The Effects of Agglomeration Economies on Technical Efficiency of Manufacturing Firms: Evidence from Indonesia

Wahyu Widodo[1], Ruhul Salim[*2] and Harry Bloch[2]

[1]Lecturer, Department of Economics
Diponegoro University
Jalan Professor Haji Soedharto, 50275, Indonesia

[2]School of Economics & Finance
Curtin business School
Curtin University

[*]**Corresponding author:** School of Economics & Finance, Curtin Business School, Curtin University, Perth, WA 6845. Phone: +61 8 9266 4577, Fax: +61 8 9266 3026, E-mail: Ruhul.Salim@cbs.curtin.edu.au

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Abstract

This article examines the effects of agglomeration economies and industrial structure upon firm-level technical efficiency in the Indonesian manufacturing industry over the period 2004-2009. A stochastic production frontier and three channels of agglomeration economies consist of specialization, diversity, and competition are used. The empirical results show that the effects of specialization and diversity upon firm-level technical efficiency are positive and negative respectively, indicating that specialization is more favourable than diversity for stimulating firms' technical efficiency. Competition has a positive sign, showing that region with high levels of competition tend to be more conducive in accelerating firm-level technical efficiency. In terms of firm location, both dummy for urban region and industrial complex turn out to be positive, indicating that firms located in both areas are experienced higher technical efficiency. Both firm size and age also have positive effect upon technical efficiency.

Key words: agglomeration economies, industrial structure, firm-level technical efficiency and stochastic frontier

***JEL Classification*:** L25; L60; R12

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1. Introduction

In general, agglomeration refers to the spatial concentration of economic activity in a limited area such as the spatial distribution of a specific industry (Brulhart 1998). According to Marshall (1920), firms concentrated due to the benefits of input sharing, labour market pooling and knowledge spillovers. Input sharing demonstrates the importance of the existence of the scale economies in input production. This condition allows down-stream firms to procure intermediate inputs from nearby companies or suppliers at relatively lower prices (Rosenthal and Strange 2004; Cohen and Paul 2009). Holmes (1999) emphasizes that firms with high purchased input intensity will be more beneficial by locating close to input suppliers. The physical proximity to input sources would allow these firms to be more flexible in obtaining inputs based on the scale of their production. Even if the firms can purchase their inputs from distant regions; this could benefit local sources, because in some cases distant suppliers cannot meet the levels of demand (Feser 2002). Labour market pooling is when workers have the flexibility to move among firms in an industry; this reduces job search cost and risk, decreases the cost of the hiring process (Cohen and Paul, 2009), and facilitates mutual learning (Nakamura and Paul 2009). Access to deep pools of labour is perhaps the most commonly recognized driver of spatial economies in the empirical work of agglomeration (Feser 2002). The availability of skilled and experienced workers enables companies to expand and contract without any significant disturbances (Krugman 1991).

Knowledge spillovers are possibly the most interesting of the micro-foundations of agglomeration, as these cover multiple areas of economics. Unlike the input sharing and labour pooling phenomena, empirically knowledge spillovers are difficult to identify (Rosenthal and Strange 2004). The root of knowledge spillovers is the interaction of people. Feser (2002) explains that the knowledge spillovers consist of two types: mobile and immobile. The term “mobile knowledge spillovers” refers to the change of technological progress that occurs continually and effectively on a global scale. By their nature, innovations, learning processes and technological inventions generally influence industrial development. Immobile knowledge spillovers are concerned with the knowledge transfer processes that do not diffuse rapidly over space, perhaps due to their tacit characteristic. In line with Marshall, there are other sources of agglomeration proposed in the literature, such as transportation cost (Krugman 1991), concentration of demand and natural advantage (Cohen and Paul 2009), local amenities (Mukkala 2004; Greenstone et al. 2008), home market effects, consumption and rent-seeking (Rosenthal and Strange 2004).

The aim of this article is to examine the effects of agglomeration economies upon firm-level technical efficiency using manufacturing data from Indonesia over the period 2004-2009. The manufacturing industry in Indonesia is localized. In 2009, for instance, 76.62 percent of manufacturing value-added was concentrated on the Island of Java; furthermore, around 48.01 percent was produced in The Capital of Jakarta and the surrounding regions. Furthermore, the distribution of manufacturing industry at district level was also highly concentrated only at the limited regions. The district is the third tier of administrative authority in Indonesia, and is equivalent to counties in China or the USA. In 2009, only the food and beverages industry (ISIC 15) and the wood products industry (ISIC 20) were distributed widely across districts, with coverage of 68.2 percent and 42.9 percent respectively. Other industries tended to be concentrated in small number of districts only. The limited empirical analysis on this issue in Indonesia affords a significant opportunity to explore the nature of agglomeration and its effects on firm-level technical efficiency.

The rest of the article is structured as follows. Section 2 describes the nature of agglomeration economies, followed by a discussion of Indonesia's industrial development and spatial concentration in Section 3. Section 4 explains the research methodology while Section 5 presents the data and the measurement of the variables. Section 6 discusses the empirical results and analysis. Section 7 concludes the article.

2. Agglomeration Economies and Externalities

Empirically, the effects of agglomeration economies upon firm-specific technical efficiency can be analysed within the framework of static and dynamic externalities. Agglomeration economies are recognized as the special type of spatial externalities. Externality is a spreading effect of one activity that affects another activity, but, importantly, this condition is not directly reflected in the mechanism of market prices (Griliches 1992; Beaudry and Schiffauerova 2009). By their nature, externalities arise due to the interaction between economic agents, so that their effects should be most prominent when agents are in close physical proximity (Dekle 2002; Claver et al. 2012). Static externalities refer to the benefit of firms from agglomeration within a single industry or within what are recognized as localization economies. These static externalities benefit from urban scale and diversity or urbanization. According to Marshall (1920), the existence of such externalities is due mostly to access to natural resources, transport advantages, and the saving costs of moving inputs. However, dynamic externalities arise primarily from dynamic interactions between firms or labour (Henderson et al. 1995).

Dynamic externalities such as knowledge spillovers or learning by doing (Lucas 1988; Romer 1986) can be the driving-force for long-run economic and industrial growth (He and Pan 2010). Similarly, Hoover (1937) argues that external economies might include localization economies that result from firms in the same industries being located in specific regions and urbanization economies, which result from the co-location of firms in different industries. Because these external advantages tend to increase with the number and output of collocating firms, the phenomenon is usually referred to as agglomeration economies (Dawkins 2003; Glaeser et al. 1992). From this point of view, agglomeration, externalities, and industrial development are an integrated chain, which plays an important role in promoting efficiency and productivity growth.

Following Glaeser et al. (1992), three channels of agglomeration economies are analysed here: Marshall–Arrow–Romer (MAR) externalities or specialization, Jacobs' externalities or diversity, and Porter's externalities or competition. The MAR externalities stress the benefit of knowledge spillovers within an industry, where knowledge accumulated from one firm's sustainable interaction process tends to assist other firms' technological development without appropriate compensation. This process can take place in a geographically concentrated industry, where the producers can learn from each other employees communicating across firms and moving from one firm to another. Unlike MAR, Jacobs' externalities focus on industrial diversity as a source of growth, because the interchange of different ideas between firms in different industries is viewed as being more likely. Jacobs (1969) argues that the most prominent sources of knowledge spillovers are those resulting from interactions between firms from different industries in a particular region.

Finally, Porter's externalities mainly focus on the role of competition in local economic or industrial growth. As with the MAR model, Porter stresses the contribution of specialization to the growth of specialized industries, or of the region they are in, or of the spillovers from firms within the same industry (Glaeser et al. 1992). Porter states that knowledge spillovers mostly occur in vertically-integrated industries, which is in line with the Marshallian specialization hypothesis (Beaudry and Schiffauerova 2009). Conversely, regarding the innovation process, Porter agrees with Jacobs that local competition is good, because it supports imitation and innovation. Moreover, Porter argues that strong competition leads to innovation and accelerates the technical progress and hence productivity growth.

3. Industrial Development and Spatial Concentration in Indonesia

Modern industrial development in Indonesia was started in the early 1970s. Initially, this development was reliant on the oil sector and high levels of protection for state-owned enterprises (SOEs). The important achievement at the macro-level of Indonesia's economy has been its structural transformation (Hill 1990a) in this period. In a relatively short period, from the mid-1960s to just before the economic crisis in 1998, Indonesia's economy was transformed from being stagnant and dominated by the agrarian sector to containing a strong manufacturing industry with its exports driving sustained economic growth (Jacob 2005). Manufacturing share to GDP increased substantially from only 7.3 percent in 1967 to 26.2 percent in 2009. Conversely, the agriculture share to GDP declined from 53.9 percent in 1967 to only 13.6 percent in 2009. Another indicator reflecting this structural transformation is the share of labour to total employment. The manufacturing contribution increased from 6.7 percent in the 1976 to 12.1 percent in 2009 (Indonesian Statistics 2009).

As well as national trends, an important phenomenon has been taking place at the regional level, namely the emergence of agglomeration or regional industrial concentration. For example, manufacturing development is concentrated on the Island of Java, whose share reaches around 80 percent. How firms tend to concentrate at specific regions is a topic of interest. From the structuralist point of view, this phenomenon could be due to an imbalance in regional development and distribution, so that particular regions obtain more benefit than others do. Moreover, from an externalities perspective, this phenomenon emerges due to the benefit received by economic agents for physical and regional proximity.

Geographically, Indonesia is an archipelagic country with around 13,000 islands. It is one of the most spatially diverse nations in terms of its natural resources, population, and the location of its economic activities. Manufacturing production and activities were mostly concentrated in Java, which had an average share of value-added of 79.0 percent during 1976–2009. The provinces of West Java, Jakarta, East Java, and Banten, dominated the share of value-added of manufacturing industry in Java while the contribution of Central Java province tended to decrease consistently from 1976 to 2009. In addition, Sumatera was the second largest island for manufacturing production activity, with the major contributors being North Sumatera, Riau, South Sumatera, and Riau Islands. In Kalimantan, the manufacturing industries tend to agglomerate in West Kalimantan and East Kalimantan, which are the two most developed provinces in this island. In Sulawesi, the concentration of industry is in South Sulawesi and North Sulawesi. In other regions of Eastern Indonesia, Bali and Papua have become the main bases for manufacturing production. The new provinces emerge in this group of regions were North Maluku and West Papua.

The Island of Java and Sumatera have long been recognized as part of Western Indonesia that is more developed than most regions in Eastern Indonesia. Java became the centre of industrial production because of the historical fact that development in Indonesia started on this island. Thus, Java provides numerous advantages for economic agents, specifically the availability of adequate infrastructure and production factors. Notwithstanding this, particular industries are spreading throughout Indonesia, specifically industries which rely on certain production inputs, such as natural resources. Table 1 provides more details of agglomeration industries at the district or regency level.

Table 1: Spatial Distribution of Manufacturing Industry 2009

No	Group of Regions	Value Added (Trillion IDR)	Labour (000)	Number of Firm	Share to National Level (%)		
					VA	Labour	Firm
	JAVA						
1	Jakarta	384.5	1,358.1	5,324	48.0	31.3	21.8
2	Surabaya	98.9	654.7	3,858	12.4	15.1	15.8
3	Kediri	27.2	54.8	152	3.4	1.3	0.6
4	Bandung	29.8	372.4	1,977	3.7	8.6	8.1
5	Semarang	25.8	341.1	1,484	3.2	7.9	6.1
6	Surakarta	9.2	141.3	895	1.2	3.3	3.7
	NON-JAVA						
7	Riau	23.7	23.3	40	3.0	0.5	0.2
8	East Coast Sumatra	20.3	103.5	747	2.5	2.4	3.1
9	Palembang	22.3	30.6	148	2.8	0.7	0.6
10	Batam	23.7	141.9	326	3.0	3.3	1.3
11	Samarinda	6.6	19.6	76	0.8	0.5	0.3
12	Padang	5.7	6.9	54	0.7	0.2	0.2
13	Pangkal Pinang	3.0	5.2	21	0.4	0.1	0.1
	Total of groups	**680.8**	**3,253.3**	**15,102**	**85.06**	**74.87**	**61.72**

Note: the spatial concentration refers to the group of regions (Jakarta means Jakarta and surrounding areas); table format is adopted from Hill (1990b)
Source: Large and Medium Industrial Statistics 2009, Statistics Indonesia *(Badan Pusat Statistik – BPS),* author's calculation.

From Table 1, it appears that Jakarta and surrounds is still the largest pole of manufacturing production activities, with its value-added share to total national industry reaching 48.0 percent in 2009. In this group of regions, Karawang has emerged as a promising new district that could function as a base for manufacturing production especially after the economic crisis in 1998. The limited capacities of Jakarta, Bogor, Tangerang and Bekasi have enabled Karawang, as the closest district, to become a new base of production.

The second largest pole of agglomerated industries, Surabaya and surrounds, is still dominated by Surabaya, Gresik, and Sidoardjo, where manufacturing industries traditionally have been established. The contribution of this group of regions to national manufacturing value-added is 12.4 percent. Other important poles of manufacturing industries in Java are Bandung and surrounds (3.7%), Semarang and surrounds (3.2%), and Surakarta and surrounds (1.2%). Outside Java, there are several groups of regions in which manufacturing industries and firms tend to agglomerate, for example Riau (3.0%), the east coast of Sumatera (2.5%), Palembang and surrounds (2.8%), Batam and surrounds (3.0%), and other regions with a share of value-added less than 1 percent i.e. Samarinda-Bontang (East Kalimantan), Padang (West Sumatera), and Pangkal Pinang.

Table 1 indicates that the tendency of firms to concentrate in a specific region is influenced by the size and the rate of growth of the cities or regions in which they are located. The growing cities or regions attract economic agents, who enter to develop their businesses around the centres of growth. Jakarta and Surabaya and their surrounding regions appear to have the requisite features for agglomeration. In addition, government's decentralization programs in the recent decade provide impetus for agglomeration through dynamic interaction between regions.

4. Methodology

Following the seminal work of Farrell (1957) and the pioneering works of Aigner et al. (1977) and Meeusen and Broek (1977) technical efficiency can be derived from stochastic production frontier which can be written as:

$$\mathrm{Y_i} = \mathrm{f}(\mathrm{x_i}; \beta)\ \exp(\mathrm{V_i} - \mathrm{U_i})\quad i=1,2,...,N \qquad (1)$$

where V_i is a random error with zero mean, which is associated with random factors not under control of the firm while U_i is associated with firm technical inefficiency. Technical efficiency (TE) is defined as the ratio between observed output (Y_i) to the maximum possible output (Y_i^*) of i^{th} firm, that is:

$$\begin{aligned}\mathrm{TE_i} &= \mathrm{Y_i}/\mathrm{Y_i^*}\\ &= \mathrm{f}(\mathrm{x_i}, \mathrm{t}, \beta)\ \exp(\mathrm{v_i} - \mathrm{u_i}) /\ \mathrm{f}(\mathrm{x_i}, \mathrm{t}, \beta)\ \exp(\mathrm{v_i})\\ &= \exp(-\mathrm{u_i}) \qquad (2)\end{aligned}$$

where $\exp(-u_i)$ implies that random variable with values between zero and one. To analyse the impact of agglomeration economies upon firm-level technical efficiency, this article applies the one-stage stochastic frontier model proposed by Battese and Coelli (1995). To estimate the parameters of the stochastic frontier model, the following functional form is specified:

$$\ln y_{it}=\beta_0+\sum_n \beta_n \ln x_{nit}+\beta_t t+\frac{1}{2}\sum_n \sum_k \beta_{nk} \ln x_{nit} \ln x_{kit}+\frac{1}{2}\beta_{tt} t^2+\sum_n \beta_{nt} \ln x_{nit} t+v_{it}-u_{it} \qquad (3)$$

where y is output and x is inputs of production consisting of L (labour), K (capital), M (raw material) and E (energy), t is time, i is firm, $\beta' s$ are parameters to be estimated, ln denotes natural logarithm, v_{it} is the stochastic error term, and u_{it} is technical inefficiency. In this model, the technical inefficiency effect is a function of agglomeration economies' variables. Following Glaeser et al. (1992), the agglomeration economies' variables used in this model include specialization or MAR externalities (LQ), diversity or Jacobs' externalities (DIV), and competition or Porter's externalities (COM). Variables of industrial structure and firm characteristics included in the model are firms' age (AGE), size (SIZE), industrial concentration ratio (CR4), and two dummy variables representing urban area (DURB) and industrial complex (DLOC). The technical inefficiency function can be expressed as:

$$u_{it}=\delta_0+\delta_1 LQ_{it}+\delta_2 DIV_{it}+\delta_3 COM_{it}+\delta_4 AGE_{it}+\delta_5 SIZE_{it}+\delta_6 CR4_{it}++\delta_7 DLOC_{it}+\delta_8 DURB_{it}+w_{it} \qquad (4)$$

where w_{it} is an error term. The stochastic production frontier in Equation (3) and the technical inefficiency function in Equation (4) can be estimated simultaneously in one-stage by using the computer program FRONTIER 4.1 under the maximum likelihood method as developed by Coelli (1996).

5. Data and Measurement Variables

This article uses the data of medium and large manufacturing industries from 2004 to 2009 provided by the Indonesian Statistics *(Badan Pusat Statistik – BPS).* The final dataset to be estimated is constructed in a balance panel data. The panel data is synchronized based on the firm's identity (PSID). All variables used in frontier production function are in values (Indonesian Rupiahs – IDR) except for labour which is represented by total number of employee. Since the variable of capital (K), raw material (M), energy (E) and output (Y) are in market values, so the wholesale price index (WPI) of manufacturing industry for 2-digit

ISIC is used to deflate these variables. After doing a data cleaning process we finally obtain a balanced panel dataset with number of firms per year 4,240 and total observations of 25,440.[1]

Table 2: Summary Statistics of Variables

Variable	Mean	SD	Min	Max
LnY	15.057	2.177	9.371	23.687
LnL	4.474	1.247	2.996	10.618
LnK	13.452	2.623	0.166	29.921
LnM	14.165	2.422	5.737	22.704
LnE	11.667	2.229	3.360	20.853
T (time)	3.500	1.708	1.000	6.000
LQ (specialization)	0.942	0.198	0.278	2.449
DIV (diversity)	7.663	2.011	1.106	10.111
COM (competition)	1.012	0.128	0.322	2.265
AGE	20.203	12.602	1.000	103.000
SIZE	4.474	1.247	2.996	10.618
CR4	27.074	15.064	9.290	93.490
DURB	0.465	0.499	0.000	1.000
DLOC	0.089	0.285	0.000	1.000

Notes: all variables in production frontiers (output, labour, capital, raw material and energy) are in natural logarithm; LQ, DIV and COM are indexes; AGE is in year; SIZE is natural logarithm of total employee; CR4 is in percentage; DURB and DLOC are dummy variables.

Variables used in technical inefficiency function are measured as follows. Specialization or MAR externality is measured by location quotient (LQ); diversity (DIV) or Jacobs' externality is measured by inverse of Hirchman-Herfindahl Index (HHI); competition (COM) or Porter's externality is measured by ratio of firm-based LQ to employee-based LQ following Nakamura and Paul (2009); firm's age (AGE) is measured by the length of production time from the beginning of establishment; firm's size (SIZE) is measured by total number of employees; industrial concentration (CR4) is measured by share of four largest firm in 2-digit ISIC level; dummy for urban area (DURB) is represented by value 1 for the firms located in urban area; and dummy for industrial complex (DLOC) is represented by value 1 for the firms located inside industrial complex.[2] Detail descriptions and methods used

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[1] The procedure of data cleaning is conducted by following Takii (2004) and Suyanto et al. (2009). We do not repeat the procedures here to conserve space.

[2] The 2-digit ISIC level for measuring industrial concentration (CR4) includes 22 industry sub-sectors, which exist in the Indonesian manufacturing structure.

to develop the agglomeration economies variables are presented in the appendix. In addition, Table 2 presents the descriptive statistics of variables.

6. Empirical Results and Analysis

The reliability of empirical results crucially depends on the correct specification of functional form in applied research. The Cobb-Douglas functional form has been widely used in stochastic frontier analysis as this affords maximum flexibility in dealing with data imperfections and combines some other attractive properties with simplicity. However, the major concern of Cobb-Douglas function is its restrictive assumptions including constant technological change. Although the Translog production function is a more general type of production function, it may not provide efficient estimates, because collinearity among the explanatory variables cannot be avoided. Thus, the Translog and the Cobb–Douglas specifications for annual (real value of output) data are sequentially tested by using the generalized likelihood ratio (LR) test as an important decision-making tool when theoretical considerations do not suggest correct functional specifications. Statistical results support the the flexible translog functional form, as specified in Equation 3, in this case. [3]

In this research, three different models are estimated to observe the impact of agglomeration economies and other firm specific factors on firm-level technical efficiency. The first model focuses on the influence of two dynamic externality variables, i.e. specialization (MAR externalities) and diversity (Jacobs' externalities). Both variables of dynamic externalities have been historically debated among scholars, especially their contribution to economic growth or industrial productivity (Glaeser et al. 1992 and Henderson 2003). The empirical results on this issue have been mixed, and the conclusions depend on the circumstances and methodologies applied (Beaudry and Schiffauerova 2009). In the second model, the variable of competition (Porter's externalities) is added. This is another important variable of dynamic externalities. In the third model, firm's characteristics such as age, size, and concentration ratio are added. Meanwhile, two dummy variables representing urban area and industrial complex are included in all the models. Before going for empirical estimation of these three models, co-efficient of correlation among all explanatory variables have been calculated and no sign of serious multicolinearity is observed. Finally, the full estimation results for the three different models are presented in Table 3

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[3] Test results are not reported here to conserve space, however, can be obtained from authors upon request.

The empirical results for the three models show consistent estimates for both coefficients in the production as well as in the inefficiency function. The interpretation of the estimation results begins with an analysis of the coefficient of production inputs. Further discussions and analysis refer to Model 3 as the estimation function for the full set. The coefficients for labour, capital, raw materials, and energy are 0.8414, 0.0510, 0.0603, and 0.2657 respectively. The signs are positive, indicating that an increase in production inputs will increase production output. This estimation result is mostly in line with previous research in Indonesia, such as that of Pitt and Lee (1981), Margono and Sharma (2006), Ikhsan (2007) and Suyanto et al. (2009). The one difference is the magnitude of the coefficient, where by labour contributes most substantially.

To examine the actual influence of the factor inputs upon the output in the production process we calculate the elasticity for each input. Table 4 shows the output elasticity with respect to labour, capital, materials, and energy during the period 2004-2009. All elasticity estimates are positive; of these, the elasticity for materials, with an average of 0.396, is the highest. This is not surprising, because raw materials represent the largest share in the structure of production inputs. In 2009, for example, the expenditure for raw materials in the structure of production inputs was 77.6 percent. The percentage value for this expenditure is similar from year to year. Related to this issue, Aswicahyono et al. (1996) and Dhanani (2000) argue that Indonesian manufacturing products are dominated by resource-based or simple assembly-processed products which causes the industry to rely heavily on raw materials.

The output elasticity for capital is relatively small, 0.166. This is also as expected, as Indonesian manufacturing is generally dominated by light or labour intensive industries, which do not depend much on capital. As argued by Hill (1990a, 1990b), capital intensive industries are mostly related to heavy-processing industries such as chemical and chemical products or heavy-engineering industries such as machines and transport equipment.

Table 3: The Estimation Results of the Production Frontier Model, 2004-2009

Variables	Parameters	Model 1		Model 2		Model 3	
		Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Production function (dep var: LnY)							
Constant	β_0	4.3677	46.96$^{a)}$	4.3777	48.43$^{a)}$	4.4847	48.70$^{a)}$
T	β_T	0.0312	2.54$^{a)}$	0.0324	2.71$^{a)}$	0.0347	2.82$^{a)}$
Ln(L)	β_L	0.8415	34.05$^{a)}$	0.8434	33.97$^{a)}$	0.8414	35.48$^{a)}$
Ln(K)	β_K	0.0503	5.46$^{a)}$	0.0493	5.72$^{a)}$	0.0510	5.50$^{a)}$
Ln(M)	β_M	0.0776	5.87$^{a)}$	0.0692	5.34$^{a)}$	0.0603	4.54$^{a)}$
Ln(E)	β_E	0.2654	23.00$^{a)}$	0.2732	24.55$^{a)}$	0.2657	22.98$^{a)}$
$[\mathrm{Ln(L)}]^2$	β_{LL}	0.0448	15.12$^{a)}$	0.0452	15.38$^{a)}$	0.0448	16.25$^{a)}$
Ln(L)* Ln(K)	β_{LK}	0.0135	7.53$^{a)}$	0.0134	7.43$^{a)}$	0.0135	7.34$^{a)}$
Ln(L)* Ln(M)	β_{LM}	-0.0912	-36.41$^{a)}$	-0.0915	-37.30$^{a)}$	-0.0907	-36.70$^{a)}$
Ln(L)* Ln(E)	β_{LE}	0.0076	3.22$^{a)}$	0.0076	3.26$^{a)}$	0.0065	2.77$^{a)}$
$[\mathrm{Ln(K)}]^2$	β_{KK}	0.0085	19.70$^{a)}$	0.0085	19.58$^{a)}$	0.0084	20.62$^{a)}$
Ln(K)* Ln(M)	β_{KM}	-0.0190	-20.33$^{a)}$	-0.0186	-20.49$^{a)}$	-0.0189	-19.89$^{a)}$
Ln(K)* Ln(E)	β_{KE}	-0.0014	-1.48$^{c)}$	-0.0017	-1.79$^{b)}$	-0.0014	-1.47$^{c)}$
$[\mathrm{Ln(M)}]^2$	β_{MM}	0.0698	87.15$^{a)}$	0.0701	88.42$^{a)}$	0.0704	86.25$^{a)}$
Ln(M)* Ln(E)	β_{ME}	-0.0638	-52.29$^{a)}$	-0.0641	-52.94$^{a)}$	-0.0641	-52.01$^{a)}$
$[\mathrm{Ln(E)}]^2$	β_{EE}	0.0327	42.78$^{a)}$	0.0328	43.65$^{a)}$	0.0330	42.64$^{a)}$
Ln(L)*T	β_{LT}	0.0047	2.35$^{a)}$	0.0047	2.35$^{a)}$	0.0045	2.28$^{b)}$
Ln(K)*T	β_{KT}	-0.0003	-0.36	-0.0001	-0.17	-0.0005	-0.59
Ln(M)*T	β_{MT}	-0.0036	-3.39$^{a)}$	-0.0033	-3.11$^{a)}$	-0.0035	-3.24$^{a)}$
Ln(E)*T	β_{ET}	0.0022	2.07$^{b)}$	0.0017	1.59$^{c)}$	0.0022	2.03$^{b)}$
T^2	β_{TT}	-0.0035	-3.38$^{a)}$	-0.0037	-3.62$^{a)}$	-0.0036	-3.51$^{a)}$

Variables	Parameters	Model 1		Model 2		Model 3	
		Coefficient	t-ratio	Coefficient	t-ratio	Coefficient	t-ratio
Inefficiency function (dep var: u)							
Constant	δ_0	-0.2257	-12.47 [a)]	-0.3752	-13.31 [a)]	-0.1753	-10.68 [a)]
LQ (specialization)	δ_1	-0.1477	-19.66 [a)]	-0.0726	-6.53 [a)]	-0.1101	-21.82 [a)]
DIV (diversity)	δ_2	0.0677	27.11 [a)]	0.0565	15.57 [a)]	0.0571	27.01 [a)]
COM (competition)	δ_3	(-)		0.1651	10.49 [a)]	0.0278	2.62 [a)]
Age (firm age)	δ_4	(-)		(-)		-0.0006	-8.94 [a)]
SIZE (firm size)	δ_5	(-)		(-)		-0.0132	-9.27 [a)]
CR4 (concentration ratio)	δ_6	(-)		(-)		0.1201	8.47 [a)]
DURB (dummy urban)	δ_7	-0.2516	-20.44 [a)]	-0.2602	-23.07 [a)]	-0.2743	-21.90 [a)]
DLOC (dummy location)	δ_8	-0.0357	-3.38 [a)]	-0.0394	-4.33 [a)]	-0.0184	-2.74 [a)]
	σ^2	0.1466	106.23 [a)]	0.1464	106.33 [a)]	0.1465	106.45 [a)]
	γ	0.0238	15.78 [a)]	0.0183	8.40 [a)]	0.0184	9.40 [a)]
Mean of TE		0.9084		0.9138		0.9156	
Establishments		4,240		4,240		4,240	
Observations		25,440		25,440		25,440	

Note: [a)], [b)], and [c)] denote significance at 1%, 5%, and 10% respectively.

Moving to the return to scale (RTS), Table 4 presents the scores of return to scale in manufacturing industries from 2004 to 2009. The RTS is the sum of output elasticities with respect to all production inputs. The average score is 1.081, greater than 1, implying that in the period 2004 to 2009 manufacturing industries in Indonesia experienced increasing returns to scale (IRTS). The result of increasing returns to scale is consistent with the rejection of the first hypothesis, the Cobb-Douglas function, which assumes constant returns to scale (CRTS) in its technological set.

Table 4: Elasticity of output with respect to production inputs, 2004-2009[4]

Year	L	K	M	E	RTS
2004	0.294	0.163	0.401	0.215	1.072
2005	0.313	0.176	0.379	0.216	1.084
2006	0.290	0.138	0.425	0.211	1.064
2007	0.293	0.144	0.411	0.222	1.070
2008	0.304	0.153	0.407	0.213	1.077
2009	0.342	0.223	0.353	0.199	1.117
Average	0.306	0.166	0.396	0.212	1.081

Source: author's calculation.

The average score of technical efficiency (TE) in Indonesian manufacturing industries from 2004 to 2009 increases consistently, with an average around 91.56 percent. This TE score is relatively higher than those of previous findings in Indonesia. Margono and Sharma (2006) find the average technical efficiency 55.9 percent for four industrial sectors: food, textiles, chemical and metal products during the period 1993 to 2000. However, in particular industrial sectors such as metal products, the technical efficiency is as high as to 85.8 percent in 2000. Similarly, Hill and Kalirajan (1993) find the average technical efficiency to be 62.5 percent for the small garments industry for the year 1986, while Pitt and Lee (1981) report an average of 67.7 percent technical efficiency for the weaving industry in period 1972 to 1975.

In model 3, the coefficient for time trend (T) is positive (0.0347) and significant at 1 percent, suggesting that, in general, technological progress occurs over time. The output level increases

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[4] The output elasticity of each production input is calculated by taking a partial derivative of the production *translog* model. Based on Equation 3, the output elasticity of labour is defined as $\varepsilon_L = \beta_L + 2\beta_{LL}(lnL) + \beta_{LK}(lnK) + \beta_{LM}(lnM) + \beta_{LE}(lnE) + \beta_{LT}(T)$. The same procedure is used to calculate the output elasticity with respect to capital, materials and energy. These estimates are calculated at the value of the variables.

3.47 percent per annum during 2004 to 2009, due to technological progress. The finding of annual technological progress is in line with previous studies, such as those of Margono and Sharma (2006). They find technical progress of 10.54 percent per annum in food industries for the period 1993 to 2000 while Ikhsan (2007) reports 7.16 percent for the period of 1988-1992 and 5.45 percent per annum for the period of 1993-1996 across all manufacturing industries. Meanwhile, Suyanto et al. (2009) note that domestic firms' experienced technological progress of 0.5 percent per year during the period 1988 to 2000.

The estimation results in Table 3 show that the coefficient of specialization (MAR externalities) is negative and significant at 1 percent. This indicates that regions with higher industrial specialization or a high relative level of regional specialization promote higher firm-level technical efficiency. Thus, in the period 2004 to 2009 the more specialized the industries in a particular region relative to the specialization of industries in all regions, the greater that region' firm-level technical efficiency. It also suggests that a high share of a particular or dominant industry in a region will stimulate higher firm-level technical efficiency in that entire region. The positive impact of industrial specialization upon firm technical efficiency ultimately lifts the firm's productivity level as technical efficiency is part of the total factor productivity (TFP).

This finding is in line with previous studies in Indonesia, such as that of Kuncoro (2009). He analyses the impact of specialization and diversity upon labour productivity in several industries by comparing three different periods: 1990–1995, 1997–2000, and 2001–2003. This results show that in general the magnitude of the influence of specialization is greater than that of diversity, especially in the textiles, garments, leather, footwear, chemicals and machineries industries. The nature of externalities and agglomeration favour industrial spillovers, that is, localization is seen to be stronger than urbanization effects.

The relative importance of specialization on firms' technical efficiency found in this study is in accordance with the empirical results in various international cases, for example, Nakamura (1985) finds that localization economies positively impact productivity in Japanese manufacturing industries; similarly Henderson (1986) for numerous industries in the U.S. and Brazil manufacturing industries. Each of these studies is more favourable to the existence of localization economies than urbanization economies. Duranton and Puga (2001) obtain a similar result using French data. Henderson (2003) finds similar result in selected Korean manufacturing industries from 1983 to 1993, whereas MAR externalities positively impact on productivity.

Adopting a different approach, Lee et al. (2010) find the same positive impact using the data of the Korean Mining and Manufacturing Survey (MMS) in 2000.

Moving to the impact of diversity or Jacobs' externalities, upon firm-level technical efficiency, the estimation results show a positive relation between diversity and firm-level technical inefficiency. This indicates that a high level of diversity in a region tends to reduce firm-level technical efficiency that is firms located in highly diversified regions tend to have lower technical efficiency levels. In the Indonesian case, this finding is consistent with Kuncoro (2009), who found that greater diversity led to lower levels of productivity in several manufacturing industries for the period 1990 to 2003. The estimation results above indicate that in the period 2004 to 2009 MAR externalities, or specialization, is more conducive to stimulating firm-level technical efficiency than Jacobs' externalities (diversity). This fact confirms that knowledge spillovers are more prevalent in firms of the same industry than in firms of different industries. Furthermore, if firms in the same industry are located close to firms of their industry, they will benefit from the emergence of knowledge, network and technology spillovers (Henderson 2003; Koo 2005).

The third dynamic externalities variable in the technical inefficiency function is competition or Porter's externalities. Similar to that for diversity, the coefficient for competition is positive. With regard to the definition of competition used in this study, the estimation results indicate that the regions with high level of competition, or the regions dominated by small firms, tend to be more conducive to fostering firm-level technical efficiency.[5] The results also mean that firms located in the competitive regions tend to experience higher technical efficiency than firms located in more oligopolistic or monopolistic regions. This shows that local competition plays a crucial role in the transmission of knowledge spillovers among firms in a particular region. This finding clearly supports Porter's argument regarding the importance of competition for stimulating firm's productivity, a position which is consistent with Jacobs'. While Porter concurs with Jacobs about the role of local competition in the transmission of knowledge across firms, but regarding intra-industries spillovers, he agrees with the MAR specialization hypothesis. To illustrate the nature of competition in Indonesia, Table 5 presents the market environment at the regional level, is specified and measured by province.

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[5] Higher value of competition index means higher level of concentration. Therefore, a positive sign of competition in inefficiency function means that inefficiency increase with higher level of concentration.

Table 5: Location Quotient and Regional Industrial Environment 2009

Region/Province		LQ_{ij}^{L}	LQ_{ij}^{F}	LQ_{ij}^{L}/LQ_{ij}^{F}	Regional Environment
11	Aceh	0.485	0.507	0.955	Competitive
12	North Sumatera	0.993	0.807	1.231	Monopolistic/oligopolistic
13	West Sumatera	0.651	0.567	1.148	Monopolistic/oligopolistic
14	Riau	0.744	0.535	1.391	Monopolistic/oligopolistic
15	Jambi	0.596	0.595	1.002	Monopolistic/oligopolistic
16	South Sumatera	0.731	0.842	0.868	Competitive
17	Bengkulu	0.537	0.508	1.057	Monopolistic/oligopolistic
18	Lampung	0.518	0.610	0.850	Competitive
19	Babel	2.209	1.739	1.270	Monopolistic/oligopolistic
21	Riau Islands	1.806	3.415	0.529	Competitive
31	Jakarta	1.260	1.259	1.001	Monopolistic/oligopolistic
32	West Java	1.126	1.065	1.057	Monopolistic/oligopolistic
33	Central Java	0.711	0.736	0.966	Competitive
34	Yogyakarta	1.003	1.063	0.943	Competitive
35	East Java	0.886	0.953	0.930	Competitive
36	Banten	1.137	1.384	0.822	Competitive
51	Bali	0.718	0.650	1.105	Monopolistic/oligopolistic
52	NTB	0.957	0.778	1.230	Monopolistic/oligopolistic
53	NTT	0.922	0.535	1.722	Monopolistic/oligopolistic
61	West Kalimantan	1.009	1.022	0.988	Competitive
62	Central Kalimantan	0.554	0.829	0.668	Competitive
63	South Kalimantan	0.616	0.733	0.840	Competitive
64	East Kalimantan	0.966	1.018	0.949	Competitive
71	North Sulawesi	0.922	0.784	1.177	Monopolistic/oligopolistic
72	Central Sulawesi	0.675	0.583	1.158	Monopolistic/oligopolistic
73	South Sulawesi	0.638	0.567	1.124	Monopolistic/oligopolistic
74	Southeast Sulawesi	1.649	0.813	2.029	Monopolistic/oligopolistic
75	Gorontalo	1.373	0.888	1.546	Monopolistic/oligopolistic
76	West Sulawesi	0.294	0.416	0.707	Competitive
81	Maluku	0.638	0.893	0.715	Competitive
82	North Maluku	1.364	1.526	0.894	Competitive
91	West Irian	0.905	1.503	0.602	Competitive
94	Papua	0.601	0.586	1.026	Monopolistic/oligopolistic

Note: LQ_{ij}^{L} is labour-based LQ; LQ_{ij}^{F} is firms-based LQ. Regional monopolistic/oligopolistic environment indicates that region *j* contains relatively large plants while regional competitive environment indicates that region *j* contains relatively small plants (Nakamura and Paul 2009).

Source: Large and Medium Industrial Statistics 2009, Statistics Indonesia *(Badan Pusat Statistik – BPS)*, author's calculation.

Based on Table 5, the competitive provinces are considered to be the regions that are more conducive to firm-level technical efficiency than those regions that have oligopolistic or monopolistic market environments. These competitive regions are dominated by small- and medium-scale industries. However, in reality most provinces' market structures are close to being monopolistic or oligopolistic. These facts confirm that the contribution of large-scale firms to the manufacturing industry is still dominant, even though the competitive regions actually support firm-level technical efficiency than oligopolistic or monopolistic regions. Other important variables in terms of firm's location that are considered as factors influencing firm-level technical efficiency are urban region/area and industrial complex. Urban area is associated with regions that have adequate and good public infrastructure and facilities. By its nature, this will attract firms to locate in the region. Urban areas generally form through a natural process that follows the development policies adopted by the government. On the other hand, industrial complexes tend to be created by special policies implemented by the government in order to accelerate the performance of particular industries.

The estimation result for the dummy variable of urban area (DURB) is negative and significant at 1% level, implying that firms located in urban areas tend to be more technically efficient than firms located in non-urban areas. This result confirms that urban area is important for stimulating firm-level technical efficiency and productivity. This finding is not surprising, due to the above-mentioned fact that urban areas can provide better public facilities and infrastructures. In Indonesia many urban regions are located adjacent to each other, as existing groups' and these groups normally have good access to centres of growth. Theoretically, urban areas may be gainful for industrial agglomeration in terms of regional advantages, home market effect and consumption levels. Home market effect implies that locations with larger local demand attract a more than proportionate share of firms in imperfectly competitive industries (Ottaviano and Thisse 2004). Moreover, in some aspects urban areas are like cities. Glaeser et al. (2001) mention that cities can provide benefits to firms in ways, such as increased consumption levels through the availability of goods and services, the availability of public goods, and more interaction between firms in the same industry due to the level of density and offer various other economic opportunities.

It is seen in Table 1 that urban regions contribute a high share of value added (85.06%), labour (74.84%), and number of firms (61.72%) to Indonesia's manufacturing industries as a whole.

This feature supports the hypothesis that firms located in these areas are likely to have higher technical efficiency. Adequate business facilities allow firm to increase the scale of production and then the average production costs declines, indeed it will be beneficial to concentrate the production in specific regions. If firms located in a region with good access to markets, it will stimulate the economic agents to increase production to meet increasing demand (Lall et al. 2004).

The second dummy variable (DLOC) is to represent industrial complex. The estimation result for this variable is negative, in line with the result for urban area. It indicates that firms located inside an industrial complex tend to have higher technical efficiency than firms located outside an industrial complex. This finding is as expected because industrial complexes normally provide a sound environment for firms to carry out their production processes. The emergence of industrial complex/area in Indonesia was started with Presidential Decree 41/1996. The decree was strengthened by a more comprehensive formal regulation namely the Government Regulation 24/2009. It was issued after a period of rapid growth of industrial areas in Indonesia.

In this case, the government took a position as regulator and facilitator. The nature of industrial areas in Indonesia cannot be directly compared to with that of industrial complexes or districts in developed countries, for example Silicon Valley in the U.S and Emilia Romagna in Italy. However, the spirit is the same i.e. to increase the performance of firms by providing better infrastructure and a sound business environment. Table 6 shows the proportion of firms located inside or outside industrial areas in 2009. Only 6.71% or 1,641 firms are located inside industrial complexes, while 93.29% or 22,287 firms are located outside these industrial areas. From 23 industrial sectors, only four sectors have a relatively high share of firms located inside industrial areas i.e. basic metals–ISIC 27 (23.5%), electrical machinery–ISIC 31 (20.56%), radio, TV and communication apparatus–ISIC 32 (35.19%) and medical and optical instruments–ISIC 33 (29.85%). Related advantages of a firm being located inside an industrial area are that the flows of experience, information and knowledge within the area are more effective, as there is less constraint to these interchanges (Marshall 1920). Further, forms benefit from collective competencies (Storper 1995) and collective learning (Cappelo 2002).

As well as the variables of agglomeration economies and location, this study includes other variables considered determinants of firm-level technical efficiency, i.e. firm age (AGE), firm size (SIZE), and industrial concentration ratio (CR4). As characteristics of the firm, these variables also represent firm structure and conduct.

Table 6: Number of Firms Located in Industrial Complex 2009

ISIC	Industries	Number of firms			(%)	
		inside	outside	total	inside	outside
15	Food products and beverages	316	5,555	5,871	5.38	94.62
16	Tobacco	53	998	1,051	5.04	94.96
17	Textiles	100	2,501	2,601	3.84	96.16
18	Wearing apparel	30	2,110	2,140	1.40	98.60
19	Tanning and dressing of leather	49	620	669	7.32	92.68
20	Wood and products of wood except furniture and plating materials	64	1,188	1,252	5.11	94.89
21	Paper and paper products	19	433	452	4.20	95.80
22	Publishing, printing and reproduction of recorded media	17	678	695	2.45	97.55
23	Coal, refined petroleum products and nuclear fuel	7	66	73	9.59	90.41
24	Chemicals and chemical products	126	963	1,089	11.57	88.43
25	Rubber and plastics products	220	1,419	1,639	13.42	86.58
26	Other non-metallic mineral products	38	1,660	1,698	2.24	97.76
27	Basic metals	55	179	234	23.50	76.50
28	Fabricated metal products, except machinery and equipment	93	820	913	10.19	89.81
29	Machinery and equipment n.e.c	52	357	409	12.71	87.29
30	Office, accounting, and computing machinery	1	8	9	11.11	88.89
31	Electrical machinery and apparatus n.e.c	51	197	248	20.56	79.44
32	Radio, television and communication equipment and apparatus	76	140	216	35.19	64.81
33	Medical, precision and optical instruments, watches and clocks	20	47	67	29.85	70.15
34	Motor vehicles, trailers and semi-trailers	21	262	283	7.42	92.58
35	Other transport equipment	47	277	324	14.51	85.49
36	Furniture and manufacturing n.e.c	177	2,232	2,409	7.35	92.65
37	Recycling	9	117	126	7.14	92.86
	Total	1,641	22,827	24,468	6.71	93.29

Source: Large and Medium Industrial Statistics 2009, Statistics Indonesia *(Badan Pusat Statistik – BPS)*, author's calculation.

Firm Age (AGE)

The estimation results in Table 3 show that firm age (AGE) has a negative effect upon firm-level technical inefficiency. It indicates that older firms have higher levels of technical efficiency than younger firms. The suggested reason for this finding is that older firms have more experience in handling equipment and surviving in difficult economic conditions than do younger firms.

Therefore, older firms are likely to carry out their production processes and management more efficiently than younger ones. Thus, the older firm benefits from its accumulated experience in production. As a consequence, they are technically more efficient. This shows the presence of ‘learning-by-doing’ (Wu 1994). This result concurs with that of previous studies; for example, Chen and Tang (1987) argue that the firm’s experience is central to older firms being more technically efficient than younger firms. More recent studies, such as that by Brouwer et al. (2005), divide firm age into various categories and their results show the older group of firms are technically more efficient in their production processes. Firm productivity increases with age. Lee et al. (2010) also find a similar result when they analyse Marshall’s scale economies and Jacobs’ externalities in Korean manufacturing industries. Again, older firms tend to have higher productivity. Similar results are found in: Wu (1994) in Chinese rural textiles firms; Battese and Coelli (1995) for the agricultural sector in Australia, where older farmers are more technically efficient; Henderson (1986) in Brazilian manufacturing industries; and Kalkulis (2010) in semi-conductor and pharmaceutical industries in the U.S.

Firm Size (SIZE)

The second variable is firm size (SIZE). Its coefficient is also negative, which implies that larger firms tend to have higher technical efficiency levels than the smaller firms. It also indicates that large firms in Indonesian manufacturing industries can effectively manage their power to control the market so that they can reach an optimal level of technical efficiency and place the small firms or new entrants in the position of ‘followers’. This finding is similar to those of the previous research; for example, Pitt and Lee (1981) find that firm size positively effects the technical efficiency level in the Indonesian weaving industry; Bhandari and Ray (2012) find similarly for the Indian textile industry; Fan and Scott (2003) report likewise for furniture and plastic products in Chinese industries; Cingano and Schivardi (2004) for Italian manufacturing industries; Kalkulis (2010) for the semi-conductor and pharmaceutical industries in the U.S; and, finally, Jennen and Verwijmeren (2010) find a similar result in Dutch firms, where size positively impacts firms’ financial performance.

Industrial Concentration (CR4)

The third variable is industrial concentration (CR4). The estimation results show a positive sign for this variable, indicating that firms in a competitive business environment will tend to have higher technical efficiency levels than firms in a less competitive market. It also means that an oligopolistic or monopolistic industrial structure is not suitable for driving firm-level technical efficiency. This result is in line with Setiawan et al. (2012) for the periods of 1995 to 2006. They find a positive relation between industrial concentration and inefficiency-level in Indonesian food and beverages industries at the 5-digit ISIC level. Salim (2008) finds similar results for Bangladesh food processing industries as well. Competition is important because equal power between firms in an industry will reduce levels of market inefficiency. By its nature, competition will stimulate firms to achieve their maximum level of technical efficiency.

Table 7: Industrial Concentration Ratio (CR4) in 2-Digit ISIC 2009

ISIC	Industries	CR4 (%)
15	Food products and beverages	16.42
16	Tobacco	59.63
17	Textiles	33.59
18	Wearing apparel	28.02
19	Tanning and dressing of leather	48.01
20	Wood and products of wood except furniture and plating materials	12.91
21	Paper and paper products	56.03
22	Publishing, printing and reproduction of recorded media	23.54
23	Coal, refined petroleum products and nuclear fuel	61.38
24	Chemicals and chemical products	52.81
25	Rubber and plastics products	17.70
26	Other non-metallic mineral products	45.38
27	Basic metals	37.12
28	Fabricated metal products, except machinery and equipment	29.46
29	Machinery and equipment n.e.c	45.01
30	Office, accounting, and computing machinery	96.75
31	Electrical machinery and apparatus n.e.c	38.89
32	Radio, television and communication equipment and apparatus	32.76
33	Medical, precision and optical instruments, watches and clocks	66.76
34	Motor vehicles, trailers and semi-trailers	60.16
35	Other transport equipment	74.82
36	Furniture and manufacturing n.e.c	24.35
37	Recycling	23.50
	Average	42.83

Source: Large and Medium Industrial Statistics 2009, Statistics Indonesia *(Badan Pusat Statistik – BPS)*, author's calculation.

To investigate the actual market condition for Indonesian manufacturing industries, Table 7 shows the industrial concentration ratio for two-digit ISIC level. From the above table, it appears that the majority of industries have an oligopolistic structure. In 2009, for example, the industrial concentration ratios (CR4) for 11 industries in 2-digit ISIC were greater than 40 percent, with the average for all 23 industries being 42.82 percent. With regard to the estimation results, these facts in Table 7 are actually not conducive to stimulating firm-level technical efficiency. Thus, as mentioned, the oligopolistic and monopolistic structure of Indonesian industries has been widely concerned since the early 1990s. This is because it has been considered as one of the main determinant of market distortion.

7. Conclusion

This article examines the impact of agglomeration economies upon firm-level technical efficiency by using the flexible translog production frontier. The estimation results for the main production inputs are consistent with the theory, in which labour, capital, material, and energy positively impact the firms' output level. In addition, the empirical results show that MAR externalities (specialization) are more important to firm-level technical efficiency than Jacobs' externalities, implying that knowledge spillovers are more effectively transferred among firms in the same industry than diverse industries. Porter's externalities or local competition also stimulate firm-level technical efficiency. Furthermore, the results confirm that urban area and industrial complex contribute positive effects, indicating that a sound business environment and adequate infrastructures are necessary conditions to improve firm-level technical efficiency.

In terms of firm characteristics, there are several different interpretations. The sign of firm age indicates that older firms tend to have higher technical efficiency than younger firms, as they have longer experience– not only in managing their firms but also in facing external shocks. The higher technical efficiency of larger firms implies that firm size has a positive association with firm-level technical efficiency. For the market structure, the results show that a competitive market stimulates greater firm-level technical efficiency than an oligopolistic or monopolistic market, which is indicated by the positive coefficient of the concentration ratio.

From an industrial policy perspective, the empirical results indicate that industrial agglomeration should be considered by the Indonesian government, especially in formulating national industrial development policy. Industrial agglomeration in Indonesia is confirmed as having positive impact upon the firm-level technical efficiency and it may have an important role in increasing productivity in the long-term. This finding is supported by the fact that manufacturing industries in Indonesia tend to concentrate around centres of growth. Moreover, from a macroeconomic point of view, improved productivity levels can potentially increase earnings, income and standards of living. Economists claim that the level of a country's productivity is proportional to its people's standard of living, indicating that higher productivity contributes to a higher standard of living. Furthermore, as the presence of industrial complexes has a positive effect upon firm technical efficiency, the government should continue to implement this policy by creating the number of industrial complexes needed to promote a better business environment for the firms.

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APPENDIX

Measurement of Agglomeration Economies Variables

Agglomeration economies variables that consist of MAR externalities (specialization), Jacobs' externality (diversity) and Porter's externality (competition) are measured based on two-digit ISIC in the provincial level, in which included 22 industry sub-sectors in 33 regions.

MAR Externalities or Specialization (LQ). The regional specialization of an industry can be measured by location quotient (LQ) (Henderson et al.1995; Glaeser et al. 1992). Following Nakamura and Paul (2009), the regional specialization index is defined as the share of industry *i's* employment relative to total industry employment in a specific region *j*, compared to the share of region *j's* employment relative to total (national) employment in industry *i*. That is, the specialization level (denoted S) in region *j* with respect to industry *i* is given by:

$$S_{ij}^{S}=\frac{X_{ij}}{\sum_{i=1}^{I}X_{ij}}=\frac{X_{ij}}{X_{*j}},\ i=1,\ldots,I;j=1,\ldots,J, \qquad \text{(A.1)}$$

where the denominator is aggregated over industries rather than over regions as for industrial localization. Further, at a national level industrial composition is represented by:

$$S_{i*}=\frac{\sum_{j=1}^{J}X_{ij}}{\sum_{i=1}^{I}\sum_{j=1}^{J}X_{ij}}=\frac{X_{i*}}{X_{**}}, \qquad \text{(A.2)}$$

so the regional specialization index relative to national industrial composition can be expressed as:

$$\text{Specialization Index}=LQ_{ij}^{S}=\frac{S_{ij}^{S}}{S_{i*}}=\frac{X_{ij}/X_{*j}}{X_{i*}/X_{**}},\ i=1,\ldots,I \qquad \text{(A.3)}$$

That is, this form of location quotient represents the specialization of industry *i* in region *j* relative to the specialization of industry *i* in all regions. The average of these location quotients across industries can be expressed as:

$$\text{Specialization Index}=LOC_{j}^{S}=\frac{1}{I}\sum_{i=1}^{I}\frac{S_{ij}^{S}}{S_{i*}}, \qquad \text{(A.4)}$$

where $LOC_j^S > 1$ indicates a high relative level of regional specialization for region *j*. This parameter measures how specialized a region is in a particular industry relative to the national level (Glaeser et al. 1992).

Jacobs' Externalities or Diversity (DIV). One of the approaches which can be used to measure the regional diversity or Jacobs' externalities is the inverse of the Hirchman-Herfindahl Index (HHI) in terms of regional specialization, as proposed by Duranton and Puga (2000). It can be written as:

$$\text{Diversity Index}=DIV_{j}^{A}=1\Big/\sum_{i=1}^{I}\left(S_{ij}^{S}\right)^{2}, \qquad \text{(A.5)}$$

where DIV_j^A takes a value of *I* (the number of industries in the industrial classification) if industrial employment in region *j* is evenly distributed among all industries, i.e. maximum diversification (Nakamura and Paul 2009).

Porter's Externalities or Competition (COM). Porter argues that local competition will accelerate imitation and the improvement of innovators' ideas. Competition creates a pressure for firms to innovate more and firms that do not advance technologically will be excluded from the market or industries. Porter believes that competition among local firms leads to the innovations of others being adopted and improved upon, and so generates industry efficiency (Glaeser et al. 1992). Following Nakamura and Paul (2009), the degree of regional competition in this study is measured by the ratio of the employment-based location quotients ($\mathrm{LQ}_{\mathrm{ij}}^{\mathrm{S(E)}}$) to the plant-based location quotients ($\mathrm{LQ}_{\mathrm{ij}}^{\mathrm{S(P)}}$). So that, local competition is measured by ratio of $\mathrm{LQ}_{\mathrm{ij}}^{\mathrm{S(E)}}/\ \mathrm{LQ}_{\mathrm{ij}}^{\mathrm{S(P)}}$. Therefore, if $\mathrm{LQ}_{\mathrm{ij}}^{\mathrm{S(E)}} > \mathrm{LQ}_{\mathrm{ij}}^{\mathrm{S(P)}}$, so that the ratio is greater than one, region *j* contains relatively large plants or has a monopolistic/oligopolistic regional environment. However, if $\mathrm{LQ}_{\mathrm{ij}}^{\mathrm{S(P)}} > \mathrm{LQ}_{\mathrm{ij}}^{\mathrm{S(E)}}$, so that the ratio is less than one, region *j* contains relatively small plants or has a competitive regional environment.