Firm Size, Age and Technical Efficiency of Indonesian Firms

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Abstrak

Studi ini bertujuan untuk mengetahui faktor-faktor yang mempengaruhi *technical inefficiency* dari perusahaan-perusahaan di Indonesia, dengan mengaplikasikan fungsi produksi Cobb-Douglas terhadap *unbalanced panel* dari 141 perusahaan BUMN maupun swasta dalam waktu 10 tahun. Estimasi dilakukan secara terpisah pada kedua jenis perusahaan tersebut untuk mengetahui apakah terdapat hubungan antara variabel-variabel spesifik perusahaan seperti: *size, age* dan *leverage* terhadap kinerja efisiensi. Hasil analisis menunjukkan bahwa jumlah karyawan *(size)*, usia dan tingkat *leverage* mempunyai efek yang negatif terhadap perusahaan BUMN. Sebaliknya, pada perusahaan swasta, umur perusahaan *(age)* dan *leverage* mempunyai pengaruh positif sedangkan *size* perusahaan mempunyai pengaruh yang negatif terhadap kinerja efisiensi.

Keywords: **Stochastic Frontier Approach, Technical Efficiency, state-owned enterprises, private sector enterprises**

Public sector and private sector firms play important roles in the Indonesian economy. The existence of Indonesia's state-owned enterprises (SOEs) can be traced to the Dutch colonial government, which started the SOEs in the late Nineteenth and at the beginning of Twentieth centuries. These companies were established to produce essential services as ports, printing, transportation and basic commodities such as drinking water and salt. The new national government that took over in 1945 nationalized these firms. Such firms are often mandated to produce a large amount of outputs, in areas where the private sector is unable to provide the capital and organizational framework needed for large-scale production. On the other hand, the establishment of the private sector firms (PSEs) in Indonesia based upon ownership by private individuals. It is formalized by the Chapter 10 of the Rule and Regulation of The Indonesian Chambers of Commerce and Industry (Gitosardjono, 2000) as well as the laws passed by the State.

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Since public and private sector firms cover different purposes, therefore they are different in various management styles and regulations, which often lead to different goals and thus performance differences. In many other developing countries, public sector firms are typically found to be less efficient than their counterparts in the private sector firms, although this conclusion is not yet firmly established in the literature. For example, in China, SOEs are generally found to be operating inefficiently compared to the PSEs (see, Huang, Cai and Duncan, 1997; Lin, Cai and Li, 1998).

The most widely applied measure to evaluate public and private sector firms are financial measures, which is not the same as production efficiency, which motivates this study. In general, there are three main reasons for performance measurements: a concern for value of money in all evaluation process; a concentration upon economy, efficiency and effectiveness; and a focus on management rather than administration staff (Sharma, 2001).

These ratios provide tools for managing information in order to analyse a firm's financial condition and performance (Shapiro *et al.* (2000; 36). These can provide a profile of a firm's economic characteristics, competitive strategies, operating, financial, and investment decisions relating to other firm or industry (White *et al.* (1998; 41)). However, there are some limitations of the financial ratios as performance measures. The fundamental limitation of the traditional univariate ratio analysis is that the choice of a single ratio does not provide enough information about the various dimensions of the *performance* of a firm. In fact, the firm's performance represents the complexity of multidimensional outputs and inputs. Since a firm' performance is a complex phenomenon, it requires more than a single ratio or even selected ratios to characterise it (Smith, 1990). Another limitation of the financial ratio analysis is the choice of a benchmark against which to compare a univariate or multivariate scores from ratio analysis. Since the choice of benchmark is purportedly by users, different users may require different benchmark for different purposes.

To overcome these problems in ratio analysis, a newer method of addressing the issue of efficiency measures is appropriate. One such technique which has been widely used is the *Stochastic Frontier Approach (SFA)*. This is a parametric able to assess multiple variables simultaneously; therefore, we can consolidate multiple measures of financial performance, such as sales, margin, total assets, etc, into a single summary of performance measure. Necessarily, there must be an influence of firm's specific variables, such as size, age and the use of leverage with its inefficiency performance. This aspect of influence of these variables to firm's efficiency performance has still not been sufficiently studied in Indonesian context. Hence this study is a modest effort to start looking at this association.

This study aims to (1) to measure and then compares the technical efficiency performance of SOEs and PSEs, and (2) to examine whether the technical efficiency is dependent on a firm's specific variables such as size, age, and the use of leverage. Findings reported in this paper would be very useful for describing the aspects investigated while economic/financial policymakers could benefit from our findings reported in this study.

The results employing the *Stochastic Frontier Approach (SFA)* methodology show that the existence of technical inefficiency effects in the model. In contrast with Battese and Coelli (1993), Lundvall and Battese 2000), Pitt and Lee (1972), Meagistae (1996), and Brada, King and Ying Ma (1997), we find that firm's size have a negative correlation with the technical inefficiency. As in Hill and Kalirajan (1993), the age of firms has a negative and significant influence on inefficiency scores in the public sector firms but positive in the private firms. Another factor, financial leverage is strongly associated with inefficiency scores in SOEs: this is interpretable as unique to Indonesian firms loaded with too much debt. The effect is positive for both sectors, which means that firms with more debt appear to have more inefficiency. Our test shows that there is a linkage between the traditional accounting ratios and the efficiency scores. Overall, the result indicates that private sector firms outperformed public firms, although the performance is nowhere near to indicate efficiency gains.

Literature Review

Like the non-parametric DEA, the stochastic frontier method is also defining efficiency as the relative distance of a firm from some best practice frontier. However, one has to use the econometric estimation to model factors that explain firm's technical efficiency. Unlike the DEA approach, the stochastic frontier approach uses an econometric approach to estimate static technical efficiency, which was independently proposed by Aigner et al. and Meeusen and van den Broeck in 1977. This approach helps to overcome the primary shortcomings of the DEA of not accommodating measurement errors, which can have an influence on the shape and positioning of the estimate frontier (See, Seiford and Thrall, 1990). In addition, comprehensive reviews of literature of the econometric estimation of the stochastic frontier production function provided are Bauer (1990) and Greene (1993).

Following Aigner *et al.* (1977), this study will use the stochastic frontier function to estimate the technical inefficiency in the production, which is an asymmetric non-negative random error u_i. The production function is as follows:

$$\ln(y_i) = x_i\beta + v_i - u_i,\ i = 1, 2, \ldots, N, \quad (1)$$

$\ln(Y_i)$ is the logarithm of the output for the *i-th* firm; x is vector of inputs; β is a vector of parameters to be estimated; v_i is a symmetric random error that is assumed to account for measurement error and other factors not under control of the firm; and u_i is an asymmetric non-negative random error assumed to account for associated technical inefficiency in production. The values of the unknown parameters of this model usually estimated by maximum likelihood, after making assumptions regarding the distributions of u_i and v_i which are often to be normal and half-normal, respectively (Coelli *et al.*, 1998).

The likelihood ratio test can be used to test the hypothesis of no technical inefficiencies of production as well as the adequacy of the Cobb-Douglas production function. Coelli *et al.* (1998) calculated the statistical test for the null hypothesis as follows:

$$LR = -2\ln\{L(H_0)/L(H_1)\} = -2\{\ln[L(H_0)] - \ln[L(H_1)]\}$$

where $L(H_0)$ and $L(H_1)$ are the value of the likelihood function under null and alternative hypotheses, H_0 and H_1 respectively. It is assumed to have asymptotic chi-square or mix chi-square distribution if the appropriate null hypothesis, H_0 is true.

The test statistics for the null hypothesis of no technical inefficiencies of production is calculated and reported by the FRONTIER Version 4.1 program as the LR test of the one-sided error. The value of this test statistic should be compared with the critical value obtained from Table 1 of Kodde and Palm (1986) for the degree of freedom equal to the number of restriction involved.

This study will follow Battese and Coelli (1995) formulation, in which the technical inefficiency effects of the error term, u_i, is explained by a set of variables, z_i, which have parameter, δ, that is estimated in the same step. The equation is therefore as follows:

$$u_{it} = z_{it}\delta + Wit \quad (3)$$

where: z_{it} is a (1xM) vector of explanatory variables associated with the technical inefficiency effects;

δ is an (Mx1) vector of unknown parameters to be estimated

W_{it} is defined by the truncation of the normal distribution with zero mean and variance.

In addition, the null hypothesis that technical inefficiency effects are not random is expressed by, $H_0 : \gamma = 0$ where $\gamma = \sigma^2/(\sigma_v^2 + \sigma^2)$.

DATA AND METHODOLOGY

Data Description

This study based on unbalanced panel of 141 firms with the total of 1410 observations in two sectors, public and private sector firms, expressed in nominal monetary value of the country with a high inflation.[3] Thus these data need to be adjusted for inflation (Ma *et al.* (2002; 298-312)), using the *Consumer Price Index (CPI)* with base year as 1993 prices, to obtain real values.

3 The average inflation rate during 1999 –2001 is 8 per cent

Methodology

The stochastic frontier production function is used to examine firms' technical efficiency to identify also the factors influencing the technical inefficiency of matched public and private sector firms. Those variables are: firm's size (proxies by number of employees); age; and the use of leverage, which indicates firm's ability to leverage equity with more debt, which again is not expected of public sector firms receiving State budget support.

These variables are chosen based on the assumption that firms' performance is multidimensional in nature and that there exist a various indicators of firms' performance. The input indicators represent three production input (based on the Cobb-Douglas production function: material, labor and capital inputs) used to generate outputs. In addition, sales as the output variable represents possible outputs produce by a firm.

Factors Influencing Technical Inefficiency

This section reports new findings on firms' technical efficiency and the relationship between firm's specific variables and technical efficiency of matched public and private sector firms. A stochastic frontier production function is defined for unbalanced panel of 141 firms with the total of 1410 observations in two sectors, public and private sector firms, in which the non-negative technical inefficiency effects are assumed to be a function of size, age, and the use of leverage.

The maximum-likelihood method is applied for the estimation of the parameters of the model and the prediction of the technical efficiencies of the firms over time using the production accounting data. We adopt a translog stochastic frontier production function. The inefficiency effects in the input use are modeled in terms of one output variable: sales obtained by the firms in the given year, and three production inputs: material cost (input 1), labour cost (2) and depreciation expenses (3), the last item is a proxy for capital input. The generalised likelihood-ratio test is considered as relevant to test the null hypotheses that the inefficiency effects do not exist and that these effects do not depend on the firm-specific variables, namely size (proxies by the number of employees), firm's age, and leverage (the ratio of total debt to total assets) The maximum likelihood estimates of the model were obtained using the software package FRONTIER Version 4.1c (Coelli, 1996).

Table 1
Generalised Likelihood-Ratio Tests of Null Hypotheses for Parameters in the Stochastic Frontier Production Function of SOEs and PSEs (1992-2001)

Null Hypotheses Ho	SOEs	PSEs	Critical Value*
$\beta_{ij} = 1,2,3,4$	41.3	87.21	11.07
(Cobb-Douglas function)			
$\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = 0$	44.55	499.96	10.37
(no inefficiency effects)			

*Critical values are obtained from the appropriate chi-square distribution, except fro the test of hypotheses involving $\gamma = 0$. *(Kodde and Palm, 1986, Table 1; Coelli and Battese, 1998)*

Table 1 contains the likelihood ratio (LR) statistics for parameters in the stochastic production function for all firms in public and private sectors. The first test reported in Table 1 is to select the functional form. The null hypothesis is that the Cobb-Douglas functional form is an appropriate function to represent the data. The result form the likelihood ratio test reveals that the null hypothesis is rejected in both sectors, which means that the translog functional form is a general functional form as better suited to represent the data. The second test is the test of the null hypothesis of no technical inefficiencies of production, which led to the rejection that is zero in the public as well as in the private sectors. This suggests that inefficiency is present in production and that the traditional average response in production, in which firms are fully technically efficient, is not an adequate representation of the data.

Table 2 reports the estimation of the parameters for unbalanced panel of 141 firms with total of 1410 observations in two sectors, public and private sector firms, in which the non-negative technical inefficiency effects are assumed to be a function of size, age and the use of leverage. The observation includes 40 SOEs and 101 PSEs over 1992-2001, in three industry groupings namely the Agricultural and Chemicals, Industrial and Mining, and Transportation and Services.

State-Owned Enterprises (SOEs)

The estimated coefficients of four inputs for the SOEs are reported in Panel A, in Table 6.2. The result shows a negative sign on the estimated coefficient for material in this sector. The negative sign implies that the public sector firms' efficiency decreased because firms used more material inputs, which is consistent with theory. In addition, the estimated labour coefficient of the stochastic frontier of SOEs has a positive sign, which is significantly associated with efficiency. This finding means that the greater use of labour leads to lower efficiency. The estimated coefficient for capital is also positive and but is insignificant, which implies that SOEs' productivity increases as they use more capital inputs, a result which is consistent with theory as well as findings reported in the last chapter. Thus capital scarcity of this country is a limiting factor for efficiency. Finally, we also found a negative association between time and production efficiency. This indicates that the SOEs' efficiency decreased over time during the observation periods. However, the associations were not strong and were insignificant, except for the labor variable.

Panel B results: The estimated δ -coefficients of the firms' specific explanatory variables in the model for technical inefficiency effects have important implications and are of interest. We observed that size of the firms has negative effect. The negative sign indicates that the firms with more employees tend to be more technically inefficient than firms with fewer employees. The estimated coefficient associated with age is negative, and is statistically significant.

It indicates that the older firms are more technically efficient than those younger firms. This is consistent with theory that learning takes time, and learning is associated with improved efficiency and establishes growth (Jovanovic, 1982, 1995). Firm's leverage has a positive association with inefficiency in this sector. The positive association implies that firms with greater use of capital tended to be more technically inefficient. A positive coefficient would appear to suggest that technical inefficiency increases as debt increases.

Panel C results: The parameters $\sigma_s^2 = \sigma_v^2 + \sigma^2$) and $\gamma = \sigma^2/\sigma_s^2$, are associated with the variances of the random variables, v_{it} and u_{it}. The results show that the estimate for the γ-parameter is close to unity (0.834), which means that the frontier model is appropriate for the public sector firms. This result is supported by the LR test of hypothesis that technical efficiency effects are not simply random errors is significantly rejected (44.55). It implies that the variance of the inefficiency effects is significant component of the total variances of the error terms. That indicates that the technical inefficiency effect has an impact on the output. This result is consistent with the value of γ, which is close to unity.

Technical efficiency: The average technical efficiency (TE) of 0.731 for SOEs is obtained. It indicates that, on average, private sector firms produce 73.31 percent of the output that could be theoretically produced with the same bundle of inputs by a technically efficient firm. Therefore, SOEs need to increase their output by 26.90 percent to become fully efficient.

Table 2: Maximum-Likelihood Estimates of Parameters of the Translog Stochastic Frontier Production Function for SOEs and PSEs (1992-2001)

Variable	Parameter	SOEs	PSEs
A. Frontier Function			
Constant		3.928	8.889
		(5.829)***	(10.217)***
log (Material)		-0.297	-0.981
		(-1.425)	(-8.205)***
log (Labour)		1.045	0.894
		(4.381)***	(7.098)***
log (Capital)		0.178	0.865
		(1.298)	(11.692)***
log (Time)		-0.314	-2.095
		(-1.050)	(-7.973)***
log mat*log mat		0.156	0.158
		(4.640)***	(16.058)***
log mat * log lab		-0.211	-0.158
		(-3.182)***	(-13.222)***
log mat * log cap		-0.053	-0.142
		(-1.922)*	(-9.591)***
log mat*log time		0.013	0.449
		(0.260)	(14.498)***
log lab* log lab		0.047	0.006
		(1.187)	(0.599)
log lab * log cap		0.308	0.109
		(1.013)	(7.317)***
log lab * log time		0.13	-0.008
		(1.962)**	(-2.150)
log cap * log cap		0.012	0.015
		(1.145)	(3.345)***
log cap * log time		0.007	-0.266
		(0.157)	(-11.052)***
log time * log time		-0.342	0.0003
		(-1.094)***	(0.809)
B. Inefficiency Model			
Constant		-0.371	-12.055
		(-0.816)	(-4.473)***
Size		-0.0009	0.00008
		(-2.545)***	(5.096)***
Age		-0.083	-0.131
		(-3.267)***	(-4.516)***
Leverage		0.004	-0.005
		(2.168)**	(-6.906)***
C. Variance Parameters			
		1.438	8.528
		(8.303)***	(5.496)***
		0.834	0.980
		(22.048)***	(272.33)
Log-likelihood**		44.55	499.96
Mean TE		0.731	0.679

Private Sector Enterprises

Table 2 presents the estimation of the parameters of the translog stochastic production function, for 40 SOEs with a total of 400 observations. Panel A reports the estimated coefficient of three inputs for the private sector firms. As in the SOEs, the result shows negative sign of the estimated coefficient for the material inputs, though it is insignificant. The negative and significant association implies that private sector firms' efficiency decreases as they use more material inputs, which is inconsistent with theory (when a firm operates to maximize profit, it is expected to increase output).

The estimated labor coefficient for private sector firms has also shown a positive sign. This is expected since greater use of labor (up to the point of marginal revenue being equal to the marginal cost of inputs), must lead to greater efficiency. We also found that the estimated coefficient for capital is positively and significantly associated with firms' efficiency in this sector. This implies that private sector firms' productivity increases as they use more capital inputs, a result which is consistent with theory, especially in a country where capital is scarce, and is often rationed by lenders/providers. In addition, there was also a negative association between time and firm's efficiency. This implies that the efficiency of the private firms decreases over time. The possible reason for the negative association is that one half of the observation periods included the years after the crisis period, which affected almost all of the sectors in the Indonesian economy.

Panel B results: The estimated δ-coefficients of the firm-specific variables in the model for technical inefficiency effects have important implications and are of interest. We observed that the size of the firms (proxies by the number of employees) has positive effect for the PSEs. The positive sign indicates that the firms with more employees tend to be more technically inefficient than those with fewer employees.

The estimated coefficient associated with age is negative. The negative sign indicates that the older firms are more technically efficient than those younger ones. This is consistent with the theory that learning takes time. Firms' leverage has also a negative sign for the PSEs. The negative association implies that firm with greater use of leverage tended to be more technically efficient. A positive coefficient for PSEs would appear to suggest that technical inefficiency is decreased by more debt. A potential reason for this is that firms can improve efficiency by investments in a new production technology by using more debt.

Panel C results: The parameters and, are associated with the variances of the random variables, and. The estimation for the -parameter is 0.980 with the LR-ratio of 499.96. It implies that the variance of the inefficiency effects is a significant component of the total of the variances of the error terms. Hence the translog production function is an adequate representation of the data. It indicates that the technical inefficiency effects have impacts on the output. This result is consistent with Panel B results, indicating all of z-variables are significant for the inefficiency effect model.

Technical efficiencies: The average technical efficiency (TE) of 0.679 in PSEs is obtained using the translog stochastic production function. It indicates that on average, private sector firms produce 67.90 percent of the outputs that could be theoretically produced with the same bundle of inputs by a technically efficient firm. Therefore, PSEs need to increase their output by 32.10 percent to become fully efficient.

Conclusion

This paper provides new findings on the factors influencing firms' technical efficiencies in the public and the private sector firms in Indonesia, using ten years of firm level accounting financial and factor value data. Test for the adequacy of the Cobb-Douglas functional form relative to the translog shows that the Cob-Douglas form is rejected for both sectors. The rejection of the null hypothesis implies that the translog functional form is a more general functional form, which would be a better model in representing the data in the public and private sectors. The null hypothesis that there is no inefficiency effect in the model is rejected in both sectors. This suggests that inefficiency is present in the production and that the traditional average response in production, in which firms are fully technically efficient, is not an adequate assumption for analysis. These results are also consistent with studies in the literature but covering other economies. U

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