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Technical Efficiency and Total Factor Productivity Growth: Case of Indonesia's Food and Beverage Manufacturing Sector

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Abstract

Technical efficiency and total factor productivity are important part of production process. This study estimated the technical efficiency and the determinant of inefficiency for Indonesia's food and beverage manufacture sector. Another objective of this study is to estimate the decomposition of total factor productivity (TFP) growth. Stochastic Frontier Analysis (SFA) and TFP growth decomposition method were implemented to address the paper's objectives. This study found that food industries in Indonesia are less efficient with mean of technical efficiency was 81.5per cent. Furthermore, inefficiency in this type of industry is contributed by size and capital ownership status. These two characteristics have a negative correlation with inefficiency. If the firm produced more output, its efficiency will increase. Foreign direct investment firms are more efficient than domestic firms. Another result was the average TFP in the food industry was – 36 per cent, which is dominated by technological progress components. Moreover, Indonesia's food and beverage manufacturing sector is more labor oriented during the study period. Furthermore, the positive effect of FDI on efficiency can be boosted by implementing tax incentives to approved project in food industries.

Keywords— Stochastic Frontier Analysis, TFP Decomposition, Indonesian Food And Beverage Manufacturing Sector.

Introduction

There are two components of efficiency of a firm, namely technical efficiency reflecting the ability of a firm to obtain maximal output from given input production and allocative efficiency, which reflects the ability of a firm to use the inputs in optimal proportions, given their process. These two components combine to result total economic efficiency. (Farell 1957 cited in Coelli et al 2003, p. 183). Previous empirical studies estimated the technical efficiency in the production function. Technical efficiency of Spanish's manufacturing sector between 1990 and 1994 was observed by Marcos and Galvez (2000). Diaz and Sanchez (2008) analyze the efficiency of Spanish small and medium-size manufacturing firms during 1995-2001. They find that small firms are less efficient than medium-size firms. Kaynak and Pagan (2003) estimate the effect of implementing just-in-time purchasing (JIP) technique on technical efficiency in the US manufacturing sector. Their results suggest that implementing JIP technique results in higher technical efficiency in the production process. Furthermore, Technical efficiency of Australian textile and clothing firms was examined by Wadud (2004). The results of this paper show that the level efficiency varied depending on firms' characteristic such as, age, size, capital intensity, proportion of non-production to total workers and legal status.

In addition, the measurement of technical efficiency has also been done in Indonesia's case.There are also several studies related to Indonesian manufacturing efficiency. Pitt and Lee(1981) estimated technical efficiency in 50 Indonesian weaving firms during 1972, 1973 and 1975. They found that in this type of industries, the mean efficiency was between 60 per cent and 70 per cent. Moreover, Hill and Kalirajan(1993) examined technical efficiency in Indonesia's garment industries. They argue that there is a positive correlation between technical efficiency and export orientation, financial integration and female participation in the workforce. They also find that there is a significant level of labor–capital substitution in the industry.

Another issue in economic growth is the measurement of total factor productivity (TFP) growth. Total factorproductivity growth can be measuredby several methods. First is the neoclassical method, which assumes that output growth is not from the input of production. Another method is the growth accounting method assuming no decomposition of TFP growth. The last method is the decomposition method. In this method, TFP is decomposed by three factors, namely technical progress, technical efficiency and scale component.

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Some empirical studies observe the TFP growth. Kalirajan et al (1996) found that TFP growth in Chinese agricultural sector was negative before reform period andpositive after reform period. In Indonesia's manufacturing industries case Timmer (1999) implemented the growth accounting method to measure TFP growth from 1975-1995. He concluded that the annual TFP growth of this type industry was 2.8 per cent. By implementing the samemethod, the TFP growth of 28 Indonesian manufacturing sectors varied along the period 1975-1993 with 2.3 per cent on average rate (Aswicahyono & Hill 2002). Furthermore, Margono et al (2011) observing TFP growth across Indonesian provinces in the period 1993-2002 found that TFP decreased by 7.5 per cent across provinces because of technical inefficiency.

The technical efficiency of production can be measured by DEA and stochastic frontier analysis. DEA implements linear programming whereas stochastic frontier analysis implements econometrics method (Coelli et al 2003, p. 183). There are some differences between these two methods. The major different is that the stochastic frontierestimation results standard errors of technical efficiencies whereas anonstatistical approach, i.e., DEA cannot provide standard errors of efficiencies(Bera & Sharma1999 cited in Margono& Sharma 2006, p. 981). Similarly, three approaches for TFP growth estimation result in different outcomes. Growth accounting approaches consist of the impact of technological progress solely. This method cannot estimate other factors that contribute to TFP Growth. On the other hand, the decomposition method can estimate the TFP growth and decompose its components (Margono& Sharma 2006, p.981).

In order to minimize the shortcomings of the DEA implementation and growth accounting method, purpose of this study is to estimate the technical efficiency, the determinants of inefficiency and TFP growth by implementing stochastic frontier analysis and the decomposition approach for Indonesia's manufacturing of food products and beverages sector from 2004 to 2009. The results suggest that food industries in Indonesia is less efficient. Factor contributing positive effect in efficieny is size and foreign capital ownership status. This manufacturing sector is chosen due to its importance in the Indonesian economy.

The remainder of the paper is organized as follows. Section 2 discusses the role of food and beverages manufacturing sector to Indonesia's economy. The data and methodology are discussed in Sections 3 and 4. The technical efficiencyanalysis and the total factor productivity analysis are discussed inSections 5. Discussion is presented in Section 6. Section7concludes this study.

The role of food and beverage manufacturing sector

The important role of the food and beverage manufacturing sector to Indonesian economies can be examined by its share of manufacturing employment and value added. The food and beverage industry has the largest share of manufacturing employment and value added. In 2004, there were more than 700.000 people employed in this sector. This is the highest number among the three largest industries contributing to the labor market in Indonesia; food and beverage sector, textile and garment industry. The number of labors in the food industry increased from 2004 to 2009. Approximately 23 per cent of all enterprises that operate in the manufacturing sector in 2008 were engaged in food and beverage processing, with more than 6,300 enterprises operating. This increased from 4,500 enterprises in 2001. Furthermore, in 2009 this sector employed more than 900,000 workers. The number of workers engaged in the three biggest manufacturing sectors is reported in Figure 1.

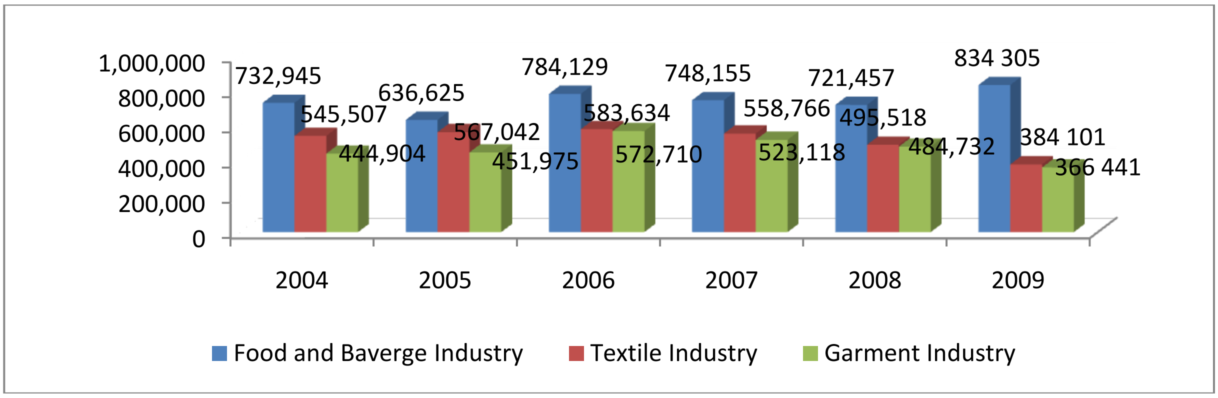

Figure 1: Number of workers engaged in the three biggest manufacturing subsector, 2004-2008
Source: Indonesian Central Bureau (2011), Statistic Indonesia Press ReleaseNo 10/02 Year XIV.

Another measurement of industries role in economies is the value added. In the period 2004-2009, Indonesia's manufacturing sector had the three highest valued added resulted from food and beverage manufacturing sector, tobacco industry and chemical industry. For five years, the food industry had the highest value added. In 2004, its value added was more than 50,000 billion Rupiah. This value added increased along the period. In the last study period, the amount of value added reached 147.730 billion rupiah. A higher value added a better possibility to result in forward and backward linkage in the economies. The amount of value added resulted is reported in Figure 2.

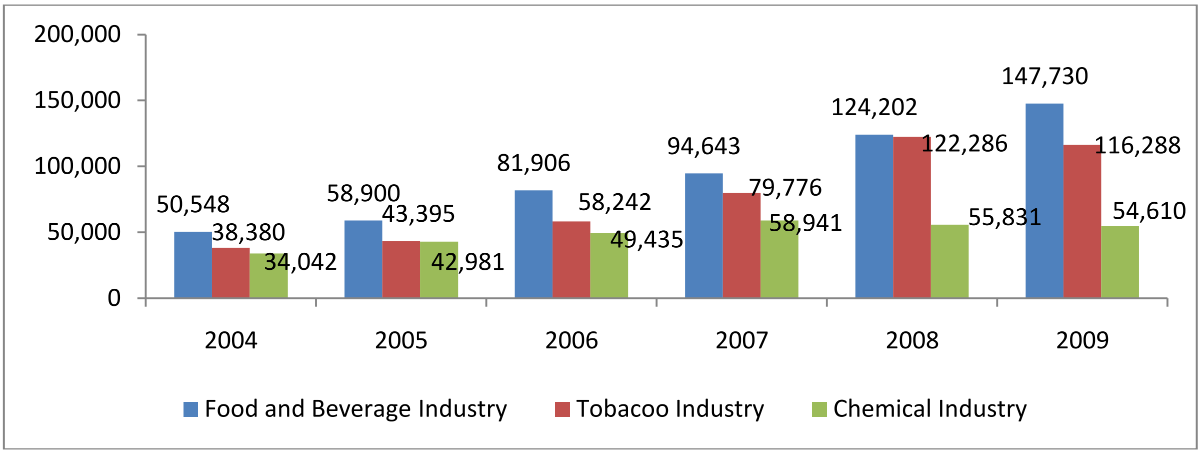

Figure 2: The value added of the three biggest manufacturing subsectors, 2004-2009 (Million Rupiah)
Source: Indonesian Central Bureau 2011, Statistic Indonesia Press Release No 10/02 Year XIV

Data

The balanced panel data method was used to estimate the stochastic frontier for manufacture of food products and beverages (ISIC 15) sector in Indonesia. Individual firm data from 2007 to 2012 was obtained from Indonesian Yearly Large and Medium Manufacturing Industries survey conducted by the Indonesian Central Bureau of Statistic. Additional data used as a deflator for monetary variables was wholesale price index (WPI). Before data was constructed as a unique balanced panel data, there were 5,648 individual firms in food manufacturing industries. During the adjustment process, in order to create a balanced panel, some observations that have missing values and inconsistency of industrial code were removed from the sample.Afterthe adjustment and cleaning,the observations were reduced to 6,444 that consist 1074 firms for six years. The summary statisticsfor the main variables used in the econometric analysis arepresented in Table 1.

Table 1:
Summary Statistics

Variable	Mean	Min	Max	Std.Dev
Y	1.76e+07	4127887	4.80e+09	1.26e+08
C	2.54e+07	6745036	1.23e+11	1.53e+09
L	101.46	20	7396	246.78
Ownerships	0.029	0	1	0.17
Location	0.074	0	1	0.26
Size	0.058	0	1	0.23

Methodology

A stochastic frontier approach

The maximum output that can be obtained under the existing technology with the input of production is defined by a frontier production function. If firms operate on the frontier, they are technically efficiency. The specification for a non-negative random component in the error term is allowedfor technical inefficiency. According to Battese andCoelli (1995, p. 329) a production function and an inefficiency function can be estimated simultaneously by the stochastic frontier approach (SFA).

According to Kalirajan&Shand (1996, p. 15), the production frontier can be modeled as

$$Y_{it} = f(x_{it}, t; \beta). Exp(vi_{it} - u_{it}) \quad (1)$$

Where y_{it} is the output of the i'th firm in t period, xit is a vector of inputs, and β is a vector of the parameters to be estimated. The error term $v_{it}$is assumed to be independently and identically distributed, N (0, σ_v^2). The uit is technological inefficiency in production, which is assumed as a firm-specific, non-negative and independently distributed but truncated at zero of the normal distribution.

Following Battese andCoelli (1995, p. 329), the determination of technical inefficiency can be estimated as:

$$u_{it} = z_{it}\delta + \omega_{it} \quad (2)$$

Where u_{it} is the technical inefficiency effects, z_{it} is a vector of the explanatory variables, δ is a vector of unknown parameters to be estimated and $\omega_{it}$is defined as an observable random variable with the truncated of the normal distribution assumption.

According to Battese and Coeli (1993) variance terms are measured by substituting σ_v^2 and σ_u^2 with

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \text{ and } \gamma = \frac{\sigma_u^2}{(\sigma_v^2 + \sigma_u^2)} \quad (3)$$

The technical efficiency of each firm is based on the conditional expectation that the expected maximum value of Y_{it} is conditional on $\mu_{it}= 0$ and the values of $v_{it} - u_{it}$ is evaluated at the maximum likelihood estimation (Battese&Coelli 1998 cited in Kompas 2004, p. 1634). The conditional expectation of technical efficiency can be defined as

$$TE_{it} = \frac{E(Y_{it} \mid u_{it}, X_{it})}{E(Y_{it} \mid u_{it} = 0, X_{it})} = e^{-u_{it}} \quad (4)$$

Where E is defined as the expectations operator.

The functional form of study

The stochastic frontier analysis can be estimated by any functional forms of the production function. Suyanto and Bloch (2009, p. 1866) argue that a flexible functional form that is a translog production function can be used as a based functional form. The risk of errorsin the model specification can be reduced by implementing a flexible production function. The translog productionfunction used in this study can be defined as:

$$lny_{it}= \beta_0 + \beta_c lnc_{it}+ \beta_l lnl_{it} + \beta_t t + 1/2 [\beta_{cc} (lnc_{it})^2 + \beta_{ll} (lnl_{it})^2 + \beta_{tt} (t)^2] + \beta_{cl} lnc_{it}*lnl_{it} + \beta_{ct} t*lnc_{it} + \beta_{lt} t*lnl_{it} + v_{it} - u_{it} \quad (5)$$

The implementation of the translog model in equation (5) may not an appropriate functional form that represents the data in the study. Therefore, various sub models of translog should be considered and tested. These various sub models are Hicks-Neutral technological progress, no-technology progress in the production frontier, Cobb Douglas with efficiency model and Cobb Douglas without efficiencymodel (Suyanto& Bloch 2009, p. 1866-1867).The various models of the translog model are described in table 2.

Table 2:
Functional Form of Translog's Sub-Model

Sub-Model	Functional Form	Null Hypothesis
Hicks-Neutral technological progress	$lny_{it}= \beta_0 + \beta_c lnc_{it}+ \beta_l lnl_{it} + \beta_t t + 1/2 [\beta_{cc} (lnc_{it})^2 + \beta_{ll} (lnl_{it})^2 + \beta_{tt} (t)^2] + \beta_{cl} lnc_{it}*lnl_{it} + v_{it} - u_{it}$	$\beta_{nt}= 0$
No-technology progress in the production frontier	$lny_{it}= \beta_0 + \beta_c lnc_{it}+ \beta_l lnl_{it} + 1/2 [\beta_{cc} (lnc_{it})^2 + \beta_{ll} (lnl_{it})^2 +] + \beta_{cl} lnc_{it}*lnl_{it} + + v_{it} - u_{it}$	$\beta_t= \beta_{tt} = \beta_{nt} = 0$
Cobb Douglas with efficiency model.	$lny_{it}= \beta_0 + \beta_c lnc_{it}+ \beta_l lnl_{it} + v_{it} - u_{it}$	$\beta_t= \beta_{tt} = \beta_{nt} = \beta_{nk} =0$
Cobb Douglas without efficiency model	$lny_{it}= \beta_0 + \beta_c lnc_{it}+ \beta_l lnl_{it} + v_{it}$	$\gamma =\delta_0 = \delta_j = 0$

Source: Suyanto&Bloch (2009).

To choose an appropriate functional form for the data, the generalized likelihood ratio statistic is employed. The likelihood ratio (LR) test is measured by the difference between the maximum likelihood estimator of unrestricted $\left(\hat{\theta}\right)$ and the restricted model. The LR test is computed as LR = $2\left[\log L\left(\hat{\theta}\right)-\log L\left(\tilde{\theta}\right)\right]$. The value of LR is compared by a Chi square distribution (χ^2 distribution) with the degree of freedom is a number of restricted variable. If the value of LR test is bigger that χ^2 distribution the null hypothesis is rejected. (Verbeek2008, p.183).

The next step, after estimating the production function, is to estimate the determination of technical inefficiency. The factors that can affect technical inefficiency are examined by estimating:

$$u_{it} = \delta_0 + \delta_1 Ownerships + \delta_2 Location + \delta_3 Size + \omega_{it} \quad (6)$$

Where $\omega_{it}$is an error term to measure the random differences across firms.

Definitions of each variable used in this study are represented in Table 3.

Table 3:
Definition of variables

Variables	Definitions
Production Function	
Y	Output (million rupiah) measured by the value of goods produced which is deflated by wholesale price index for five-digit ISIC industries at a constant price of 2000
C	Capital (million rupiah) deflated by wholesale price index for manufacturing capital goods at a constant price of 2000
L	Labor which is total workers per working day
Inefficiency function	
Ownerships	Capital ownership status which is represented by dummy variable: 1 if the capital is owned by foreign, and 0 if otherwise
Location	Location of company measured by dummy variable: 1 if the company is located inside industrial area, and 0 if otherwise
Size	Size of firm which is determined by dummy variable: 1 if the value of firm's output is greater than 100 million rupiah, and 0 if otherwise

Total Factor Productivity Decomposition

Total factor productivity (TFP) growth can be decomposed into three components namely, rate of technological change (TP), ascale component (SC) and a change in technical efficiency (TE). Technological change is measured by the partial derivative of the production function with respect to the time, scale component is the elasticity contribution to the TFP growth and the technical efficiency changes the derivative of technical efficiency with respect to time. From this definition for general translog model and time varying technical efficiency model technological progress and scale component can be formulated as: (Kumbhakar& Lovell 2000)

$$TP = \frac{\partial \ln(y_{it})}{\partial t} = \beta_t + \beta_{tt} t + \beta_{ct} \ln c_{it} + \beta_{lt} \ln l_{it} \quad (7)$$

$$SC = (e-1)\sum_j \left(\frac{e_j}{e}\right)\dot{X}_j \quad (8)$$

Where e_j is the elasticites of output with respect to input and $\dot{X}_j$ is the growth rate of input. The elasticities of output with respect to each input measures the relative change in each input owing to a relative change in output. An elasticity can be calculated as follows (Verbeek 2008, p. 56.):

$$e_l = \beta_l + \beta_{ll} \ln l_{it} + \beta_{cl} \ln c_{it} \quad (9)$$

$e_c = \beta_c + \beta_{cc} lnc_{it} + \beta_{cl} lnl_{it}$ (10)

In this study the elasticities are estimated at the value of input at *i'th*firm in *t* time.

From technical efficiency resulted from equation (1), the change of technical efficiency can be defined as (Khalifah et al 2008, p. 93)

$$TEC = \frac{TE_{i(t+1)}}{TE_{it}} \quad (11)$$

From equation 7 to 9 TFP growth decomposition can be calculated by

$$\dot{TFP} = TP + SC + TEC \quad (12)$$

Results

Finding the functional form

The first step in the stochastic frontier analysis is to find an appropriate functional form that can represent the data. In this study, five functional forms are considered and tested. Translog model is the largest model in terms of variables. Therefore, first we test whether Tanslog or Hicks-Neutral model that represents the data better. The the null hypothesis for this test is β_{nt}= 0. Since the LR test result is 4.34 which is smaller than a χ^2 distribution with a degree of freedom is 2 at any confidence interval, the null hypothesis is failed to rejected. Therefore, the Hicks-Neutral production model is accepted. The next LR test is to choose the better model between Hick Neutral and No-technological progress with $\beta_t = \beta_{tt} = 0$ as the null hypothesis. The LR test obtained is 41.1, which is bigger than a χ^2 distribution tested at 1 per cent level. This means the null hypothesis is rejected so that the Hicks-Neutral is a better model than the No-technological progress model.

Furthermore, result of the log likelihood ratio test shows that the Hicks-Neutral production function fits better to represent the data than the Cobb Douglas with efficiency model and the Cobb Douglas with no efficiency model. It can be seen from the result of the LR test that is larger than a Chi square distribution tested at 1 per cent level. The LR test between Hicks Neutral and Cobb Douglas with efficiency is 177.1 and 1421.6 for Hick Neutral and Cobb Douglass with no efficiency test. This means that stochastic effects and technical inefficiency are an important factor contributing to the performance of the food manufacturing sector. This inclusion is consistent with the value of Gamma in Hicks Neutral that is significant tested at 1 percent level. Furthermore, the Hicks Neutral production function requires that the marginal rate of substitution of inputs does not depend on technical change. Therefore, technical change must be examined along the firm's expansion path. (Blackborby et al1976, p. 847).The result for the Log likelihood ratio test can be seen in Table 4.

Table 4:
Test of Functional Form for Stochastic Frontier Analysis

Sub Model	H_0	The LR test	χ^2(1 percent level)	Conclusion
Hicks Neutral	β_{nt}= 0	4.34	13.82	Hicks Neutral failed to rejected
No-technological progress	$\beta_t = \beta_{tt} = 0$	41.1	13.82	No technological progress rejected
Cobb-Douglas with efficiency	$\beta_t = \beta_{tt} = \beta_{nn} = \beta_{nk} = 0$	177.1		Cobb-Douglas with efficiency rejected
Cobb Douglas No efficiency	$\gamma = \delta_0 = \delta_j = 0$	1421.6		Cobb Douglas No efficiency rejected
Conclusion: Hicks Neutral model is failed to rejected to represent the data				

Source: Author's calculation from the log likelihood ratio.

Stochastic frontier analysis results

The estimation results of Hicks Neutral model show that the coefficient of labor and capital is positive and statistically significant tested at 1 percent level. This result confirms that if amount of capital and labor increase, the output of firms in food production will increase. In contrast, the coefficient of labor squared (L^2) is negative and highly significant at 1 per cent level. This negative value indicates a diminishing return to labor in the food manufacturing sector. This means that when the firm increases their labor input, the output will increase but at some point the increase of the labor will decrease output. However, the diminishing return does not hold in capital input. The squared variable of capital (C^2) is positive and significant at 1 per cent level. This may happen since capital is not purely an independent variable. Capital can be embodied by technology and human capital. Therefore, anything that increase the technology and human capital manifested in capital goods will increase the productivity of capital through time. This is a principal of endogenous growth model (Zaman&Goschin 2010, p. 5).

Furthermore, the estimated coefficient for interacting variable between labor and capital is negative and significant when tested at 1 percent level. According to Ogundari and Brummer (2011 p. 67)if the second orderforcross-effects of the inputs is negative the inputs of production have a substitution effect. Therefore, labor and capital have a substitution effect in this type of manufacturing sector. This condition is similar to the pharmacy sector that has a substitution effect between labor and capital. (Suyanto& Bloch 2009, p.1867). For times variable, the results are different between the level and squared times variable. The coefficient estimated of T is significantly positive tested at 1 per cent level, which means that time representing technological progress, has a positive effect on a firm's output. In contrast, the coefficient estimated for time squared (T^2) is negative and highly significant. This shows that the effect of time will decrease at the some point. The Hicks-Neutral implemented in this study explained that the marginal rate of substitution between labor and capital is unaffected by technical change. Therefore, the relative contribution of inputs to the output produced is not affected by the technical change (Aczel& Gehrig 1989, p. 35). The result for the production function estimation is presented in Appendix panel A.

The estimation of technical inefficiency determination is another particular interest in this study. The coefficient of the dummy variable for ownership is negative and statistically significant when tested at 1 per cent level. This indicates that foreign capital ownerships status has a negative effect on technical inefficiency. In other words, a company in food manufacturing sector having foreign direct investment status obtains higher efficiency than domestic investment status. This result supports some previous studies. For example, Suyantoand Bloch (2009, p. 1868) found that foreign firms have a higher efficiency than domestic firms in the Indonesian chemical and pharmaceutical industries. They argue that Multi National Corporations (MNCs) have a superior knowledge and efficiency terms of intangible assets compared to domestic firms.

Moreover, the location of a company does not have any effect on technical efficiency of food production industry. This can be seen from the coefficient of the dummy variable for location, which is negative but statistically insignificant at any level of significance. This means that whether a company is located inside or outside industrial area may not affect the technical efficiency of the firm. The negative and highly significant on the size dummy variable indicates the positive and significant efficiency spillover in the manufacture of food products and beverage sector. This suggests that the bigger the company in terms of output, a higher technical efficiency is achieved. This result is consistent with a pervious empirical study on the Indonesian manufacturing sector, which used the data set from Indonesia Stock Exchange from 2000 to 2005 on all manufacturing sectors (Prabowo&Cabanda 2011, p. 30). The result of the inefficiency model is presented in Appendix panel B.

On average, technical efficiency in the food industry has a decreasing trend from 2007 to 2012. In 2007, the mean of technical efficiency for all firms in the food industry was 82.3 per cent. This value decreased by approximately 0.4 per cent in 2008. In the following year, technical efficiency increased more than 0.6 per cent. However, in 2010 there was a significant decrease in the mean of technical efficiency. The mean of efficiency of firms dropped in 2011 as the lowest technical efficiency in this study period. Then, the value of technical efficiency increased to 81 per cent in 2012. The mean of technical efficiency trends are shown by Figure 3.

Total Factor Productivity Decomposition and Elasticity Analysis

There was consistently negative total factor productivity (TFP) growth between 2008 and 2012 for manufactures of the food products and beverage sector. Moreover, the negative TFP growth increased from 2008 to 2011, which means productivity was worse during these times than during the first year of observation. In 2007, TFP decreased by approximately 21 per cent. In the following year, TFP declined by dramatically. The lowest TFP growth was in 2011 when TFP dropped by more than 50 per cent. In the last period of study, TFP growth was still in a negative value but smaller than the initial year.

From the TFP decomposition result, it can be seen that the decomposition dominated by the technological progress (TP). From six years observation sample, more than 75 percent component of TFP growth was from TP factor. In 2008 technological progress decreased by more than 20 per cent. The biggest decrease in TP was in 2011 when the negative value of TP growth was 58.2 per cent. In contrast, the smallest part of TFP growth is contributed by scale component. The value of SEC was less than 1 per cent along the time observation. In addition, technical efficiency growth (TEC) had a more fluctuated trend than other components of TFP growth. In 2008, TEC dropped by, but in the last period it increased significantly.

Furthermore, it is useful to observe the effect of input changes on output changes. To examine how much output will change when the level of input changes can be calculated by estimating the elasticities of output with respect to the inputs, capital and labor. Total elasticities (e) for food industry suggest that this sector exhibits increasing return to scales irrespective of the size of the company. Next, by comparing the value of elasticities of output we can see that outputs of manufacture of food products and beverage in Indonesia are driven more by labor than by capital input. From 2007 to 2012 the elasticities of output with respect to labor were more than 1 whereas the elasticities of capital were less than 1.

Discussion

The stochastic frontier analysis shows that on average Indonesia's food and beverages manufacturing sectors were less efficient during 2007-2012. This can be examined by means of technical efficiency, which is approximately 80 per cent. This result is higher than the average technical efficiency of 50 Indonesian weaving firm in 1972, 1973 and 1975 which was around 60 per cent to 70 per cent (Pitt&Lee1981). Dhanani (2000 p.50) argues that the less efficiency of food industries in Indonesia's was due to absence of effective industrial technology support systems and weak human resources. Moreover, he explains that food industries lack centre productivity networks, which produce highly technological output. Labor engaged in these type industries is also less able to adapt to foreign technology. Furthermore, the results show that labor and capital have a substitution effect in this industry sector. This is identical to the result obtained for garment industries by Hill and Kalirajan(1993).

The technical inefficiency estimation shows that foreign direct investment represented by a dummy variable, has a positive impact to technical efficiency. Foreign direct investment (FDI) results in positive spillovers to efficiency in many ways. Technology transfer is a positive spillovers from FDI. FDI can create both vertical and horizontal linkages. Vertical linkages connect suppliers and consumers in the home country whereas horizontal linkages attach the competing and complementary firms in the same industry. Another important role of FDI is human capital development (OECD, 2002).

Furthermore, TFP growth in the food industry, which is on average – 36 per cent was resulted from TFP decomposition approach. This result is different from the result obtained by Timmer (1999, p. 90) who found that the food industry had 5.7 per cent TFP growth in the period 1991-1995. Furthermore, Aswicahyono and Hill (2002, p. 158) report that TFP growth in all Indonesian manufacturing industry was -4.9 per cent from 1981 to 1993.

Conclusion

This study used stochastic frontier analysis to estimate the technical efficiency in Indonesia's food and beverage manufacturing sector from 2007 to 2012. This analysis results in the food industries are less efficient with a mean average of technical efficiency is 81.5 per cent. It is found that characteristics of firms such as size and capital ownerships have a significant effect on technical efficiency. A lager output results a higher technical efficiency. In addition, firms with foreign capital ownerships have higher technical efficiency than domestic firm ownership. In contrast, the location of companies does not have any significant relationship with inefficiency.

In addition, the TFP decomposition approach reveals that during the study period average TFP growth of the food industry was approximately – 36 per cent. The decomposition of TFP growth was dominated by technological progress change, with more than 75 per cent contribution. Moreover, the elasticities of output with respect to labor were higher than the elasticities of output with respect to capital. This indicates that Indonesia's food sector was labor oriented. The total elasticities in this type of production are more than 1 which means Indonesia's food industry exhibits increasing returns to scale production function.

This study found that foreign direct investment (FDI) has a positive impact on efficiency. This means FDI inflow should be increased in Indonesia's food manufacturing sectors. Government can attract more FDI by implementing fiscal policy in terms of tax incentives or tax holiday regime. Recently, Indonesian government introduced a new sectoral tax holiday regime. Tax holiday will be granted to approved projects. However, Indonesian government implements the sectoral tax incentives to some industries only; textiles, selectedchemicals and pharmaceuticals, iron and steel, and crude oil refining (UNCTAD 200, see United Nations Conference on Trade and Development). Therefore, in order to boost the effect of FDI in efficiency of food industries, tax incentives should be implemented in this sector.

However, this study has some limitations due to the lack of input variables imposed in the production function. The limitation of variables is caused by the limitation of data available especially data of price index for material used in production. Therefore, in the future research this problem could be solved. Furthermore, this study results in technical efficiency solely. Whereas, the allocative efficiency, which is another type of efficiency, could not be estimated due limitation of data for firm's cost function. Hence, in the future estimation the allocative efficiency could be resulted.

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