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Stochastic Frontier Approach Applied in Measuring Economic Efficiency and Determining Factors on Local Broiler Breeder in Manokwari Regency, West Papua.

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Abstract: This study was conducted for 2 months with 31 local farmers to analyze the factors influencing broiler production and estimate the level of technical, allocative, and economic efficiency of local broiler breeders in Manokwari Regency, West Papua.The analysis was carried out using the stochastic frontier production function model, the Ordinary Least Square (OLS), maximum likelihood estimate (MLE) methods. The results showed that the variables of feed, DOC, and cage area affected broiler production. Furthermore, the Manokwari Regency local broiler breeders are technically, allocative, and economically efficient. The age, education level, and business experience of the farmers are factors that contribute to the increasing technical inefficiency. Meanwhile, local farmers can further increase broiler production and efficiency by increasing the number of DOC, feed, and cage areas.

Keywords: broiler. local breeders, efficiency,

Introduction

Indonesia has abundant natural and human resources which are expected to offer the maximum potential to meet the people's needs such as the livestock sub-sector. Based on government projections, the population in Indonesia is estimated to reach 273.7 million in 2025(Hidayati, 2017), (Statistik & Bappenas, 2005), which leads to an increase in the need for foodstuffs such as meat, eggs, and milk.

Broilers are a prospective livestock commodity designed to meet the growing need for animal protein for humans. Based on meat production, the broiler breeding business contributes an average of 58.07% of the total production from 2013 to 2017 (Director General of Animal Husbandry and Animal Health, 2017). In Indonesia, meat consumption has reached 7.75 pounds per capita per year and approximately 49% is contributed by broilers. Meanwhile, factors that influence the large consumption of broilers include 1. The characteristics that are valued by the entire community, 2. The elasticity of income demand is relatively high compared to other livestock products, 3. Broiler meat has a lower cholesterol content compared to other livestock, and 4. The price of broiler meat is relatively cheaper. These factors are used as opportunities to develop a broiler farm and make it a prospective business to manage.

Meanwhile, constraints that are often faced by local farms include price fluctuations, both the price of production factors such as DOC, feed, medicine, vitamins, together with equipment and the DOC of the products, namely live chickens and meat. The use of production factors such as Day Old Chick (DOC), feed, medical,labor, electricity, fuel prices, enclosure, and equipment investment have a significant impact on broiler livestock business profits (Sunarno, Purnomo, & Rahayu, 2017). Meanwhile, it is assumed that broiler poultry farms in Manokwari Regency and farmers use resources efficiently.

Based on BPS data in Manokwari Regency, the total number of broiler farms is 76 local breeders in 6 districts, with a maintenance scale of 500-2000 heads. However, breeders in this Regency are ignorant of the degree of technical, allocative, and economic efficiency, as well as the factors that affect broiler production.

RESEARCH METHODS

This study was carried out in Manokwari Regency for 2 months and the population used were local broiler breeders. The samples were determined using a purposive sampling method, which is a deliberate sampling with consideration of easily accessible and deemed eligible places.

Data Analysis Method

Ordinary Least Square (OLS) and maximum likelihood estimation (MLE) tests are used to determine the factors influencing the production function of the broiler business. The error component model analysis options are used to determine a breeder's level of technical efficiency, while the cost function modelwas used to analyze the allocative efficiency. Analysis of economic efficiency wasfrom the multiplication between technical and allocative efficiency analysis.

Conceptual Framework

The efficiency by which farmers allocate their resources to different alternative production activities determines the sum of farm revenue. Meanwhile, thereare likely to be capacities that have not been used to increase farm income and produce surpluses when farmers are not making use of such instruments effectively. However, when farmers distribute their capital efficiently, the additional contribution to the agricultural sector only be from the related sector through the efforts of achieving growth-oriented production. The determination of resource efficiency is a critical issue that defines the nature of various opportunities in the agricultural sector based on their potential contribution to economic growth and the advancement of farm household welfare (Weersink, Turvey, & Godah, 1990).

A stochastic production function assumes minimal output in the stochastic frontier model. This model is appropriate in the case of Cobb-Douglas:

$$Y_i = A + \sum_j a_j x_{ij} + (V_i - U_i) \ldots \quad 1$$

Deviations (Vi-Ui) is divided into two sections:

(1) Symmetric components that determine random boundary variance between measurements, the effects of measurement errors, random disturbances, and other factors (2) a one-sided portion of the junction that captures inefficiency's influence. (Aigner, Lovell, & Schmidt, 1977), (Meeusen & van Den Broeck, 1977), meanwhile,the model was improved by(Schmidt & Lovell, 1979) and (Jondrow, Lovell, Materov, & Schmidt, 1982). The deviations that cause statistical instability in the model are assumed to be independent and normally distributed at the boundary.

The half-normal distribution is the most commonly considered.There is possibilty to determine the function and compute the probability estimator when two deviations are independent with the inclusion of various distribution assumptions, such as normal and semi-normal distributions in a row. Furthermore, the stochastic frontier method has the advantage of representing disturbances, measurement errors, and exogenous disturbances that are beyond the control of the production device.

A statistical overview on the use of a stochastic frontier production function model to estimate technical efficiency at the farm level is stated below:

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

Where Yi * signifies the output, Xi denotes the real input variable and the production function parameter's uncertain magnitude. There are two parts to the error term:

$\varepsilon_i = V_i - U_i$ 3

The asymmetric error component Vi is assumed to be N (0, 2v) equal, independent, and normally distributed. The second Ui is a Vi-independent error term, which is usually distributed as N (0, 2u). Meanwhile, the real production level can be lower than the frontier output function because of this error. The technical efficiency estimate is shown by the average distribution of inefficiency (Ui) with a specific value, according to (Ogundari, Ojo, & Ajibefun, 2006), the formula for inefficiency is expressed as follows:

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

Where $\lambda = \sigma u / \sigma v$ and $\sigma 2 = \sigma 2u + \sigma 2v$ are located, f and F define the standard normal density, and cumulative distribution functions fromi/, respectively. Technical farming efficiency is defined as a ratio of actual production conditions (Yi) to Frontier output (Yi *) with available technology.

TE = Yi / Yi * = [E (Yi | Ui, Xi) / E (Yi | Ui = 0 Xi)]

= E [exp (-Ui) / εi] 5

When the TE value is in the 0 to 1 or 0 TE 1 range, the farm is in good working condition,and when TE = 1, it is in good working order. For the estimation of economic efficiency at the level, a cost function model frontier stochastic was used and it is mathematically expressed as:

$C_i = g(Y_i, X_i; \alpha) + \varepsilon_i \quad i = 1, 2, \ldots.\ n$ 6

Where Ci denotes total output cost, Xi represents actual input cost, which is a cost function parameter, and is the error term that consisted of two components:

$\varepsilon_i = V_i + U_i$, ... 7

The formula below is used to calculate economic efficiency:

$$\text{EE} = \frac{C*}{C} + \frac{E\ (Ci/ui=0, Yi, Pi)}{E\ (Ci/ui, Yi, Pi)} = E\ [exp.(Ui)/\varepsilon] \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 8$$

In the first observation, EEi denotes economic efficiency, C* denotes the cost under ideal conditions or at peak performance, while C is the actual cost observation. To compute an inefficiency coefficient, the price ratio under ideal conditions (C*) to real costs based on observations is used (C). When Ci* = Ci, there was no wasted impact (Ui = 0) on the observation. With an economic efficiency index value of 1 (EEi = 1) at observation I,the expenses incurred are relatively modest, meanwhile, inefficiency (Ui> 0) and an EEi index are greater than 1 when(Ci* 0). The economic utility of value ranges from 0 to 1.

Version 4.1c of the frontier computing scheme is used to estimate cost efficiency (CE), the results are the inverse of equation 8 Coelli, Rao, O'Donnell, and Battese (1998), or economic efficiency (EE), which is the inverse of cost efficiency or cost efficiency (CE).

According to (Ogundari & Ojo, 2007), the formula below is used to estimate economic efficiency (EE) at the farm level:

$$\text{EE} = 1/CE \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 9$$

Technical efficiency (TE) and allocative efficiency (AE) for each observation are combined to form economic efficiency (EE) (Kumbhakar & Lovell, 2003). The economic efficiency equation is stated below:

EEi = TEi x AEi 10

When the technical efficiency (TE) and economic efficiency (EE) values are specified, the magnitude of the allocative efficiency (AE) is determined using equation 9 above (Martin & Taylor, 1997). A previous study stated that allocative efficiency (AE) does not have to be smaller than one or zero (Ogundari et al., 2006). The following formula determines the value of allocative efficiency (AE):

$$AE = EE/TE \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 11$$

Specifications of the Model

Broiler production is influenced by elements such as Day Old Chick (DOC), feed, medicine, Electricity, fuel, and labor. The Cobb-Douglas functional form is calculated using the formula below:

LnY = β0 + β1LnX1 + β2 LnX2 + β3 LnX3 + β4 LnX4 + β5 LnX5 + β6 LnX6 + β7 LnX7 + Vi - Ui 12

Description:

Yi = Broiler production (Kg), X1 = Day Old Chick (DOC) (head/pp), X2 = Feed (IDR/Kg), X3 = medicine (IDR/Unit), X4 = Electricity (IDR), X5 = Fuel (IDR/liter), X6 = Labor (IDR/day), X7 = Cage area (m2), β O = Constant, β1-β7 = input variable parameter Ln = Natural logarithm e = 2,718, Vi = exogenous shocks effects, Ui = Effect of technical efficiency.

Battese and Coelli (1995)has established a methodology to assess the impact of technical inefficiency, which is by factor vi. Meanwhile, the distribution of value parameters for technical inefficiency is as follows:

$\mu i = \delta 0 + \delta 1Z1 + \delta 2Z2 + \delta 3Z3 + \delta 4 Z4 + \delta 5Z5$ 13

Z1 = Age of the farmer (years), Z2 = Education of the breeder (years), Z3 = business experience (years), Z4 = family members (people), Z5 = dummy gender 0 indicates a female, 1 = male, δ0 = constant, δ1-δ5 = inefficiency parameters

The costs of Day-old chick (DOC), feed, medical, energy, fuel, labor, and production have an impact on broiler breeding business costs. The formula is as follows:

$LnCi = \alpha 0 + \alpha 1LnW1 + \alpha 2LnW2 + \alpha 3LnW3 + \alpha 4LnW4 + \alpha 5LnW5 + \alpha 6LnW6 + \alpha 7LnY + Vi + Ui$ 14

W1 = DOC costs (IDR/head), W2 = cost of feed (IDR/kg), W3 = cost of medicine (IDR/unit), W4 = cost of energy (ID /pp), W5 = cost of fuel (IDR / liter), W6 = cost of labor, W6 = cost of electricity (IDR/pp)

A stochastic frontier generated with Frontier software version 4.1c is a rough approximation of the variables that control the output and cost functions.

RESULTS AND DISCUSSION

Production Function Analysis

The results of the analysis of production functions using the Maximum Likelihood Estimation (MLE) method are shown in table 1.

Table 1. Results of Analysis using Maximum Likelihood Estimation (MLE)

Variable	MLE		
	Coefficient	Standart-error	T-ratio
Constanta	0.084	0.990	0,.85
Day Old Chicks/DOC (head) (x1)	1.004	0.148	6.772 *
Feed (x2)	0.017	0.051	3.381 *
labor (x3)	0.011	0.119	0.091
Medicine (x4)	0.018	0.163	0.113
Fuel (x5)	-0.013	0.026	-0.499
Electricity (x6)	-0.014	0.057	-0.251
Cage area (x7)	0.002	0.122	3.419 *
Rq (adj)			96.00
F-ratio			90.972

Information: * = Significantly at the 95% level

Based on the analysis, the DOC variable has a positive sign and a magnitude of 1.004, whichshowed that for every 1% increase in DOC, broiler productionn is increased by 1.004%. Furthermore, T-ratio is greater than T-table with 6.772> 2.3397, which indicated that the DOC variable influenced the number of broiler farms production. This is because the quality of DOC used in the broiler breeding business is good enough to survive and maintain until completion. These results are in line with previous studies byEzeh, Anyiro, and Chukwu (2012), Areerat-Todsadee, Ngamsomsuk, and Yamauchi (2012),(Udho & Etim, 2009), S Pakage, B Hartono, Z Fanani, and BA Nugroho (2015b), add (Nchinda & Thieme, 2012), which stated that DOC influenced the production of broiler chickens. This is because retained DOC havepassed through the selection process to have good quality. Similarly, a study by(Yunus, 2009) also has the same result, where DOC has an influence on the production of broilers in partnership and independent patterns. According to (Praditia, Sarengat, & Handayani, 2015), broiler production is not only influenced by maintenance factors but also by DOC quality. Meanwhile, the quality of DOC greatly affects the smoothness of the production process and reduce the mortality rate of chickens during the maintenance period Siregar (2008).

The regression coefficient of the feed variable has a positive sign and the magnitude was 0.017, which indicated 0.017%. Since the T-ratio value for the feed variable was greater than the T-table or 3.381> 2.339, itinfluenced the amount of broiler production. This is because the production of broilers highly depends on the quality and quantity of feed to achieve maximum growth and production Suprijatna, Atmomarsono, and Kartasudjana (2005). Previous studies by(Ezeh et al., 2012), (Areerat-Todsadee et al., 2012), add, (Udho & Etim, 2009), (Ali, Ali, & Riaz, 2014), (Nchinda & Thieme, 2012) also discovered that feed variable isan influential factor in increasing broiler production. Therefore, one of the critical inputs that need broiler breeders 'attention to achieve maximum production is the variable feed. This is in line with a study byYunus (2009)which stated that feed has a strong and positive impact on output. Similarly,(Sjofjan & Djunaidi, 2016)stated that livestock growth is determined by the quantity and quality of feed.

The cage area has a regression coefficient of 0.002, which indicated that each 1% increase in the cage area increases the production of broilers by 0.002%. The T-ratio value was 0.129 and smaller than the T-table 3.418> 2.397, which showed that the cage area influenced the broiler production variable becauseit is proportional to the number of broiler kept. On average,breeders do not use a divider as a temporary barrier, and the harvesting process is not carried out simultaneously. This is not in line with a study by(Yunus, 2009), where the area of the cage has no effect, although, the direction was positive on the production of broilers. Meanwhile, it is assumed to be caused by the different harvesting times between breeders and the relatively short harvest age. However, the variable labor, fuel medicine, and electricity did not affect the production of broilers in the Manokwari Regency.

Technical Efficiency

The technical efficiency of the local broiler breeding business in Manokwari Regency was analyzed by the production function model stochastic frontier using frontier 4.1c. The results of the characteristics of technical efficiency values are shown in Figure 1:

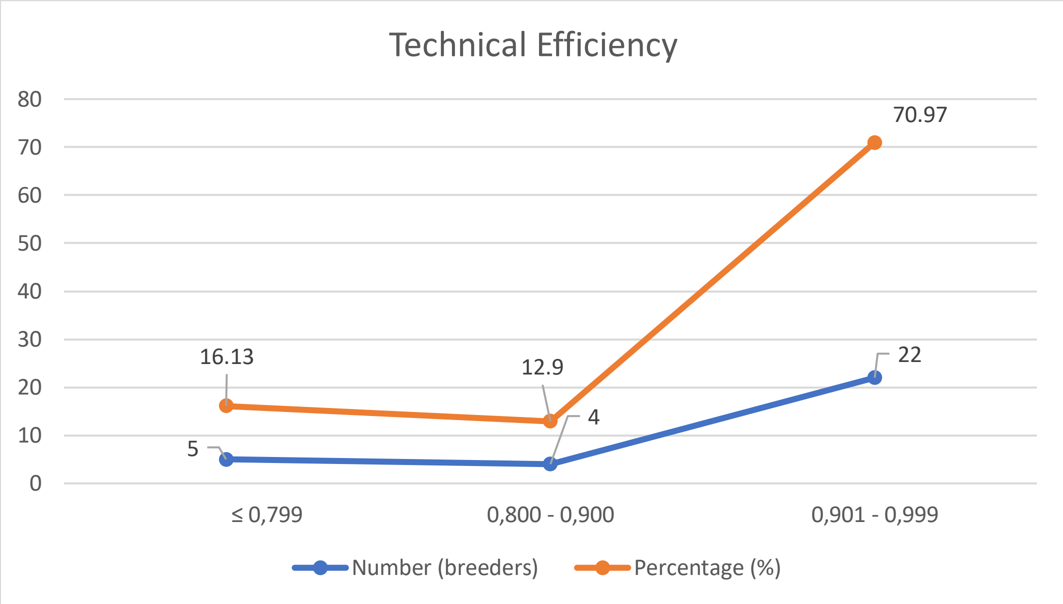

Figure 1. Characteristics of the Technical Efficiency values of local broiler breeders in the Manokwari Regency

The distribution of efficiency values of farmers are categorized as low efficiency ≤ 0.799 (16.3%), moderate efficiency 0.800-0.900 (12.90%), and high efficiency 0.901-0.999 (70.97%). This showed that the differences in the estimated efficiency level due to governance use different input factors between breeders. Therefore, the ability to determine and regulate the use of factors of production between breeders is different, which makes the level of technical efficiency of livestock business becomes diverse.

Theefficiency analysis showed the value of Maximum technical efficiency of 0.995 and a Minimum of 0.751 with an average level of efficiency of 0.923 (Table 2). This indicated that respondent farmers in the Manokwari Regency were technically efficient in their broiler poultry production. Moreover, technical efficiency is classified as efficient because it produces a value of more than 0.700 as the efficient limit Coelli, Rao, O'Donnell, and Battese (2005).

The average technical efficiency of the same object in Kendari City was 0.923 and ranged from 0.743 to 0.923 (Ismunandar, 2012). Another study by (Yunus, 2009)where the average level of technical efficiency achieved by broiler farmers in Palu is 0.868 and in the partnership system is 0.874 and independently reaches 0.866. Meanwhile, differences in the elements of determination by farmers are responsible for the wide range of technical efficiency index results.

Allocative Efficiency Analysis

To achieve the largest production outputs, every business determinant in production usesnumerous inputs in an ideal amount. The use ofone business determinant of specific production factors differsfrom another, which leads to differentproduction outputs and profits. In Manokwari Regency,local broiler breeders have also observed a change, meanwhile,disparities in the ability of information about livestock business and finance are the source of the differences. Furthermore,thedifferences in the amount and the price of production factors arefromvariation in broiler breeder skill. Since the use of production factors and pricing differs amongst breeders, therefore, optimizing earnings variedbased on the farmer's ability. The efforts of broiler farms in maximizing profits are seen from the achievement of allocative efficiency values, whichare shown in Figure 2.

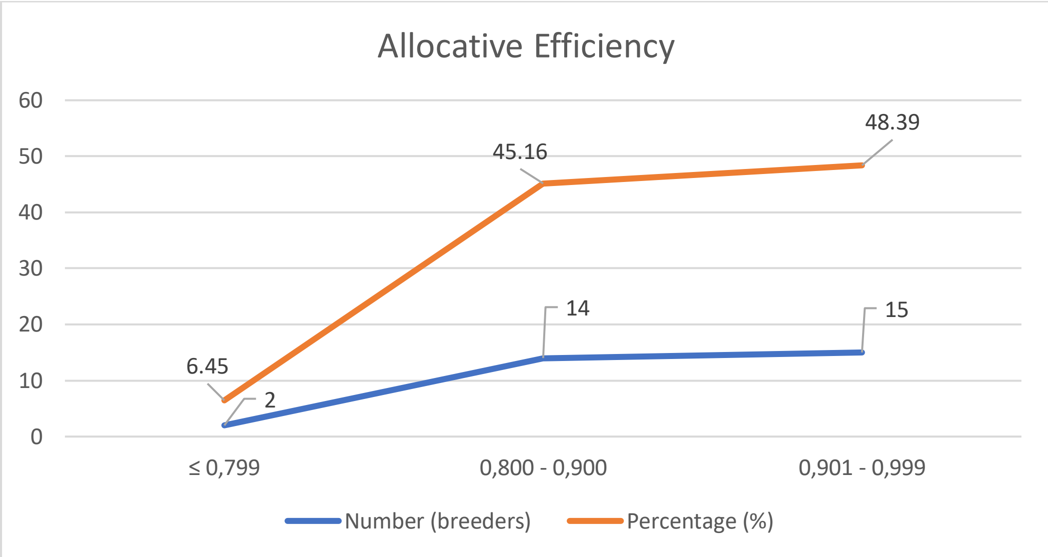

Figure 2. Characteristics of the allocative efficiency values of local broiler breeders in the Manokwari Regency

The distribution of allocative efficiency values was achieved in the range of 0.901-0.999 in the high-efficiency category with a moderate percentage of (48.39%), moderate-efficiency has a percentage distribution of values from 0.800 to 0.900 with a percentage (45.16%),and low-efficiency distribution coefficient value of ≤ 0.799 with a percentage of (6.45%). Also,individual broiler breeders' allocative efficiency values differ due toproduction variables and financial capabilities to offer production factors. However, the overall broiler breeders are allocative efficient in the process of broilers with a minimum value of 0.733, a maximum of 0.958, and an average of 0.886 (Table 2). A similarresult was obtained using the same allocative efficiency estimate technique, whichinvolved calculating the ratio between the results of both the level of economic efficiency from the frontier cost function and the level of technical efficiency from the frontier production function. A previous study by(Ismunandar, 2012)showed that the value of efficiency in the broiler business in the city of Kendari, rangingfrom 0.944 to 1.131, has a good value in the livestock business.

Economic Efficiency

The application of production factors in creating high output with the lowest expenses to the elements of production showed the success rate of local broiler breeders in theManokwari Regency. Whentechnicallyeffective breeders employ the factors of production by streamlining the prices of theelements of production, the success rate of broiler farms becomeseconomically efficient. Based onfigure 4, the amount of success obtainedby local broiler breeders in theManokwari Regency differs from other breeders due to variation in knowledge and capacity to achieve economic efficiency.

Tabel 2. Categories of technical, allocative, and economic efficiency

Categories	Technical efficiency	Allocative efficiency	economic efficiency
Minimum	0.751	0.733	0.624
Maximum	0.995	0.958	0.939
Average	0.923	0.886	0,813

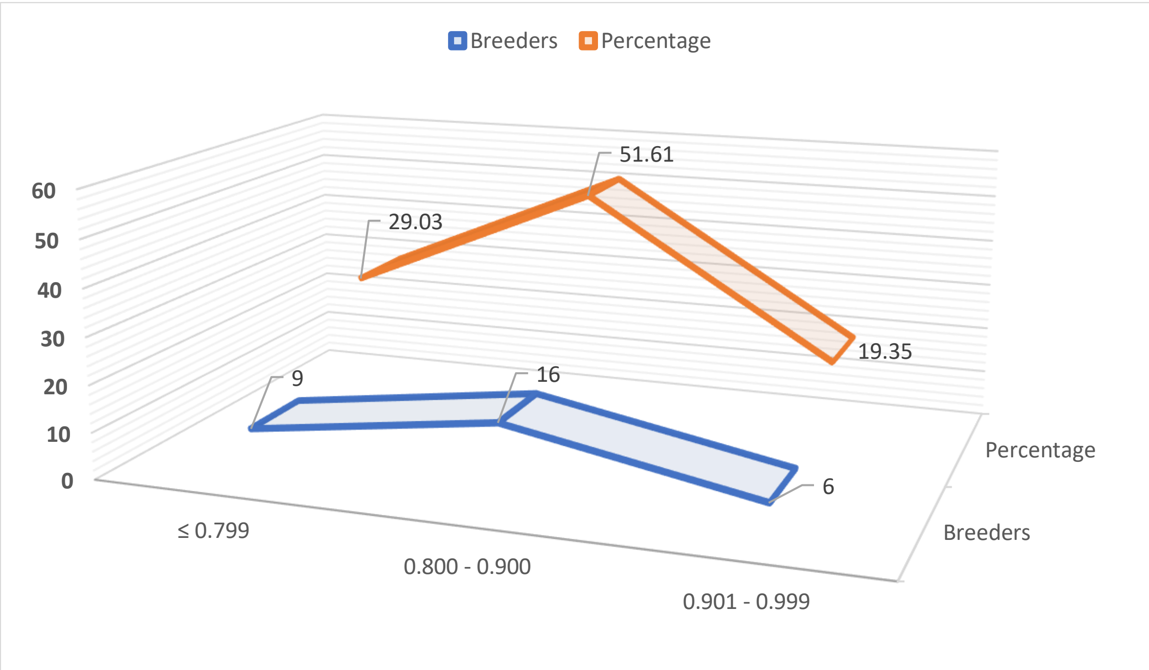

Figure 3. Characteristics of the economic efficiency of local broiler breeders in the Manokwari Regency

The economic efficiency values obtained by local broiler breeders in Manokwari Regency are grouped in three categories, as shown by the values obtained per individual broiler breeders, which ranged from ≤ 0.799 to 0.999. Basedon the distribution of economic efficiency values achieved per individual breeder, there are differences in the use of production factors with the lowest possible cost to produce maximum production. The differences are seen in the achievement of the lowest level of economic efficiency, namely the distribution of efficiency values ≤ 0.799 has a percentage of (29.03%), values from 0.800 to 0.900 has a percentage of (51, 61%), and values from 0.901 to 0.999 has a percentage of (19.35%). The minimum value is 0.624, the maximum value is 0.939, and the average value is 0.813, whichshowed that the economic efficiency value obtained per individual local broiler breeders in Manokwari Regency varies.

The results of a study conducted by Ismunandar (2012) in the broiler business in Kendari City showed that the average value of economic efficiency of 0.937 differs from the study ofYunus (2009). In the Palu City, there were 1.590 differences and the average value of economic efficiency in the broiler business was discovered. These differences in studies are due to variations in the price of production factors.

Determinant Factors

Table 3. Estimation of Technical Inefficiency Effects of Stochastic Frontier Production Function in Local Broiler Breeders InManokwari Regency

Variable	Coefficient	Standard Error	T-Ratio
Constant	-0.979611	0.537021	-2.91324 *
Age	0.004864	0.000925	3.98720 **
Education Level	0.023803	0.008016	3.67627 **
Business Experience	0.012117	0.005315	2.27982 *
Number of Family Dependents	-0.198408	0.072221	-1.78444
Dummy Employment Status	0.058802	0.039568	1.78803

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

At the 0.01 and 0.05 significance levels, the results showed that age, education level, and business experience of the farmers had an impact on increasing technical inefficiency, with vector coefficients of 0.004864, 0.023803, and 0.012117, respectively, and t-ratio values of 3, 98720, 3, 3.67627, and 2.27982. (Table 3). This indicated that a further increase in the age of the farmer gave a 0.004864 increase in technical inefficiency. The addition of one year to education and farmer experience increases technical inefficiency by 0.023803 and 0.012117, respectively. These results showed that as farmers get older, production becomes less in terms of output and input, and the ability to work, difficulty in business, desire to take risks, and introduce developments alsodeclined.This is in line with previous studies by Udho and Etim (2009), Ezeh et al. (2012), Onyenweaku and Nwaru (2005), and Ajibefun and Daramola (2003), which stated that as people get older, technological productivity suffers due to fewer number of people that are available to function. However, an increase in educational level and business experience inversely predicts this result. This is because breeders learn and adopt technology quickly when they have a proper and experienced level of education, which improves their technical efficiency. According to Ezeh et al. (2012), education level is detrimental to technical efficiency.

Conclusion

The input variables that have a very significant influence and a positive direction on production are day-old chick (DOC), feed, and cage area. Also, the local broiler breeders in Manokwari Regency have been technical, allocative, and economically efficient. The age of the farmer, level of education, and business experience are determinants that contribute to an increase in technical inefficiency.

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