p-ISSN 2615-787X e-ISSN 2615-790X
Accredited by Directorate General of Higher Education, Research, and Technology, Republic of Indonesia, No. 225/E/KPT/2022

Tropical Animal Science Journal, September 2023, 46(3):382-388
DOI: https://doi.org/10.5398/tasj.2023.46.3.382
Available online at https://journal.ipb.ac.id/index.php/tasj

Determinants of Cost Inefficiency and Farmer Performance in Broiler Contract Farming

J. M. M. Aji[a], M. Rondhi[a], A. Suwandari[a,*], T. D. Hapsari[a], J. Januar[a], R. Yanuarti[a], & Rokhani[b]
[a]Department of Agribusiness, Faculty of Agriculture, University of Jember
[b]Department of Agricultural Extension, Faculty of Agriculture, University of Jember
Jalan Kalimantan No. 37 Jember 68121, East Java, Indonesia
*Corresponding author: anik.faperta@unej.ac.id
(Received 15-12-2022; Revised 09-06-2023; Accepted 21-06-2023)

ABSTRACT

The broiler industry plays an important role in meeting the growing demand for animal protein. Ensuring favorable farming conditions are needed to maintain the meat supply, and theoretically, this can be improved through the implementation of Contract Farming (CF). CF grants farmers the privilege to predict quantities, prices, and reduce production risks. However, one of the key challenges in establishing CF is the cost efficiency and performance of farmers. This study aims to develop a cost function for farmers, identify factors contributing to inefficiency, and evaluate farmer performance. The purposive sampling method is employed to select broiler farmers participating in contract farming as the sample for this study. Primary data were collected through surveys. Stochastic frontier cost analysis is utilized to derive a broiler cost function while examining the causes of farm inefficiency and their relationship with farmers' performance variables. The results indicate that the broiler cost function is significantly influenced by labor costs, the price of day-old chickens, feed expenses, and harvest tonnage. Meanwhile, the inefficiency effect is substantially influenced by farmer age, education, household size, experience, and mortality ratio (MR). Reducing the MR can increase broiler yield, directly improving cost efficiency and, thus farmers' income. Nonetheless, a comprehensive approach that includes training, monitoring, feedback, and incentivization is needed to enhance farmer performance in broiler contract farming.

***Keywords:** broiler; efficiency; farmer performance; mortality ratio; stochastic frontier cost function*

INTRODUCTION

The Indonesian economy heavily depends on the poultry sector. The Indonesian Feed Producers Association, locally known as *Asosiasi Produsen Pakan Indonesia* (APPI/GPMT), claims that the industry can produce 65% of Indonesia's animal protein needs, employs 12 million people (10.63% of the country's workforce), and is worth over 34 billion USD (31.22% of the country's total investment in agriculture, forestry, and fishing) (Wright & Darmawan, 2017). Based on data from the Indonesian Central Bureau of Statistics, 3,426,042 tons of broiler chicken were produced in 2021, a rise of 6.43% from 2020. Concurrently, the global demand for animal protein is rising due to the expanding world population. The fact that broiler chicken meat is less expensive than other animal protein sources, the business plays a crucial part in meeting the demand for animal protein. Despite its relatively lower prices, broiler chicken meat remains popular among consumers (Sugiharto, 2022).

Predictions stated that the broiler sector will expand, but starting a firm requires a substantial upfront investment (Haryuni & Fanani, 2017). Meanwhile, Big firms' presence has been crucial in enabling Indonesia to develop a rising level of supply independence and technical modernization. According to estimates, industrial farms produce 60% of the world's poultry (closed housing system), with the other 40% going to small and medium-sized producers (open housing system) (Brockotter, 2017).

Independent farmers who are not affiliated with any larger poultry enterprise have a much smaller position. According to the Indonesian Public Poultry Association (PINSAR Indonesia), the proportion of independent farmers' market share has decreased from 70% in 2008 to 18% in 2016, while the total of independent farmers has decreased from 100,000 to 6,000 (Wright & Darmawan, 2017). To cope with the high capital need in broiler farming, a partnership model can help farmers regarding capital and product absorption in the market. Moreover, Wijayanto *et al*. (2014) stated that the amount of capital needed to establish a broiler farm is one reason farmers often engage in partnerships.

One critical issue surrounding the contract farming scheme is the technical performance of farmers (Tapsir et al., 2011). The survival of broiler contract farmers significantly depends on their profitability and performance. The sustainability of this industry relies on three key factors: effectiveness, the ability to overcome challenges in the competitive market, and the competitiveness of those engaged in this business (Majid & Hassan, 2014). According to Samarakoon & Samarasinghe (2012), while mortality is an inherent part of broiler production, growers should implement customized management programs to minimize its overall impact on flock performance. Farmer performance can cause inefficiency in broiler farming, which will cause disadvantages for both parties (the farmer and the company). Thus, farmer performance is essential to analyze to improve policy recommendations and cost efficiency.

Assessing cost inefficiency as well as farmer performance holds significant importance in the context of broiler contract farming. The primary reason is its ability to enable farmers to optimize profits by identifying areas where costs can be reduced. This, in turn, can improve financial outcomes and establish a more sustainable business model (Hansen *et al*., 2019; Kramer & Porter, 2011). By monitoring farmer performance and cost inefficiency, companies can identify potential risks and proactively address them before they escalate into major issues, thereby ensuring efficient risk management (Kayikci *et al*., 2022; Settembre-Blundo *et al*., 2021). In summary, the evaluation of farmer performance and cost inefficiency plays a critical role in ensuring profitability, quality, and sustainability within the realm of broiler contract farming.

Research on factors that influence broiler cost have discussed by Baracho *et al*. (2019), Pakage *et al*. (2014), and Emokaro & Emokpae (2018). Ali *et al.* (2014), Areerat-Todsadee *et al*. (2012), Etuah *et al.* (2020), and Ullah *et al*. (2019) have studied the determinant of cost efficiency in broiler farming. The effectiveness of broiler farming has been extensively studied around the world using two frontier approaches (parametric stochastic frontier analysis (SFA) as well as non-parametric data envelopment analysis (DEA), each of which has distinct benefits and downsides, but not many discuss specifically cost function. Majid & Hassan (2014) conducted a study on farmer broiler performance using the mortality ratio as one of its indicators. Moreover, Myeki *et al.* (2022) also stated that the determining factors for the efficiency types were evaluated using the mortality rate. However, their study did not address the aspect of cost efficiency. Additionally, the study did not estimate farmer performance in contract farming in relation to cost inefficiency. Therefore, this paper aims to bridge this research gap by incorporating the mortality ratio as a proxy for farmer performances and its influence on cost function efficiency in broiler farming. The utilization of the chicken mortality ratio as a proxy for assessing farmer performance in broiler farming represents an innovative approach in evaluating the efficiency of the broiler farming cost function. Although the significance of the mortality ratio as an independent variable in broiler farming studies has been acknowledged, its application as a measure of farmer performance is relatively recent. Traditional methods for evaluating farmer performance have typically relied on various metrics, such as the index performance (IP) or the feed conversion ratio (FCR). Through examining the correlation between the mortality ratio and cost function efficiency, this study brings attention to the crucial role of effective management practices in the success of broiler farming partnerships. Furthermore, these findings can provide valuable insights for decision-making within the broiler farming industry.

METHODS

Data

This research was conducted in 2022, utilizing the purposive method to select the research area, which includes Jember, Banyuwangi, and Lumajang. These regions are significant regions of broiler sectors in Indonesia. Meanwhile, aligning with the research objectives, the purposive method was also employed to select only broiler farmers participating in CF as the sample to examine their performance and its impact on cost inefficiency. The total number of samples collected was 150, distributed as follows: 49 farmers from Jember, 52 from Lumajang, and 49 from Banyuwangi. Primary data were collected through surveys directly from the broiler farmers, ensuring a first-hand source of information.

Analytical Procedure

The frontier cost function is used to determine broiler cost function inefficiency. The frontier measure of cost efficiency indicates that efficient firms operate precisely on the cost frontier (Etuah *et al*., 2020). In this context, performance refers to the minimization of costs involved in producing a particular product, considering the input price vector and other external factors that define the operational environment (Kumbhakar & Lovell, 2000). Consequently, the degree to which a farm or firm deviates from its cost frontier represents its cost inefficiency (Lovell, 2008).

Following Kumbhakar & Lovell (2000), the implicit stochastic cost frontier model can be represented by the following equation:

$$C= (f(y,w;\beta).exp\{v\}).exp\{v+u\} \quad (1)$$

Here, C denotes the total cost, y signifies the output level, w represents the vector input prices, and β is the vector of estimated parameters. So that $f(y,w;\beta).exp\{v\}$ describes the minimum frontier cost, v denotes the random effect beyond the variable, and u reflects the level of cost inefficiency.

A functional form is required to distinguish between the two error terms to estimate the model accurately. Various functional forms commonly used include the Cobb-Douglas, constant elasticity of substitution, quadratic, normalized-quadratic, generalized Leontief, and trans-log functions. However, for the purpose of simplicity, this study opts for the Cobb-Douglas (log-linear) functional form instead of more intricate alternatives. This choice offers practical advantages in statistical estimations. Given the available technology, producer-specific cost efficiency (CE) scores can be computed by calculating the ratio of observed cost (C^{obs}) to the matching minimum cost (C^{min}). This calculation can be expressed as (Etuah *et al.*, 2020):

$$CE = \frac{C^{obs}}{C^{min}} = \frac{f(y,w;\beta).\exp\{v+u\}}{f(y,w;\beta).\exp\{v\}} = \exp\{u\} \quad (2)$$

CE can range from 0 to 1, with 1 denoting a cost-effective farm. As was before demonstrated, u stands for cost inefficiency.

The stochastic cost frontier model for the broiler farms in the study area can be explicitly defined by utilizing the Cobb-Douglas (log-linear) functional form as follows:

$$C = \beta_0 X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} Y^{\beta 4}.\exp\{v+u\} \quad (3)$$

Where $X_{1\text{-}3}$ and Y, respectively, are labor cost, day old chick cost (DOC), feed cost, and harvest tonnage of chicken. C is the total cost, β_0 is the constant, $\beta_{1\text{-}4}$ are coefficients for each independent variable. The Cobb-Douglas model equation is not yet linear, necessitating a transformation into a linear form to facilitate the calculation process. Additionally, our analysis focuses on the measure of C per 1000 birds, which allows for the identification of inefficiencies and efficiencies within the system.

$$\text{Ln } C = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln Y \quad (4)$$

Along with the fundamental stochastic cost frontier model, there is a need for an inefficiency model that can account for the influence of socioeconomic variables on farmers. The inefficiency model (U_i) is formulated as follows:

$$U_i = \delta_0 + \sum_{n=1}^{5} \delta_n Z_{ni}$$

The inefficiency model (Ui) is employed to gauge the cost-related inefficiencies of farmer-i, with its unit of measurement expressed in monetary units (IDR). Z_1 represents farmers' age, Z_2 represents farmer education, Z_3 represents household size, Z_4 represents farmer experience, and Z_5 represents Mortality Ratio (MR) as the indicator of farmer performance. These explanatory variables, such as age, education, household size, experience, and mortality, are included in the inefficiency model, consistent with previous studies examining efficiency at the farm level, e.g. (Dziwornu & Sarpong, 2014; Etuah *et al.*, 2020; Ezeh *et al.*, 2012; Oji & Chukwuma, 2007; Tuffour & Oppong, 2014; Udho & Etim, 2009). Excluding the mortality ratio, the remaining variables are believed to reduce inefficiency.

Furthermore, we have introduced additional variables for this study to enhance our understanding of farm-level disparities in cost inefficiency. The presence of a mortality ratio is used as a farmer performance indicator based on our preliminary discussion with the broiler contracting firm. Contracting firms can't control farmers daily, including the input investment such as DOC given to farmers. The mortality ratio becomes an indicator of broiler farmer performance, as stated by Jamhari (2006). Various factors affect the mortality ratio leading to unbalanced information from the farmer and contracting broiler sides. Moreover, this will lead to social trust and distrust in the farmer (Azadi *et al.*, 2019; Mao *et al.*, 2022) and in broiler firms that provide a contract. Table 1 shows a detailed description of the variables included in the analysis.

RESULTS

The analysis of the primary data collection results (Table 2) reveals that the majority of farmers' expenses in broiler production are attributed to feed costs, accounting for 53.63% of the total expenditure (calculated using the average costs per annum). The age range of respondents is between 20-70 years, with an average family member of 4 people. Respondents get an education up to high school on average. The average farmer's experience in broiler farming is 6.58 years, with an average mortality ratio of 4.77%.

Coelli (1996) mentioned that there are three steps in estimating frontier cost function, which starts with ordinary least square estimation (OLS) and continues with maximum likelihood estimation (MLE). Our model

Table 1. Description of variables used on cost function efficiency estimation of broiler farming in Jember, Lumajang, and Banyuwangi in 2022

Code	Factors	Description	Units	Source
C	Total cost	Total cost of broiler farming process	IDR	Interview
X_1	Labor cost	Total cost on labor used by farmer	IDR	Interview
X_2	Day old chick (DOC) cost	Total cost on DOC purchase by farmer	IDR	Interview
X_3	Feed cost	Total cost on feed provided by farmer	IDR	Interview
Y	Harvest tonnage of chicken	Total harvest of chicken	Kg	Interview
Z_1	Age	Farmers age in the year when the research was conducted	Year	Interview
Z_2	Education	Farmer formal education	Year	Interview
Z_3	Household size	The total number of farmers family members	Person	Interview
Z_4	Experience	Farmers experience in the year when the research was conducted	Year	Interview
Z_5	Mortality Ratio (MR)	The ratio of broiler chicken obtain mortality obtain by subtracting the number of docs coming in and the number of harvested chickens per head, divided by the total doc and multiplied by the percent	%	Interview

Source: own elaboration, 2022

has completed all the classical assumptions to achieve the best linear unbiased estimation (BLUE). The normal P-Plot shows that the data are spread along the line. Based on these results, it can be stated that the data used are usually distributed. Table 3 shows the values of VIF for all independent variables are below 10, and the tolerance value is more than 0.1. This indicates that the model is free from multicollinearity disturbances. The Durbin-Watson is 0.979 (d), producing a value of (4-d) of 3.021. The value is greater than the du value (1.802); this indicates that the model is free from autocorrelation disturbances. The Scatterplot obtained shows that the data do not form a certain pattern meaning the data are free from heteroscedasticity (as seen in Figure 1).

Adj R^2 value is 0.737, meaning that 73.7% of the diversity of the dependent variable can be explained by the diversity of the independent variables in the model. In contrast, the diversity of the other variables outside the model explains the rest. F value shows a significance of 0.000 (probability value <0.05); this shows that the independent variable jointly influences the dependent variable.

DISCUSSION

Table 4 presents the maximum-likelihood estimates, estimated standard errors, and statistical significance thresholds of the stochastic cost frontier. The coefficients of all variables demonstrate the anticipated positive trends, suggesting that higher input costs or output levels correspond to the increased production costs. This observation aligns with previous research (Etuah *et al*., 2020; Pakage *et al*., 2014; Subardin *et al*., 2018). The labor cost, cost of a day-old chick, and feed cost are statistically significant, at least at a 90%-95% confidence level, confirming that the above variables are essential cost elements in broiler production. In the estimated cost function of Cobb-Douglas, the regression coefficient reflects the coefficient of elasticity (Subardin *et al*., 2018). Hence, the value implies that an increase of 1% relative to output labor cost, then in almost absolute terms, would increase the total cost by 0.0535%, and so does the other variables relations with each of the coefficients.

Table 5 presents farm-specific cost inefficiency scores. The findings reveal that approximately 88% of farmers have an inefficiency score below 32%, indicating that most farms operate near their cost-efficiency frontier. This aligns with the findings of previous studies (Etuah *et al*., 2020; Hassan, 2021). The overall inefficiency

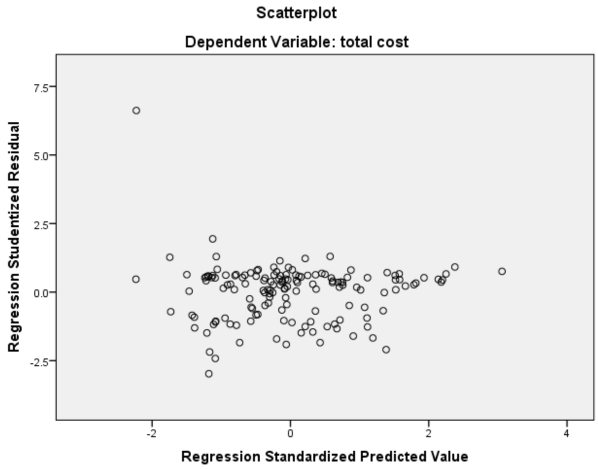

Figure 1. The Scatterplot of broiler farming in Jember, Lumajang, and Banyuwangi in 2022

Table 2. Descriptive statistic of variables of frontier cost function analysis on broiler farming in Jember, Lumajang, and Banyuwangi in 2022

Factors	Units	N	Mean	Std. Deviation
Total cost	IDR	150	450,958,168.00	429,296,945.10
Labor cost	IDR	150	2,242,222.68	2,085,694.99
Day old chick (DOC) cost	IDR	150	68,037,303.56	60,550,999.93
Feed cost	IDR	150	241,865,520.60	218,344,468.10
Harvest tonnage of chicken	Kg	150	63,271.57	562,174.84
Age	Year	150	42.52	10.92
Education	Year	150	9.42	4.16
Household size	Person	150	3.78	1.25
Experience	Year	150	6.58	5.59
Mortality ratio (MR)	%	150	4.77	3.52

Source: Own elaboration (calculate using the average over a one-year period).

Table 3. Statistical test on ordinary least square estimation of broiler cost function in Jember, Lumajang, and Banyuwangi in 2022

Variables	Collinearity statistics		Durbin Watson	F-Value signification	Adjusted R-Square
	Tolerance	VIF			
Labor cost	0.751	1.331	0.979	0.000	0.737
Day old chick (DOC) cost	0.408	2.454			
Feed cost	0.561	1.782			
Harvest tonnage of chicken	0.678	1.455			

Source: own elaboration.

Table 4. Maximum likelihood estimates of broiler farming stochastic cost function in Jember, Lumajang, and Banyuwangi in 2022

Determinants of cost frontier	Variables	Coefficients	Standard-Error
Labor cost	X_1	0.0535*	0.039
Day old chick (DOC) cost	X_2	0.6611**	0.074
Feed cost	X_3	0.3173**	0.057
Harvest tonnage of chicken	Y	0.005**	0.044
Constant	β_0	-0.189	0.766

Source: own elaboration; ** 95% confidence level; * 90% confidence level.

Table 5. Statistical description of cost efficiency on broiler farming in Jember, Lumajang, and Banyuwangi in 2022

Cost efficiency estimates	Level of cost inefficiency	Number of farmers	Relative frequency (%)
1.056-1.146	0.056-0.146	65	43.333
1.147-1.238	0.147-0.238	54	36.000
1.239-1.329	0.239-0.329	13	8.667
1.330-1.421	0.33-0.421	10	6.667
1.422-1.512	0.422-0.512	3	2.000
1.513-1.604	0.513-0.604	3	2.000
> 1.605	> 0.605	2	1.333
TOTAL		150	100
Mean Cost Inefficiency		0.242	
Minimum		0.056	
Maximum		8.838	

Source: own elaboration.

Table 6. Determinants of cost inefficiency of broiler farming in Jember, Lumajang, and Banyuwangi in 2022

Variables		Coefficients	Standard-Eror
Age (year)	Z_1	0.0361**	0.014
Education (year)	Z_2	-0.1220**	0.051
Household size (person)	Z_3	-0.3813**	0.162
Experience (year)	Z_4	-0.1304**	0.059
Mortality ratio (MR) (%)	Z_5	-0.1095**	0.156

Source: own elaboration; ** 95% confidence level.

scores range from 0.056 to over 0.605, with a mean inefficiency score of 0.242. This suggests that, on average, broiler farms are 24.2% cost inefficient, indicating room for improvement in their cost management systems. Notable cost reductions can be achieved by enhancing efficiency without introducing novel production technologies.

Determinants of farm-specific cost inefficiencies can be seen in Table 6. The positive coefficient for age suggests that older farmers tend to exhibit higher levels of cost inefficiency in their farm operations. Meanwhile, negative coefficients are found in education, household size, experience, and mortality ratio. Household sizes have a negative coefficient meaning that the increase in household size will decrease cost inefficiency. As stated in Ali & Flinn (1989) and Ezeh *et al*. (2012) research, larger households may utilize family labor, which helps reduce labor costs and creates a formidable basis for improved efficiency.

Education and years of experience in broiler production enhance farmers' understanding of resources and procedures, enabling them to utilize production inputs and achieve cost savings efficiently. This, in turn, enhances their critical thinking abilities. For instance, farmers with such knowledge can determine the optimal brooding temperatures, timing of feedings, lighting conditions, and vaccination schedules for the birds. This finding supports the conclusions reported by Ike & Ugwumba (2011); Udho & Etim (2009) that farmer's experience and education significantly increases efficiency in poultry production. Moreover, Adeoti (2004) asserts that prolonged engagement in a specific occupation enhances experience and productivity, thereby reducing inefficiency among farmers.

The mortality ratio (MR) value is used to indicate farmer performance in broiler farming. Farmer performance directly influences cost inefficiency in the process of broiler farming. The result is found in the study where MR has negative coefficients, which means the increase in MR will decrease farmer inefficiency. Further, we can state that farmer efficiency is increasing; the result supports the research conducted by Galanopoulos *et al*. (2006), Nguyen *et al*. (2018), and Ojo (2003). Decreasing MR can increase broiler yield, directly affecting the cost efficiency as farmers get more income. Myeki *et al*. (2022) also stated that the determinants for the efficiency types were assessed using variable mortality rate, which found that the variable had a negative association, indicating that more death rates in reared broiler birds tend to lead to technical and economic inefficiencies.

CONCLUSION

The broiler cost function is significantly affected by the cost of labor, day old chicken, feed, and harvest tonnage. At the same time, the inefficiency effect is significantly caused by farmer age, education, household size, experience, and mortality ratio. Therefore, this study makes a valuable contribution to the body of literature by employing the stochastic frontier cost function, which incorporates the effects of cost inefficiency and allows for the estimation of cost inefficiency in small-scale broiler production while recording the mortality ratio as an indicator of farmer performance. The findings of this research have significant implications for ensuring the profitability, quality, and sustainability of broiler businesses. To enhance overall effectiveness and profitability, providing farmers with adequate training and support is crucial, enabling them to improve their education and experience in farm management. Furthermore, reducing the mortality ratio can be achieved through regular monitoring and feedback on farmer performance. These measures are essential for promoting the long-term success and sustainability of broiler farming operations.

CONFLICT OF INTEREST

There is no conflict of interest with any financial, personal, or other relationships with other people or organizations related to the material discussed in the manuscript.

ACKNOWLEDGEMENT

This research was supported by the Institution of Research and Community Development University of Jember Grant 2023 (No:3319/UN25.3.1/LT/2023).

REFERENCES

Adeoti, A. L. 2004. Impact of HIV/AIDS and related sicknesses on the technical efficiencies of farms in Benue State, Nigeria. Afr. J. Biomed Res. 11:145-153.

Ali, M. & J. C. Flinn. 1989. Profit efficiency among Basmati rice producers in Pakistan Punjab. Am. J. Agric. Econ. 71: 303–310. https://doi.org/10.2307/1241587

Ali, S., R. Asif, & M. Nawaz. 2014. Profitability and cost efficiency analysis of open shed broiler farmers in Punjab, Pakistan. International Journal of Economics, Commerce and Management (IJECM). 2:1–10.

Areerat-Todsadee, H.-K., K. Ngamsomsuk, & K. Yamauchi. 2012. Production efficiency of broiler farming in Thailand: A stochastic frontier approach. J. Agric. Sci. 4:9752–9760. https://doi.org/10.5539/jas.v4n12p221

Azadi, Y., M. Yazdanpanah, & H. Mahmoudi. 2019. Understanding smallholder farmers' adaptation behaviors through climate change beliefs, risk perception, trust, and psychological distance: Evidence from wheat growers in Iran. J. Environ. Manage. 250:109456. https://doi.org/10.1016/j.jenvman.2019.109456

Baracho, M. S., I. de A. Nääs, N. D. S. Lima, A. F. S. Cordeiro, & D. J. Moura. 2019. Factors affecting broiler production: A meta-analysis. Rev. Bras. Cienc. Avic. 21:1-9. https://doi.org/10.1590/1806-9061-2019-1052

Brockotter, F. 2017. Ventilation in the poultry house makes a world of difference. https://www.poultryworld.net/poultry/ventilation-in-the-poultry-house-makes-a-world-of-difference/ [December 15, 2022).

Coelli, T. J. 1996. A Guide to frontier Version 4.1: A Computer Program for Stochastic Frontier Production and Cost Function Estimation. CEPA Working Paper No. 7/96, Department of Econometrics, University of New England, Armidale. http://www.uq.edu.au/economics/cepa/frontier.php

Dziwornu, R. K. & D. B. Sarpong. 2014. Application of the stochastic profit frontier model to estimate economic efficiency in small-scale broiler production in the Greater Accra region of Ghana. Review of Agricultural and Applied Economics (RAAE), 17:10–16. https://doi.org/10.15414/raae.2014.17.02.10-16

Emokaro, C. O. & O. P. Emokpae. 2018. Cost function and profitability analysis of broiler production in Edo State, Nigeria. NISEB Journal. 14:76-81.

Etuah, S., K. Ohene-Yankyera, Z. Liu, J. O. Mensah, & J. Lan. 2020. Determinants of cost inefficiency in poultry production: Evidence from small-scale broiler farms in the Ashanti region of Ghana. Trop. Anim. Health Prod. 52:1149–1159. https://doi.org/10.1007/s11250-019-02115-6

Ezeh, C. I., C. O. Anyiro, & J. A. Chukwu. 2012. Technical efficiency in poultry broiler production in Umuahia Capital Territory of Abia State, Nigeria. Greener Journal of Agricultural Sciences 2:1–7. https://doi.org/10.15580/GJAS.2013.3.1206

Galanopoulos, K., S. Aggelopoulos, I. Kamenidou, & K. Mattas. 2006. Assessing the effects of managerial and production practices on the efficiency of commercial pig farming. Agric. Syst. 88:125–141. https://doi.org/10.1016/j.agsy.2005.03.002

Hansen, B. G., K. Moland, & M. I. Lenning. 2019. How can dairy farmers become more revenue efficient? Efficiency drivers on dairy farms. International Journal of Agricultural Management 8:65-73.

Haryuni, N. & Z. Fanani. 2017. Study of feasibility on broiler business development. Journal of Development Research 1:63–67. https://doi.org/10.28926/jdr.v1i2.25

Hassan, F. A. M. 2021. Data envelopment analysis (dea) approach for assessing technical, economic and scale efficiency of broiler farms. Iraqi Journal of Agricultural Sciences (IJAS) 52:291–300. https://doi.org/10.36103/ijas.v52i2.1290

Ike, P. C. & C. O. A. Ugwumba. 2011. Profitability of small scale broiler production in Onitsha North local government area of Anambra State, Nigeria. Int. J. Poult. Sci. 10:106–109. https://doi.org/10.3923/ijps.2011.106.109

Jamhari, J. 2006. Incentive, performance and the choice of strategy in broiler contract farming: a case study in yogyakarta. International Seminar on Tropical Animal Production (ISTAP), 2:505–513.

Kayikci, Y., N. Subramanian, M. Dora, & M. S. Bhatia. 2022. Food supply chain in the era of Industry 4.0: Blockchain technology implementation opportunities and impediments from the perspective of people, process, performance, and technology. Production Planning & Control 33:301–321. https://doi.org/10.1080/09537287.2020.1810757

Kramer, M. R. & M. Porter. 2011. Creating Shared Value. Harv. Bus. Rev. 89:62–77.
Kumbhakar, S., & C. Lovell. 2000. Stochastic Frontier Analysis. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9781139174411
Lovell, C. 2008. Frontier Analysis in Health Care. University of Georgia, Athens.GA 30602.
Majid, R. Bin & S. Hassan. 2014. Performance of broiler contract farmers: a case study in Perak, Malaysia. UMK Procedia 1:18–25. https://doi.org/10.1016/j.umkpro.2014.07.003
Mao, H., Y. Fu, G. Cao, & S. Chen. 2022. Contract farming, social trust, and cleaner production behavior: field evidence from broiler farmers in China. Environ. Sci. Pollut. Res. Int. 29:4690–4709. https://doi.org/10.1007/s11356-021-15934-8
Myeki, L. W., N. B. Nengovhela, L. Mudau, E. Nakana, & S. Ngqangweni. 2022. Estimation of technical, allocative, and economic efficiencies for smallholder broiler producers in South Africa. Agriculture 12:1601. https://doi.org/10.3390/agriculture12101601
Nguyen, L. A., T. B. V. Pham, R. Bosma, J. Verreth, R. Leemans, S. De Silva, & A. O. Lansink. 2018. Impact of climate change on the technical efficiency of striped catfish, Pangasianodon hypophthalmus, farming in the Mekong Delta, Vietnam. J. World Aquac. Soc. 49:570–581. https://doi.org/10.1111/jwas.12488
Oji, U. O. & A. A. Chukwuma. 2007. Technical efficiency of small scale poultry–egg production in Nigeria: Empirical study of poultry farmers in imo state, Nigeria. Res. J. Poult. Sci. 1:16–21.
Ojo, S. O. 2003. Productivity and technical efficiency of poultry egg production in Nigeria. Int. J. Poult. Sci. 2:459–464. https://doi.org/10.3923/ijps.2003.459.464
Pakage, S., B. Hartono, Z. Fanani, & B. A. Nugroho. 2014. Analysis of technical efficiency of poultry broiler business with pattern closed house system in Malang East Java Indonesia. Journal of Economics and Sustainable Development (JEDS) 5:16–22.
Samarakoon, S. M. R. & K. Samarasinghe. 2012. Strategies to improve the cost effectiveness of broiler production. Postgraduate Institute of Agriculture, University of Peradeniya: Peradeniya. https://doi.org/10.4038/tar.v23i4.4869
Settembre-Blundo, D., R. González-Sánchez, S. Medina-Salgado, & F. E. García-Muiña. 2021. Flexibility and resilience in corporate decision making: a new sustainability-based risk management system in uncertain times. Glob. J. Flex. Syst. Manag. 22:107–132. https://doi.org/10.1007/s40171-021-00277-7
Subardin, M., D. Susetyo, S. A. Kadir, & S. Suhel. 2018. Economies of scale and efficiency of the pulp industry in Indonesia: Cobb-Douglas cost function approach. Int. J. Econ. Financ. Issues 8:284–289.
Sugiharto, S. 2022. Potential benefits of plant-derived products on broiler meat characteristics - A Short Review. Jurnal Sain Peternakan Indonesia 17:29–43. https://doi.org/10.31186/jspi.id.17.1.29-43
Tapsir, S., H. L. Mokhdzir, S. Nor Rahim, & N. Jalil. 2011. Issue and impact in broiler contract farming in Peninsular Malaysia. Economic and Technology Management Review 6:33–57.
Tuffour, M. & B. A. Oppong. 2014. Profit efficiency in broiler production: evidence from greater accra region of ghana. Int. J. Food Agric. Econ. 2:23–32.
Udho, E. J. & N. A. Etim. 2009. Measurement of farm level efficiency of broiler production in Uyo, Akwa Ibom State, Nigeria. World Journal of Agricultural Sciences 5:832–836.
Ullah, I., S. Ali, S. Ullah Khan, & M. Sajjad. 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 18:361–366. https://doi.org/10.1016/j.jssas.2017.12.002
Wijayanto, N., Z. Fanani, & A. B. Nugroho. 2014. Analisis kinerja finansial peternakan broiler antara pola kemitraan dan pola mandiri (studi kasus di Kabupaten Jombang). Jurnal Peternakan 4:1-18
Wright, T. & B. Darmawan. 2017. Indonesia Voluntary Poultry Report; GAIN Report: 1701. United States Department of Agriculture Foreign Agricultural Service.