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THE ROLE OF R&D AND LOCATION IN A CLUSTER ON TOTAL FACTOR PRODUCTIVITY GROWTH OF INDONESIAN MANUFACTURING

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Abstract

Indonesian manufacturing sector plays a key role in the effort to improve economic growth for making the largest contribution to the total GDP. However, the growth of manufacturing sector is still unstable and the realization of its growth is still below the expected target. On one hand, examining the total factor productivity (TFP) growth can help to explain the overall economic growth. On the other hand, R&D and industrial clustering have been considered as an important factor to improve the efficiency that leads to a higher TFP growth. This study attempts to examine the source that mainly driven the TFP and the determinant of TFP growth: particularly the effect of R&D activity and firms' location in the industrial cluster, since specific studies that investigate the effect of both factors are still limited. This study uses balanced panel data of Indonesian large and medium manufacturing firms in the chemical, textile, food and metal sectors for the period from 2003 to 2013. This study employs stochastic frontier analysis to calculate the efficiency and TFP growth decomposition. The finding shows that TFP growth on the chemical, metal, food and textile sector are 5.8%, 3.3%, 7.3% and 6.4%, respectively. The technical progress mainly contributes to TFP growth of all four sectors. Additionally, the result also shows that the R&D activity significantly affects the growth of TFP in the food and chemical sectors. Furthermore, the industrial cluster positively affects TFP growth in the food and textile and metal sectors, while it negatively affects the TFP growth in the chemical sector.

Key words

TFP growth, Efficiency, Manufacturing, Indonesia, R&D

INTRODUCTION

The industrial sector plays a key role in the effort to improve the economic growth. This sector can support the acceleration of GDP growth since it makes the largest contribution to the total GDP. The government has acknowledged the importance of this sector by targeting the industrial share at 24 to 30% of total GDP by 2020 and the average growth rate of the industrial sector to reach 9.5 percent in the period of 2010-2020 (Ministry of Industry, 2012: 11). However, the growth of the industry is still unstable, and the realization is still below the expected target. The growth of medium and large manufacture production index plummeted in 2006 at -1.63%. In the next period from 2010 to 2015, the growth index slightly increased even though there was a decrease in 2014 and 2015. In 2015, the share of manufacturing to total GDP reached 21.5% and the growth of non-oil and gas manufacturing 5.34% in 2014. Both are still under the targets.

This uneven growth has been triggered many scholars to study what factors that lead the slowing economic growth and what factors that trigger it. Productivity has been viewed to have an important role in explaining the overall economic growth. By examining the total factor productivity (TFP) growth, we can see the other factors of the growth of output that are not accounted for, by the growth of the inputs in the production function. The growth accounting method is one way to measure the sources of growth by distinguishing input growth as one source and TFP growth reflected in the residual as a second source of growth. Furthermore, there is another way to analyze the source of TFP growth more deeply by decomposing the TFP. Unlike the growth accounting method, the decomposition of TFP growth assumes that not all firms are fully efficient in their production process, which is more relevant to the real world. Moreover, with the decomposition method we can identify the contributing factors of TFP growth.

Several studies have been conducted to examine the TFP growth of the Indonesian manufacturing sector using the decomposition method (Ikhsan, 2007; Margono & Sharma, 2006; Suyanto et al, 2009). However, none of these studies accounted for R&D activity and the location of firms in an industrial area as possible determinants of TFP growth. Griffith et al, (2004) note two channels where the R&D can have an impact on TFP growth. R&D activity of firms generates product and process innovation that leads to TFP growth. It also can create knowledge diffusion which works at three levels: as basic research, as applied research in the private sector and as applied research in the academic and state research institute. This knowledge diffusion will affect the long-run growth in the economy as reflected in the improvement of TFP growth.

Along with R&D, industrial clustering is also considered as an important factor to improve the efficiency of firms that leads to a higher TFP growth. Porter (1998) notes that firms can operate more productively as a member of a cluster since it benefits the members with better access to employees and suppliers, access to specialized information, and the complementarities as a host of industry linkages among member firms. Several studies found that the cluster of small-scale industries in Indonesia has a significant impact on the productivity of the firms (Najib et al, 2011; Berry et al, 1999). The positive effect from clustering on the productivity of small-scale industries has made the Government of Indonesia to advocate the clustering for larger and medium manufacturing in the national industrial policy (Tijaja & Faisal, 2014: 14).

Since the specific studies that investigate the effect of R&D activity and the industrial cluster are still limited, this study aims to fill the gap by examining the role of firms' R&D activity and the industrial cluster on the efficiency and total factor productivity growth of the Indonesian manufacturing sector.

LITERATURE REVIEW

The pivotal point of TFP growth in explaining the economic growth can be traced back to the study of Abramovitz (1956) who argues that the TFP growth might be interpreted as a proxy to measure the economic growth. Solow (1957) proposes that the TFP growth might explain the difference in income per capita across countries and Romer (1990) provides a theoretical study to show that TFP endogenously explains the economic growth. The study by Klenow and Rodriguez-Clare (1997) argues that TFP growth represents 90% of the difference of output growth across nations.

Total factor productivity growth is the residual of the output growth that cannot be accounted for by inputs growth in the production function. The decomposition of TFP growth to the components of technical progress, technical efficiency and scale of firm operation explains the source of economic growth beyond those reflected in the production function.

In the case of Indonesia, the sharp difference of growth in the manufacturing sector before and after the economic crisis in the mid 1990's has led the increasing number of studies on productivity growth in this sector. Some of the studies estimate the TFP growth of the manufacturing sector in Indonesia, including a study by Timmer (1999) that find that annual TFP growth in Indonesian manufacturing during 1975-1999 was 2.8%. Aswincahyono and Hill (2002) note that the average TFP growth of Indonesian manufacturing during 1975-1993 was 2.3%. The growth increased between 1976 and 1981, but declined during the period 1981-1993 with negative growth rate of -4.9% per annum. Margono and Sharma (2006) study the TFP growth of four sectors of Indonesian manufacturing namely the chemical sector, food sector, metal sector and textile sector during 1993-2000 using the stochastic frontier model. They found that the productivity of the chemical, textile and metal sector decreases in that period but the productivity of chemical sector increases at the rate of 0.5%. The decomposition method identified that the growth is driven positively by technical efficiency changes in all four sectors; however, there is a decreasing technological progress in all four sectors during this period. Ikhsan (2007) studies the TFP growth in Indonesian manufacturing in the period 1988-2000 considering the liberalization policies and the economic crisis in 1997. Using the stochastic frontier analysis with TFP decomposition, the finding showed that TFP grew by 1.5% between 1988 and 2000. The TFP growth is mostly driven by the technical progress and there is the negative trend in technical efficiency change reflecting the learning process of technology adoption that has not been used efficiently.

In analyzing the manufacturing sector, the study of the efficiency of firms is also important to measure industry performance. The level of efficiency in the industrial sector indicates how well the firms in that industry can produce maximum output with a given set of inputs. With the frontier approach introduced by Farrel (1957) we can examine the efficiency of firms in an industry by measuring the maximum production on the frontier and the actual production that is not on the frontier. This approach assumes that firms may operate below the frontier due to inefficiency.

The main independent variables used in this study are R&D, and location in an industrial area (hereafter cluster). The impact of R&D is expected to come from two channels that reflect the two faces of R&D (Griffith et al, 2004). On one hand, R&D generates process innovation by producing products more efficiently (for example: lower cost) or product innovation such as creating new products with better technology that will improve the TFP. On the other hand, R&D also can promote the absorptive capacity (Cohen % Levintahl, 1989; Zahra & George, 2002). It allows the identification, assimilation and exploitation of innovation by other R&D agents such as universities, specialized research institutes and other firms engaged in R&D that leads to improvement in TFP.

The idea that a cluster affects industrial performance and increases the competition was popularized by Porter (1998). He notes that firms can operate more productively as a member of a cluster. A cluster provides benefits for the members with better access to employees and suppliers, access to specialized information, and the complementarities as a host of industry linkages among member firms. Najib et al, (2011) find that small and medium firms in the food processing sector located in a cluster area have a higher performance compared to firms not located in a cluster due to the support from the government and the location that benefits to increase the performance of the firms in the cluster area. Another study by Berry et al, (1999) find that the clusters of small-scale industries in Indonesia have a significant impact on productivity due to the economy of scale in the purchasing of raw material and machinery, sale of output and spreading the economic risk.

METHODOLOGY

This study employs three-step estimation to examine the role of R&D activity and cluster on firms' TFP growth. First, we estimate the efficiency with stochastic frontier analysis using the Translog production function. From the first estimation, then we calculate the decomposition of TFP such as: technical efficiency change (TE), scale component change (SC) and technological change (TC). Then we calculate the TFP growth as the summation of that three decompositions. Finally, in the third step, we construct the regression model to examine the role of R&D and cluster on the TFP growth.

In analyzing the efficiency of firms, the concept of frontier production function can be used to explain the maximum output that can be achieved by firms with given inputs under the technology reflected in its production function. Firms are technically efficient if they can operate on the frontier while firms that fall below the frontier are not technically efficient. The stochastic frontier approach can be used to estimate the inefficiency of firms by comparing the firms' actual output to the output level at the frontier. First, the level of output on the frontier that can be achieved if all available factors of production are used efficiently must be decided, as:

$$y_{it}^{*} = f(x_{it};\beta)\exp(\mathrm{v}_{it}), \tag{1}$$

y*it is the efficient level of output of the ith firm at time t, x_{it} is a vector of inputs for the ith firm at time t, β denotes as the parameters to be estimated, and v_{it} is a random error independently distributed as $N(0, \sigma^2_V)$. The error captured on the frontier represents the random effect that cannot be controlled by firms. The output of firms (y_{it}) cannot surpass the frontier efficient level y^*_{it} since the technical inefficiency is embedded in the firm itself. However, firms can have a lower output level due to the inefficiency from the management, such as non-optimal usage of input during the production process. Then, the difference between the maximum and the actual output can be defined as the production inefficiency that is represented by an exponential factor of u_{it} on the equation below:

$$y_{it} = y_{it}^{*}\exp(-\mathrm{u}_{it}), \tag{2}$$

where $u_{it} \geq 0$ and $u_{it} \sim N^{+}(\mu, \sigma^2_u)$

Next, equation (1) and (2) can be combined to get a production function that captures the inefficiency as below:

$$y_{it} = f(x_{it};\mathrm{t},\beta)\exp(\mathrm{v}_{it} - u_{it}) = f(x_{it};\mathrm{t},\beta)\exp(\varepsilon_{it}) \tag{3}$$

where ε_{it} is the error term composed of v_{it} and u_{it} (i.e., $\varepsilon_{it} = v_{it} - u_{it}$),which are independent from each other and the time trend t is used to capture the technological change.

Rearranging the equation (2) we can measure the technical efficiency as a ratio of actual output to the maximum possible output.

$$TE_{it} = \frac{y_{it}}{y_{it}^{*}}, \; = E\left[\exp(-u_{it})|\varepsilon_i\right] \tag{4}$$

TE_{it} is the technical efficiency for the ith firm at time t and because $u_{it} \geq 0$, the ratio value will be between 0 and 1.

At the next step, a production function must be described in the functional form in equation (3) to measure the technical efficiency. Translog production function is employed in this study because this function is the most suitable production function after being tested with other production functions such as: Cobb-Douglass, Hicks-neutral and no technological progress production function. The equation of Translog production function, therefore was written in the following form:

$$\ln y_{it} = \beta_0 + \beta_k \ln k_{it} + \beta_l \ln l_{it} + \beta_m \ln m_{it} + \beta_T T + \frac{1}{2}\left[\beta_{kk}(\ln k_{it})^2 + \beta_{ll}(\ln l_{it})^2 + \beta_{mm}(\ln m_{it})^2 + \beta_{TT} \ln T^2\right] + \beta_{kl} \ln k_{it} \ln l_{it} + \beta_{km} \ln k_{it} \ln m_{it} + \beta_{lm} \ln l_{it} \ln m_{it} + \beta_{kT} T \ln k_{it} + \beta_{lT} T \ln l_{it} + \beta_{mT} T \ln m_{it} + v_{it} - u_{it} \quad (5)$$

where y is gross total output, k is capital, l is labor, m is material, T is t year and subscripts i and t indicate the i^{th} firm at t year for period 2003-2013 for each industry. This study assumes that all manufacturing sectors have the same production process and all inputs are given for each firm. Each firm makes its own decision to use a certain level of input to produce the output. Thus in that equation, output is the only endogenous variable used while capital, labor and intermediate input are the exogenous variables that influence the output.

From the Translog production function estimation, we can get useful economic information of how much output will increase when the level of inputs increases by examining the elasticity of output with respect to each input. This study follows the estimation of elasticities of output that used in Margono and Sharma (2006) with respect to capital, labor and material. Hence the elasticity of output with respect to capital, ek is estimated by:

$$e_k = \beta_k + \beta_{kk} \ln k_{it} + \beta_{kl} \ln l_{it} + \beta_{km} \ln m_{it} + \beta_{kT} T \quad (6)$$

whereas the elasticity of output with respect to labor el, is estimated by:

$$e_l = \beta_l + \beta_{ll} \ln l_{it} + \beta_{kl} \ln k_{it} + \beta_{lm} \ln m_{it} + \beta_{lT} T \quad (7)$$

and the elasticity of output with respect to materials, em is estimated by

$$e_m = \beta_m + \beta_{mm} \ln m_{it} + \beta_{lm} \ln l_{it} + \beta_{km} \ln k_{it} + \beta_{mT} T \quad (8)$$

Those elasticities are estimated at their mean values and the return to scale are estimated by summing up all the individual elasticity of output with respect to each input:

RTS = ek + el + em (9)

This study obtained the total factor productivity (TFP) growth by the decomposition method following Kumbhakar and Lovell (2000: 286). The TFP growth denoted by $T\dot{F}P$ is decomposed into three parts: rate of *technological change (TC)*, *a scale component (SC)* and a change in *technical efficiency ($\dot{T}E$)*. The *technological change* is a partial derivative of production function with respect to time; *scale component* is the elasticity of inputs contribution at the production frontier; and *technical efficiency change* is a derivative of technical efficiency with respect to time. That decomposition can be estimated with the equations below:

$$TC = \frac{\partial \ln(y_{it})}{\partial T} = \beta_T + \beta_{TT}T + \beta_{kT}\ \text{lnk}_{it} + \beta_{lT}\ln l_{it} + \beta_{mT}\ \text{lnm}_{it}, \tag{10}$$

$$SC = (\text{RTS}-1)\sum_j \left(\frac{e_j}{RTS}\right)\dot{x}_j, \tag{11}$$

$$\dot{T}E = -\frac{\partial u_{it}}{\partial t} \tag{12}$$

In the equation (11), the subscription j represents the inputs (capital, labor and material). e_j is elasticities of output with respect to input j,and $\dot{x}_j$ is the rate of change of input j. Thus, using the decomposition method, the TFP growth can be calculated as:

$$T\dot{F}P = TC + SE + \dot{T}E$$

$$= (\beta_T + \beta_{TT}T + \beta_{kT}\ \text{lnk}_{it} + \beta_{lT}\ln l_{it} + \beta_{mT}\ln m_{it}) + (RTS-1)\sum_j \left(\frac{e_j}{RTS}\right)\dot{x}_j - \frac{\partial u_{it}}{\partial t} \tag{13}$$

To examine the role of R&D activities and cluster on the industry total factor productivity, we consider the following economics model as the function of firms' R&D activity, cluster and other control variables such as:

$$T\dot{F}P_{it} = f\left(RD, Cluster, X\right) \tag{14}$$

Where *TFP growth ($T\dot{F}P$)* is the dependent variable, *RD* is R&D variable that represent the R&D activity conducted by the firms and *cluster* is cluster variable that represent if the firm located in industrial cluster or not and the *X* is a set of control variables. The econometric equation of that model takes the following form:

$$T\dot{F}P_{it} = \beta_0 + \beta_1 RD_{it} + \beta_2 Cluster_{it} + \beta_3 MAR_{it} + \beta_4 RD*MAR_{it} + \beta_5\ \text{lAge}_{it} + \beta_6\ \text{lAge2}_{it}$$
$$+\beta_7 Export_{it-1} + \beta_8 Ownership_{it} + \beta_9 Regional_{it} + u_i + \varepsilon_{it} \tag{15}$$

In the equation (15), *i* represents the *i*th firm, *t* represents time in years from 2003 to 2013. $T\dot{F}P$ is total factor productivity growth, *RD* is dummy R&D variable of firm, *cluster* is dummy of firms' location in industrial cluster, *MAR* is the concentration of industry as proxy of competition, *RD*MAR* is the interaction variable that represents firms' R&D activity in concentrated area, *lAge* is firm's age, *lAge2* is a square of firm's age, $Export_{it-1}$ is lag of export dummy variable in t-1, *Ownership* is the ownership of firm, *Regional* is dummy regional variable, *u* is the individual or group effect that affect the TFP growth, while ε is the residual.

This study used unpublished firm level data from the annual survey of medium and large sized manufacturing firms conducted by Statistic Indonesia. A second data source is the World Bank for wholesale price index (WPI) which is used as a deflator for monetary variables. To get the balanced data for the period of 2003-2013, this study conducted several data adjustments. During the data preparation process, several adjustment steps were conducted in this study, by removing the zero and negative values; cleaning for noise by removing the outliers from the dataset; choosing only four selected sectors of industries of two digit of ISIC version 4 (chemical, food, metal and textile); deflating all monetary variables with wholesale price index provided by World Bank data at constant 2003 price; and constructing a balanced panel by matching firms in the selected period based on their identification codes. After the adjustment process and construction of the balanced panel data, the observations for each sector of the industry come to 3,530 observations for the chemical sector, 14,160 observations for the food sector, 360 observations for the metal sector and 4,130 observations for the textile sector. Since the data of R&D variable only available in 2006 and 2011, this variable for the period 2003-2010 followed the 2006 data and for the period 2011-2013, this variable is defined as equal to 2011.

RESULTS

Firstly, the model of production function form is needed to be decided first. There are four production functions to be tested, namely: Translog, Hicks-neutral, No-technological progress and Cobb-Douglass production function. The null hypotheses are Hicks-neutral, No-technological progress and Cobb-Douglass production function as the suitable production function. The alternate hypothesis is the Translog production function as the suitable production function. This study employed the generalized likelihood statistic to the test performed on the relevant null hypothesis with the formula below:

$$\lambda = -2\left[l(H_0) - l(H_1)\right] \sim \chi^2_{0.99} \qquad (16)$$

Where λ is a likelihood ratio statistic , l(H1) is the log likelihood value of the Translog production function and l(H0) is the log likelihood value of the other production function. The critical value for this test is taken from Table 1 of Kodde and Palm (1986). The summary of the result of this test is presented in the Table 1. The result shows that the Translog production function is found to be the suitable form of the production function for this study to represent the data. For that reason, the Translog production function is used to estimate efficiency and productivity growth.

TABLE 1. RESULT OF PRODUCTION FUNCTION TEST

Production Function	H_0	χ^2 (0.99)	Chem Λ	Food λ	Metal λ	Text λ	Conclusion
Hiks Neutral	$\beta_{kT}=\beta_{lT}=\beta_{mT}=0$	10.50	25.89	849.40	38.65	84.59	**Reject Hiks Neutral**
No-technological progress	$\beta_T=\beta_{kT}=\beta_{lT}=\beta_{mT}=\beta_{TT}=0$	14.33	396.06	3293.16	123.15	592.37	**Reject No-technological**
Cobb-Douglass	$\beta_{nk}=\beta_t=\beta_{kT}=\beta_{lT}=\beta_{mT}=\beta_{tt}=0$	24.05	774.96	5660.47	197.75	3275.42	**Reject Cobb-Douglass**

The result of estimation of the stochastic frontier model in the four sectors of industries is shown in the Table 2. The coefficient of year indicating the annual technical progress in the four sectors is all significant at 1% level. In the textile and chemical sectors, the coefficient of year and year square showed that there was an annual technical progress, however at the certain time it would turn out to be the technical regress. In contrast, the metal sector showed that there was an annual technical regress and at the certain point of year it would turn out to be the technical progress. No significant coefficient variable of year square in the food sector showed that the annual technical progress in this sector will keep increasing through time.

The interaction coefficient of the year with labor in all sectors is positive suggesting that the technical progress for those sectors has been labor saving. While in the interaction of year and material, the significant and negative value of the coefficient shows that the technical progress is material using for all four sectors. The interaction coefficient of year and capital has a value near to zero for all sectors but the significant value is only shown by the textile sector.

The coefficient of interaction variables between capital-material, labor-material and capital-labor in the four sectors are negative and significant at 1% level, suggesting a complementary effect between those variables. The gamma coefficient represents the annual percentage change in inefficiency. Since the efficiency of the metal sector is time invariant, this sector does not have a gamma coefficient, indicating that there is no improvement nor decline on inefficiency along this period. The percentage change in inefficiency for the chemical, textile and food sector is 1.9%, 3.2% and 6.5% per annum respectively.

TABLE 2. ESTIMATION OF STOCHASTIC FRONTIER

Variables	Parameter	Chemical Loutput		Metal Loutput		Textile Loutput		Food Loutput	
		Coef	Std Err	Coef	Std Err	Coef	Std Err	Coef	Std Err
*L*capital	β_k	0.178***	0.036	0.000	0.102	0.192***	0.026	0.202***	0.015
*L*labor	β_l	1.142***	0.108	2.388***	0.309	0.814***	0.057	1.082***	0.040
*L*material	β_m	0.125***	0.026	0.289***	0.102	-0.121***	0.009	0.106***	0.012
*l*capital2	β_{kk}	0.038***	0.003	0.039***	0.006	0.029***	0.003	0.034***	0.001
*l*labor2	β_{ll}	0.055**	0.022	-0.075	0.062	0.048***	0.012	-0.016**	0.009
*l*material2	β_{mm}	0.068***	0.001	0.073***	0.003	0.065***	0.001	0.070***	0.001
capital*labor	β_{kl}	-0.011**	0.005	-0.006	0.011	-0.033***	0.005	-0.007***	0.003
capital*material	β_{km}	-0.028***	0.002	-0.024***	0.005	-0.015***	0.001	-0.028***	0.001
labor*material	β_{lm}	-0.056***	0.003	-0.097***	0.018	-0.023***	0.001	-0.043***	0.002
Year	β_T	0.190***	0.021	0.271***	0.068	0.174***	0.013	0.283***	0.009
year2	β_{TT}	-0.005***	0.002	0.008**	0.004	-0.003**	0.001	0.000	0.001
year*labor	β_{Tl}	0.002	0.003	0.021***	0.007	0.005***	0.002	0.015***	0.001
year*material	β_{Tm}	-0.005***	0.001	-0.019***	0.004	-0.004***	0.000	-0.015***	0.001
year*capital	β_{Tc}	-0.003	0.002	0.000	0.004	-0.003**	0.001	0.000	0.001
Constant		6.192***	0.386	2.174**	1.242	7.854***	0.188	5.425***	0.144
γ		-0.019***	0.006			0.032***	0.010	0.065***	0.004
Usigmas		-0.570***	0.132	-1.608***	0.466	-1.609***	0.137	-0.068	0.066
vsigmas		-1.746***	0.025	-2.152***	0.075	-2.157***	0.022	-2.209***	0.013
Log Likelihood		-2571.70		-170.34		-1885.61		-6836.75	
Number of observation		3,883		396		4,543		15576	
*** p<0.01, ** p<0.05, * p<0.1									

Table 3 shows the elasticity of output with respect to capital, labor and material in the four sectors. The value of return to scale in the chemical and food sectors for more than 1.05 indicates that those sectors have a mild increasing return to scale. The values of RTS of metal and textile sectors for less than 1.05 indicates that those sectors exhibit the constant return to scale. The elasticity of output with respect to material is the largest compared with capital and labor. Therefore, we can say that the output in all sectors is mainly driven by the material rather than by capital and labor.

TABLE 3. ELASTICITY OF OUTPUT WITH RESPECT TO CAPITAL, LABOR AND MATERIAL

Sectors	e_l	e_k	e_m	RTS
Chemical	0.333129	0.140771	0.578533	1.052432
Food	0.352281	0.118454	0.592467	1.063202
Metal	0.265239	0.080389	0.677077	1.022704
Textile	0.378432	0.153547	0.439539	0.971518

Table 4 shows that the *TFP growth* is driven primarily by the positive technical change in all four sectors. Since the technical change represents the shift in the production function, this result reflects progress in the production function due to the technology improvement in Indonesian manufacturing.

In the chemical sector, the *TFP growth* is driven by the positive change in technical efficiency, scale component, and technological change. While in the metal sector, the scale component gives the negative contribution that offset the positive contribution of *TC* growth. The scale component measures the advantage of the economies of scale. The negative sign implies that when a firm increases the output, the cost per unit input also increasing. In this case, firms in the metal sectors must face the higher per unit input cost if they want to expand their output. In the food sector, the *TFP* growth due to the positive contribution of the *technical change* along with the scale component. However, the negative change in the *technical efficiency* offsets the positive change in the two other decompositions. The negative sign in the *technical* efficiency change indicates the inability of firms in using the available technology in the production process. Less output is produced with the same amount of input or the same amount of output is produced with more input. In textile sector, the negative technical efficiency and scale component offset the positive change of technical change in the decomposition of its TFP growth.

TABLE 4. THE DECOMPOSITION OF TFP GROWTH, 2003-2013

Variable	Chemical		Metal		Food		Textile	
	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean
TC	3,530	0.043	360	0.068	14,160	0.109	4,130	0.092
TEC	3,530	0.013	360	0	14,160	-0.042	4,130	-0.010
Scale	3,530	0.002	360	-0.036	14,160	0.006	4,130	-0.018
TFP	3,530	0.058	360	0.033	14,160	0.073	4,130	0.064

Among the four sectors, the significant coefficient of *RD* only occurs in the chemical and the food sectors, as shown in the Table 5. In the food sector, firms that conduct R&D activity in a competitive location significantly have higher TFP growth than firms without R&D activity. Meanwhile, in the chemical sector, the significant coefficient of *RD* and *RD*MAR* indicates that firms in the competitive location with R&D activity have lower *TFP growth* than firms without R&D activity. The insignificant coefficient of *RD* in the metal and the textile sectors indicate that there is no difference of total factor productivity growth between firms with R&D activity and without R&D activity in both sectors. Even though the firms with R&D activities in the chemical sectors have less TFP growth compared with firms without the R&D activities and for the other sectors the firms with and without R&D activity shows no different in the TFP growth, it doesn't mean that the R&D activity has negative or no effect on the TFP growth of the firms. If the information about the performance of R&D activity of firms is available, we could further examine the impact of firms' R&D activity on their TFP performance.

The effect of *cluster* shows positive, significant results for *TFP growth* in the food, metal and textile sector. This means that firms located in a cluster get higher TFP growth in those three sectors. This result in line with the argument by Porter (1998) who states that being in a cluster will benefit the firms and increase their productivity. While for the chemical sector, the negative sign of *cluster* shows that firms located in a cluster get lower TFP growth compared with firms that not located in the cluster. Firms that located in the industrial cluster can also have the negative effect of congestion that cause the increasing in the cost of production such as excessive pollution, and higher infrastructure cost because of the emergence of new firms in cluster area (Press, 2006: 54). The negative sign in this result indicates the congestion effect of cluster that gives negative effect on a firm's productivity in the cluster.

The estimation results on the age variable show that as the firms get older, they are becoming more productive (in the food, chemical and textile sectors). However, when they reach a certain age, their productivity will decline. This finding indicates that the learning process and accumulation of experience through time tend to promote TFP Growth. The export dummy variable is statistically significant and has a positive effect on the productivity only on chemical sector. This finding indicates that firms in that sector that conduct an export activity tend to achieve a higher growth in total factor productivity. This result confirms Greenaway and Keller (2007) study that a firm can get "learning effect" from the export activity and imply their improvement in productivity. Meanwhile, the regional dummy variable shows the various result for the four sectors.

Finally, this study recommends some insights for the future research. In this study, only a dummy variable for R&D activity was employed. However, a more precise result might be obtained when using research expenditure as the proxy of R&D activity. In addition, a study that includes other information related to R&D activities such as the number of R&D employees, the level of education of the R&D

employees or the number of patents might offer a more comprehensive analysis to the related research.

TABLE 5. RESULT OF TFP GROWTH REGRESSION IN FOUR INDUSTRIAL SECTORS

VARIABLES	(1) Chemical TFP	(2) Food TFP	(3) Metal TFP	(4) Textile TFP
RD	-0.0114**	0.0103**	-0.0768	-0.0371
	(0.00580)	(0.00388)	(0.0702)	(0.0264)
Cluster	-0.517***	0.135***	0.0465**	0.429*
	(0.0324)	(0.0144)	(0.0198)	(0.232)
MAR	0.000277	0.00726**	-0.0193	0.00110
	(0.00146)	(0.00298)	(0.0126)	(0.00530)
RD*MAR	0.00172*	0.00538**	0.0282	-0.00747
	(0.00088)	(0.00174)	(0.0266)	(0.00620)
Lage	0.0846***	0.0601***	-0.127	0.124**
	(0.0117)	(0.00928)	(0.197)	(0.0489)
lage2	-0.0471***	-0.0322***	0.0193	-0.0360***
	(0.00274)	(0.00265)	(0.0348)	(0.0103)
Lag of export	0.00738**	0.00105	-0.0127	-0.0207
	(0.00345)	(0.00315)	(0.0304)	(0.0126)
Ownership	-4.14e-05	-3.02e-05	5.45e-05	0.000594
	(7.83e-05)	(2.59e-05)	(0.000242)	(0.000542)
Regional Dummy	0.408***	-0.158***	-0.0185	-0.574
	(0.0264)	(0.0104)	(0.0652)	(0.238)
Constant	0.169***	0.170***	0.300	0.186***
	(0.0188)	(0.00940)	(0.283)	(0.0514)
Observations	3,517	14,103	360	4,121
R-squared	0.412	0.376	0.110	0.117
F	11.33	102.3	-	5.727
P-value	0.0000	0.0000	-	0.0000
Number of firms	353	1416	36	413

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

CONCLUSION

This study examine the role of R&D activity and firms' location in an industrial cluster to the total factor productivity growth for manufacturing sector in Indonesia using a balanced panel data in four sectors of manufacturing (chemical, food, textile and metal). Stochastic frontier analysis is employed to estimate the efficiency of firms and decomposed the total factor productivity growth.

The finding shows that R&D activity significantly affects the TFP growth of firms on the food and chemical sectors. However, R&D activity does not significantly affect the metal and textile sectors. These results might be due to the data limitation used in this study that not capture the performance of the R&D unit of firms specifically. Additionally, compared to the firms that are not located in cluster, on the food, metal and textile sectors, the firms that perform their activities in the industrial cluster tend to gain a higher TFP growth. Nevertheless, on the chemical sector, the firms that are located in a cluster is found to get lower TFP growth compared to firms outside industrial cluster, indicating the congestion effect of cluster. These findings conclude that in general, being in a cluster will benefit the firms to get higher TFP growth. However the congestion effect also should be considered to avoid the negative effect of the cluster. The results of this study also show that TFP growth on chemical, metal, food and textile sector are 5.8%, 3.3%, 7.3% and 6.4% respectively. The technical progress mainly contributes to the total factor productivity growth.

RECOMMENDATION

The main finding of this study indicates that R&D activity and industrial cluster positively affect the TFP growth of the firms. Therefore, to stimulate the improvement of TFP growth, the government should give incentive to encourage the firms conducting R&D activity and continue the policy of industrial cluster to stimulate the innovation by taking account the congestion effect of the cluster. In addition, the quality of labor must always be enhanced to improve the adaptation of technology.

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