ISSN: 0852-3681
E-ISSN: 2443-0765

Jurnal Ilmu-Ilmu Peternakan 33(2): 207-216
Available online at http://jiip.ub.ac.id

Measurement of Efficiency Levels in Open House System Broiler Breeders in Malang Regency, Indonesia

Stepanus Pakage[1)], Budi Hartono[2)], Bambang Ali Nugroho[2)], Deny Anjelus Iyai[1)], Alnita Baaka[1)], Agustinus Gatot Murwanto[1)], John Arnold Palulungan[1)], Irba Unggul Warsono[1)], Trisiwi Wahyu Widayati[1)], Isti Widayati[1)], Dwi Nurhayati[1)], Noviyanti[1)], Rizky Arizona[1)], Purwaningsih[1)], Elfira Kariane Suawa[1)], Muhammad Affan Mu'in[1)], Mohammad Jen Wajo[1)], Sangle Y Randa[1)] and Djonly Woran[1)]

[1)] Faculty of Animal Husbandry, University of Papua, Jl. Gn. Salju, Amban Manokwari, West Papua Indonesia
[2)] Faculty of Animal Husbandry, Universitas Brawijaya, Jl. Veterans Malang 65145 East Java Indonesia

Submitted: 27 February 2022, Accepted: 07 August 2023

ABSTRACT: Broiler farming in Malang Regency, East Java, Indonesia, has experienced rapid growth, significantly contributing to the regional economy. In this region, the open cage system is among the broiler cage systems that are commonly used. Therefore, this study aims to analyze 1) factors affecting growth, 2) factors causing technical inefficiency, and 3) technical, allocative, and economic efficiency. The results showed that factors such as day-old chicks (DOC), feed, and drugs positively affected broilers' development. However, there was a variation in the level of technical efficiency of 0.047 due to inefficient sources, which included the age of breeders, education level, work experience, number of family members, and employment status. Despite the variation in efficiency levels, the average breeder demonstrated high technical, allocative, and economic efficiency with values of 0.93, 0.99, and 0.92, respectively. This performance indicated that the average breeders had yet to reach peak efficiency but were categorized as high-efficiency. To further enhance productivity, broiler farming required additional DOC feed and adequate training for broiler breeders to maximize productivity and resource utilization. Based on these results, recommendations were made to provide loans to broiler farms with simple terms and conditions, specifically for purchasing DOC, feed, labor, medicines, and fuel.

Keywords: Cost function; Production function; Stochastic frontier

*Corresponding Author: stpakages@yahoo.com

INTRODUCTION

Livestock belongs to the agricultural sector that provides humans with meat as an essential source of protein. In Indonesia, the significant value of broilers has led to an increase in their populations. According to Direktorat Jenderal Peternakan dan Kesehatan Hewan, 2020, the country had a broiler population of 3,137,707,479 in 2018, resulting in a production volume of 3,409,558 tons, which increased by 7.36% from the previous year. Additionally, it was reported that the national meat intake surpassed 7.75 kg/capita/year in 2017, with chicken meat contributing up to 49%, or 3.80 kg/capita/year. As the fourth largest population in the world, Indonesia has a considerable market size, leading to high demand for broiler meat. The available data also indicate that broilers have promising prospects for market growth.

In Indonesia, the broiler farming business is an open-house operation; different breeders have a varying willingness to address environmental issues and make resource allocation decisions. This discrepancy occurs due to the variation in farmers' skills, the region's abilities, and the business environment. These disparities also affect the output produced by combining multiple production sets (Mishra, Wilson, & Williams, 2009). To maximize benefits, broiler breeders should integrate the use of production factors and prioritize cost-saving measures. The number of production factors used should be sufficient, cost-effective, and economically efficient. However, broiler breeders need more awareness of their businesses' technical, allocative, and economic efficiency. This makes it necessary to investigate the variables influencing the cost function and the achievement of allocative efficiency.

MATERIALS AND METHODS

Location and time of study

This study was conducted for one month in Malang Regency, in Dampit, Bantur, and Pangelaran districts. These districts were selected due to their status as broiler development areas that use an open house system.

Sample determination and study process

A purposive sampling technique was used in this study, which involved selecting 40 broiler breeders for data collection. Interviews were conducted with respondents to determine various aspects of production, cost, and management, as stated in the model's specification.

Specification of the model

Factors affecting broiler production were DOC, feed, medication, energy, fuel, and labor. The relationship between these factors was analyzed using Cobb-Douglas functional form, expressed mathematically as follows:

$$LnY = \beta 0 + \beta 1 LnX1 + \beta 2\ LnX2 + \beta 3\ LnX3 + \beta 4\ LnX4 + \beta 5\ LnX5 + \beta 6\ LnX6 + Vi - Ui. \quad \ldots.. \quad 1$$

Y = broiler production per production period (kg /pp), X1 = number of DOCs per production period (head /pp), X2 = feed usage per production period (kg /pp), X3 = drug use per production period (kg /pp), X4 = electricity usage per production period (kwh /pp), X5 = fuel used per production period (liter/pp), X6 = total labor used per production period (people /pp), β0 = constant, β1to β6 = estimated input variable, Ln = natural logarithm = 2.718, Vi = error due to random sampling, and Ui = effect of technical efficienc

This study analyzed the effect of technical inefficiency using the model developed by Battese and Coelli (1995). Meanwhile, the technical inefficiency effect was computed using the variable vi. The distribution of value parameters for technical inefficiency is as follows:

$$\mu i = \delta 0 + \delta 1Z1 + \delta 2Z2 + \delta 3Z3 + \delta 4\ Z4 + \delta 5Z5 \quad (2)$$

Where: μi = technical inefficiency effects; Z1 = age of breeders (years); Z2 = education level of breeders (years), Z3 = business experience (years), Z4 = dependent numbers (people), Z5 = dummy gender with 0 = female 1 = male, δ0 = constant, δ1 to δ5 = parameter of variable inefficiency

Factors affecting the role of broiler breeding business costs included DOC costs, feed costs, medical costs, energy costs, fuel costs, labor costs, and production. The mathematical formula is stated as follows:

$$LnCi = \alpha 0 + \alpha 1LnW1 + \alpha 2LnW2 + \alpha 3LnW3 + \alpha 4LnW4 + \alpha 5LnW5 + \alpha 6LnW6 + \alpha 7LnY + Vi + Ui \quad (3)$$

Where:
W1 = cost of DOC (IDR / head), W2 = cost of feed in one production period (IDR / kg), W3 = cost of medication (IDR / unit), W4 = cost of energy used (IDR / pp), W5 = cost of fuel (IDR / liter), W6 = cost of labor used, and W6 = cost of electricity used per production period (IDR / pp).

A stochastic frontier made with Frontier software version 4.1c approximates the variables influencing the production and cost functions, respectively.

Conceptual framework of the model

The efficiency of breeders in allocating capital to various alternative development activities plays a crucial role in determining the amount of farm revenue. When breeders inefficiently use these resources, certain capita remains untapped, resulting in the inability to increase farm income and generate surpluses. However, when breeders demonstrate high resource allocation efficiency, they can contribute significantly to the agricultural sector through growth-oriented development efforts in related sectors. Identifying resource efficiency is an essential issue determining different agricultural sector opportunities. This situation has potentially contributed to economic growth and the advancement of farm households' welfare (Weersink, Turvey, & Godah, 1990).

In the stochastic frontier model, a stochastic production function assumes minimal output. Meanwhile, in the case of Cobb-Douglas, the model is as follows:

$$E = \left({}^{U_i}/_{\varepsilon_i}\right) = \frac{\sigma_u \sigma_v}{\sigma}\left[\frac{f(\varepsilon_j\,\lambda/\sigma)}{1-F(\varepsilon_i\,\lambda/\sigma)} - \frac{\varepsilon_i\,\lambda}{\sigma}\right] \quad (4)$$

Deviations (Vi-Ui) consist of two parts, namely (1) symmetric components that allow the capturing of random boundary variance between measurements and the effects of measurement errors, random shocks, etc., and (2) a one-sided portion of the junction that captures the inefficiency effect. This model was developed by Aigner, Lovell, and Schmidt (1977), Meeusen and van Den Broeck (1977), and improved by Schmidt and Lovell (1979) and Jondrow, Lovell, Materov, and Schmidt (1982).

Deviations causing statistical instability in the model are considered independent and are often distributed at the boundary. Assuming independence between two deviations involves including independent distributions and installing various assumptions, such as normal and semi-normal, in a row. This allows the definition of the probability function and the estimation of the maximum probability estimator. The stochastic frontier approach has the advantage of reflecting disturbances, measuring errors, and exogenous disturbances beyond the production unit's reach in terms of disturbances.

The mathematical description at the farm stage was carried out using a stochastic frontier production function model as expressed below to estimate technical efficiency:

$Y_i^* = f(X_i; \beta) + \varepsilon_i \quad i = 1,2 \ldots n$ 5

Y_i^* is the output, X_i is the actual input variable, β is the unknown magnitude of the production function parameter, and ÿ is the error term. Meanwhile, the error term contains two elements, namely:

$\varepsilon_i = V_i - U_i$ 6

Component V_i is an asymmetric error believed to be equal, independent, and normally distributed with N (0, $\sigma^2 v$). Meanwhile, U_i is an independent error term typically distributed as N (0, $\sigma^2 u$), allowing the actual production level to be below the frontier output function. The technical efficiency estimate is shown by the average distribution of inefficiency (U_i) with a certain value, according to Ogundari, Ojo, and Ajibefun (2006), with the following formula for inefficiency.

$\varepsilon_i = V_i + U_i,$ 7

Where $\lambda = \sigma u / \sigma v$ and $\sigma^2 = \sigma^2 u + \sigma^2 v$ are located. Meanwhile, the regular normal density and cumulative distribution functions calculated from $\varepsilon_i \lambda/\sigma$ are shown by f and F, respectively.

Technical farming efficiency is defined using available technology as the ratio of the actual production condition (Y_i) to the frontier output (Y_i^*).

$TE = Y_i / Y_i^* = [E(Y_i \mid U_i, X_i) / E(Y_i \mid U_i = 0\ X_i)] = E[\exp(-U_i) / \varepsilon_i]$ 8

The TE value is in the 0 to 1 or $0 \leq TE \leq 1$ interval, and the farm is efficient when TE = 1. According to Lai, H. P., & Kumbhakar, S. C. (2019), a cost function model called frontier stochastic was used to estimate economic efficiency at the breeders level, as mathematically shown below:

$C_i = g(Y_i, X_i; \alpha) + \varepsilon_i \quad i = 1, 2, \ldots n$ 9

Where C_i is the overall production cost, X_i denotes the actual input cost, α is the cost function parameter, and ε is the error term consisting of 2 components, namely:

$\varepsilon_i = V_i + U_i,$ 10

By using the following equation, economic efficiency is estimated:

$AE = EE/TE$ 11

Where, in the first observation, EEi demonstrates economic productivity, C* is the price under optimum circumstances or the cost at maximum efficiency. At the same time, C is the real cost based on observations. The coefficient of inefficiency is determined by the ratio of costs under ideal conditions (C *) to actual costs based on observations (C). When Ci * = Ci, there is no inefficient effect (Ui = 0) on the observation unit. These conditions demonstrated that the costs achieved are relatively low and have an economic efficiency index value equal to 1, or EEi = 1. During observation, when EEi index> 1 and Ci * <Ci, it indicates that there is an inefficiency effect (Ui> 0). The economic efficiency of value is between 0 and 1.

Cost efficiency (CE) is estimated by version 4.1c of the frontier computing system with the opposite results of equation 11 (Coelli, Rao, O'Donnell, & Battese, 1998), or economic efficiency (EE) is the opposite of cost efficiency (Kumbhakar, S. C., & Tsionas, M. G., 2021). Ogundari and Ojo (2007) stated that the following equation is used for estimating economic efficiency (EE) at the breeders' level:

$$LnY = \beta0 + \beta1LnX1 + \beta2\, LnX2 + \beta3\, LnX3 + \beta4\, LnX4 + \beta5\, LnX5 + \beta6\, LnX6 + Vi - Ui \quad \ldots 12$$

Economic efficiency is the product of technical efficiency (TE) and allocative efficiency (AE) for each observation. According to Kumbhakar and Lovell (2003), the economic efficiency equation is as follows:

$$EEi = TEi \times AEi \quad \ldots\ldots\ldots\ldots \quad 13$$

Martin and Taylor (2003) stated that when the values of technical efficiency (TE) and economic efficiency (EE) are determined, the magnitude of allocative efficiency (AE) can be calculated using equation 12, as expressed above. The allocative efficiency (AE) magnitude is not necessarily lower than or equal to one or 0 < AE < 1 (Ogundari et al., 2006). The magnitude of allocative efficiency (AE) can be determined using the following equation:

$$LnCi = \alpha0 + \alpha1LnW1 + \alpha2LnW2 + \alpha3LnW3 + \alpha4LnW4 + \alpha5LnW5 + \alpha6LnW6 + \alpha7LnY + Vi + Ui \quad \ldots\ldots\ldots\ldots \quad 14$$

RESULT AND DISCUSSION

Table 1 showed that the average production function's variable coefficients of DOC, feed, medicine, electricity, fuel, and labor were 0.412, 0.527, 0.066, 0.041, 0.041, 0.097, and -0.071, respectively. These coefficients were significantly different in the empirical model of the stochastic frontier production function, with values of 0.44, 0.59, 0.07, -0.04, -0.004, and -0.15, respectively.

These results showed that production increased by 0.44% when there was a 1% rise in DOC. A 1% increase in the feed variable also caused an increase in productivity by 0.59%, while a 1% rise in the medicine variable caused a 0.07% increase in broiler production. However, a 1% increase in the variable electricity, fuel, and labor costs reduced the production of broilers by -0.04%, -0.004%, and -0.15%, respectively.

This showed that using electricity, fuel, and labor was excessive, indicating the need for usage reduction. The coefficients of the variables for DOC, feed, and medicine also increased by 0.023, 0.060, and 0.009, respectively.

DOI: 10.21776/ub.jiip.2023.033.02.08

Table 1. Results of stochastic frontier production function analysis of breeders of open house system

Variable	OLS		MLE	
	Coefficient	T-Ratio	Coefficient	T-Ratio
Constant	-0.128056 (± 0.672699)	-0.19036	-0.026986(± 0.305162)	-0.0884
Day Old Chick (DOC)	0.411917 (± 0.108353)	3.80163**	0.435195 (± 0.042935)	10.1361**
Feed	0.527448 (± 0.077263)	6.82667**	0.587102 (± 0.028761)	20.4134**
Medicine	0.065640 (± 0.040670)	1.61396	0.074991 (± 0.035105)	2.1362*
Electricity	0.041425 (± 0.054337)	0.76238	-0.042637 (± 0.007171)	-5.9456**
Fuel	0.096898 (± 0.094983)	1.02016	-0.003903 (± 0.036693)	-0.1064
Labor	-0.070577 (± 0.079212)	-0.89099	-0.145520 (± 0.022503)	-6.4668**
R-Sq (adj)	92.1			
F-Ratio	76.83			
P-Value	0.000			

Source: Survey data estimates, 2019
Description: ** = Significant on the level $\alpha = 0.01$
* = Significant on the level of $\alpha = 0.05$

The variable coefficients of electricity, fuel, and labor decreased to -0.084, -0.101, and -0.075, respectively. This decrease indicated that the DOC, feed, and medicine variables were more elastic in estimation with an empirical model of the stochastic frontier production function. In contrast, the electric, fuel, and labor variables showed an opposite trend. Based on tableTable 1, each variable's significance level was 10.14, 20.41, 2.14, -5.95, -0.11, and -6.47, respectively.

These results aligned with previous studies by Ezeh, Anyiro, and Chukwu (2012), Areerat-Todsadee, Ngamsomsuk, and Yamauchi (2012), Pakage, Hartono, Fanani, and Nugroho (2015), Udho and Etim (2009), Ali, Ali, and Riaz (2014), Nchinda and Thieme (2012), where the DOC and feed significantly influenced broiler production. Similarly, the results of the allegations on the medicine variable were in line with the values obtained by Pakage et al. (2015), Udho and Etim (2009), and Ohajianya et al. (2013). The use of labor variables was consistent with the report of Ezeh et al. (2012) and Pakage et al. (2015), while Ali et al. (2014) stated that labor affected production. The estimation of the fuel and electricity variables contradicted the results of Pakage et al. (2015), Junga, R., Pospolita, J., Niemiec, P., & Dudek, M. (2019), Król, J., & Ocłoń, P. (2018). Regarding labor input, Ali, Khan, and Sajjad (2019) obtained inversely proportional results due to price, time, and place of study variations.

Analysis of variance and parameters (γ) model effect of technical inefficiency of the stochastic frontier production function

The sigma squared (σ2) value obtained was 0.00551, indicating that technical efficiency was 0.55% of the diversity of broiler production caused by inefficiency factors.

Table 2. Results of the analysis of variance and parameters (γ) from the model of technical inefficiency effects of the stochastic frontier production function

Component	Coefficient	Std-Error	T-Ratio
Sigma-squared (σs2 = σv2 + σu2)	0.00551	0.0020031	2.750***
Gamma (γ = σu2 / σs2)	0.99	00061144	163.548***
Log-Likelihood			71.180
LR Test			35.125

Source: Survey data estimates, 2019

Table 2 shows that the gamma value (γ) obtained by broiler breeders was 0.99 with a significance value of 163.548. The value obtained suggested that the variation in interference errors caused by technical efficiency was 99%. Therefore, the difference between the actual and the maximum possible production due to variations in technical efficiency varied between 99.0% and 0.1%, accounting for stochastic effects such as measurement errors.

The analysis results of parameter γ, which was the ratio of technical efficiency variance (μi) to total production variance (εi) of breeders, were very significant. Meanwhile, the gamma value (γ) close to 1 indicated that the one-sided error Ui dominated the symmetrical error distribution of Vi. The significant acquisition of the LR value of the test of one-sided error also supported this. The value showed that almost all variations in output from frontier production were considered due to achieving technical efficiency related to managerial issues. Alrwis and Francis (2003), Ezeh et al. (2012), Areerat-Todsadee et al. (2012), and Pakage et al. (2015) also obtained similar values. However, the results contradicted Carvalho, Zilli, Mendes, Morello, and Bonamigo (2015), where the gamma value was smaller.

Analysis of technical, allocative, and economic efficiency

The technical efficiency value of broiler breeders in Figure 1 ranged from 0.75 to 0.99, with an average of 0.93. Meanwhile, the average value implied that breeders increased output by 7% and demonstrated technical efficiency in achieving marginal production. The average breeders saved costs by 6.06% ((1- (0.93 / 0.99)) * 100) when the technical efficiency achieved was the same as the competitor breeders. This also applied to breeders with the lowest technical efficiency, but those who achieved the highest efficiency can save costs by 24% ((1- (0.75 / 0.99) * 100). The technical efficiency obtained was the same as Pakage et al. (2015) but more significant than that of (Ali et al., 2014), Ullah et al. (2019), Ezeh et al. (2012), and Areerat-Todsadee et al. (2012). The value of allocative efficiency achieved by breeders ranged from 0.87 to 1.13, with an average of 0.99. The average value indicated that breeders had a 1% chance of achieving allocative efficiency. Meanwhile, when the average breeders save costs by 12.39% ((1- (0.99 / 1.13)) * 100) when they achieved the highest efficiency. This was also applicable to efficient breeders with the lowest allocative when they reached the highest deficiency and saved cost by 23.01% ((1- (0.87 / 1.13) * 100). Pakage et al. (2015) obtained a greater average value of 1.01 for allocative efficiency. The average value of economic efficiency achieved by breeders was 0.92, with a range between 0.72 and 1.00.

The average value showed that breeders had an 8% chance of achieving maximum production. Meanwhile, the diversity of technical, allocative, and economic efficiency values achieved by breeders was caused by managerial ability, especially in regulating, formulating, and using production factors to produce several outputs and maximize profits. The variation in efficiency due to differences in management was estimated using input factors from breeders. The ability to determine and regulate the use of production factors varies based on the background, experience, education, and age of the breeders, leading to variation in technical efficiency.

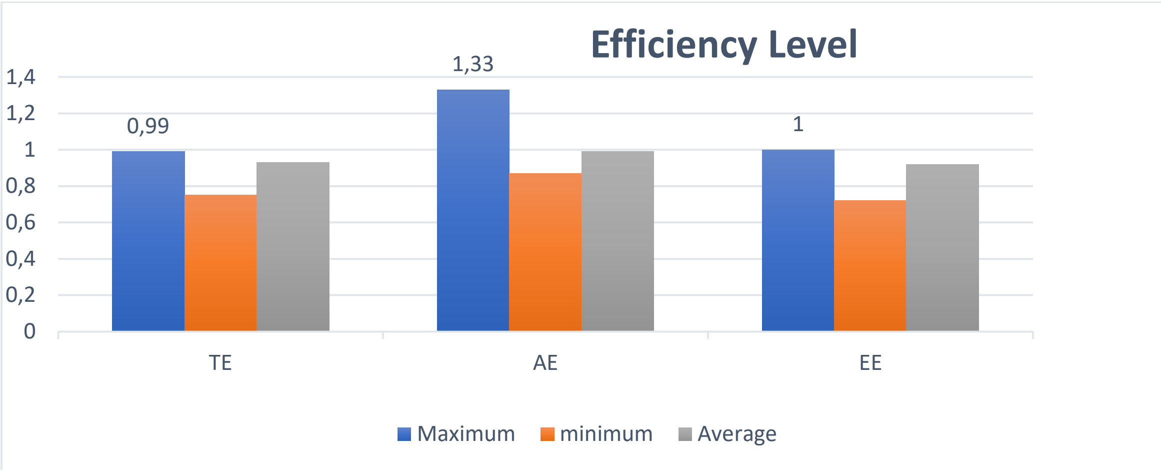

Figure 1. Analysis of Technical, Allocative, and Economic Efficiency Results in Effects of Technical Inefficiencies

Table 3. Estimation of technical inefficiency effects of stochastic frontier production function in broiler farming with the open house system

Variable	Value Estimated	Standard Error	T-Ratio
Constant	-0.779611	0.337021	-2.31324 *
Age	0.014864	0.003925	3, 78720 **
Education Level	0.033803	0.018016	1.87627 *
Business Experience	0.012117	0.005315	2.27982 *
Number of Family Dependents	-0.098408	0.052221	-1.88444 *
Dummy Employment Status	0.068802	0.049568	1.38803

Source: Survey data estimates, 2019
Description: ** = Significant on the level α = 0.01
* = Significant on the level of α = 0.05

The results showed that age, education level, and business experience affected the increase in technical inefficiency at a significant level of 0.01 and 0.05. As shown in Table 3, coefficients on the age variables of breeders, education level, and business experience were 0.014864, 0.033803, and 0.012117, as well as 3.78720, 1.87627, and 2.27982, respectively. This indicated that an increase in the age of the breeder by one year caused a rise in technical inefficiency by 0.014864. Similarly, the addition of 1 year of education level and breeders' experience increased technical inefficiency by 0.033803 and 0.012117, respectively. This showed that aging breeders exhibited inefficient production and utilization of inputs. The increase in the age of breeders affected their ability to work, struggle in business, risk-taking willingness, and desire to implement innovations diminished. Udho and Etim (2009), Ezeh et al. (2012), Onyenweaku and Nwaru (2005), Ajibefun and Daramola (2003), and Tesema, T. (2021) also stated that increasing age caused a decrease in technical efficiency, as the work was less energy intensive.

Additionally, the relationship between education level and business experience was inversely proportional to the expected results. This indicated that the adequate level of education and relevant experience of breeders facilitated their ability to absorb information and adopt technology, leading to an increase in technical efficiency. Ezeh et al. (2012) and Ahiale, Abunyuwah, and Yenibehit (2019) discovered that the level of education was detrimental to technical efficiency.

CONCLUSION

This study showed that DOC, feeds, medicine, electricity, and labor affected the production of broilers in the Malang Regency. Furthermore, the ages of breeders, education level, business experience, and family members caused an increase in technical inefficiency. These results showed that average breeders demonstrated technical, allocative, and economic efficiency.

REFERENCES

Ahiale, E. D., Abunyuwah, I., & Yenibehit, N. (2019). Technical efficiency analysis of broiler production in the mampong municipality of Ghana. *J. Econ. Sustain. Dev*, *10*(14), 152-158.

Aigner, D., Lovell, C., & Schmidt, P. (1977). Formulation and estimation of stochastic. *Review of Economics and Statistics, 80*(3), 454-465.

Ajibefun, I. A., & Daramola, A. G. (2003). Efficiency of microenterprises in the Nigerian economy.

Ali, S., Ali, S., & Riaz, B. (2014). Estimation of technical efficiency of open shed broiler farmers in Punjab, Pakistan: A stochastic frontier analysis. *World (kg/year), 42*, 43.40.

Areerat-Todsadee, H.-K., Ngamsomsuk, K., & Yamauchi, K.-e. (2012). Production efficiency of broiler farming in Thailand: A stochastic frontier approach. *Journal of Agricultural Science*, *4*(12), 9752-9760.

Battese, G. E., & Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical economics*, *20*(2), 325-332.

Carvalho, E., Zilli, J., Mendes, A., Morello, G., & Bonamigo, D. (2015). Main factors that affect the economic efficiency of broiler breeder production. *Brazilian Journal of Poultry Science*, *17*(1), 11-16.

Coelli, T. J., Rao, D. P., O'Donnell, C. J., & Battese, G. E. (1998). An introduction to productivity and efficiency analysis. *Springer Science: New York*.

Direktorat Jenderal Peternakan dan Kesehatan Hewan. 2020. Statistik Peternakan dan Kesehatan Hewan. Kementerian Pertanian. Jakarta.

Ezeh, C., Anyiro, C., & Chukwu, J. (2012). Technical efficiency in poultry broiler production in Umuahia Capital Territory of Abia State, Nigeria. *Greener Journal of Agricultural Sciences*, *2*(1), 1-7.

Jondrow, J., Lovell, C. K., Materov, I. S., & Schmidt, P. (1982). On the estimation of technical inefficiency in the stochastic frontier production function model. *Journal of econometrics*, *19* (2-3), 233-238.

Kumbhakar, S. C., & Lovell, C. K. (2003). *Stochastic frontier analysis*: Cambridge university press.

Meeusen, W., & van Den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. *International economic review*, 435-444.

Mishra, A., Wilson, C., & Williams, R. (2009). Factors affecting financial performance of new and beginning farmers. *Agricultural Finance Review*.

Nchinda, V., & Thieme, O. (2012). Technical efficiency of family poultry husbandry in Artibonite and South Departments of Haiti. *Livestock Research for Rural Development, 24*(12), 2012.

Ogundari, K., & Ojo, S. (2007). An examination of technical, economic and allocative efficiency of small farms: The case study of cassava farmers in Osun State of Nigeria. *Bulgarian Journal of Agricultural Science, 13*(2), 185.

Ogundari, K., Ojo, S., & Ajibefun, I. (2006). Economies of scale and cost efficiency in small scale maize production: empirical evidence from Nigeria. *Journal of Social Sciences, 13*(2), 131-136.

Ohajianya, D., Mgbada, J., Onu, P., Enyia, C., Henri-Ukoha, A., Ben-Chendo, N., & Godson-Ibeji, C. (2013). Technical and economic efficiencies in poultry production in Imo State, Nigeria. *Journal of Experimental Agriculture International*, 927-938.

Onyenweaku, C., & Nwaru, J. (2005). Application of a stockastic frontier production function to the measurement of technical efficiency in food crop production in Imo State, Nigeria. *Nigeria Agricultural Journal, 36*, 1-12.

Pakage, S., Hartono, B., Fanani, Z., & Nugroho, B. (2015). Analysis of technical, allocative and economic efficiency of broiler production using closed house system in Malang District of East Java Indonesia. *Livest. Res. Rural. Dev, 27*(9), 174.

Schmidt, P., & Lovell, C. K. (1979). Estimating technical and allocative inefficiency relative to stochastic production and cost frontiers. *Journal of econometrics, 9*(3), 343-366.

Udho, E., & Etim, N. (2009). Measurement of farm level efficiency of broiler production in Uyo, Akwa Ibom State, Nigeria. *World Journal of Agricultural Sciences, 5*(S), 832-836.

Ullah, I., Ali, S., Khan, S. U., & Sajjad, M. (2019). Assessment of technical efficiency of open shed broiler farms: The case study of Khyber Pakhtunkhwa province Pakistan. *Journal of the Saudi Society of Agricultural Sciences, 18*(4), 361-366.

Weersink, A., Turvey, C. G., & Godah, A. (1990). Decomposition measures of technical efficiency for Ontario dairy farms. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie, 38*(3), 439-456.