial crisis, Indonesia

1 Introduction

Since industrialisation began its heyday in Indonesia's economy in the mid-1960s, the manufacturing industry has now become one of its leading sectors. In the boom years of the early 1990s, the sector's role in the growth and vitality of the economy was especially remarkable. Nevertheless, this trend was overturned by the financial crisis of 1997–1998 as the industry saw decreased growth despite the introduction of certain deregulations, for example, in foreign ownership and tariff reduction, to stimulate investment in the sector (Aswicahyono et al. 2010). Eventually, Indonesia's manufacturing-driven economic growth was effectively paralysed (Poczter et al. 2013). Nevertheless, the sector is still a dominant force in the economy and contributes an average of 27.5% of gross domestic product (GDP) despite only registering about 4% growth performance from 2001 to 2010, compared to 10% from 1990 to 1996. Also interesting is the fact that the slower growth of the manufacturing sector is not linked to the increase in labour productivity, which



Source: Annual survey of large and medium firms 1990-2010, BPS and World Bank Development (WDI) data, author's calculation.

Figure 1: Indonesia's Economic and Manufacturing Sector Growth: The Manufacturing Sector's Contribution and Its Productivity

suggests that external factors like higher wage rates in agglomerated regions might have affected productivity (see Figure 1).

This paper is an attempt to investigate how external economies of scale, or agglomeration economies, affect productivity throughout the economic cycle, which in this case is represented by the period before, during, and after the Asian financial crisis of 1997–1998. Therefore, it is also an attempt to close the academic gap by studying the effects of external agglomeration economies – i.e., localisation and urbanisation economies – on productivity over the pre-crisis and post-crisis recovery periods. According to the literature, localisation economies capture the economic activities of similar firm clusters or industry concentration (Rosenthal, Strange 2004), where firms gain benefits from input sharing, spatial concentration, intra-industry knowledge sharing, labour pooling, and innovative competition (Gill, Goh 2010). Meanwhile, urbanisation economies focus on the diversity of a region's industrial structure (Rosenthal, Strange 2004), in which firms are more productive in a diversified region and enjoy the variation of business services, inter-industry exchange of ideas, enlarged market size, and more innovations (Gill, Goh 2010).

Even though a great deal of literature has explained the connection between productivity and agglomeration economies, there is arguably no study that compares the sources and magnitude of agglomeration economies along the financial crisis periods. De Groot et al. (2016) argued that using micro-panel data can enhance our understanding of how agglomeration externalities have played a key role in impacting productivity and find systemic variations among the element of agglomeration. Few authors, including Martin et al. (2011) and Henderson (2003), have utilised micro-panel data to examine the properties and sources of agglomeration economies. Nevertheless, none of them discussed how changing economic circumstances might have influenced the sources of agglomeration economies, especially surrounding the 1997-1998 financial crisis. The effect of the crisis on the nature of agglomeration economies might have been overlooked since these studies have either only utilised data collected over a short period or demonstrated little knowledge of the crisis. Conversely, several studies (for instance, Aswicahyono et al. 2010, Narjoko, Hill 2007, Poczter et al. 2013) have chosen to examine the financial crisis' effect on firm productivity, but their approaches were preoccupied with the effects related to firm's internal economies of scale, such as export performance, labour cost, and ownership.

Notwithstanding a few previous studies that have investigated similar issues (Henderson 2003, Martin et al. 2011, Day, Ellis 2013, Graham 2009, Kuncoro 2009), the novelty of this paper is that it examines the effects of localisation and urbanisation and how they differ across plants of different sizes, industries, and periods. The linking of the issue of agglomeration economies and productivity to external shocks and the cyclical behaviour of the economy is worthy of examination. Nonetheless there is available literature that has raised the issue in a rigorous style, such as explaining that growth and productivity might be linked to various types of structural or more short-term cycles. However, there is nothing obviously evident regarding the direction in which causality might run and whether the connection between agglomeration economies and productivity with external shocks result in the form of positive or negative externalities. This paper provides new empirical evidence about the impact of agglomeration economies on plant-level productivity by accounting for distinct economic stages; in doing so this paper aims to broaden the empirical literature on agglomeration economies studies.

In this introduction, we have presented a brief overview of the importance and novelty of this study. In Section 2 that follows, we survey the existing body of literature surveys on related subjects. The empirical modelling of this study is discussed in Section 3, while Section 4 reports the data and variable construction, and Section 5 discusses the analysis and results. We offer our conclusion for this study in Section 6.

2 Related Literature

The academic discussion over whether scale externalities are related to localisation or urbanisation economies have led to the question of the validity of the sources of agglomeration economies. Many authors have pointed to extensive literature which attempts to address the question by providing empirical evidence and guidelines on formulating better estimations and identifications (Beaudry, Schiffauerov 2009, Rosenthal, Strange 2004). Rosenthal, Strange (2004) stressed the importance of temporal, industrial, and geographic scopes in examining the sources and nature of agglomeration economies. Gill, Goh (2010) laid out the differences between urbanisation and localisation economies while highlighting the inter- or intra-industry exchange of ideas and technology to attain productivity growth. Moreover, Beaudry, Schiffauerov (2009) discovered the methodologies and measurements to determine the supported types of externalities. The debate has also been the subject of other studies which focus on empirical estimation. The seminal paper by Glaeser et al. (1992) inspired many empirical works attempting to explain the relationship between local industrial structure – namely, specialisation, competition, and diversity – and growth patterns in cities. Glaeser et al. (1992) explained how urban areas and local economies develop over time through the contributions of three types of externalities: intra-industry knowledge spillover, inter-industry knowledge spillover, and local competition.

According to Gill, Goh (2010), firms and workers within a particular industry located near each other can enjoy knowledge spillover from similar or different technologies, access a pooled market of labour and employment skill, and benefit from intermediate input sharing, all of which enhances firm productivity. In a dynamic context, Marshal, Arrow, and Romer (MAR) externalities explain the existence of external scale economies, or intra-industry knowledge spillover effects (Glaeser et al. 1992). The importance of knowledge as a source of both firm dynamics and local growth calls into debate which type of economic activity facilitates knowledge spillover (De Groot et al. 2016). The spillover of knowledge is believed to improve technological change, subsequently increasing economic growth.

On the other hand, Gill, Goh (2010) defines inter-industry exchanges of ideas and technology among different kinds of industries that could create more variety in business services, enlarge market size on the supply and demand sides, and facilitate more product innovation and firm growth. In a dynamic context, these effects are known as Jacobs externalities (Glaeser et al. 1992). Jacobs' notion of externalities is believed to have an impact on employment growth when the diversity is positively related and specialisation is negatively related to growth (Glaeser et al. 1992, Frenken et al. 2007). Finally, the third type of externality known as Porter externalities stems from the recognition that local competition also plays a role in firms' development. Local competition is a main source of pressure on firms to create innovative products and adopt new technologies (Glaeser et al. 1992).

Related to this study, by employing plant-level data, several empirical studies have produced the evidence suggesting localisation economies as the source of agglomeration economies; but this result might be different across various industries (Graham 2009, Henderson 2003, Martin et al. 2011). Moreover, variation in magnitude and source of agglomeration economies might also be the result of different data aggregation levels and estimation techniques, as argued by Melo et al. (2009) in their meta-study. Henderson (2003), who analysed the firm-level data of high-tech and machinery industries in the United States, argued that agglomeration is the result of localisation economies and found no evidence that pointed toward urbanisation economies. Similarly, Graham (2009) used the findings from the service and manufacturing industries in the United Kingdom to suggest that urbanisation and localisation economies exist. Still, only localisation economies returned significant positive effects on productivity. Martin et al. (2011) in their study supported the above findings by concluding that, while limited evidence of urbanisation economies was found, localisation economies were proven to enhance plant-level productivity in France. As these cases from the developed world have shown, localisation economies have been considered more dominant than urbanisation economies.

The prevalence of localisation economies in the discussion of agglomeration sources in Indonesia is also supported by Kuncoro (2009), who examined four selected industries and concluded that localisation as a form of agglomeration generates stronger benefits than those produced by urbanisation. More recently, Day, Ellis (2013) in their study of Indonesia's agglomeration economies, argued that identified benefit comes from localisation economies contributing to manufacturing growth, rather than from urbanisation. Similarly, we applied the classification of agglomeration effects into urbanisation and localisation economies as utilised in Kuncoro (2009) and Day, Ellis (2013). Nevertheless, this paper differs from the preceding works through its utilisation of a unique, long-panel data set at the plant level which enabled us to observe plant behaviours spanning years and over an economic cycle. As supported by Rosenthal, Strange (2004), using microdata in agglomeration studies improves estimation results reliability, as it positions the econometric model to address the endogeneity concerns. Recently, the survey by De Groot et al. (2016) emphasised the importance of micro-data in conjunction with applying spatial analysis to examine the impact of agglomeration.

3 Data and Variables

This study utilises time-series data from 1990 to 2010, which contains two different economic periods in Indonesia pertaining to the 1997-1998 Asian financial crisis: pre-crisis (1990–1998) and post-crisis (1999–2010). This study uses the Central Bureau of Statistics (BPS)'s unpublished electronic dataset of their annual medium and large firms survey (*Statistik Industri*). The publication surveyed companies with 20 or more employees, including new industrial companies with newly established commercial production. In this study, an establishment or a plant represents each individual unit of observation since the information did not differentiate a firm with many establishments from a standalone establishment. We used the terms 'firm' and 'establishment' interchangeably in the analysis, but the latter should be considered the primary concept. It includes data for 459,677 plants in the period 1990–2010. After data cleaning and adjustments, we were able to construct an unbalanced panel of cleaned observations consisting of 441,187 unique observations, representing 95.98% of the original sample (see Appendix for the cleaning process). The cross-tabulation report of entry and exit rates between an observational year and group classes is provided in Table A.2 of the Appendix. The average exit and entry rates were about 9 to 11 %, whereas the small size classes reported the highest rates. The average exit and entry rates were around 12 to 14 %, 6 to 9%, and 4 to 5% for small, medium, and large size classes, respectively.

In the *Statistik Industri*, each plant is identified using either a Plant Identity Code (PSID) or *Nomor Kode Induk Perusahaan* (NKIP) across different periods of the survey publication. To bridge the different coding, we developed a concordance table with data series for some years that are available in both codes. Moreover, we also classified a plant according to the Indonesian Field Business Classification (KLUI), which is published by

BPS following the International Standard Industrial Classification (ISIC). Multiple ISIC versions are present in the dataset. Data from 1990 until 1997 are classified based on ISIC Revision 2. Meanwhile, ISIC Revision 3 (ISICrev3) is used for 1998–2009. The 2010 data has followed the United Nation's standards of the updated ISIC Revision 4 (ISICrev4). We were able to construct a complete time series dataset for the whole data periods using the BPS-provided bridge table of the five-digit ISIC.

We expressed all values in a given year in constant 2000 prices and we used wholesale price indices (WPIs) which are published monthly in BPS's bulletin, Statistik Bulanan Indikator Ekonomi. The data were collected from the CEIC database and the Statistik Indonesia annual publication. Using the manufacturing WPI in five-digit ISIC, output, value-added, intermediate input, and materials were deflated. Furthermore, we deflated wage and energy and electricity using a GDP deflator and a weighted price of oil for the industry sector, accordingly.

Perpetual investment method (PIM) was applied to estimate firms' capital stock in Indonesia (Arnold, Javorcik 2009, Jacob, Meister 2005). Investment values of a plant is understood as the sum of land, building, machinery, vehicles, and other types of investment. Building investment was deflated using a residential and non-residential WPI according to Jacob, Meister (2005). Meanwhile, machinery and vehicles were deflated using the imported machinery and imported transport equipment WPI. Using the construction WPI, other investments were changed into real values.

Regional district data were utilised to specify natural endowments and regional characteristics. Road-length data were collected from BPS, and data for land-area were retrieved from the Ministry of Home Affairs. We employed the BPS' Village Potential Survey (PODES) to obtain data of share of coastal areas and share of households with electricity. Due to changing number of districts over the years – especially since 2001 reflecting the start of regional autonomy in Indonesia – we maintained the number of districts at 284 (the number in 1990) by reintegrating new districts into their original districts. By this approach, cross-district comparison from 1990 to 2010 was achievable. Since 2001, regional autonomy and fiscal decentralisation have stimulated the splitting of the country into new regions. In 2016 there were 34 provinces and 508 districts and cities in Indonesia.

4 Empirical Estimation

A two-step empirical approach was employed in the agglomeration economies modelling. The first step was running the semiparametric estimation of total-factor productivity (TFP) for each three-digit ISIC, as suggested by Levinsohn, Petrin (2003). The semiparametric estimators were used to control the endogeneity problem when firm- or plant-level data were used. LP methods propose a control function approach using a proxy variable to estimate the production function. This proxy variable should not be correlated at all with the unobserved productivity shock that is represented by a firm's investment decision or capital stock (Van Beveren 2012). We applied the LP method because of inadequate reliable investment data in the manufacturing data from Indonesia. As is common in the data from developing countries, there is a significant number of zero investments reported. Fortunately, that is not the case when using intermediate inputs such as materials, energy, or electricity consumption as a proxy variable for capital stock because such information is available from Indonesian manufacturing data (Vial 2006). To calculate plant-level production function, we ran the 'levpet' command on Stata that was developed by Petrin et al. (2004).

The second step involved running a fixed-effect panel data analysis to investigate how plant-level TFP is influenced by agglomeration economies while controlling for regional and plant characteristics. We referred to the application of an augmented standard production function model for the general framework of the agglomeration economies modelling by Rosenthal, Strange (2004).

$$y_i = g(A_i) f(\boldsymbol{x}_i) \tag{1}$$

and hence

$$TFP_{it} = g(A_{it}) \tag{2}$$

where y_i is the value-added from the plant, $g(A_I)$ indicates the production function shift from external economies, and x_i is a vector of the plant's levels of traditional inputs such as capital and labour. Through this framework, neutrality of productivity or a status of balance between labour and capital is assumed and agglomeration economies through $g(A_i)$ in which $g^{'}(.) \geq 0$ may be estimated. Based on Equation (2), it is now possible to set the econometric parameters into a model for testing the effects of urbanisation and localisation on plant-level productivity.

We computed localisation and urbanisation variables at the three-digit industrial classification in order to accurately separate agglomeration externalities, as advised by Beaudry, Schiffauerov (2009). Adhering to Henderson (2003), we estimated the static localisation through the decomposition of the local industry's employment into that of the local industry plant as well as employment average of other local plants. Additionally, population density was used to quantify static urbanisation, as this was more robust when concerning district areas and precisely exposed potential congestion costs or productivity benefits arising from urbanisation economies in a region (Melo et al. 2009). In addition to population density in reflecting urbanisation economies, we measured a diversity index to scrutinise whether an area is relatively more diverse when compared to other regions in Indonesia, following Khoirunurrofik (2018) and Marrocu et al. (2013). Log form was used for all non-dummies and share variables.

We specified the fixed-effect model at the plant level and incorporated industry-year (two-digit ISIC) fixed effects.

$$\begin{aligned} \ln TFP_{irt} = \; & \alpha_0 \beta_1 \ln Age_{irt} + \beta_2 \ln Size_{irt} + \beta_3 DFDI_{irt} + \beta_4 DGov_{irt} + \\ & \beta_5 DExport_{irt} + \beta_6 Coastal_{rt} + \beta_7 Electricity_{rt} + \beta_8 Roaddens_{rt} + \\ & \beta_9 \ln Distport_{rt} + \beta_{10} \ln Avrindregemp_{jrt} + \beta_{11} \ln Locplant_{jrt} + \\ & \beta_{12} \ln Popdens_{rt} + \beta_{13} \ln Diversity_{rt} + \epsilon_{irt} \end{aligned} \tag{3}$$

TFP_{irt} indicates the TFP of plant i in region r in year t. *Avrindregemp* calculates average number of employees in the same industry j but excludes the number of employees of their own plant i. *Locplant* signifies number of plants in industry j in region r at time t. *Popdens* denotes population density in region r at time t, not the total number of people in a region. *Diversity* measures the variety level challenged by a plant in a specific industry j in region r at time t.

Age and *Size* were defined respectively as the plant's age and plant's number of employees. Meanwhile, *DFDI*, *DGov*, and *DExport* respectively act as dummy variables for foreign ownership, government ownership, and export activity. If at least 10% of the plant was subject to foreign ownership, then *DFDI* was valued at 1, while if the share of the government in the plant was greater than 50%, then *DGov* was equal to 1. Nevertheless, although we named these variables as Dummies, they represent the conditions in a particular year and may change ownership from 1990 to 2010. Additionally, *DExport* was equal to 1 if the plants exported in the respective year. *DExport* may also change across years.

Furthermore, *Coastal* denotes the percentage of villages within a coastal area. Since there were some proliferation of villages, the number of villages with coastal areas changes over time, and thus also changes the value of coastal areas. It should be noted that this coastal area is not a time-invariant variable since number of villages in a district can increase. Finally, the percentage of households with access to electricity was represented by *Electricity*, while *Roaddens* indicates the ratio of the total length of three road types – national, provincial, and district roads – to provincial roads. We provide a complete description of variable definition and data sources in the Appendix (Table A.1).

Plant fixed effects were applied in order to control for the unobservable characteristics of the plant and location selection bias (Henderson 2003). These treatments were intended to avoid the plant behaviour bias, which could possibly lead to plants in the most agglomerate and productive regions being located. Nevertheless, endogeneity bias or

Table 1: Descriptive Statistics of Variables

Variable	Mean	SD	Min	Max
Dependent Variable (441,187 observations)				
ln (*TFP*)	4.172	1.432	-8.039	11.874
Plant Characteristics (441,187 observations)				
ln(Size)	2.396	0.914	0.000	4.700
ln(Age)	4.193	1.179	2.996	10.661
DFDI	0.068	0.252	0.000	1.000
DGov	0.069	0.253	0.000	1.000
Dexp	0.149	0.356	0.000	1.000
Regional Characteristics (283 observations)				
Coastal (%)	12.615	17.366	0.000	89.000
Electricity (%)	89.659	11.483	16.613	99.920
ln(Roaddens)	-0.902	0.920	-3.311	2.327
ln(Distport)	6.812	0.470	6.159	8.408
Agglomeration Economies (4,864 observations)				
ln(Locplant)	2.399	1.166	0.000	5.832
ln(Avrindregemp)	2.340	2.058	0.000	8.022
ln(Popdens)[a]	5.680	1.889	0.902	9.840
ln(Diversity)	-2.286	1.654	-10.216	1.136

Note: SD = Standard deviation. [a] Number of observations = 283.

possible reverse causality still might have existed owing to unobservable industries and regions characteristics which might influence plant productivity. To account for this, following Henderson (2003) and Maré, Graham (2013) we then split the error term into two – industry-time-period fixed effects and residual white noise error – so that the remaining shocks not absorbed by plant fixed effects would be absorbed by industry-year fixed effects. Additionally, to anticipate the possibility of correlation among plants in the same industry sector in a given region but not across industries which may create errors by in-cluster correlation, we allowed the clustering of standard errors by industry district to avoid underestimated errors and the more likely possibility that the null hypothesis would be rejected Cameron et al. (2011), Nichols, Schaffer (2007).

5 Results and Analysis

We used the TFP level that was calculated from the plant-level production function estimation as the dependent variable. The estimation results of the plant-level production function for each three-digit SIC are reported in the Appendix (Table A.3). It indicates that in 66% of the sectors, constant returns to scale could not be rejected. We then categorised independent variables into three groups: plant characteristics, regional characteristics, and agglomeration economies. At first glance, there is considerable heterogeneity concerning plant size and age as depicted in Table 1. Likewise, a high variation of road density implies an imbalance in the amount of transport infrastructure across regions. The table also demonstrates that urbanisation economies' measurement is slightly more dispersed than that of localisation economies. Nevertheless, the diversity index, with an average of negative values, indicates that the industry in most of regions are less diverse, implying that those regions tend to specialise in a specific industry.

5.1 Aggregate Estimate

For the dependent variable, we employed the TFP level estimated from the plant-level production function for each three-digit SIC. The empirical model estimation returned the main results depicted in Table 2. Columns (1) and (2) provide the estimation results for the baseline model, which investigates the existence of agglomeration externalities in Indonesia. As the estimated coefficients from the OLS estimation results show in

Column (1), we found significant effects of urbanisation and localisation economies. The pairwise correlation coefficients between the level and first difference of lnlocplant and lnavrindregemp were respectively 0.254 and -0.009. Therefore, no multicollinearity was found between variables representing localisation. However, the true values might have been overestimated in the results due to the likelihood of reversed causality between agglomeration variables and productivity.

Upon the application of industry-year dummies and fixed-effects methods, we observed that localisation economies greatly determined productivity as indicated in the Column (2) results and a significant coefficient value at 0.066, which means a 1% increase in the number of plants of industry for each district would lead to 0.066 improvements in plant productivity. Contrary to Kuncoro (2009), who observed significant coefficients for all specifications between 0.13 and 0.24, our estimate of the localisation economies was below half. The discrepancies are the results of our improvements in the estimation method by eliminating possible input endogeneity and plant self-selection biases and accommodating the unobserved plant fixed effects. Nevertheless, when compared to localisation economies in other countries' cases, our result apparently exhibited a similar magnitude. These include the 0.02 to 0.08 for the United States manufacturing (Henderson 2003), 0.03 for British manufacturing (Graham 2009), 0.032–0.063 for Korean manufacturing (Lee et al. 2010), and 0.05–0.06 for French manufacturing (Martin et al. 2011). This finding contradicts the survey of De Groot et al. (2016) that conclude it would be a less likely insignificant effect of specialisation when using micro-panel data as it might be less important at the firm level. Although between localisation and specialisation, some time is interchangeable, it shows a different impact of static and dynamic agglomeration measurement on productivity direction when we utilise the micro-data level. Additionally, we found the insignificantly negative findings for diversity to be consistent with the conclusion of De Groot et al. (2016), but it does not support Jacobs externalities theory, which states that it has to be positive. Another fascinating result is that the estimation result of the agglomerated regions of Java and two megapolitan areas, namely Greater Jakarta and Greater Surabaya, shows that localisation economies are consistent, revealed in columns 3 to 6, which is even higher than the basic estimation (column 2).

We discovered that all plant characteristics of the control variables significantly determine productivity, with the exception of the export dummy. Plant's age returned significant with a positive coefficient, which demonstrates internalisation of the accumulated knowledge of the plants over a period of improved productivity. We also found company size to be positive and statistically significant, which means larger plant sizes generate higher productivity. Government plants and foreign direct investment (FDI) returned statistically significant and had a positive effect, indicating that higher productivity plants possibly have better access to overseas markets and capital sources (Narjoko, Hill 2007). To further explore of the role of FDI in industrial development in Indonesia, we then looked at different effects of agglomeration between Java and Outside Java as well as in the area where the Multi-National Enterprises (MNEs) are mostly located (Greater Jakarta and Greater Surabaya). We have provided sub-sample estimations to examine whether the MNEs have acquired agglomeration benefits, particularly in Java and Major cities. These findings indicate that the manufacturing sector is saturated, concentrated in Java. Since the beginning of Indonesia's industrial development, the government has put in a great deal of investment to build a large number of industrial zones in Java, particularly around the capital city, Jakarta, contributing to the global economy (Firman et al. 2007). However, the negative effect of urbanisation in Greater Jakarta is due to the fact that urban areas contain many types of industries and tend to develop rapidly over time, thus facing problems of congestion and over-utilisation of infrastructure.

Furthermore, we obtained a confirmation about the significance of network externalities as depicted by road density. Between 0.065 and 1.687, the estimated coefficients were fairly robust, which implies that road infrastructure improvement across cities or districts in a province not only creates network connectivity between plants and jobs and their equivalents in other regions, but also raises productivity. Meanwhile, electricity and coastal location showed positive effects on productivity, which suggests that regional competitiveness is a necessary factor in improving productivity at the plant level. We

Table 2: Agglomeration Externalities: Main Results

Dependent Variable:	Total Factor Productivity (LnTFP)					
Empirical Method:	OLS	FE	FE	FE	FE	FE
Sample	All	All	Java	Non Java	Grt Jakarta	Grt Surabaya
	(1)	(2)	(3)	(4)	(5)	(6)
Age (Ln)	-0.067***	0.109***	0.100***	0.133***	0.152***	0.079***
	[0.009]	[0.009]	[0.010]	[0.023]	[0.017]	[0.022]
Size (Ln)	0.287***	0.060***	0.075***	-0.007	0.078***	0.080***
	[0.011]	[0.012]	[0.013]	[0.024]	[0.015]	[0.016]
DFDI (1=Foreign)	0.330***	0.119***	0.131***	0.085**	0.136***	0.054
	[0.036]	[0.018]	[0.019]	[0.039]	[0.026]	[0.057]
DGov (1=Gov)	0.402***	0.238***	0.273***	0.110***	0.138***	0.280***
	[0.036]	[0.026]	[0.030]	[0.026]	[0.033]	[0.033]
Dexp (1=Exp)	0.004	-0.005	-0.009	0.020	0.028*	0.020
	[0.021]	[0.009]	[0.010]	[0.016]	[0.014]	[0.018]
Coastal (%)	0.001	0.005***	0.008**	0.004	-0.002	-0.048
	[0.001]	[0.002]	[0.004]	[0.003]	[0.004]	[0.031]
Electricity (%)	-0.004**	0.002**	0.001	0.004***	-0.001	0.002
	[0.002]	[0.001]	[0.001]	[0.001]	[0.002]	[0.001]
Roaddens (Ln)	0.000	0.065***	0.094***	0.032	0.021	1.687**
	[0.020]	[0.023]	[0.027]	[0.033]	[0.036]	[0.664]
Distport (Ln)	0.526***	-1.152**	-3.048**	-0.512	0.024	-2.440
	[0.069]	[0.464]	[1.462]	[0.476]	[1.206]	[1.523]
Avregindemp (Ln)	0.114***	0.005	0.001	0.009	0.005	-0.026**
	[0.010]	[0.004]	[0.005]	[0.006]	[0.009]	[0.011]
Locplant (Ln)	-0.013	0.066***	0.083***	-0.002	0.117***	0.116**
	[0.023]	[0.018]	[0.022]	[0.027]	[0.028]	[0.047]
Popdens (Ln)	0.041***	0.015	0.013	0.017	-0.117**	0.024
	[0.014]	[0.013]	[0.021]	[0.016]	[0.051]	[0.016]
Diversity (Ln)	-0.008	-0.001	0.005	-0.010	-0.015	0.013
	[0.010]	[0.007]	[0.010]	[0.008]	[0.013]	[0.023]
Constant	-1.958***	10.665***	22.390**	7.281**	4.175	19.440*
	[0.624]	[3.034]	[9.399]	[3.341]	[7.843]	[9.871]
Industry-Year Dummies	Y	Y	Y	Y	Y	Y
Plant Fixed Effects	N	Y	N	N	Y	N
N x T	441,187	441,187	360,163	81,024	116,012	66,699
R^2	0.376	0.054	0.073	0.083	0.086	0.124

Notes: Robust standard errors for correcting at the industry-district level are reported in brackets. Significance levels: * p <0.10, ** p <0.05, *** p <0.01..

also found the GIS-Euclidean distance that measured the distance from district capital to the seaport as a qualified approximation of transport costs and travel time, despite not considering the quality and availability of the network. The statistically significant and consistently negative estimated coefficients demonstrate that, as the distance to the international seaports increase, so do the travel time and costs.

5.2 *Agglomeration Externalities over Economic Stages*

In this section, we present our analysis of the disaggregated data to investigate the effects of agglomeration on plant productivity across economic stages. The plants were categorised as 'small' (20–49 employees), 'medium' (50–249), and 'large' (250+). The classification of plants according to size is important for knowing which group is more adapted to economic change (crisis) as part of the firm and industrial life cycles in acquiring agglomeration externalities (Neffke et al. 2011). Since small firms may spend a lower sunken cost of investment, they may be more flexible to enter and exit from the market, and usually, their ages are typically young. On the contrary, large firms are more established and are classified as mature industries with large sunken costs. In terms of plant size, a specific pattern was observable among the small, medium, and large plants as presented in Table 3. Considerable differences in agglomeration effects were present related to plant-size heterogeneity.

As shown in the table, small plants were flexible – they exhibited the capacity of adjustment and dynamic behaviour as a reaction to the economic situations. During pre-crisis, all plants seem to not have benefited from agglomeration economies except the large plants that received a small benefit from diversity. At later stages, however, the agglomeration sources of localisation economies have appeared in post-crisis for all plant sizes, in addition to urbanisation effects for small and medium plants.

Evidence of changing industrial structure was also found, where small and medium plants have gathered urbanisation externalities in the post-crisis period. It shows that small and medium plants have an advantage in the diversity of the environment across industries in the whole region and are more likely to have much stronger productive advantages in large cities. Meanwhile, large manufacturing plants are inclined to gather small external economies from localisation, benefiting from Marshallian externalities such as labour pooling, knowledge spillover, and input sharing in that period. Strong agglomeration effects on small plants' productivity after the crisis are echoed by Aswicahyono et al. (2010), who found that small plants were the single contributor to employment growth while recording a robust growth at around 8.8% between 1996 and 2006.

Interestingly, at pre-crisis, the urbanisation economies have had different effects on medium and large plants. Table 3 also depicts a significant negative impact of urbanisation economies against medium plants, which signifies that the de-clustering for medium plants might be the results of labour cost, congestion, or institutional costs in large areas. It may be due to the relatively lower scale of economies of medium plants against the cost of urbanisation. However, it does not make a case for a large plant that acquired the benefit of diversity from other sectors in a region.

The agglomeration effects on productivity were examined further through industry grouping. The industries from the three-digit SIC were divided into six groups of industry following Henderson et al. (2001): (a) traditional, (b) heavy, (c) transportation equipment, (d) machinery and electronics, (e) high-technology, and (f) other industries. Externalities of labour pooling were assumed to occur between plants sharing the same two-digit SIC and region. Detailed information about the industrial grouping of industries is provided in the Appendix (Table A.3).

Table 4 shows the different effects of economic stages across industry types where traditional industries, machinery, and electronics were more productive in a localised area and absorbed external benefits from localisation economies. In the post-crisis period, localisation economies persistently benefited traditional industries (such as food and beverage, wood and furniture, and tobacco). It is evident that a specialised environment might be preferable to these labour-intensive, resource-based, and typical industries (as they are described in the OECD classification; OECD 1987). In addition, traditional industries have also acquired benefits from urbanisation economies.

The fact that the location of mature firms is attractive to new plants further supports this finding, as it provides information about the most suitable area compared to others with comparable situations (Henderson, Kuncoro 1996). Infrastructure improvements and localisation economies also strongly inform firms' decisions in Indonesia over plant location and other activities, as pointed out by Deichmann et al. (2005). In a similar vein, Amiti, Cameron (2007) observed that the firms benefited from at least two of the three agglomeration sources, i.e., labour-market pooling and input sharing. Their findings imply that Indonesia's localisation economies come to light by observing the inter-firm interaction in supply and demand relations.

Additionally, transport equipment was found as the only industry that obtained negative externalities from urbanisation in period preceding the crisis – that said, external benefits emerging out of this industry's agglomeration economies were weakened by the crisis. Through this finding, it was possible to explain the properties of the industries receiving more external costs from large areas and diversified environments. The failure of transport industries to absorb external benefits from any agglomeration economies source is contrary to the conclusions from Lee et al. (2010) and Henderson et al. (2001). They studied the same industry in Korea and found that it sourced external benefits from localisation. The Korean case shows that the transport industry is composed of businesses operating in specialised and concentrated areas. Also important to note is the finding

Table 3: Agglomeration Externalities by Plant Size over Economic Cycles

Dependent Variable:	Total Factor Productivity (Ln TFP)	
Economic Cycles	Pre-Crisis (1990–98)	Post-Crisis (1999–2010)
Small Firm (20–49 Workers)		
N x T	89,938	146,997
Locplant (Ln)	0.030	0.101***
	[0.025]	[0.030]
Popdens (Ln)	0.006	0.056***
	[0.036]	[0.018]
Diversity (Ln)	0.001	0.004
	[0.009]	[0.013]
Medium Firm (50–249 Workers)		
N x T	54,028	84,070
Locplant (Ln)	0.010	0.106***
	[0.031]	[0.035]
Popdens (Ln)	-0.090*	0.045**
	[0.052]	[0.018]
Diversity (Ln)	-0.016	-0.014
	[0.013]	[0.012]
Large Firm (≥ 250 Workers)		
N x T	26,119	40,035
Locplant (Ln)	0.050	0.082*
	[0.041]	[0.044]
Popdens (Ln)	0.030	-0.027
	[0.073]	[0.031]
Diversity (Ln)	0.031*	-0.011
	[0.017]	[0.016]
All Firm		
N x T	170,085	271,102
Locplant (Ln)	0.046**	0.101***
	[0.020]	[0.024]
Popdens (Ln)	0.026	0.033**
	[0.029]	[0.013]
Diversity (Ln)	0.003	0.002
	[0.008]	[0.010]

Notes: Estimations include fixed effects at the plant level and industry-year dummies. Each regression includes control for the plant's characteristics of age, size, dummies of ownership (DFDI, DGov), and export activity, and regional characteristics of coastal area, access to electricity, road density, and distance to the closest international port. Robust standard errors for correcting at the industry-district level are reported in brackets. Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Agglomeration Externalities by Industry over Economic Cycles

Dependent Variable:	Total Factor Productivity (Ln TFP)	
Economic Cycles	Pre-Crisis (1990–98)	Post-Crisis (1999–2010)
Traditional Industries		
N x T	106,848	178,582
Locplant (Ln)	0.041*	0.112***
	[0.025]	[0.028]
Popdens (Ln)	0.015	0.023*
	[0.037]	[0.013]
Diversity (Ln)	0.002	0.014
	[0.010]	[0.009]
Heavy Industries		
N x T	42,724	64,891
Locplant (Ln)	0.037	0.058
	[0.040]	[0.055]
Popdens (Ln)	0.031	0.072***
	[0.060]	[0.027]
Diversity (Ln)	0.016	-0.028
	[0.014]	[0.029]
Transport Industries		
N x T	4,634	7,090
Locplant (Ln)	0.109	-0.137
	[0.094]	[0.131]
Popdens (Ln)	0.089	-0.143*
	[0.173]	[0.076]
Diversity (Ln)	-0.008	-0.113
	[0.043]	[0.076]
Machinery and Electronic Industries		
N x T	9,056	8,952
Locplant (Ln)	0.077	0.206*
	[0.067]	[0.124]
Popdens (Ln)	0.155*	0.047
	[0.082]	[0.099]
Diversity (Ln)	-0.042	0.003
	[0.028]	[0.037]
High-Technology Industries		
N x T	1,486	3,156
Locplant (Ln)	-0.452**	0.222
	[0.198]	[0.306]
Popdens (Ln)	0.497	-0.066
	[0.326]	[0.077]
Diversity (Ln)	0.042	-0.031
	[0.089]	[0.104]
Other Industries		
N x T	5,337	8,431
Locplant (Ln)	0.103	0.278***
	[0.072]	[0.085]
Popdens (Ln)	-0.272**	0.061
	[0.118]	[0.094]
Diversity (Ln)	-0.039	0.047
	[0.036]	[0.034]

Notes: Estimations include fixed effects at the plant level and industry-year dummies. Each regression includes control for the plant's characteristics of age, size, dummies of ownership (DFDI, DGov), and export activity, and regional characteristics of coastal area, access to electricity, road density, and distance to the closest international port. Robust standard errors for correcting at the industry-district level are reported in brackets. Significance levels: * p <0.10, ** p <0.05, *** p <0.01.

that the high-technology industry gained negative externalities or faced deagglomeration economies before the crisis; the sector started to benefit from agglomeration economies, though it is insignificant. Accordingly, we found the different result to that of Henderson (2003), who observed positive effects and significance in the industry in the United States concerning productivity.

Especially during the post-crisis period, the existence of localisation economies generally dominated that of urbanisation economies. The varied effects of agglomeration economies across industrial groups in relation to the shifting economic circumstances should be a revelation for policymakers to help them in formulating the applicable policies. Localisation economies positively and strongly affected productivity in resource-based industries such as traditional industries (e.g., apparel, food and beverage, paper, tobacco, textile, leather, furniture, and wood) and other industries (e.g., waste and recycling), and moderately improved productivity in machinery industries (such as machinery, electrical motor, wire, cable, battery) during the post-crisis period. In contrast, we found heavy industries to be more productive in a diversified environment created by urbanisation economies. Additionally, the productivity of traditional industries is also considerably affected by urbanisation economies, showing the importance of the size of the population for this sector as a market target.

For heavy and traditional industries, we looked at the agglomeration economies by plant size across an economic cycle in order to learn the changing industrial structure of small-sized plants. Both sectors make up 89.1% of the total number of observations in our study period and thus are the two biggest industry groups. As shown in Table 5 below, small plants in both industries were behind the industry structure change from no benefits of agglomeration to capture both localisation and urbanisation economies during post-crisis. The results imply that the larger the plant size, the smaller the magnitude of agglomeration benefits from both sources. In particular, for large plants in traditional industries, benefits came only from localization economies. Furthermore, the larger the size of plants in heavy industries, the effect of urbanisation become insignificant.

The ability to capture agglomeration sources of small plants in heavy and traditional industries was due to a number of developments. Firstly, after the credit rationing in the recovery periods, small plants had limited access to finance (Aswicahyono et al. 2010), which might have led small plants to switch their strategy from relying on diverse industries in a region to taking advantage of a specialised environment created by similar industries. To reduce production costs, smaller plants tapped into input sharing, knowledge transfer, and labour pooling in an industry. Aswicahyono et al. (2010) added that the crisis might have increased an entry barrier, which resulted in a higher exit rate compared to the entry rate. As a consequence, a reduced entry rate made urbanisation economies appear on a smaller scale. At the same time, the surviving plants had matured during the post-crisis phase and mostly moved to specialised areas while receiving the perks of localisation economies.

Second, these results are consistent with the findings of Khoirunurrofik (2018) that younger and smaller industries within Indonesian manufacturing can grow faster in diversified cities due to the competition that creates pressure for firms to innovate to survive. As Duranton, Puga (2001) describe it in the industry life cycle theory, urbanisation economies usually suit new-entry and small plants that considerably rely on their external environments during their early days; this is referred to as a 'nursery city', where an urban area provides a diversified environment for productivity growth.

Additionally, to some classes of firms our finding explains the importance of the diversity that major agglomerations afford, particularly for traditional industries, and would perhaps constitute a natural part of Jacobs externalities alongside the traditional pairing of localisation and urbanisation economies. It can be argued that a diversified economy may facilitate an inter-industry knowledge environment that supports the sustainability of firms by diversifying their products. As the economic stage enters the recovery phase, the industrial diversity would mean that firms could operate in more stable demand conditions with a wide choice of inputs that reduce the revenue risk and operational cost due to external shocks and price fluctuations (Neffke et al. 2011, Potter, Watts 2011). Likewise, our finding is in line with those of Brown, Greenbaum

Table 5: Agglomeration Externalities by Plant Size over Economic Cycles for Traditional and Heavy Industries

Dependent Variable:	Total Factor Productivity (Ln TFP)			
Industry Groups	Traditional Industries		Heavy Industries	
Economic Cycles	Pre-Crisis (1990–98)	Post-Crisis (1999–2010)	Pre-Crisis (1990–98)	Post-Crisis (1999–2010)
Small Firm (20–49 Workers)				
N x T	57,510	101,745	21,935	32,674
Locplant (Ln)	0.007	0.105***	0.028	0.096
	[0.032]	[0.034]	[0.050]	[0.069]
Popdens (Ln)	0.016	0.051***	0.000	0.099**
	[0.046]	[0.019]	[0.059]	[0.042]
Diversity (Ln)	-0.001	0.024**	0.015	-0.033
	[0.012]	[0.012]	[0.015]	[0.032]
Medium Firm (50–249 Workers)				
N x T	31,713	50,520	15,091	23,254
Locplant (Ln)	0.007	0.120***	0.003	0.020
	[0.040]	[0.043]	[0.065]	[0.075]
Popdens (Ln)	-0.099	0.042**	-0.084	0.065*
	[0.066]	[0.020]	[0.104]	[0.033]
Diversity (Ln)	-0.020	-0.013	0.016	-0.038
	[0.016]	[0.013]	[0.028]	[0.034]
Large Firm ($\geq$ 250 Workers)				
N x T	17,625	26,317	5,698	8,963
Locplant (Ln)	0.054	0.124**	0.078	-0.050
	[0.050]	[0.048]	[0.082]	[0.114]
Popdens (Ln)	-0.037	-0.052	0.244	0.027
	[0.080]	[0.035]	[0.183]	[0.084]
Diversity (Ln)	0.032	-0.005	0.016	-0.009
	[0.021]	[0.017]	[0.027]	[0.040]

Notes: Estimations include fixed effects at the plant level and industry-year dummies. Each regression includes control for the plant's characteristics of age, size, dummies of ownership (DFDI, DGov), and export activity, and regional characteristics of coastal area, access to electricity, road density, and distance to the closest international port. Robust standard errors for correcting at the industry-district level are reported in brackets. Significance levels: * p <0.10, ** p <0.05, *** p <0.01.

(2017) that during periods of economic downturn, counties in United States with a more diverse industry structure performed better compared to more concentrated counties performing well in recovery phases or 'periods of prosperity.' Finally, the power of small plants in adapting to economic conditions indicated that the life cycles of Indonesian industries occurred, at least for small and medium sized plants along with various types of dynamic agglomeration economies, precisely diversity, in accordance with localisation and urbanisation.

6 Conclusion

The central finding of this study is that both agglomeration sources – localisation and urbanisation economies – co-exist, which both have a positive effect on plant-level productivity. At large, the localisation effects are stronger than urbanisation effects. It is supported by the fact that, even after more than 20 years since the financial crisis hit the nation in 1998, there are small significant changes in the concentration of economic activity across the country's main islands.

Looking at the effects of agglomeration economies on plants of different sizes and plants in different industries, the present study discovered that for small and medium plants, the effects of localisation are stronger than those of urbanisation in post-crisis. This finding sheds some light on the nature of agglomeration economies and suggests that the sources of agglomeration experienced a shift in accordance with changing economic stages. We also demonstrated that the positive externalities of agglomeration economies on productivity are the response of a plant to benefit more from within an industry and a region.

In terms of industrial groups and plant-size heterogeneity, productivity is improved by localization economies for all plant sizes, in addition to traditional, machinery, electronics, and "other" manufacturing sectors. Meanwhile, productivity in a heavy industry is enhanced by urbanisation economies. Furthermore, the productivity of small and medium-sized plants is demonstrably enhanced by both agglomeration sources, but not for large-sized plants. These differential effects are compelling, and the results differ considerably depending on which of the various subsamples are used, although it is quite difficult to discern any clear patterns in the differential effects. Moreover, the breakdown estimation across economic cycles suggests an adjustment and change of agglomeration magnitudes and sources. After the financial crisis of 1997–1998, the agglomeration externalities have demonstrated themselves to be in favour of localisation economies for productivity and advise that the industry has, to a certain extent, undergone a structural change for seizing benefits from external economies.

It is conceivable that some limitations might have influenced the results obtained. As we identified a spatial autocorrelation of productivity in cross-border region beyond the administrative boundary[1], further studies on spatial scope of externalities are important to investigate the impacts of agglomeration with the attention of spatial and temporal variation as suggested by De Groot et al. (2016). In addition, as the data is a survey and not census, we do not know the exact number of entry and exit firms. Therefore, we were not able to measure the precise level of competition for each industry which is enormously important for agglomeration economies.

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A Appendix

A.1 Data cleaning process

1. Possible mistakes in data keypunching:
   - The constructed panel was adjusted for possible mistakes in data keypunching and inconsistencies in the input across firms or plants such as starting year of operation, different ISIC used, and the sum of the percentage of ownership.
   - By spotting the firm identifier, we examined the consistencies of imputing the information of similar firms. If we found inaccurate information, we made an adjustment to retain correct and consistent information.
   - Generating variables such as output, value-added, intermediate input, materials, and so on, we resorted to manual accounting for calculating those variables instead of using reported variables that may have contained mistakes due to typing errors
2. Missing observation and non-reporting items
   - These may be because some firms opted out of the survey or they exited the market because they downsized to less than 20 employees, and the firm no longer met the definition of a medium or large manufacturer.
   - To solve these problems, we estimated the cell value by conducting linear interpolation or an average of the value within a window of two consecutive years for certain variables.
   - This approach does not apply for missing observations in the beginning or end period of series since we do not know whether the firm still exists.
3. Duplicate observations
   - We found that a few observations had similar numbers for the main part of the variable set such as the number of employees, output, value-added, etc.
   - We suspected confidently that these double observations were due to the plants that belonged to a similar firm. The manufacturing survey asked for plant-level information. Therefore, for a multi-plant firm, the headquarters may have completed the questionnaire with the consolidated value of all the plants owned.
   - To account for this, we selected only one observation for these duplicate observations.

Finally, to generate a panel series with unique observations, we resorted to the following steps:

- Excluding East Timor as part of Indonesia.
- Removing the observations if it has zero values of a key variable such as input, output, value-added, and labour.
- Removing observation with repeated values of the key variables or similar PSID.
- Removing outlier observations that have productivity values of ratio between output to labour and value-added to labour were below the lowest (1 percentile) and higher than the highest (99 percentile).
- Removing observation for which capital stock cannot be estimated.

A.2 Additional Information

Table A.1: Variable Definition and Data Source

Variable	Label	Definition	Source
Dependent Variable			
Total factor productivity	TFP	Total factor of productivity using the Letvin-Petrin control function approach	Estimated from SI 1990–2010, BPS
Plant Characteristics			
Age	Age	Age of plant as a difference between the year production started and year of survey	SI 1990–2010, BPS
Size	Size	Number of workers	SI 1990–2010, BPS
Foreign ownership	DFDI	= 1 if foreign has at least 10% share of ownership	Constructed
Government ownership	DGov	= 1 if central or local government has at least 50% share of ownership	Constructed
Exporter	DEexp	= 1 if plant exports	Constructed
Regional Characteristics			
Coastal	Coastal	Percentage of villages located offshore in a district/city	PODES 1990–2011
Electricity	Electricity	Percentage of households that has access to electricity in a district/city	PODES 1990–2011
Road density	Roaddens	Length of road infrastructure per square kilometres in a province	BPS and Ministry of Home Affairs
Distance to intl. seaport	Distport	GIS distance from capital of district/city to capital of city where the closest international port is located	Constructed
Agglomeration Economies			
Localisation (plants)	Locplant	Own industry plant in the district/city (plants)	Calculated from SI 1990–2010, BPS
Average industry-region employment	Avrindregemp	Average industry employment in the district/city minus own plant (person)	Calculated from SI 1990–2010, BPS
Urbanisation (population)	Popdens	Employment density in the district/city	BPS
Diversity	Diversity	The diversity of the various industry in the district/city	Calculated from SI 1990–2010, BPS

Notes: BPS is the Indonesian Central Bureau of Statistics. SI is the Annual Survey of Large and Medium Firms. PODES is the Village Potential Survey.

Table A.2: Plants' Observation and Exit-Entry rate

Year	All					Small					Medium					Large				
	N	Entry	Exit	Entry rate (%)	Exit rate (%)	N	Entry	Exit	Entry rate (%)	Exit rate (%)	N	Entry	Exit	Entry rate (%)	Exit rate (%)	N	Entry	Exit	Entry rate (%)	Exit rate (%)
1990	15,562					8,651					4,832					2,079				
1991	15,885	2,910	2,117	18.32	13.33	8,383	1,639	1,485	19.55	17.71	5,071	909	501	17.93	9.88	2,431	362	131	14.89	5.39
1992	17,074	2,597	1,383	15.21	8.10	8,941	1,534	913	17.16	10.21	5,434	819	373	15.07	6.86	2,699	244	97	9.04	3.59
1993	17,543	1,940	1,401	11.06	7.99	8,821	1,161	952	13.16	10.79	5,825	622	335	10.68	5.75	2,897	157	114	5.42	3.94
1994	18,389	2,119	1,217	11.52	6.62	9,115	1,359	833	14.91	9.14	6,202	630	288	10.16	4.64	3,072	130	96	4.23	3.13
1995	20,853	3,587	1,118	17.20	5.36	11,076	2,684	766	24.23	6.92	6,585	780	267	11.85	4.05	3,192	123	85	3.85	2.66
1996	22,297	3,234	1,804	14.50	8.09	12,185	2,386	1,273	19.58	10.45	6,833	709	411	10.38	6.01	3,279	139	120	4.24	3.66
1997	21,718	1,733	2,294	7.98	10.56	11,632	1,075	1,701	9.24	14.62	6,825	523	435	7.66	6.37	3,261	135	158	4.14	4.85
1998	20,764	1,551	2,319	7.47	11.17	11,134	955	1,740	8.58	15.63	6,421	475	478	7.40	7.44	3,209	121	101	3.77	3.15
1999	21,410	1,400	979	6.54	4.57	11,378	982	813	8.63	7.15	6,686	334	138	5.00	2.06	3,346	84	28	2.51	0.84
2000	21,502	1,091	1,083	5.07	5.04	11,307	723	801	6.39	7.08	6,809	283	203	4.16	2.98	3,386	85	79	2.51	2.33
2001	20,724	3,698	4,568	17.84	22.04	10,712	2,448	3,181	22.85	29.70	6,635	911	994	13.73	14.98	3,377	339	393	10.04	11.64
2002	20,491	1,000	1,094	4.88	5.34	10,542	569	764	5.40	7.25	6,599	327	216	4.96	3.27	3,350	104	114	3.10	3.40
2003	19,716	950	1,657	4.82	8.40	9,992	622	1,145	6.22	11.46	6,425	263	361	4.09	5.62	3,299	65	151	1.97	4.58
2004	20,071	1,847	1,487	9.20	7.41	10,290	1,125	906	10.93	8.80	6,466	522	379	8.07	5.86	3,315	200	202	6.03	6.09
2005	20,057	1,485	1,360	7.40	6.78	10,354	946	899	9.14	8.68	6,482	433	320	6.68	4.94	3,221	106	141	3.29	4.38
2006	28,525	11,019	2,463	38.63	8.63	16,686	8,124	1,728	48.69	10.36	8,389	2,423	495	28.88	5.90	3,450	472	240	13.68	6.96
2007	27,205	1,243	2,663	4.57	9.79	15,832	896	1,978	5.66	12.49	7,958	261	522	3.28	6.56	3,415	86	163	2.52	4.77
2008	24,967	818	3,241	3.28	12.98	14,253	576	2,396	4.04	16.81	7,421	185	654	2.49	8.81	3,293	57	191	1.73	5.80
2009	23,781	491	1,881	2.06	7.91	13,336	328	1,449	2.46	10.87	7,183	118	339	1.64	4.72	3,262	45	93	1.38	2.85
2010	22,653	834	2,327	3.68	10.27	12,315	525	1,793	4.26	14.56	7,017	210	413	2.99	5.89	3,321	99	121	2.98	3.64
(1990-10)	441,187					236,935					236,935					66,154				
(1991-09)	402,972	44,713	38,456	10.56	9.02	215,969	30,132	26,031	13.95	12.05	126,249	11,527	7,621	9.13	6.04	60,754	3,054	2,687	5.03	4.42

Notes: Years of The Census of Manufacturing: 1996 and 2006

Table A.3: Group and ISIC3-Industry

Group	3 Digits-ISIC	Industry
Traditional	151	Meat, fish, fruit, vegetables, oils
	152	Dairy products
	153	Grain mill products, animal feeds
	154	Other foods
	155	Beverages
	160	Tobacco products
	171	Spinning, weaving & textile finish
	172	Other textiles
	173 & 174	Knitted, crocheted fab., articles, and Kapok
	181 & 182	Apparel and fur
	191	Leather tanning and products
	192	Footwear
	201	Wood saw milling and planning
	202	Wood product
	210	Paper and products
	221 & 222	Publishing and printing
	223	Media recording reproduction
	361	Furniture
	369	Jewelry, sports goods, games
	231 & 232	Coke oven and refined petroleum products
	241	Basic chemicals
	242	Industries other chemical products
	243	Manmade fibers
Heavy	251	Rubber products
	252	Plastic products
	261	Glass products
	262	Porcelain products
	263	Clay products
	264	Cement and lime products
	265	Marble and granite product
	266	Asbestos products
	269	Other nonmetallic products
	271	Basic iron and steel
	272	Basic precious, nonferrous
	273	Iron and steel smelting product
	289	Other fabricated metal products
	281	Structural metal products
Transportation	341	Motor vehicle assembly
	342	Motor vehicle bodies
	343	Motor vehicle components
	351	Building and repairing ships and boats
	352 & 353	Manufacture of railway and aircraft
	359	Motorcycle, bicycle, other
Machinery and Electronic	291	General purpose machinery
	292	Special purpose machinery
	293	Domestic appliances n.e.c.
	311	Electrical motors, generators, etc.
	312	Electrical distribution equipment
	313	Insulated wire, cable
	314	Batteries and cells
	315	Lamps and equipment
	319	Other electrical equipment n.e.c.
High-technology	300 & 321	Office, acc., computing machinery & electronic components
	322 & 323	TV and radio transmitters, and TV, radio, video equipment
	331	Medical, measuring equipment
	332& 333	Optical, photographic equipment, watches, and clocks
Other	371	Metal waste and scrap recycling
	372	Non-metal waste and scrap recycling

Table A.4: Plant-Level Production Function Estimation

3 Digits ISIC	Industry	OLS (Factor share)		Levin Petrin Production Function			
		α	β	α	β	$\alpha+\beta$	Wald test
151	Meat, fish, fruit, vegetables, oils	0.296	0.704	0.086	0.666	0.752	44.3***
152	Dairy products	0.105	0.895	0.169	1.074	1.243	3.04*
153	Grain mill products, animal feeds	0.252	0.748	0.247	0.600	0.847	7.64***
154	Other foods	0.195	0.805	0.135	0.850	0.985	0.3
155	Beverages	0.154	0.846	0.213	0.876	1.089	2.1
160	Tobacco products	0.171	0.829	0.146	0.848	0.994	0.0
171	Spinning, weaving & textile finish	0.200	0.800	0.131	0.620	0.751	49.04***
172	Other textiles	0.166	0.834	0.250	0.747	0.997	0.0
173&174	Knitted, crocheted fab., articles, and Kapok	0.162	0.838	0.172	0.750	0.922	4.57**
181&182	Apparel and fur	0.145	0.855	0.188	0.783	0.970	1.7
191	Leather tanning and products	0.173	0.827	0.245	0.859	1.105	1.8
192	Footwear	0.076	0.924	0.021	0.876	0.897	2.4
201	Wood saw milling and planning	0.170	0.830	0.104	0.720	0.823	22.66***
202	Wood product	0.190	0.810	0.119	0.817	0.936	4.38**
210	Paper and products	0.177	0.823	0.224	0.836	1.060	1.3
221&222	Publishing and printing	0.087	0.913	0.151	0.800	0.951	2.0
223	Media recording reproduction	0.112	0.888	0.604	0.733	1.337	1.1
231&232	Coke oven and refined petroleum products	0.036	0.964	0.273	0.793	1.067	0.1
241	Basic chemicals	0.203	0.797	0.137	0.788	0.925	1.3
242	Industries other chemical products	0.230	0.770	0.170	0.672	0.843	15.66***
243	Manmade fibers	0.129	0.871	0.494	1.111	1.605	4.00**
251	Rubber products	0.251	0.749	0.191	0.573	0.764	32.99***
252	Plastic products	0.198	0.802	0.222	0.739	0.961	3.08*
261	Glass products	0.086	0.914	0.595	0.818	1.413	7.8***
262	Porcelain products	0.269	0.731	0.323	0.605	0.928	0.3
263	Clay products	0.162	0.838	0.278	0.774	1.051	0.2
264	Cement and lime products	0.193	0.807	0.261	0.838	1.100	1.8
265	Marble and granite product	0.167	0.833	0.246	0.817	1.063	0.8
266	Asbestos products	0.077	0.923	0.186	1.032	1.218	0.4
269	Other nonmetallic products	0.196	0.804	0.313	0.808	1.121	0.2
271	Basic iron and steel	0.167	0.833	0.011	0.835	0.845	0.8
272	Basic precious, nonferrous	0.311	0.689	0.039	0.479	0.519	4.81**
273	Iron and steel smelting product	0.248	0.752	0.264	0.525	0.789	1.5
281	Structural metal products	0.126	0.874	0.116	0.978	1.094	2.6
289	Other fabricated metal products	0.202	0.798	0.247	0.671	0.918	6.81***
291	General purpose machinery	0.139	0.861	0.235	0.845	1.080	1.3
292	Special purpose machinery	0.221	0.779	0.175	0.686	0.861	6.11**
293	Domestic appliances n.e.c.	0.027	0.973	0.044	0.798	0.842	1.8
311	Electrical motors, generators, etc.	0.194	0.806	0.333	0.741	1.075	0.2
312	Electrical distribution equipment	0.175	0.825	0.344	0.809	1.153	1.0
313	Insulated wire, cable	0.030	0.970	0.077	0.872	0.949	0.1
314	Batteries and cells	0.113	0.887	0.267	1.008	1.276	3.65*
315	Lamps and equipment	0.124	0.876	0.158	0.616	0.774	0.8
319	Other electrical equipment n.e.c.	0.039	0.961	0.508	0.715	1.224	0.3
300&321	Office, acc., computing machinery & electronic components	0.190	0.810	0.122	0.595	0.718	2.83*
322&323	TV and radio transmitters, and TV, radio, video equipment	0.083	0.917	0.060	0.809	0.869	1.0
331	Medical, measuring equipment	0.113	0.887	0.245	0.841	1.086	1.7
332&333	Optical, photographic equipment, watches, and clocks	0.105	0.895	0.237	0.829	1.066	0.1
341	Motor vehicle assembly	0.035	0.965	0.935	0.600	1.535	0.2
342	Motor vehicle bodies	0.134	0.866	0.033	0.789	0.822	1.8
343	Motor vehicle components	0.214	0.786	0.291	0.740	1.030	0.0
351	Building & repairing ships & boats	0.225	0.775	0.213	0.854	1.067	1.3
352&353	Manufacture of railway & aircraft	0.540	0.460	0.826	0.673	1.498	0.3
359	Motorcycle, bicycle, other	0.126	0.874	0.200	0.797	0.997	0.0
361	Furniture	0.138	0.862	0.072	0.783	0.855	28.54***
369	Jewelry, sports goods, games	0.131	0.869	0.127	0.784	0.911	8.26***
371	Metal waste and scrap recycling	0.127	0.873	0.485	1.458	1.942	1.7
372	Non-metal waste & scrap recycling	0.080	0.920	0.326	0.808	1.134	0.4

Notes: α is the capital coefficient and β is the labor coefficient. Wald test of constant returns to scale is a test where the sum of the coefficients equals 1. Significance levels: * p <0.10, ** p <0.05, *** p <0.01.