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Technical And Economic Efficiency Of Broiler Farming In Different Partnership Models In Sukabumi Regency, West Java, Indonesia

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Abstract – The broiler industry in Indonesia is the livestock industry with the fastest growth compared to other types of livestock. There is a downward trend in the number of broiler breeders due to limited capital and low livestock business efficiency. This study aims to analyze factors affecting broiler production and measure the level of technical and economic efficiency of broiler farming in the PIR (the nucleus-smallholders models) and Makloon models. Sukabumi Regency was chosen as the research location because it is one of the production centers for broiler farming in West Java Province, Indonesia. The data used is broiler production in 2021, which is 130 units for the PIR and 116 units for the Makloon models. Cobb-Douglas Production Stochastic Frontier (CDPSF) function is used to analyze this study. Factors that have a significant effect on broiler production are DOC, starter feed, finisher feed, and labor. The elasticity of starter feed is the highest compared to other production factors. The proportion of farmers in the Makloon model is greater than in the PIR model, both for technical and economic efficiency. This shows that the Makloon model is better than the PIR.

Keywords – Makloon, Partnership, PIR, Production

I. INTRODUCTION

In Indonesia, the poultry industry, especially broilers, is the livestock industry with the highest growth compared to other types of poultry. During the period 1991 - 2020, the population growth rate of broilers reached 9.2% per year. The structure of the broiler farming industry is the most complete compared to other livestock industries, both upstream and downstream. The contribution of broiler meat to national meat production is the highest (70.05%) compared to other types of livestock. The per capita consumption of chicken meat is the highest compared to other livestock meat consumption, with a growth rate of 9.87% per year (Directorate General of Livestock and Animal Health 2021).

In terms of population, livestock companies control 85 % of broiler production, and only about 15% are controlled by independent smallholder farmers (Indonesian Center for Agricultural Socioeconomic and Policy 2016). Even in terms of the number of business actors, there are only 133 companies that raise broilers (Indonesian Central Statistics Agency 2019). On the other hand, the condition of smallholder farmers is faced with limited capital and market access. Farmers face price risk, both input prices, and output prices, in addition to production risk. One of the efforts to overcome the conditions faced by smallholder farmers is through partnerships. For farmers, partnerships are expected to be able to overcome limited capital and market access, while for companies to ensure the quantity, quality, timing of distribution, and continuity of live chicken supply (Daryanto 2019).

West Java Province is the center of the national broiler industry, with a share of 25.59%, then Central Java at 19.49%, East Java at 14.29%, and Banten at 6.36% (Directorate General of Livestock and Animal Health 2021). Sukabumi Regency is a broiler production center in West Java, ranking third after Bogor and Ciamis Regencies. Sukabumi Regency is also one of the centers of chicken breeding companies in addition to Purwakarta and Subang Regencies. Sukabumi Regency is also a broiler farming area for integrator companies, as well as a center for middle-class broiler companies (Food Security and Livestock Agencies of West Java Province 2020).

Broiler farming is generally faced with limited capital and marketing (Bakal & Penkar 2016; Sally 2015; Swain 2014). Smallholder farmers are relatively difficult to access capital from formal financial institutions such as banks due to limited collateral as the main requirement. Thus likewise with marketing, smallholder farmers generally have limited market access so that farmers generally act as price takers with a weak bargaining position, partly because the market structure of the livestock production facilities industry is an oligopoly and the market structure of livestock production tends to be oligopsony, others are caused by imperfect market information (Kakade et al 2012; Siregar et al 2016; Wainaina et al 2012; Taylor & Domina 2010). This condition causes smallholder farmers to be very vulnerable to price risk, both input prices, and output prices. Parties, and broiler farming activities are faced with a relatively high production risk because broilers are very susceptible to environmental conditions (North & Bell 1990).

In Sukabumi Regencies, there are two models of partnership broiler farming, namely PIR (Perusahaan Inti Rakyat - the nucleus-smallholders models) and Makloon models. In both models, DOC (day-old chick), feed, and medicines + vitamins are supplied by the company, while farmers provide operational costs such as husk, gas, electricity, labor, and disinfectant. The difference is in the payment system for production and incentives. In the PIR models, farmers get production results and incentives after harvest, while in the Makloon models, the payment is made at the beginning of production and production incentives after harvest, the amount of which depends on the achievement of production performance set by the company. This study aims to : (1) analyze factors affecting broiler production, and (2) measure the level of technical and economic efficiency of broiler farming in the PIR and Makloon models.

II. MATERIAL AND METHOD

The concept of technical efficiency (TE), is the ability of a company (farming) to obtain maximum output from the use of a set of inputs (Farrell,1957; Coelli *et al.*, 1998). In Figure 1, the points along the isoquant (SS') represent technically efficient production. Second, allocative efficiency (AE) is the ability of a company (farming) to use inputs in optimal proportions at certain prices and production technologies (as long as isocost – AA'), and third is economic efficiency (EE) or total efficiency is the condition of the company to produce maximum output at a certain cost (TE and AE combined), namely at point Q'. The SS curve is an isoquant frontier that describes the minimum input combination to produce the most technically single unit output efficiently. Points P and Q represent two producer conditions in production with combined input with proportion the same x_1/y and x_2/y inputs. A producer which combines inputs to produce one unit of output that is at point P is said to be technically inefficient because technical inefficiency is described by the distance QP i.e. the number of inputs that can be reduced proportionally without reducing output. The number of inputs that need to be reduced to be technically efficient is shown by QP/OP ratio. Technical input combination efficient i.e. point Q because it is right at the isoquant frontier. The value of efficiency is technically measured by the OQ/OP ratio.

Allocative efficiency using criteria minimum cost to produce a number of a certain output on an isoquant. The input price ratio information is as follows: the slope of the isocost line. If the price-price ratio inputs x_1 and x_2 are indicated by lines AA' then the allocative efficiency can be calculated. Allocative efficiency can be determined if the line AA' is tangent to the isoquant SS' curve i.e at the point Q' as measured by the ratio OR/OQ. RQ distance shows reduction costs that can be used to achieve allocative efficiency. Efficient point allocatively and technically or in words others, economic efficiency is at the point Q'. Economic efficiency is a multiplication between technical efficiency and efficiency allocative. Economic efficiency is calculated based on the OR/OP ratio.

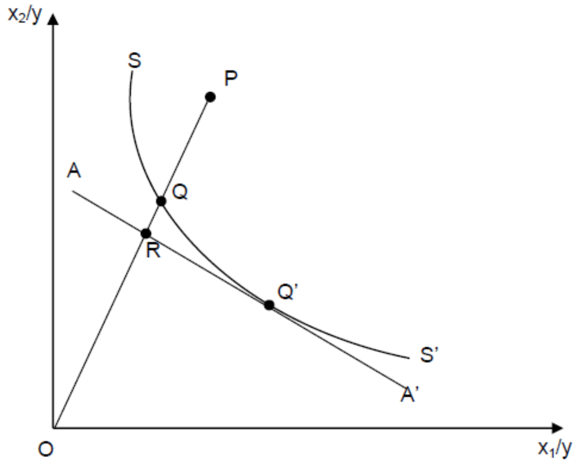

Figure 1. Efficiency measurement

Source: Farrell (1957) and Coelli *et al.* (1998)

The stochastic frontier production function model originally put forward by Aigner *et al.* (1977), later developed by Coelli *et al.* (1998) stated that the frontier production function is a function of production that describes the output the maximum achievable from each input usage rate. When farming is at a point in the production function frontier means that farming is technically efficient. If the production function frontier is known, the inefficiency can be estimated technically through a comparison of the actual position relative to the frontier. Next is the stochastic function frontier is an extension of the original model deterministic to measure the effects unexpected inside production frontiers. In this production function added random error, v_i into the non-negative random variable, u_i as stated in the equation the following :

$$\ln y_i = x_i'\beta + v_i - u_i \tag{1}$$

where y_i represents the output of the i-th firm; x_i' is a K x 1 vector containing the logarithms of inputs; β is a vector of unknown parameters, and u_i is a non-negative random variable associated with technical inefficiency.

Random error, v_i to calculate error size and other random factors like the weather, etc., together with the combined effect of undefined input variables in the production function. Variable v_i is a random variable that is independent and identically normally distributed (i.i.d) with a mean of zero and its variance assumed i.i.d exponential or variable random half normal. The u_i variable is used to capture the effect of technical inefficiencies reflecting components an internal error. The u_i variable is also a non-random variable negative with a half distribution normal.

Equation (1) is called a stochastic frontier production function because the values are bounded from above by the stochastic (i.e. random) variable $\exp(x_i'\beta + v_i)$. The random error, v_i can be negative or positive and so the stochastic frontier outputs vary about the deterministic part of the model, $exp\ (x_i'\beta)$. Farmers who produce the actual output below deterministic frontier production, but output the stochastic frontier exceeds the output deterministic, then this can happen because of the farmer's production activities are influenced by favorable conditions (for example, heavy rain v_i is positive). Farmers who produce actual output below the production deterministic frontier can happen because farmers' production activities are affected by unfavorable conditions where v_i is negative (Coelli *et al.*, 1998). The most common output-oriented measure of technical efficiency (TE) is the ratio of observed output to the corresponding stochastic frontier output (Battese and Coelli, 1995).

$$TE = exp\ (-\mathrm{E}[[\mathrm{ui}|\epsilon\mathrm{i}]]) = \frac{y_i}{\exp\ (x_i'\beta + v_i)} = \frac{\exp(x_i'\beta + v_i - u_i)}{\exp\ (x_i'\beta + v_i)} = exp(-u_i) \tag{2}$$

Value of technical efficiency 0 ≤ TEi ≤ 1, inversely related to the value of the effect of technical inefficiency.

Location and Sampling

Sukabumi Regencies purposively selected as the location of study with the consideration that this location is one of the broiler production centers in West Java Province, after Bogor and Ciamis Regencies (Food Security and Livestock Agencies of

West Java Province, 2021). The sample in this study is the number of broiler production periods from January – December 2021, each of 6 production periods on PIR models and 5 periods on Makloon models, resulting in 130 units of sample PIR models and 116 units of Makloon models.

Method of Data Analysis

The efficiency of broiler farming in this study uses the Cobb-Douglas Production Stochastic Frontier (CDPSF), which is transformed into a natural logarithmic linear form. In the production function, the factors that are thought to affect broiler production are DOC, starter feed, finisher feed, and labor. The CDPSF model for broiler farming is as follows:

$$\ln y_i = \beta_0 + \beta_1 \ln x_{1i} + \beta_2 \ln x_{2i} + \beta_3 \ln x_{3\mathrm{i}} + \beta_4 \ln x_{4i} + \beta_5 \ln x_{5i}\ \beta_6 D_{1\mathrm{i}} + (v_i\text{-}u_i) \tag{3}$$

where :

y_i = broiler production (kg); x_{1i} = DOC (heads); x_{2i} = starter feed (kg); x_{3i} = finisher feed (kg); x_{4i} = labor (person); x_{5i} = medicines + vitamins (units);

D_{1i} = dummy of partnership models (PIR = 1, Makloon = 0); $(v_i\text{-}u_i)$ = technical efficiency effect in the model; i = sample

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6 > 0$

Technical efficiency analysis can be measured by using the following formula (Coelli *et al*., 1998; Battese and Coelli, 1995):

$$TE_i = \frac{y_i}{\exp\,(x_i'\beta + v_i)} = \frac{\exp(x_i'\beta + v_i - u_i)}{\exp\,(x_i'\beta + v_i)} = exp(-u_i) \tag{4}$$

where TE_i is the technical efficiency of the i-th farmer, with the value $0 \le TE_i \le 1$, inversely related to the value of the effect of technical inefficiency. V-Random error, v_i, is useful for calculating error size and factoring other random things like weather, etc., together with the combined effect of undefined input variables in function production. Variable v_i is a variable free random and identically normally distributed (i.i.d) with an average value of zero and the variance is constant, σ^2 or $N(u_i, \sigma^2)$.

To measure economic efficiency, one must determine the dual cost function of the Cobb-Douglass production homogenous function (Doll and Orazem, 1984; Debertin, 1986; Rasmussen, 2010). The assumption used is the form of the function production of Cobb-Douglas using i-inputs as follows:

$$y_i = \beta_0 x_i^{\beta i} \qquad = \ln y_i = ln\ \beta_0 + \beta_i \ln x_i \tag{6}$$

and the input cost function is :

$$\mathrm{C} = \textstyle\sum_{i=1}^{5} r_i x_i \tag{7}$$

where : x_1 = DOC (heads); x_2 = starter feed (kg); x_3 = finisher feed (kg); x_4 = labor (person); x_5 = medicines + vitamin (units); r_1= price of DOC (Rp/heads); r_2 = price of starter feed (Rp/kg); r_3 = price of finisher feed (Rp/kg); r_4 = price of labor (Rp/person); r_5 = price of medicine + vitamin (Rp/units);

The form of the dual cost function can be derived using assumptions of cost minimization with output constraint $y = y_0$. To obtain the dual cost function must obtain the value of the expansion path (expansion scale of business) which can be obtained through langrange function as follows:

$$\mathrm{L} = \textstyle\sum_{i=1}^{5} r_i x_i + \lambda(\ln y_i - (ln\beta_0 + \sum_{i=1}^{5} \beta_i \ln x_i)) \tag{8}$$

To get the values of x_i, the expansion path Lagrange function is derived on the first-order conditions as follows:

$$\frac{dL}{dx_i} = r_i - \lambda ln\beta_0 + \textstyle\sum_{i=1}^{5} \beta_i \ln x_i) = 0 \tag{9}$$

$$\frac{dL}{d\lambda} = \ln y_i - ln\beta_0 + \textstyle\sum_{i=1}^{5} \beta_i \ln x_i) = 0 \tag{10}$$

To get the dual cost function frontier, substitution equations (9) and (10) to equation (7):

$$C^{*} = f(r_i,\ y_i) \tag{11}$$

$$\ln C^{*} = \gamma_0 + \gamma_1 \ln r_{1i} + \gamma_2 \ln r_{2i} + \gamma_3 \ln r_{3i} + \gamma_4 \ln r_{4i} + \gamma_5 \ln r_{5i} + \gamma_6 \ln Y + \varepsilon_i \tag{12}$$

where: $\ln C^{*} =$ minimum total cost of production observed (Rp); ε_i = error term

$\gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5 < 0\ ;\ \gamma_6 > 0$

According to Jondrow *et al.* (1982), efficiency economy (EE) is defined as the ratio between the minimum total cost of production observed (C*) with the total cost actual (C), as shown in the equation following:

$$EE = \frac{C^{*}}{C} = \frac{E(C_i \mid u_i = 0, y_i, r_i)}{E(C_i \mid u_i, y_i, r_i)} = E[\exp.(u_i/\varepsilon)] \tag{12}$$

The greater the ratio EE, the more economically efficient, on the contrary, the smaller the ratio, the more economically inefficient.

III. RESULTS AND DISCUSSION

The estimation results of the CDPSF parameters with the MLE method are presented in Table 2. Estimation results using the MLE method obtained a gamma value of 0.951 and a significant effect on the level of = 0.01. This shows that 95.1 % of the variation in broiler production among farmers is caused by technical efficiency, while the side of 0.049 % is influenced by effects stochastic.

DOC, starter feed, finisher feed, and labor have a significant effect on broiler production at the level of α=0.01, while the variables of medicines + vitamins were not significant. The parameter values in CDPSF show the production elasticity of each variable, while the number of parameters shows the elasticity of production. The elasticity of production is 0.681, meaning that if all inputs are increased simultaneously by 10 %, then broiler production will increase by 6.81 % (stage II of the classical production curve). All signs parameters on broiler production are positive, except DOC and medicines + vitamins.

Table 2: Estimation of CDPSF parameters of broiler production in Sukabumi Regency, West Java

Variables	coefficient	standard-error	t-ratio
Constant	0.25319410E+01	0.20806957E+00	0.12168723E+02
DOC (x_1)	-0.10093634E-08^a	0.43867955E-10	-0.23009128E+02
Starter feed (x_2)	0.50951354E+00^a	0.52347168E-01	0.97333544E+01
Finisher feed (x_3)	0.41203702E-09^a	0.63165364E-10	0.65231481E+01
Labor (x_4)	0.17195065E+00^a	0.42276845E-01	0.40672537E+01
Medicines+vitamins (x_5)	0.17195065E+00^a	0.68269006E-10	-0.12852585E+00
Dummy partnerships (D_1)	0.14282715E+00^a	0.53857285E-01	0.26519559E+01
sigma-squared	0.47369170E+00	0.11077558E+00	0.42761382E+01
gamma	0.95100200E+00	0.16176037E-01	0.58790791E+02
log-likelihood function =	-0.14044442E+02		
LR test of the one-sided error =	0.40467914E+02		

^{a}significant at α = 0.01; ^{ns}not signifikan

DOC has a significant effect on broiler production in this study, but the sign of the DOC parameter is negative, meaning that the use of DOC has exceeded the recommended capacity, in stage III of the classical production curve. DOC elasticity of -0.10093634E-08 means that if the use of DOC is increased by 10 %, broiler production will decrease by -0.10093634E-07 %. The production response as the effect of increasing DOC is very low. DOC is the input that has a significant effect on broiler production but with a positive parameter sign (Putri *et al*., 2020; Package *et al*., 2015),

The starter feed parameter was the highest, 0.509, meaning that if the use of starter feed was increased by 10 %, broiler production would increase by 5.09 %, while the finisher feed parameter is relatively low. The starter feed has a higher nutritional content, especially protein, than the finisher feed. Based on the National Standardization Agency of the Republic of Indonesia, the protein content of starter feed is at least 20% (SNI 8173.2:2015), while finisher feed is 18% (SNI 01-3931-2006). The parameters starter feed was higher than the results of Putri *et al.* (2020), but lower than those of Pakage *et al.* (2015), with parameter values of 0.425 and 0.464, respectively.

Labor is the input that provides the second largest response to production. Labor has a significant effect on broiler production in this study, with a parameter value of 0.172, meaning that if the use of labor is increased by 10 %, broiler production will increase by 1.72 %. The farmer's decision to increase the use of labor depends on the value of the marginal product of labor (VMP_L) compared to the price of labor (w). If $VMP_L > w$, then labor needs to be increased up to $NPM_L = w$. The partnership dummy variable has a significant effect on broiler production, meaning that there is a significant difference in broiler production between the PIR and Makloon models by 0.143 kg.

Technical efficiency (TE) is analyzed using CDPSF model with the Maximum Likelihood Estimation method (MLE), while the level of economic efficiency (EE) is analyzed using dual cost frontier. The results of the analysis of technical and economic efficiency are presented in Table 3.

Table 3: Technical and economic efficiency of broiler farming in PIR and Makloon models in Sukabumi Regency, West Java

Category	Technical Efficiency (TE)				Economic Efficiency (EE)			
	PIR		Makloon		PIR		Makloon	
	Number	%	Number	%	Number	%	Number	%
0.00 - 0.30	0	0.00	1	0.86	0	0.00	0	0.00
0.31 - 0.40	18	12.24	3	2.59	0	0.00	0	0.00
0.41 - 0.50	4	2.72	0	0.00	0	0.00	0	0.00
0.51 - 0.60	7	4.76	2	1.72	4	3.08	2	1.72
0.61 - 0.70	6	4.08	7	6.03	28	21.54	5	4.31
0.71 - 0.80	22	14.97	16	13.79	47	36.15	43	37.07
0.81 - 0.90	60	40.82	56	48.28	49	37.69	38	32.76
0.91 - 1.00	30	20.41	31	26.72	2	1.54	28	24.14
Average	0.811		0.826		0.763		0.824	
Maximum	0.968		0.972		0.913		0.996	
Minimum	0.377		0.282		0.541		0.503	
Range	0.591		0.690		0.372		0.493	

The average value of the TE of broiler farming in this study was 0.811 on the PIR models and 0.826 on the Makloon models, meaning that both models were technically efficient. The average value EE in the PIR models is 0.763, while in the Makloon model is 0.824, which means that both models are economically efficient. The average TE and EE of broiler farming in the Makloon models are higher than in the PIR models. The maximum value of TE and EE of the Makloon models is higher than that of the PIR models, but vice versa with the minimum value. The TE and EE disparity (range) of the PIR models is better than that of the Makloon models.

For TE, the largest proportion of farmers is in the 0.81-0.90, both in the PIR and Makloon models, respectively at 40.82% and 48.28%, the proportion of the Makloon models is greater than the PIR models. If TE > 0.70 is categorized as efficient, then the proportion of technically efficient farmers in the Makloon models is greater than the PIR models, respectively 88.79% and 76.19%. This is supported by Paramita et al (2017) who state that most broiler farmers have been efficient.

Farmers are required to have the knowledge and technical skills of broiler farming so that production risk can be reduced. This production risk can be reflected in the still low productivity due to the management of broilers that is not as recommended, such as cage preparation, DOC handling, feeding, disease management, and harvest handling. Indicators of poor production performance, among others, are reflected in the depletion/mortality rate (MR) and feed conversion ratio (FCR), which are above standard. These two indicators reflect that the technical efficiency of broiler farming at the level of smallholder farmers is still low. Several studies have shown that the efficiency of broiler farming carried out by farmers is still relatively low (Abda and Amin 2011). The low efficiency is caused not only by physical factors (use of production facilities) but also by non-physical factors such as age, experience, education, land area, and ownership of asset endowments (Indonesian Center for Agricultural Socioeconomic and Policy 2016; Wainaina et al 2014; Farayola et al 2013; Rasak & Hassan 2013; Mohammed et al 2013; Begum et al 2012; Ezeh et al 2012; Ologbon & Ambali 2012). Another problem faced by broiler farming is the increase in the feed price due to, among other things, the high dependence on imports of feed raw materials (Indonesian Center for Agricultural Socioeconomic and Policy 2016).

For EE, the largest proportion of farmers with the PIR models is in the 0.81-0.90 category at 37.69%, while the PIR models are in the 0.71-0.80 category at 37.07%. If EE > 0.70 is categorized as efficient, then the proportion of economically efficient farmers in the Makloon models is greater than in the PIR models, which are 75.38% and 93.97%, respectively.

The majority of farmers using the Makloon models are more efficient than the PIR models, both technically and economically. This indicates that the majority of broiler farming in Sukabumi Regency has been optimally allocating the use inputs at the level of the minimum cost. The same thing was expressed by Putri et al (2020) and Pakage et al (2015), that the economic efficiency of broiler farming is efficient, with the EE category > 0.90. On the other hand, based on TE and EE disparities, the PIR model is lower than the Makloon models, this means that the cost that can be saved on the average and the least farmers' PIR models is lower than the Makloon models. For the average farmer, the cost saved was 16.43% in the PIR models and 17.27% in the Makloon models.

IV. CONCLUSIONS

Factors that have a significant effect on broiler production are DOC, starter feed, finisher feed, and labor. The elasticity of starter feed is the highest compared to other production factors. The proportion of farmers in the Makloon model is greater than in the PIR model, both for technical and economic efficiency. It's indicated the Makloon model is better than the PIR.

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