Original Article

Analysis of technical efficiency and determining factors of the broiler business in North Sulawesi

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Abstrak

Tujuan: Usaha peternakan broiler dengan pola kemitraan masih menjadi pilihan bagi masyarakat dalam meningkatkan pendapatan keluarga. Meskipun dalam kondisi tertentu peternak memperoleh pendapatan yang tidak sesuai dengan harapan, karena produksi yang dihasilkan menurun. Hal ini karena pengaruh penggunaan input yang kurang efisien dan manajemen yang kurang baik. Penelitian ini bertujuan untuk mengestimasi efisiensi teknis usaha peternakan broiler dengan system kandang terbuka dan yang melakukan pola usaha kemitraan, serta menganalisis faktor-faktor yang mempengaruhinya.
Metode: Penentuan Teknik purposive sampling digunakan untuk mengidentifikasi 80 peternak yang terdiri dari 50 peternak di dataran rendah dan 30 peternak di dataran tinggi. Parameter Fungsi Produksi Stokastik Frontier diestimasi dengan menggunakan metode Maximum Likelihood Estimations (MLE) dan menggunakan program Frontier 4.1.
Hasil: Nilai taksiran gamma dalam model secara statistik (=0.8634), menunjukkan bahwa hasil pendugaan model fungsi produksi dianggap baik, sehingga fungsi produksi cobb-douglas mampu dengan baik menjelaskan data yang ada mengenai fenomena inefisiensi teknis pada usaha peternakan broiler. Hasil perhitungan nilai LR test parameter retriksi = 89.99 yang nilainya lebih besar dari nilai kritis dari Tabel Kodde dan Palm = 19.384 pada tingkat signifikan $p < 0.01$, artinya ada efek inefisiensi dalam model yang sifatnya stochastic. Nilai sigma square dengan nilai parameter sebesar 0.0133 secara statistik signifikan pada tingkat kepercayaan 99% artinya bahwa variasi produksi yang disumbangkan oleh inefisiensi teknis adalah sebesar 1.33%.
Kesimpulan: Nilai efisiensi teknis yang dicapai oleh peternak broiler dengan pola kemitraan pada open house system yaitu 0.95. Variabel yang mempengaruhi peningkatan produksi broiler yaitu pakan, vitamin dan obat-obatan, jumlah jam kerja, dan jumlah listrik. Variabel determinan yang dapat menurunkan inefisiensi teknis adalah umur, pengalaman, dan status kepemilikan lahan/kandang.

Kata Kunci: Broiler; Efisiensi teknis; Pola kemitraan; Stochastic frontier

Abstract

Objective: The broiler business under the partnership model has become a choice of society in improving their living. In certain circumstances, however, broiler farmers receive income far beyond their expectations due to declining production, because of some impacts of inefficient input

utilization and worse management. The research, then, aims to estimate the technical efficiency of the broiler farming business with an open house system and a partnership business pattern, as well as to analyze the determining factors.

Methods: Purposive sampling was employed to identify 80 farmers. In detail, the parameter of the production function of the Stochastic Frontier was estimated by using the Maximum Likelihood Estimations (MLE) method and the Frontier 4.1 program.

Results: The estimated value in the statistic model (γ=0.8634) depicts that the hypothetical result of the production function model was assumedly better, so the production function of Cobb-Douglas was able to explain the existing data related to a phenomenon of the technical inefficiency in broiler business. The calculation result of the value of restriction parameter of LR test was 89.99, which was greater than the critical value of the Kodde and Palm Table (=19.384), by the significance level at p<0.01. This means the existing inefficiency effects in the stochastic model. Further, the value of sigma square with the parameter value of 0.0133 was statistically significant by the trust level of 99%, describing that the production variation contributed by technical inefficiency was 1.33%.

Conclusions: In conclusion, the value of technical efficiency obtained by broiler farmers under the partnership model in the open-house system was 0.95. Then, the determining variables of the broiler production were feeds, vitamins, medicine, working hours, and the total of electricities. Determinant variables that could reduce technical inefficiency were age, farming experience, and ownership status of lands/cages.

Keywords: Broilers; Technical efficiency; Partnership model; Stochastic frontier

INTRODUCTION

Broiler, one of the livestock, has become the most satisfying supply of livestock. The increasing of the population, incomes, and education of the society will cause the improving demand for animal products, particularly the need for meats. This condition seems important to increase production to satisfy the demand.

The development of a large or small scale (backyard farming) broiler business located in the Province of North Sulawesi is mostly conducted under the partnership model (between the nucleus and the plasma). A partnership is one of the mutual relationships among business actors. Typically, the concept of partnership is that farmers raise broilers for a vertically integrated company. Two parties involved in this model are farmer (plasma) and company (nucleus). Farmers, then, usually provide lands, cages, equipment, and worker. The company as the nucleus, on the other side, supplies Day-Old Chick (DOC), feed, medicines, and managerial instruction.

In general, farmers commonly deal with shortages and limitations, such as capital, skills, market, and ability to project a fluctuating market. Those conditions have

significantly made dependency on the company in the procurement of DOC, feed, and other production inputs, so they have a weak bargaining power [1]. Nonetheless, the partnership model remains the last choice for most farmers because of the motivation on the security of broiler business, the involvement in broiler cultivation sampling, information access on the partnership, and low-risk business [2].

The broiler business under the partnership model conducted mostly by farmers in the Province of North Sulawesi to limit business risk is due to production guarantee (quality, quantity, and price), marketing, revenue by the company. In detail, there are some determining factors of the broiler business. Despite the total of inputs [3-5], agroecosystem-based site of broiler business [6,7], temperature and humidity [8], and business management can affect the total production, productivity, and business efficiency of the broiler business.

The researches analyzing the business efficiency of the broiler business have been largely conducted [4,9-14], such as comparing both the partnership and non-partnership models [conducted by 3,15,16], comparing the contract and profit-sharing models [performed by 5], and analyzing between the formal and informal contracts [17].

Therefore, the research aims to estimate the technical efficiency of the broiler business under the open-cage system and the broiler business with the partnership model and analyze its determining factors. The distinguished significance of this research relies on whether or not the different site and ownership status of lands/cages have an impact on the technical efficiency of the broiler business.

MATERIALS AND METHODS

Site and time of the research

The research was performed in the Province of North Sulawesi, where the regions were divided into four sites. There are some steps conducted in this research, such as pre-research/preparation, data collecting, analysis, and synthesis. The data collecting was done for four months, such as March 2021 to July 2021.

Type and source of data

Data utilized in this research were both primary and secondary data. The primary data was the result of field observation and interviews from selected farmers (respondents) based on a list of questions (questionnaire), previously arranged. In addition, the primary data comprised of the broilers production, total of production inputs, prices of the production input, the broiler's price in farmers' level, data of socio-economy of farmers' household, and other data required and relevant for the analysis as drafted in the model. While the secondary data were obtained from various publications of related institutions for this research.

Sampling method

The selection of respondents was a purposively sampling technique, a sampling method based on certain criteria, such as the use of the open-house system for the broiler business, and respondents as the plasma under the partnership model with the company as the nucleus. Specifically, the selected Regency and City had the largest population of broilers and were located at different altitudes. While the respondents of this research were 80 farmers, consisting of 50 farmers domiciled in the lowland at < 500 asl (the Regency of Minahasa Utara) and 30 farmers domiciled in the highland at > 900 asl (City of Tomohon).

Analysis method

In this research, the analysis employed the production function model of Cobb-Douglas Stochastic Frontier. The usage consideration of this model was that the production function model of Cobb-Douglas could reduce the occurrence of multicollinearities; it was homogenous, where it could be used to decrease the linear function; and, this model was mostly used in research related to agriculture. Efficiency consists of three components, such as technical efficiency, allocative efficiency, and economic efficiency [18,19]. For this research, the analysis used technical efficiency. Technical efficiency is an ability of a business unit to produce along the isoquant curve, producing an optimal output with the combination of input and certain technology. An activity could be said technically efficient if it was in the point of the frontier production function. The form of the production function of Cobb-Douglas is, then, shown in the following equation:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + \alpha D + (v_i - u_i)$$

where:
Y = Broilers' production sold (kg)
X_1 = Total of DOC (kg)
X_2 = Total of feeds (kg)
X_3 = Total of vitamins and medicines (gr)
X_4 = Total of HOK (hour)
X_5 = Total of electricity (kwh)
X_6 = Total of LPG (kg)
D = *Dummy* site (1 for the highland and 0 for the lowland)
β_0 = Intercept
i = Farmers as the-i respondents (i = 1,…,80)
β_i = Coefficient of estimated parameter ($\beta_i > 0$; i=1,…6)
$v_i - u_i$ = Effect of technical inefficiency in the model

The model of technical inefficiency used in this research referred to the model of the

Table 1. Characteristics of the respondents

Characteristics of the respondents	Total	Percentage
Age of farmers (Years)		
21 – 30	18	22.5
31 – 40	33	41.25
41 – 50	12	15
51 – 60	9	11.25
>60	8	10
Level of education		
Elementary	2	2.5
Junior high school	6	7.5
Senior high school	44	55
Undergraduate	28	35
Farming experience (Years)		
1 – 5	51	63.75
6 – 10	10	12.5
> 10	19	23.75

effect of technical efficiency [19]. While the u_i variable was a random variable displaying technical inefficiency within production and related to internal factors. The greater the u_i value, the larger the agricultural inefficiency performed by farmers. The random u_i variable could not have a negative value, and its distribution a half normal with a distribution value of N ($\mu_i \sigma^2 u$). To determine the value of the distribution parameter (u_i), the effect of technical inefficiency of broiler business in this research utilized the following model of technical inefficiency, as follows:

$$u_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 D$$

where:
u_i = Inefficiency effect, Z_1 = Respondent's age (years old), Z_2 = Respondent's education level (years), Z_3 = Farming experience (years), D = *Dummy* ownership status of lands/cages (1 is self-ownership, 0 is rented), δ = Estimated parameter ($\delta_i < 0$)

Parameter hypothesis of the production function and inefficiency in the first and second equation was simultaneously performed by the Frontier 4.1 program [19]. The parameter testing of stochastic frontier and the effect of technical inefficiency was done in two steps. The first step was the hypothesis of β_i parameters, using Ordinary Least Squares (OLS). Next, the second step was the hypothesis of all parameters of δ_i, intercept (β_0), β_i, and variation of u_i and v_i, using Maximum Likelihood (MLE), the trust level of

α was 1%, 5%, 10%, and 20%. The technical efficiency (TE_i) can be measured by the following equitation, as follows:

$$TE_i = \frac{y_i}{exp\ (x_i\beta)} = \frac{exp\ (x_i\beta - u_i)}{exp\ (x_i\beta)} = exp\ (-u_i)$$

The technical efficiency value is $0 \leq TE_i \leq 1$, where the technical efficiency value is reversely related to the impacts of the technical inefficiency value, and it is only be used for functions having a certain total of output and input (*cross-section data*) [19]. The value of technical efficiency was categorized into sufficiently efficient as the value of ≥ 0.7, and inefficient as the value of < 0.7.

RESULTS

Characteristics of the respondents

As shown in Table 1, the characteristics of the respondents comprised of age, education, and farming experience. In this research, the respondents were owners and workers, being responsible for broiler production. Generally, the respondents; ages ranged from 31 to 40 years old, their education level was Senior High School, and their farming experience was mostly less than five years.

Hypothetical result of the production function of stochastic frontier broiler in the Province of North Sulawesi

Based on the analysis, the following equation was derived, as follows:

$$lnY1 = 0.3195 - 0.0102lnX_{1i} +$$
$$0.3218lnX_{2i} + 0.0028lnX_{3i} +$$
$$0.6520lnX_{4i} + 0.0068lnX_{5i} -$$
$$0.0129lnX_{6i} + 0.0001D + (vi - ui)$$

Based on Table 2, the hypothetical result depicts that the model of production function was assumedly better. This was based on its gamma estimated value that was statistically > 0 ($\gamma = 0.8634$). It means that 86% of the production variation of broilers business among respondents in the research's site was due to the difference of technical efficiency and external effects, such as climate, disease, and error modeling. As a fact, it proves that the production function of Cobb-Douglas was able to explain the existing data related to a phenomenon of technical inefficiency in the broiler business.

The calculating result of restriction parameter test of LR value was = 89.99, where the value was bigger than the critical value from the Kodde and Palm Table (= 19.384) in the significance level of p < 0.01. This states the existence of the inefficiency effect in the stochastic model. Moreover, the value of sigma square by the parameter value was statistically 0.0133, where the trust significance was 99%, describing that the production variation contributed by technical inefficiency was 1.33%.

Determining factors of technical inefficiency in the broiler business

Based on the analysis, the following equation was derived, as follows:

$$u_i = 1.5202 - 0.23090.2309Z_{1i} +$$
$$0.0049Z_{2i} - 0.1457Z_{3i} - 0.0006D$$

The negative mark in the variable of coefficient value in Table 3 depicted that the variables of age, farming experience, and dummy ownership status decreased technical inefficiency, but, contrastingly, the positive mark showing the increase of variable would improve technical inefficiency or declining technical efficiency.

Technical efficiency of the broiler business in the Province of North Sulawesi

The distribution of the value of technical efficiency is described in Table 4. The findings of this research show that the mean of technical efficiency in the broiler business utilizing the open-house system and the partnership model (the nucleus and the plasma) in the Province of North Sulawesi was 0.95, ranging between 0.45 to 0,99.

DISCUSSION

In this research, the characteristics of the respondents were largely in their productive age, having better physical appearance rather than non-productive age. Their education level was higher and supported with the productive age, enabling them in making innovations, receiving knowledge and novel technology [20]. Additionally, the farming experience in raising broilers was less than five years. The more experience in the broiler business, the more knowledge obtained [21].

The factors of production consisting of Day-Old Chick (DOC), feed, vitamins, medicines, workers, and electricity had a significant effect on the broiler production, but

Table 2. Hypothetical result of the stochastic frontier of production function in the broiler business using Maximum Likelihood Estimation (MLE) method in the Province of North Sulawesi

Variables	Coefficient	Error standard	t-ratio
Constant	0.3195	0.2103	1.5193
Total of DOC (X_1)	-0.0102*	0.0003	-32.2835
Total of feeds (X_2)	0.3218*	0.0586	5.4925
Total of vitamins and medicines (X_3)	0.0028*	0.0006	4.5883
Total of HOK (X_4)	0.6520*	0.0531	12.2802
Total of electricity (X_5)	0.0068*	0.0006	12.0213
Total of LPG (X_6)	-0.0129	0.0122	-1.0507
Dummy site (D)	0.0001	-0.0003	0.2880
Sigma square	0.0133*	0.0036	3.7132
Gamma	0.8634*	0.0482	17.9175
L-R test	89.9973		

*p < 0.01

Table 3. Hypothetical result of the parameter model of the inefficient effect of production technicon the stochastic frontier in the broiler business in the Province of North Sulawesi

Variables	Coefficient	Error standard	t-ratio
Constant	1.5202	0.3872	3.9265
Age (Z_1)	-0.2309*	0.0707	-3.2674
Level of education (Z_2)	0.0049*	0.0016	3.0131
Farming experience (Z_3)	-0.1457*	0.0486	-2.9959
Dummy ownership status (D)	-0.0006	0.0014	-0.4326

*$p < 0.01$

Table 4. Frequency distribution of technical efficiency of broiler farmers in the Province of North Sulawesi

Level of efficiency	Frequency	Percentage
< 0.50	1	1.25
0.51-0.60	0	0
0.61-0.70	0	0
0.71-0.80	1	1.25
0.81-0.90	5	6.25
0.91-1.00	73	91.25
Total	80	100
Minimum	0.45	
Maximum	0.995	
Mean	0.952	

LPG and business site had not had a significant effect. However, the coefficient value of Day-Old Chick (DOC) had a negative value (-0.0102). It means that the total of Day-Old Chick (DOC) and broiler production were non-parallel. This finding was similar to [12], but different with the research's results by [4,9,10,13,14,17,22]. Though the coefficient value of Day-Old Chick (DOC) was small, yet the impact was significant. In this research, the addition of the total of Day-Old Chick (DOC) decreased the broiler production. It was because the quality of Day-Old Chick (DOC) raised was sufficiently varied. Day-Old Chick (DOC) was provided by the main companies, a partner of respondents, under the partnership model in the Province of North Sulawesi, such as PT. Ciomas, PT. BSB (Bintang Sejahtera Bersama), PT. Kartika Eka Dharma, PT. DMC (Dinamika Megatama Citra), and PT. Celebes. During the data collecting, Day-Old Chick (DOC) distributed to the plasma (farmers) by the nucleus (company) was probably not based on a better selection. If Day-Old Chick (DOC) raised had worse quality, the production would not be optimally obtained; though the environment factor had been maximal. Opposingly, if Day-Old Chick (DOC) raised had better quality, there would not any obstacle during the raising period, so the production resulted was based on its environmental factor.

Further, the coefficient of the total of feeds was positive and significant ($p < 0,01$), depicting that the increase of feed intake by broilers would increase their production. This finding, then, was in line with previous results by [4,9,10,13,22]. The result depicts that the total of feeds supplies by broiler farmers in the Province of North Sulawesi had been in accordance with the recommendation of the main companies and feeds used in the broiler raising had satisfied nutrition needs. Thus, it could significantly improve broiler production.

By *ceteris paribus* assumption, the addition of the total of inputs on vitamins and medicines could increase broiler production. The result describes that broiler farmers in the Province of North Sulawesi were rational if they added input of vitamins and medicines to increase the broiler production. This finding, then, was in accordance with the research conducted by [4], finding that vitamins and

medicines have a positive and significant effect on broiler business. Though the percentage of vitamin needs in broilers' ransom was definitely smaller than other nutrition, such as carbohydrate, protein, and fat, vitamins were mandatorily given related to their function as micro-nutrient metabolism catalyst to optimize the broiler growth. In practice, dosage, time, and frequency of vitamins and medicines supply were directed by counselors and provided by the main companies. Consequently, if the production would increase, vitamins and medicines were given to boost broilers' immunity against disease.

Meanwhile, the total of hired workers had impacted the output of the broiler business. The result was in line with the findings of [3,4,10], stating that workers have a positive significance to the broiler business. Most workers employed in the broiler business in the Province of North Sulawesi were male and female, originating from both inside and outside of the farmers' family. A worker could raise to 5000 broilers, where the elder farmers would hire daily workers as the age of broilers was ready to be harvested. The daily workers only lifted feeds and cleaned cages. In the research, the output of working hours was calculatedly based on the total of wages divided by prevailing hourly-daily wage. The total of wages for workers hired from outside of the farmers' family was varied, such as working days, monthly work, period, and a total of harvested broilers. The greater the total of broilers harvested (low mortality), the higher the wages received. It motivated farmers to raise broilers by adding the time to check broilers' condition in cages.

Furthermore, electricity and LPG had an indirect impact on broiler production. It was in accordance with the raising management, such as related to the use of brooder. All broiler farmers used brooder to maintain cage temperature. The warm temperature of cages is usually maximized at night, and broilers were at one to 10 days old. The brooding aimed to provide an efficiently and economically comfortable and healthy environment for chicks and support optimal growth [23]. Brooding used by farmers was powered by either electricity or LPG. While

the usage was based on the total of broilers, climate, and weather.

Dummy sites had not had a significant effect on broiler production. However, the positive sign of the variable shows that the broiler productivity in the highland was higher than the broiler productivity in the lowland [6]. The altitude had an indirect impact on the physiology status and production performance, such as feed consumption, drinking water, weight addition, FCR, the final weight of raising, and the carcass' weight. According to the interview results with respondents, the mortality in the highland usually occurred as the age of broilers was under two weeks. Comparatively, the mortality in the lowland usually happened as broilers were three weeks. It was related to cages' temperature and environment.

The hypothesis of Return to Scale (RTS) value was 0.9603, meaning that the broiler production in the Province of North Sulawesi was in the decreasing return to scale or business scale was declining due to the elasticity value from six variables, where the amount was smaller than one. The calculation of input elasticity functioning as the productivity size of the total of resources was less than one (0.96). It demonstrates that respondents were in the rational step to produce since the input addition still caused the increase of total production.

Also, despite the use of production input, the technical efficiency was related to the factors of technical inefficiency. The technical inefficiency statistically declined with the growing age and respondents' farming experience. While the status of ownership could also decrease the technical inefficiency, but it was statistically insignificant. The significance of the age variable was in accordance with [9,10,14,24,25], and the variable of farming experience was in line with [5,10,25,26].

According to the research, the variable of education level was calculatedly based on the total of years experienced by respondents during formal education. Formal education could not be able to improve the technical efficiency in the broiler business in the Province of North Sulawesi. This happened

due respondents having a higher education might not have sufficient experience. Another possibility was that respondents, having higher education, only acted as owners/investors, who were indirectly involved in the broiler business. Those respondents only hired others in their broiler business/raising. This finding was different from the research's result by [3,9], arguing that the higher the formal education, the more decreasing the technical inefficiency and the more increasing the technical efficiency of the broiler business.

Lastly, the value of technical efficiency from mostly broiler businesses using the open-house system, compared with those under the partnership model, in the Province of North Sulawesi was similar to previous researches [3], regarding the value of technical efficiency of the non-partnership farmers in the Regency of Kupang. However, the result of this research was higher than [4, 10, 11, 25] and smaller than [12] from initial research. The smaller value of technical efficiency was experienced by farmers obtaining worse Day-Old Chick (DOC). Then, the increase of technical efficiency could be achieved by improving formal education for farmers, mainly improving their knowledge in assessing a better and healthy Day-Old Chick (DOC)

CONCLUSION

In conclusion, the value of technical efficiency obtained by broiler farmers under the partnership model in the open-house system was 0.95. Then, the determining variables of the broiler production were feeds, vitamins, medicine, working hours, and the total of electricities. Determinant variables that could reduce technical inefficiency were age, farming experience, and ownership status of lands/cages.

CONFLICT OF INTEREST

In this writing, "The authors declare no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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