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Technical Efficiency and Its Determinant Factors of Dairy Farms under Membership of Different Scales of Cooperative in Bogor District, West Java

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ABSTRACT

The purpose of this study was to measure the technical efficiency and its determinant factors of dairy farms in the District of Bogor, West Java, under two difference scales of cooperative membership. A total of 80 dairy farmers was selected by purposive random sampling. These farmers were categorized into two groups consist of 40 dairy farmers each, which represented membership of two different scales of cooperative, i.e. KPS Bogor (large-scale/Group I) and KUD Giri Tani (small-scale/Group II). Data related to dairy farms during a year was collected by direct interviews using questionnaires. The Cobb-Douglas stochastic frontier analysis using the single-stage estimation procedure was employed. The study revealed that the technical efficiency of dairy farms in both groups of farmers lies below the potential level of technical efficiency. Around 75% of surveyed farmers in Group I attained technical efficiency of 81-90% category, while this in Group II was only 25% of sampled farmers. Thus, Group I and II had a median TE of 93.8 and 66.7%, respectively. The result indicates that the output per farm still can be increased with existing technology without incurring any additional production costs. Three statistically significant factors associated with variation in milk production were lactating cow, labor, and capital which had a positive impact on production efficiency. Among the inefficiency factors, the coefficients of education, and forage feed land had negative signs and significant irrespective of the groups of farmers. The other variables had mixed effects on the efficiency of dairy farms in each group.

Key Words: Technical Efficiency, Dairy Farms, Scale of Cooperatives, Bogor

INTRODUCTION

Dairy farming has long been developed in Bogor, as well as other livestock commodities. Data showed that during the period 2008-2013, the dairy cattle population has increased by an average of 12.4% per year, from 5,907 into 9,526 heads. In line with this, milk production also experienced increasing by an average of 3.2% per year (Bogor Livestock and Fisheries Services 2013). Similar to other regions, the development of dairy farms in Bogor also cannot be separated from the role of cooperatives as a mediator for dairy farmers to sell their products, also providing the means of production, marketing, animal health services, reproductive cows, and so forth. Most dairy farmers are members of dairy cooperatives. There are two dairy cooperatives in the district of Bogor, namely *Koperasi Produksi Susu* (KPS) Bogor and KUD Giri Tani.

KPS Bogor is the biggest dairy cooperative in Bogor, which was established in 1970. At 2015, the number of memberships reached 900 persons, however the number of active members who deposit milk to KPS Bogor was only about 270 members. With the population of dairy cattle accounted of 4,529 heads, the cooperative can collect around 12,000 tons of fresh milk per year from its members (GKSI Jawa Barat 2016). Most fresh milk is sold to milk processing companies (PT Indolacto, PT Cimory, PT Nutrifood and PT Unifarm) and only a small portion of that (500 kg/day) is processed by the cooperative into yoghurt and pasteurized milk. Another cooperative, KUD Giri Tani, is a small cooperative with a total membership of 166 persons who owned about 1,248 heads of dairy cattle. This cooperative was established since 1973. The total production of fresh milk from its farmer members amounted to 6,550 tons/year, which is mostly sold to PT Cimory and PT Nutrifood. KUD Giri Tani also processes a small portion of milk into yoghurt, i.e. 500 kg/day (GKSI Jawa Barat 2016).

By joining the cooperative, farmers are expected to further expand their business, increasing the ownership of cows, increase production capacity, and reduce production cost. However, in reality, these expectations are still not achieved yet. Majority of dairy farmers is still small farmers with low ownership of dairy cattle (2-4 heads of lactation cow/farmer), low productivity (12-14 liters/cow/day, or about 3,139 litres/period), and high production costs, especially for feed costs (Directorate General of Livestock and Animal Health 2013). To overcome these problems, the farmers have to increase milk production because only with high production of milk will be able to cover the high production costs and increase the profits of dairy farmers. One way to increase production of milk and reduce costs of production can be done by improving the efficiency of production factors used in the dairy farming.

Dairy production involves a production process where various inputs are used to produce an output, i.e. fresh milk. It describes an empirical relationship between the maximum outputs that can be produced from different combinations of inputs using a given technology. The important concept that can be explained using this production function is production efficiency. There are three important types of production efficiency, namely, allocative, technical, and economic efficiencies. Technical efficiency, its measurement, and the factor determining it, are crucially importance, because in order to be economically efficient, a farm must first be technically efficient (Aragon 2010). However, not all farmers able to utilize the minimum of required inputs to produce the expected quantity of output in a given technology and reach technically efficient. The studies by Aisyah (2012), Mariyono (2006), and Djoni (2003) in the District of Getasan, Sleman, and Tasikmalaya showed that the dairy farms in those districts have not reached the conditions of technical efficiency. It means that the utilization of factors of production has not been able to produce the maximum output and there is still a chance to increase the productivity by increasing technical efficiency. However, there is no information yet regarding to technical efficiency of dairy farms in the district of Bogor.

Technical efficiency (TE) is the capability of a producer to obtain the maximum level of production given the set of inputs (Trestini 2006). It is the difference between the average production of the total production and the potential/maximum production of the farm. Thus, TE is the difference of the farm's actual output (Y) to the technical maximum possible output (Y*) give a set of resources (Figure 1a) (Aragon 2010). Greene (2005) stated that efficient producers are those that have produced outputs as much as possible with the actual inputs employed or whether they have produced that output at minimum cost. A producer can be characterized as technically efficient if they able to operate on the production frontier, i.e. operate with every combination of inputs along the isoquant (Figure 1b).

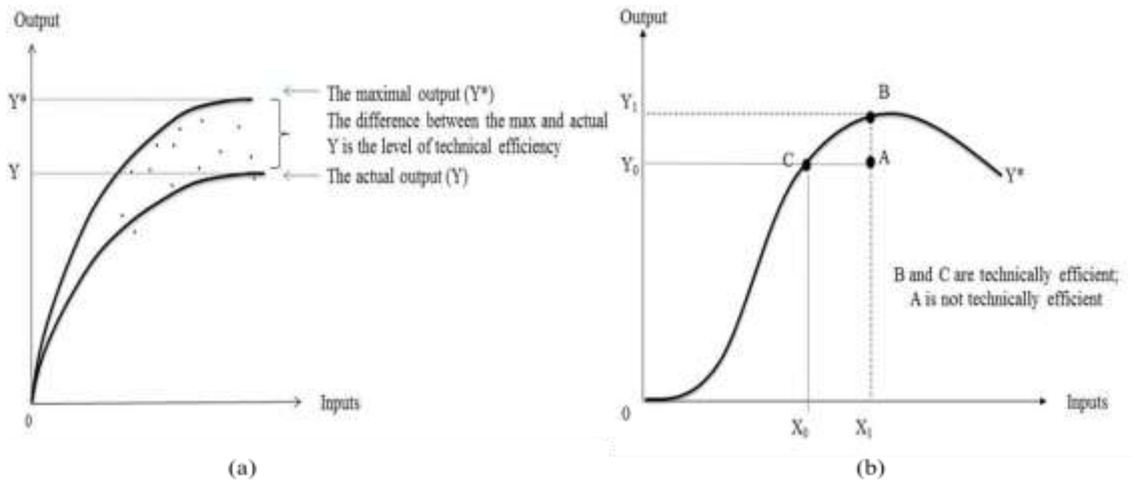

Figure 1. Production frontier and technical efficiency

Stochastic frontier production function (SFPF) has become one of widely used methods for assessing the efficiency of farmers since it incorporates the traditional random error of regression. The original specification of SFPF as proposed by Coelli (1996), involved a production function specified for cross-sectional data. The model includes two stages of estimation with respect to two error components, i.e. one associated with the presence of technical inefficiency (u_i), and the other a conventional random error (v_i). The Cobb-Douglass stochastic frontier production function can be specified as follows (Batesse 1992):

$$Y_i = f(X_i, \beta) \exp \varepsilon \quad (1)$$

$$\varepsilon = v_i - u_i \quad (2)$$

The frontier of production function is given by combining (1) and (2):

$$Y_i = f(X_i, \beta) e^{v_i - u_i}$$

In logarithm term, the SFPF is expressed as follows:

$$\ln Y_i = \ln f(X_i, \beta) + v_i - u_i$$

i = 1,2,…, N
Y_i = The possible production level for the ith sample unit
$f(X_i, \beta)$ =A suitable function (*e.g.*, Cobb-Douglas or Translog) of the vector, X_i of inputs for the ith sample unit, and a vector of parameters, β to be estimated
N = The number of units involved in a cross sectional survey
ε = A stochastic disturbance term consisting of two independent elements u_i and v_i.
v_i =Random variation in output due to factors outside of the control of farmer (weather and diseases), assumed to be independently and identically distributed as N~ (0, σ_v^2)
$u_i \geq 0$ –> farm specific technical inefficiency relative to the stochastic frontier, which assumes only positive value, and assumed to be independent and identical half normal distribution |N~(0, σ_u^2)|

Since the technical efficiency is measured as the ratio of *Y* to the maximum attainable (frontier) level of output *Y**, thus it can be denoted by:

$$TE_i = \frac{observable\ output}{maximum\ attainable\ output} = \frac{Y_i}{Y_i^*} = \exp(-u_i)$$

Thus, the technical efficiency of production for *i*-th farmer is defined by:

$$TE_i = e^{-u_i}$$

This equation means that the difference between *Y* and *Y** is embedded in u_i. If u_i = 0, then *Y* is equal to *Y** which means that the production lies on the stochastic frontier. Hence, the farmer is technically efficient implying that the farm is able to obtain its maximum possible output given the level of inputs. If u_i>0, production lies below the frontier and the farm is considered technically inefficient (Aragon 2010).

This study aims to measure the technical efficiency and its determinant factors of dairy farms has different scales in the district of Bogor under membership of cooperative. Such study is important because measurement of technical efficiency provides useful information on the competitiveness of farms and potential to improve productivity, with the existing resources and the level of technology.

MATERIAL AND METHODS

This study was conducted in the district of Bogor, West Java as the second largest of the milk production area in West Java, in January 2015. A total of 80 dairy farmers were selected by purposive random sampling which represented membership of two different scales of cooperatives, i.e. KPS Bogor (large scale) and KUD Giri Tani (small scale). These farmers were categorized into two groups which each consist of 40 dairy farmers from KPS Bogor (group I) and KUD Giri Tani (group II). Data related on dairy farms during a year was collected by direct interviews using questionnaires. The stochastic frontier analysis using the single-stage estimation procedure developed by Batesse and Coelli (1995) was employed. The Cobb-Douglas function form was used in this Stochastic Frontier Production Function (SFPF).

One output and five inputs were considered as dependent and independent variables, respectively, in the empirical formulation of this study. The dependent variable was total milk production per year per farm expressed in liters.The five inputs as independent variables were the number of lactation cow, the amount of forage, the amount of concentrate, the amount of labor, and the value of capital (depreciation of cow, building, vehicle, and equipment). Empirically, the Cobb-Douglas production frontier model for this study was specified as follows:

$$lnY_i = \beta_0 + \beta_1 lnX_{1i} + \beta_2 lnX_{2i} + \beta_3 lnX_{3i} + \beta_4 lnX_{4i} + \beta_5 lnX_{5i} + V_i - U_i$$

β_0	=	The intercept
$\beta_1 \dots \beta_5$	=	Regression coefficient of the explanatory variables in the stochastic production function
i	=	1,2,…, N, N = Number of farmers
ln	=	Natural logaritma
Y_i	=	Quantity of milk produced per farm per year (liters/farm/year)
$X_1 \dots X_5$	=	Explanatory variables defined in Table 1
V_i, U_i	=	It accounts for factors that are not under the control of the firm, factors not included in the production function, and error measurements
V_i	=	Random variable assumed to be independently and identically distributed N (0, σ_v^2) and independent of U_i
U_i	=	Non-negative random variable that is assumed to account for technical inefficiency in production

Table 1. Independent variable definitions and measurement

Variables		Units	Definition
X_1	Lactating cow	Animal unit	Quantity of lactating cows
X_2	Forage	kg/year	Quantity of forage(grass, legume, crop by product)
X_3	Concentrate	kg/year	Quantity of concentrate feed,
X_4	Labor	Mandays/year	Quantity of labor used
X_5	Capital	IDR/year	Value of fixed costs (depreciation of cow, building, vehicle, and equipment)

The technical inefficiency model for the dairy farm was defined as follows:

$$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} + \delta_8 Z_{8i} + \theta_i$$

δ_0 = Intercept
$\delta_1 \ldots \delta_8$ = Regression coefficients of the explanatory variable in the technical inefficiency model to be estimated
$Z_1 \ldots Z_8$ = Factors assumed to explain technical inefficiency defined in Table 2
θ = Error terms, assumed to be independently and identically distributed N $(0,\sigma_\theta^2)$
Subscripts i, refer to the i^{th} farmer; $i = 1, 2, \ldots, N$, N = Number of farmers

Table 2. Variable definition for technical inefficiency effects

Variable	Definition	Unit	Expected signs
Z_1	Farmer's age	Years	-
Z_2	Farmer's years of schooling	Years	-
Z_3	Farmer's experience in dairy farming	Years	-
Z_4	Herd size	Animal Units	-
Z_5	Forage feed land	m^2	-
Z_6	Dummy for participation in extension	1: Get extension services 0: Otherwise	
Z_7	Dummy for access to credit	1: With credit 0: Otherwise	-
Z_8	Dummy for membership of farmer group	1: Member of farmer group 0: Otherwise	-

Expected sign (-) means that the relevant variable has positively related to technical efficiency, vice versa

For purpose of comparison, two stochastic frontier analyzes were fitted, one for dairy farms under large-scale cooperative and one for dairy farms under small-scale cooperative memberships. The technical efficiency index was defined as the ratio of observed output to the corresponding frontier and was given by:

$$TE_i = \exp(-U_i)$$

The above model for the inefficiency effects can only be estimated if theinefficiency effects are stochastic and have a particular distributional specification. Hence, there is interest totest the null hypothesis that the inefficiency effects are not present;

$$H_0: \gamma = \delta_1 = \cdots = \delta_7 = \delta_8 = 0$$

The coefficients of the variables in the model for the inefficiency effects are zero:

$$H_0: \delta_1 = \cdots = \delta_7 = \delta_8 = 0$$

This null hypothesis is tested using the generalized likelihood-ratio statistic, λ, defined by:

$$\lambda = -2\ [L\ (H_0) - (L\ H_1)]$$

$L(H_0)$ = Value of the log-likelihood function of a OLS frontier model as specified by a null hypothesis, H_0

$L(H_1)$ = Values of the log-likelihood function under the alternative hypothesis, H_1 (i.e.,MLE model).

If the null hypothesis is rejected, this means that the observed in efficiency among the sample farmers can be attributed to the Z_i variables included in the model.

The maximum likelihood estimation proposed by Battese & Coelli (1995) was used to simultaneously estimate the parameters of the stochastic productionfrontier and the technical inefficiency effects model. It was automatically derived using the computer program,FRONTIER Version 4.1 described in Coelli (1996).

RESULTS AND DISCUSSION

Estimation of stochastic frontier production function for dairy farms

The summary statistics of surveyed dairy farmers for all variables was showed in Table 3. Group I had higher values for all measured variables compare to Group II, it means that dairy farms in Group I had bigger scale of business.

Tabel 3. Characteristics of the surveyed dairy farmers

Variables	Group I (large scale)		Group II (small scale)	
	Mean	Std. deviation	Mean	Std. deviation
Milk production (litres/year)	42,784.69	35,059.97	19,256.94	17,987.01
Lactating cows (animal unit/farm)	13.40	9.46	5.12	4.79
Forage (kg/year)	242,445.10	143,915.10	80,459.00	76,129.35
Concentrate feed (kg/year)	32,848.75	23,155.43	12,649.88	13,273.99
Labor (mandays/year)	651.46	379.58	376.01	266.91
Capital (IDR)	6,956,854.00	3,766,996.00	2,845,040.00	2,692,346.00
Farmer's age (year)	46.77	6.65	43.37	10.68
Farmer's years of schooling (year)	11.40	2.13	10.10	2.61
Farmer's experience in dairy farming (year)	7.52	4.00	7.92	6.40
Herd size (heads)	24.00	16.06	8.12	7.83
Forage feed land (m^2)	4,106.25	1,001.42	666.25	1,210.71

Source: Author's calculation

Table 4 presents the comparative maximum likelihood estimation (MLE) of the parameter of Cobb-Douglass stochastic production frontier of dairy farms of Group I and II. Since the model is a log linear model, the coefficients of the variables in this SFPF (β_0,

β_1, β_2, β_3, β_4, β_5, …) are the elasticity of average output with respect to the different inputs used in the milk production.The results suggest that majority of variables were consistent with prior expectation. The variables had a positive sign, although some of them were statistically insignificant. This indicates that dairy producers were operating below the maximum allowable level of production given the technology available to them. The coefficient of lactating cow was positive and significant at the 1% level for both groups of farmer. It means that if the number of lactating cows increased by 1animal unit, thus the milk production would be increased by 0.624 and 1.195 litres for Group I and II, respectively. For labor and capital variables, the coefficients were positive and significant at the 1% level for farmers in Group I, and those were positive and significant at 5% level in Group II. It implies that if the application of labor increased by one person in Group I,the milk production would be increased by 0.659 litres. Similarly, if the use of capital increased by 1% in Group I, thus the milk production of dairy farms would be increased by 0.788 litres. The estimated coefficients of forage was negative and significant at the 1% level for dairy farms in Group I, but insignificant in Group II. It implies that the amount of forage used by farmers in Group I should be reduced in order to get better production of milk. It implies that the forage was used with a rather high degree of inefficiency. The coefficients of concentrate feed both in Group I and IIwere statistically insignificant.

Tabel 4. MLE of Cobb-Douglas stochastic production frontier for dairy farms under memberships of different scales of cooperative, Bogor

Name of variables	Parameters	Group I		Group II	
		Coefficient	t-ratio	Coefficient	t-ratio
Constant	β_0	2.076**	1.809	9.489***	6.582
		(1.147)		(1.442)	
Lactating cows (X1)	β_1	0.624***	7.965	1.195***	9.942
		(0.078)		(0.120)	
Forage (X2)	β_2	-0.437***	-2.964	0.057^{ns}	0.270
		(0.147)		(0.012)	
Concentrate feed (X3)	β_3	0.00015^{ns}	1.227	-0.276^{ns}	-1.206
		(0.00012)		(0.229)	
Labor (X4)	β_4	0.659***	3.883	0.110**	1.751
		(0.169)		(0.147)	
Capital (X5)	β_5	0.788***	5.155	0.041**	1.635
		(0.153)		(0.116)	

*, **, ***Indicate significant at 10, 5, and 1% level, respectively; ns: Indicates insignificant; Figures in parenthesis represent the standard error

Source: Frontier 4.1 package program

The distribution of the dairy farms level of technical efficiency for each group can be seen on Table 5. The surveyed dairy farmers in Group Iwereabout to produce milk with a range from about 37.6-97.9% of the potential stochastic frontier production levels. About 30sample farmers (75%) attained efficiency belongs to 81-100% category, thus Group I had a median TE of 93.7%. In Group II, the dairy farmers had technical efficiency with a range from about 47.9-99.9%, given the levels of their inputs and technology used. However, only tensample farmers in this group (25%) had score of 81-100% category of technical efficiency, thus Group II only had a median TE of 66.8%. The surveyed dairy farms had a wide variance of TE, where Group I mostly dairy farms had TE over 80%, conversely dairy farms in Group II mostly had TE below 80%. It can be concluded that the larger the scale of production,the more efficient the business.

Tabel 5. Distribution of the dairy farm level of technical efficiency

Degree of technical efficiency (%)	Number of dairy farms	
	Group I	Group II
≤50	2	1
51-60	0	13
61-70	4	9
71-80	4	7
81-90	8	7
91-100	22	3
Total number of farms	40	40
Minimum TE	0.376	0.479
Maximum TE	0.979	0.999
Median TE	0.936	0.667

Source: Frontier 4.1 package program, author's calculation

Determinant factors of technical efficiency of dairy farming

A summary of the empirical results of the coefficient estimation for the determinants of technical efficiency is also provided in Table 6.

Among the inefficiency factors, the coefficients of age, education, forage feed land, and participation in extension had negative signs irrespective of the groups of farmers. It means that those variables had positive influences to the technical efficiency in both groups. However, not all coefficients were statistically significant. In Group I, the significant coefficients were only age, education, and forage land ownership (at the 10% level). So, it can be evident that if the farmers in Group I had higher age, education, and forage land, the inefficiency of dairy farming would decrease, meaning that their efficiency would be increased. In Group II, the coefficient of education found negative and significant at the 5% level, while the coefficients of forage land and participate in extension were also negative and significant at the 10% level. It implies that if dairy farmers in Group II had higher education, forage land ownership, and participation in extension, the efficiency of milk production would be increased. Age of farmer was significant only in Group I, it means that older farmers were relatively had more experience in dairy farming, thus can be more efficient. As expected, education was positively associated with efficiency. Similar results were reported for farmer in Turkey (Demircan et al. 2010), Bangladesh (Rahman 2004), and Central Ethiopian Highlands (Wubeneh and Ehui 2006). The role of education in improving skills and technology adoption of farmers have been extensively documented. More educated farmers are more likely to adopt technology earlier (Wubeneh and Ehui 2006). The well-educated farmer will perform better production practices than the less educated one.

The results of the analysis regarding the herd size revealed unexpected indicator. The coefficient of herd size had positive sign and significant at the 1% level, irrespective of the groups. It denotes that herd size had an inverse relationship with farming efficiency, which means that the increase of herd size, will reduce the efficiency of dairy farms. This result conversely with the results of studies by Demircan et al. (2010) and Al-Sharafat (2013). The possible explanation for this result was the composition of herd consist of more non-lactating cows than lactating cows. The more the population of non-lactating cows, the higher the production costs to be borne by farmers, thus increased the inefficiency in milk production.

Tabel 6. Determinants of technical efficiency of milk production, Bogor, 2015

Name of variables	Parameters	Group I		Group II	
		Coefficient	t-ratio	Coefficient	t-ratio
Constant	δ_0	0.798^{**}	1.803	0.005^{**}	1.735
		(0.994)		(0.406)	
Age	δ_1	-0.033^{*}	-1.390	-0.002^{ns}	-0.223
		(0.024)		(0.009)	
Education	δ_2	-0.070^{*}	-1.545	-0.014^{**}	-1.687
		(0.456)		(0.021)	
Experience in dairy farming	δ_3	0.027^{ns}	0.745	0.0003^{ns}	0.018
		(0.036)		(0.016)	
Herd size	δ_4	0.030^{***}	4.188	0.351^{***}	3.622
		(0.007)		(0.0097)	
Forage feed land	δ_5	-0.00009^{*}	-1.353	-0.0005^{*}	-1.377
		(0.00007)		(0.00004)	
Extension service	δ_6	-0.027^{ns}	-0.151	-0.335^{*}	-1.474
		(0.189)		(0.227)	
Credit	δ_7	-1.006^{***}	-2.944	0.052^{ns}	0.506
		(0.342)		(0.103)	
Farmer group membership	δ_8	0.651^{***}	2.759	-0.185^{ns}	-0.841
		(0.236)		(0.002)	
Log-likelihood value		22.029		26.753	
Mean technical efficiency		0.866		0.702	
Variance parameter					
Sigma-square	σ^2	0.042**	1.956	0.029***	3.865
		(0.021)		(0.220)	
Gamma	γ	0.666***	4.270	0.999***	62.009
		(0.156)		(0.016)	

*, **, ***: Indicate significant at 10, 5, and 1% level, respectively; ns: Indicates in significant; Figures in parenthesis represent the standard error

Source: Frontier 4.1 package program

The coefficient of credit had a positive impact on the technical efficiency of dairy farming in Group I, but not in Group II. It can be explained that since the majority of dairy farmers in Group II were small farmers with dairy cattle ownership below 10 animal units, thus sometimes they used the credits for consumption, not for production. It would more burden the production costs due to repayment of credits and lead to increasing inefficiency. The variable of farmer group membership also revealed unexpected indicator, i.e. had a significant negative influence to TE in Group I. This means that farmers who are members of farmer groups will reduce the efficiency of dairy farms. It can be understood since the main motivation of dairy farmers in the Group I became a member of a farmer group was to acquire plots for theirdairy cattle business in Kunak area (an area provided by KPS Bogor which specially used to develop dairy farming). Thus, they never actively do activities in the farmer groups to improve their skill and knowledge in dairy farming management. It also can be seen from Table 6 that the value of γ in the two models was estimated to be very high and was highly significant at the 1% level, especially for Group II. The gamma statistic, which is a measure of the overall, was highly significant indicating the presence of a high systematic inefficiency which explains about 90% of the variation in milk output of Group II. This indicates that the technical inefficiency effects were a significant component of the total variability of milk output, especially in Group II.

The results of hypothesis testing were shown in Table 7. The null hypothesis was H_0, means that there was no inefficiency effect ($\gamma = 0$) or technical inefficiency in the model was absent.

Tabel 7. Generalized likelihood ratio test of null hypotheses for parameters of the inefficiency function

Test of null hypothesis	Large-scale				Small-scale			
	Test statistic (λ)[a]	df	Critical value (χ^2)	Conclusion	Test statistic (λ)[a]	df	Critical value (χ^2)	Conclusion
Dairy farmers are completely efficient in producing milk ($\gamma = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = 0$)	22.66	9	16.274[b]	Reject H_0	18.714	9	16.274 [b]	Reject H_0

[a]$\lambda = -2$ [L (H0) − L (H1)], [b]Critical values (16.274 at 5% probability level with k + 1 is the degree of freedom) obtains from Kodde & Palm (1986)

Source: Frontier 4.1 package program

The analysis showed that the hypothesis was strongly rejected for both of the groups as the value of LR were greater from the critical χ^2, indicating that in milk production, there was presence of technical inefficiency effect. Further, this result was confirmed by the value of γ in Table 6, which was very close to one and significantly different from zero, particularly in Group II (0.999). This establishes the fact that high level of inefficiencies exists among the surveyed dairy farmers. Thus, the MLE was the adequate estimation for this study.

CONCLUSION

The technical efficiency levels of surveyed dairy farmers were below the potential stochastic frontier production levels,irrespective of the groups. About 75% of sampled dairy farms in Group I attained efficiency belongs to 81-100% category with a median TE of 93.8%. In Group II, only 25% of surveyed dairy farms had score of 81-100% category of technical efficiency with a median TE of 66.7%. The result indicates that the output per farm still can be increased with existing technology without incurring any additional production costs. Three statistically significant factors associated with variation in milk production were lactating cow, labor, and capital which had a positive impact on production efficiency.

Among the inefficiency factors, the coefficients of education, and forage feed land had negative signs and significant irrespective of the groups of farmers. It means that those variables had positive influences to the technical efficiency. Another variables that had negative signs and significant were age and credit in Group I, and extension service in Group II. Contrarily, the variables of herd size had inversely influence to the technical efficiency, irrespective of the groups of farmers. The possible explanation for this result was the composition of herd consist of more non-lactating cows than lactating cows. The more the population of non-lactating cows, the higher the production costs to be borne by farmers, thus increased the inefficiency in milk production.

The gamma value was highly significant indicating the presence of a high systematicinefficiency which explains about 90% of the variation in milk output of Group II. This indicates that the technical inefficiency effects were a significant component of the total variability of milk output, especially in Group II.

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