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Economies of Scale and Efficiency of the Pulp Industry in Indonesia: Cobb-douglas Cost Function Approach

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ABSTRACT

This study aims to analyze the economies of scale and efficiency using long-term Cobb-Douglas function model to derive coefficients that require economies of scale and efficiency in the pulp industry. The economies of scale are derived from the Cobb-Douglas Deterministic cost function model. While the level of cost efficiency is obtained from the use of Cobb-Douglas Stochastic Frontier cost function model. This study used data panel that include five companies in the pulp industry during the observation period of 2009–2014. The results show that the pulp industry reaches economies of scale but there is cost inefficiency. The factors that drive the pulp industry to have high concentrations of which are large economies of scale supported by efficiency. Despite of reaching economies of scale, cost inefficiency has occurred. The cost inefficiency indicates that the economic scale of a large pulp company is relatively not supported by the company's ability to eliminate cost inefficiency, but the company enjoy an economies of scale advantage as reflected in production levels under the minimum efficient scale (MES). It implied that an increase in industry concentration ratio, entry barriers and large capital needs enter into the pulp industry.

Keywords: Cobb-Douglas Cost Function, Stochastic Frontier Analysis, Economies of Scale, Inefficiency, Minimum Efficient Scale
JEL Classiffications: D24, L11, L60

1. INTRODUCTION

The pulp industry in Indonesia is concentrated in two large enterprise groups namely Raja Garuda Mas with PT. Toba Pulp Lestari (Inti Indo Rayon) in North Sumatra Province and Riau Andalan Pulp & Paper in Riau Province. Then Sinar Mas Group (SMG) with PT. Indah Kiat Pulp & Paper (IKPP) in Riau Province and PT. Lontar Papyrus in Jambi Province. Except PT. Tanjung Enim Lestari in South Sumatra Province, originally owned by the Barito Group consortium with Marubeni Japan, is now fully owned by Marubeni Japan.

Each plant is generally supported by the Industrial Plantation Forest (HTI) around the plant. Along with the increase in demand for pulp, the need for wood raw materials cannot be fullfilledby HTI around the plant. SMG, for example, brings wood raw materials from South Sumatra and Kalimantan to supply Indah Kiatplantin Riau. PT. TanjungEnim Lestari in South Sumatra in recent years has brought in logs from Kalimantan. Given such condition, the pulp plantswill try to get the cheap price of wood raw material.

The cost of pulp and paper production in Indonesia is relatively cheaper than that in competing countries. According to one of the most prominent research results in the world, Information Information System Inc. (RISI), the production cost (cash cost) of short pulp fiber per ton in Indonesia is only US $ 184, in USA about US $ 385, in Canada around US $ 330, and in Brazil US $ 271 (Ministry of Industry, 2009).

Table 1 shows the development of input cost structure of the pulp industry where the largest cost composition is for raw material procurement. During the observation period, the average cost of raw materials reached 85.51% of the total cost of industrial inputs.

Table 1: Composition of pulp industry input cost

Input type	Year (%)						
	2009	2010	2011	2012	2013	2014	Average
Raw material	86.02	87.49	81.89	76.92	83.78	97.01	85.51
Fuel	7.76	5.21	7.53	6.54	5.09	2.42	5.75
Electricity	0.01	0.01	0.74	3.28	3.82	0.13	1.33
Building rent	0.00	0.01	0.01	0.04	0.04	0.00	0.01
Industrial services	0.00	0.15	0.18	6.22	1.82	0.09	1.41
Other expenses	6.20	6.45	9.65	7.01	5.45	0.35	5.85

Source: Central Bureau of Statistics (BPS), Processed Data

This indicates that the control over raw materials (chipwood) is very important for the pulp industry. The low cost of raw materials will increase industry efficiency.

The pulp industry in Indonesia is concentrated in two companies. The high concentration of the two company ratios shows the level of competition is in decline. The dominance of the largest company's high output also indicates the ability to perform a monopoly power, i.e. when the price and output decisions of the company are more difficult to be resisted by the market. High market control means industrial demand in this case is equal to the output of the company. The company's production capacity will be determined by the price level. The higher the capacity is used, the lower the price becomes, yet the higher the productive capacity is unused, the higher the price will be (Hasibuan, 1993).

Efficiency is associated with reduced costs. The production level having the most efficient cost is called minimum efficient scale (MES). The value of MES pulp industry is very high above 10% which reaches an average of 37%, so that the number of market segments that must be obtained can be determined if one wants to enter the industry (Table 2).

Under high MES conditions, new investments are only possibly conducted by the old companies such as increasing production capacity or an owner of a holding company establishes a new plant. For example, PT. OKI Pulp and Paper Mills in South Sumatra with an investment value of US $ 5.4 billions having pulp production capacity of 2 million tons per year which can be increased to 2.8 million tons per year. The output of MES (Q^{MES}) condition of the pulp industry is 37% or 2,719,190.2 tons, close to the plan of PT. OKI Pulp and Paper Mills.

Given the above condition, will the company be able to achieve the economies of scale of its so great investment? Of course such a thing can happen when it is in line with the efficiency of the company in generating the average cost per ton of pulp which is declining. In the pulp industry, the achievement of efficiency can be seen from the decrease of the conversion factor of logs per ton of dry pulp.

Industrial efficiency is a performance parameter that is widely used in calculating the performance measures of a company. Calculation of industrial profit rate, comparison between output and input, ratio size, and so on, is often used to indicate good performance. However, some of these calculations have not yet shown the actual efficiency performance. Economic efficiency is related to the efficient use of inputs, i.e. the use of the smallest inputs to obtain maximum production. One approach of calculating the economic efficiency of an industry is to use stochastic frontier analysis (SFA).

Table 2: Development of CR2 and minimum efficient scale of pulp industry

Year	CR2	MES
2009	0.82	0.41
2010	0.71	0.36
2011	0.75	0.37
2012	0.74	0.37
2013	0.67	0.34
2014	0,72	0,36
Average	0.74	0.37

Source: Processed data. MES: Minimum Efficient Scale

The economies of scale of a company is reflected in a decrease of production costs (input) which is in line with an increase in the amount of production (output). The economies of scale is inseparable from the relationship between input and output, meaning that the production increases while the costs tend to decrease or remain (Martin, 1994). When an increase in the company's production scale results in a lower average cost, it is called an economies of scale. Some economies of scales are related to a technology, and some others result from a company size (Case and Fair, 2007). Varian (1992) states that in the long run all costs are variable (variable cost), in which case the increased average cost is unreasonable because a company will repeat the same production process. In the long run it is more likely that the average cost will be constant or even decrease.

2. LITERATURE REVIEW

2.1. The Cost Function of Deterministic Cobb-Douglas

The estimation of the long-term cost function of a long-term production using two types of capital input C, and labor L, with the price of each input is r per unit C and w per unit L, is as follows:

$$TC = f(Q, r, w) \tag{1}$$

As an alternative to estimating long-term cost functions, the Cobb-Douglas model is used since the economic concept is able to explain the effect of input price changes on long-term cost changes. The long-run total cost equation is formulated:

$$TC = \alpha Q^{\beta} r^{\gamma} w^{\delta} \tag{2}$$

In order to ensure that the long-term TC is positive and increases as output and output prices increase, parameters are made in the Cobb-Douglas model, ie: $\alpha > 0$, $\beta > 0$, and $0 < \delta < 1$.

To predict the long-run total cost function, Cobb-Douglas model is transformed into natural logarithm (ln), as follows:

$$\ln TC = \ln \alpha + \beta \ln Q + \delta \ln (w/r) + 1 \ln r \qquad (3)$$

Solution by moving 1 ln r to the left segment of the equationbecomes:

$$\ln TC - \ln r = \ln \alpha + \beta \ln Q + \delta \ln (w/r) \qquad (4)$$

Therefore, the estimation of the long-term total cost function can be performed using the Cobb-Douglas logarithmic transformation equation:

$$\ln (TC/r) = \ln \alpha + \beta \ln Q + \delta \ln (w/r) \qquad (5)$$

Furthermore, the cost elasticity can be calculated (Ec) $=\% \Delta TC/\% \Delta Q = \beta$. This coefficient can be used to measure an economies of scale. If $\beta < 1$ then there occus an economies of scale. If $\beta = 1$ there is a constant economies of scale, and if $\beta > 1$ there is a diseconomies of scale (Gaspersz, 2003).

2.2. The Cost Function of Stochastic Cobb-Douglas

Measurement of efficiency with SFA approach can be carried out through output-oriented approach for technical measurement of efficiency, and input-oriented approach for cost efficiency measurement. Technical efficiency is measured by stochastic frontier production, while cost efficiency is measured based on stochastic cost frontier (Kumbhakar and Lovell, 2000).

The result of the analysis of the SFA procedure represents the value of industry inefficiency. SFA method uses ui value (error or random factor that can be controlled) to get efficiency value. The error component (ui) is the basis of calculation to obtain efficiency value. The estimated cost efficiency value is shown by the average inefficiency distribution (ui). The inefficiency value in the cost function ranges from 1 to infinity. The cost efficiency value is the ratio of the actual minimum cost to the minimum cost observed (Coelli et al., 2005).

The study used panel data in the form of observation as many as i companies for a t time period. By using the expanded Cobb-Douglas homogeneous frontier cost function, the inefficiency parameter assumption follows the time invariant model, the stochastic cost frontier model can be written as follows:

$$\ln Cit = \beta_{0t} + \sum_{k=0}^{n} \beta_n \ln Y_{nit} + v_{it} + u_{it} \qquad (6)$$

Where:
u_{it} = error factor that can be controlled
vi_t = error factor that cannot be controlled

If the cost efficiency of the i-company is denoted by CEi then:

$$CEi = \frac{c\left(yi, wi, \beta\right)\exp\{vi\}}{Ei} \qquad (7)$$

Where c (yi, wi, β) is the cost frontier applicable to all companies, β is the vector parameter to be estimated, Ei is the cost incurred by the i-thcompany, and exp {vi} is the random portion outside the control of the company that is special for each company. Cost efficiency is defined as the minimum ratio that can be achieved in an environment characterized by exp {vi} to the actual cost.

For functional formula specifications for cost (Ci), the Cobb-Douglas cost-based frontier formula can use (Coelli et al., 2005):

$$\ln C_i \geq \beta_0 + \sum_{n=1}^{n} \beta_n \ln w_{ni} + \sum_{m=1}^{m} \Phi \ln q_{mi} + vi \qquad (8)$$

Where v_i is a symmetric component representing a random noise that represents statistical noise. It is equivalent to:

$$\ln C_i = \beta_0 + \sum_{n=1}^{n} \beta_n \ln w_{ni} + \sum_{m=1}^{m} \Phi \ln q_{mi} + vi + ui \qquad (9)$$

Where: u_i is a non-negative variable representing inefficiency. Substitution equation 9: Frontier model cost Cobb-Douglas:

$$\ln\left(C / w_{Ni}\right) = \beta_0 + \sum_{n=1}^{n-1} \beta_n \ln\left(w_{ni} / W_{ni}\right) + \sum_{m=1}^{m} \Phi \ln q_{mi} + vi + ui \qquad (10)$$

3. RESEARCH METHOD

The complete data obtained from BPS affected the time period of observation in the study. Based on the available data, the time period in this study was from 2009 to 2014. The observed object was the pulp industry (KBLI 17011). The observation year period was based on the composition of the complete raw data available for processing and analyzing was the panel data of five pulp companies taken from 2009 to 2014.

The data used in this research were as follows:

1. Total cost: The cost incurred in the production process consisting of the cost of raw materials, fuel, electricity and gas, building rental, machinery and equipment, non-industrial services. It is based on the data derived from BPS.
2. Labor costs: Wages plus allowances.
3. The price of labor is the cost of labor divided by the amount of labor.
4. Capital cost: The amount of interest, depreciation and tax. It is based on the data derived from BPS.
5. Capital Price is the cost of capital as a percentage of fixed capital. According to BPS, the definition of fixed capital is the estimation of capital accumulation from the beginning of the company establishment until now.
6. Production: The production of the pulp production process

Method of data analysis was conducted based on the aims of the study. The steps Were as follows:

1. Method of estimating cost function was based on the deterministic Cobb-Douglas cost function to find out whether the pulp industry reached economic scales. This referred to equation (5).
2. Method of estimating the cost function was based on Cobb-Douglas frontier cost function to calculate the achievement of the cost efficiency level of each observed pulp industry. This referred to equation (10).

The technique of analysis in this study was divided into two stages:

Stage 1: Was to formulate a good cost-functional estimate for the pulp industry based on the deterministic Cobb-Douglas cost-function theory:

$$\ln (TC/P_C) = \alpha + \beta_1 \ln Q + \beta_2 \ln(P_L/P_C) \quad (11)$$

Which was then formed into the original Cobb-Douglas equation to find out the coefficient sign as a function of cost and economic scales.

$$TC = \alpha\, Q^{\beta} r^{\gamma} w^{\delta} \quad (12)$$

Stage II: Input-oriented efficiency with econometric equations used in pulp industry cost analysis was Stochastic Frontier Cobb-Douglas model as follows:

$$\ln\left(\frac{C}{P_{Ci}}\right) = \beta_0 + \sum_{n=1}^{n-1} \beta_n \ln\left(\frac{P_{Li}}{P_{Ci}}\right) + \sum_{m=1}^{m} \Phi \ln q_{mi} + vi + ui \quad (13)$$

Where: C = total cost; Q = total production; PL = price of labor input; PC = price of capital input; ui = random factor that can be controlled (inefficiency); and vi = Random factors that cannot be controlled.

4. RESULTS AND DISCUSSION

The estimation results of the Cobb-Douglas Pulp industry cost function were shown in Table 3.

Table 3: Cost estimation of the cobb-douglas deterministic cost of pulp industry

Dependent variable ($\ln TC/P_C$) Total panel (balanced) observation: 30				
Variable	**Regression coefficient**	**SE**	***t*-statistic**	**Prob**
C	−8.549389	1.634952	-5.229139	0.0000
Ln Q	0.961122	0.111796	8.597083	0.0000
Ln P_L/P_C	0.724579	0.210024	3.449979	0.0019
R^2	0.917988			
F-statistic	151.1108			
Prob (*F*-statistic)	0.000000			

Source: Processed data. SE: Standard deviation

Written as follows:

$$\ln(TC/P_C) = -8{,}549389 + 0.961122 \ln Q + 0.724579 \ln P_L/P_C$$

Or it is modified in the form of a genuine Cobb-Douglas function to obtain an empirical equation of total long-term cost:

$$TC = (2{,}71828)^{-8{,}549389} Q^{0{,}961122} (P_L/P_C)^{0{,}724579} P_C$$

$$TC = 0{,}000194\, Q^{0{,}961122} (P_L/P_C)^{0{,}724579} P_C$$

The regression coefficient mark corresponded to the Cobb-Douglas model requirements: α = 0.000194 (α > 0), β = 0.961122 (β > 0), and δ = 0.724579 (0 < δ < 1). Then the elasticity of total cost could be calculated (Ec) = β. This coefficient of total β cost elasticity could be used to measure the scale of economic effort (economic scale). The value of β < 1 means that all company capacities in the industry had economic scales in the year of observation.

Based on the estimated cost function of Cobb-Douglas then the regression coefficient was the coefficient of elasticity. The equation above shows that the total output component of production (Q) has a positive and highly significant effect on the total cost. Input component in the form of ratio of labor wage to capital price (PL/PC) also had a positive and significant effect to total cost.

The output component Q with a coefficient of 0.961122, means a relative increase of 1% of output Q then in absolute terms would increase the cost by 0.9611%. So was the input component (PL/PC) with a coefficient of 0.724579, meaning that a relative increase of 1% ratio (PL/PC) in absolute would increase the total cost by 0.7245%.

The output coefficient of Q and input (PL/PC) was still below 1, indicating the cost elasticity was inelastic where if the output doubled the cost increased less than that of doubled. This means companies in the pulp industry achieved economic scales.

Economi scales are associated with a decrease in the cost of producing one unit of product due to the increase in the number of products produced per period. Economies of scales other than expressed in the level of overall company output can also be described from each function in the company, for example economic scales of raw material storage, processing, logistics, marketing and distribution (Porter, 1980).

Asia Pulp and Paper (APP) reported that Indah Kiat used 4.8 m^3 of wood and Lontar Papyrus consumed 5.0 m^3 of wood to produce 1.0 ton dry pulp. APP emphasized various planned steps to increase efficiency in order to reduce the wood conversion efficiency to 4.7 m^3 of wood per ton of pulp. It includes improved operational systems for storage and handling of timber, bark opening, chip making and screening (Wetlands and RAN, 2016).

The wood conversion factor for pulp was 4:1 or for a ton of pulp it took four tonnes of wood where one ton of wood was estimated to be equivalent to 1.2–1.3 cubic depending on the degree of dryness of the wood. The price per cubic of wood ranged from Rp.350,000 - Rp.375,000 per cubic (Interview, 2016).

Pulp industry production activities require a lot of capital in the form of machines, equipment, and buildings that are used continuously during the production process. A large initial capital expenditure is indispensable in the industry. The company's investment will increase the capital supply. The price of capital or the cost of capital use in the form of interest may decrease in the long term, the depreciation will also decrease, and generally large investments also get tax deductibility incentives.

Another cost that can be suppressed is the purchase of raw materials. This is because the pulp industry is also integrated with the supply of timber from plantation forests as raw materials. APP as the sole supplier for IKPP refinery can at least supply its timber needs from 38 HTI concessions in Sumatra and Kalimantan in the SMG.

The form of prediction model of the cost efficiency level of the pulp industry can be written as follows:

$$Ln\ (TC/P_C) = -93399977 + 0{,}87023119 ln(P_L/P_C) + 0{,}89997573\ lnQ_1 + vi + \mu i$$

Based on the estimation of stochastic frontier cost function, the regression coefficient was the coefficient of elasticity. Looking at the significance of the influence of independent variables on the dependent variables individually t-test was used. The significance of this influence can be seen by comparing t value with t table at alpha = 0.05 equal to 1.70329 (Table 4).

The labor wage ratio variable to the capital price (PL/PC) had a coefficient of 0.87023119, meaning that if the ratio of labor wages to capital prices was increased by one percent, it would raise the cost of 0.8702 percent. The variable (PW/PC) had a significant effect to the total cost because t-count value > t-table that is: 6.7238> 1.70329.

The production variable (Q1) had a coefficient of 0.89997, meaning that if production increased by one percent it would raise the total cost by 0.89997 percent. The production variable (Q1) had a significant effect on total production cost where the value of t-count> t-table, that is 4.1083 > 1.70329.

The result of the analysis showed that gamma value (γ) was 0.79802 and significant was at α = 0.05 where t count> t-table, it showed that the cost variation of 79.80% was caused by the difference in cost efficiency or inefficiency controlled randomness or component errors (ui) while 20.20% was due to the variables that were beyond the control of a company or an uncontrollable random factor (vi) including statistical noise and measurement errors.

Furthermore, the cost efficiency could be predicted from the model. The efficiency condition of each company during the 6 year observation period indicated a number greater than one indicating the inefficiency. The average inefficiency of the pulp industry during the observation period was 5.99907, meaning that the actual minimum cost was 5.9 times higher than the observed cost.

This showed that the ratio of concentration to high pulp industry was not followed by the development of efficiency level. The cost inefficiency indicated that a company was not able to lower its costs or allocation of resources did not reach its maximum level. In the long run, the ability to change the amount of capital allows the company to reduce costs. This condition was depicted by the relationship between the scale of the company's operations and the input needed to minimize its cost (Pindyck and Rubinfeld, 2013. p. 262-264).

The inefficiency in the pulp industry can be caused by the production that is below the full capacity. Factory machinery operates at cost at full operating scale, but the resulting output is not optimal because managers calculate international price conditions and world pulp demand in determining production. The conversion factor of wood chip flakes per ton of pulp may also have an effect on inefficiency. Expenditure on external controls also contributes to increased cost inefficiencies.

5. CONCLUSION

Based on the predictability of the deterministic Cobb-Douglas cost function, the pulp industry in Indonesia is at economies of scales. The achievement of economies of scales can be attributed to the advantages of absolute cost (limit-pricing), control over cheap raw materials sources, financial resources and reliable managers, favorable locations on the island of Sumatra and Kalimantan, government policies and high MES scores that limit new competitors.

Based on the estimated cost function of Cobb-Douglas stochastic frontier, the efficiency value of the pulp industry in Indonesia shows the inefficiency of costs from the activities of companies that exist in the pulp industry. One of the driving factors causing pulp industry to have high concentrations is large economies of scales supported by the efficiency. However, despite reaching economies of scales, in fact cost inefficiency has occurred. It

Table 4: Results of maximum likelihood estimation of cost function of cobb-douglas frontier stochastic pulp industry

Dependent variable: ln (TC/P_C) Stochastic frontier half normal model			Number of observation: 30	
Variable	**Parameter**	**Coefficient**	**SE**	***T* ratio (count)**
Constants	β_0	−9.3399977	1.4299936	6.5314961
Ln (P_L/P_C)	β_1	0.87023119	0.12942423	6.7238663
Ln Q1	B_2	0.89997573	0.21906157	4.1083232
σ^2 Sigma Square	$\sigma^2=\sigma^2V+\sigma^2U$	2.5021886	1.0551266	2.3714581
Gamma	$\gamma=\sigma^2U/\sigma^2$	0.79802835	0.20399800	3.9119421

Source: Processed data. SE: Standard deviation should be with a large economies of scale that many aspects of the cost of the pulp industry can be decreased. Yet, it is not the case, due to external factors such as raw material dependence, high pulp transportation costs, and externality control costs as well as internal factor such as under capacity.

The occurrence of cost inefficiency shows that the economies of scale of a large pulp company is relatively not supported by the company's ability to eliminate cost inefficiency, but the companies enjoy the economies of scale advantage due to the increase of industrial concentration ratio and entry barriers as well as the large capital requirement to enter into the industry.

Due to the high concentration ratio and oligopoly market structure, it shows that most of the market share is controlled by a small number of companies. Thus, competition in the market or industry is low. The level of competition in this case is the result of the interaction of several factors: in the form of plantation tenure, market network and the development of world pulp, environmental control and financial institution support. These factors are in part a random factor that cannot be controlled by the industry.

The slow growth of the pulp industry causes companies to compete for existing market share only. Competition to gain market share is associated with the increasing concentration ratio. Conversely, if market growth is high, companies in the industry compete to gain a large market share in associating with decreasing ratio concentration.

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