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Technical Efficiency of Beef Cattle Fattening with Self-Ownership and Partnership Systems in the Special Region of Yogyakarta, Indonesia

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Abstract
One of the issues faced by the farmers of local beef cattle in Indonesia is the small ownership scale and the low rate of production which caused by several conditions, including the low efficiency of input utilisation. This matter has caused the self-ownership program of national beef to be unable to reach the expected targets. The aims of this research are: 1) to identify the factors that influence the production of beef cattle fattening business; 2) to analyze whether the farmers are already efficiently using the production factors; and 3) to analyze the technical inefficiency factors in the business of beef cattle fattening in the Special Region of Yogyakarta, Indonesia. Cross section is collected from 120 self-ownership farmers and 120 partnership farmers of beef cattle. The stochastic production frontier is used to estimated production function and efficiency. The research results indicate that the variables of forage feed, concentrate feed, medicines, supplements, labour, and the frequency of extension are having significant influences towards the productions of self-ownership and partnership systems. The dummy variables of the type of livestock and the membership of livestock group also have controls towards self-ownership system; however, these two variables are not influencing the partnership system. The technical efficiency values of self-ownership system are in the range of 0.50-0.96, as for the partnership system is ranged from 0.39-0.97. Both self-ownership and partnership systems are categorised as efficient with 0.87 and 0.86 of average values. The factors that become the source of technical efficiency on partnership system are the variables of education and breeding experience, and the variable that influences both systems is farmers age.
Keywords: Inefficiency, Production Function, Smallholder Farmers, Stochastic Frontier

1. Introduction

Beef is one of the strategic foods that has to be enhanced by its production in Indonesia because the deficit supply of a beef commodity is occurring at present in comparison to the total food needs of Indonesian people. This condition will generate an impact on the failure to achieve the fulfilment of requirements of Indonesian people for beef and its processed product as one of the animal proteins. Self-sufficient in food through meat is one of the prioritised programs of the Ministry of Agriculture of the Republic of Indonesia which has to be realised immediately.

The main problems of community beef cattle livestock in Indonesia include the population of beef cattle which not significantly increased and the small scale of business ownership of local cattle ranch. In 2013, 12,329,477 (97.97%) beef cattle are owned by 5,078,979 livestock households. The rest 2.03% are owned by incorporated companies, traders, and others (BPS, 2013).

The development of livestock in Indonesia has been still depending on community livestock business. However, in general, the condition of community livestock still concerns in which the skills of farmers are still low, and the capital of the business is still minimum. Community livestock requires business partners who able to ensure the funding and marketing or the improvement of additional values from the production due to the low bargaining position (Matatula, 2010).

One of the provinces in Indonesia which have been quite intense in developing the beef cattle livestock is the Special Region of Yogyakarta with 314,620 potential beef cattle during the end of December of 2017. If compared to the production of beef, the annual per capita consumption on each year is 3.7 kg/capita/year with 3,679,200 populations of people; thus a deficit was still occurred especially to fulfil the households and non-household needs in the Special Region of Yogyakarta. The minimum supply of beef cattle production is caused by the low efficiency in utilising the production input by community farmers, either from self-ownership or partnership systems.

Empirical studies on the technical efficiency of beef cattle farmers have been done in other locations (Cehyan and Hazneci, 2010; Indrayani *et al.* 2012; Mlote *et al.* 2013; Isyanto, 2013; Otieno *et al.* 2014; Pramusintho, 2015; Temoso, 2016). The distinguishing factor that becomes the novelty of this study is the use of extension frequency variables in the technical efficiency model. Also, dummy variables were used to compare between farmers who raise local cattle (Ongole breed) with crossbreed cattle (Simmental/ Limousine/ Brahman), which were not used in previous studies. This study is generally aimed to analyse and compare the production

and efficiency of beef cattle fattening business on self-ownership and partnership systems in the Special Region of Yogyakarta. The specific aims are focused on 1) identify the factors that influence the production of beef cattle fattening business; 2) to analyse whether the farmers are already efficiently using the production factors; 3) to analyse the technical inefficiency factors in the business of beef cattle fattening.

2. Theoretical Framework

The stochastic production frontier (SPF) that was originally developed by Aigner *et al.* (1977) and was used by Battese and Coelli (1995), and Coelli *et al.* (1998) takes the following form:

$$Yi = f(Xi;\beta).\exp\{v_i - u_i\} \quad (1)$$

where: Yi denotes the observed output produced by farm i; Xi denotes the 1 x K vector of inputs and other explanatory variables associated with that farm, and β is the unknown parameters to be estimated.

The composite error term consists of the standard noise component v_i which is, as usual, assumed to be independently and identically distributed standard random variable with mean zero and constant variance (external factors). The ui reflects an internal (controllable) error component and typically associated with the managerial capability of the farmers in managing his business. This component is asymmetric distribution (one-sided) that is $u_i \geq 0$, a non-negative random variable representing technical inefficiency. If the production process takes efficiently, the resulting output coincides with its maximum potential, meaning $u_i = 0$. Conversely, if $u_i > 0$ means it is below its maximum potential. The distribution spreads half normal ($u_i \sim N(0;\sigma_v^2)$) and uses the Maximum Likelihood Estimation (MLE) method.

The technical efficiency of the beef cattle farm can be described as follows (Battese and Coelli, 1995):

$$TE_i = E(Y|U_i,X_i)/E(Y^*|U_i = 0,X_i) = \mathrm{E}[\exp(-\mathrm{U_i})/\varepsilon_i] \quad (2)$$

where the value of TE lies between 0 and 1 or $0 \leq TE \leq 1$. The value of the efficiency is between 0 and 1, the TE = 1 indicates that the livestock business is technically efficient, and the TE < 1 indicates that is not efficient.

3. Research Methodology

This research was conducted in 4 regencies namely Gunungkidul, Bantul, Sleman, and Kulonprogo. The locations were determined purposively by considering that those locations are the basis of beef cattle livestock business in the Special Region of Yogyakarta which still contains potentials to be developed. In each regency, 60 samples were taken proportionally through simple random sampling, which consists of 30 farmers of self-ownership system and 30 farmers of partnership system; therefore, 240 respondents as beef cattle farmers were acquired. This research was conducted in September through December 2017.

3.1 Production function analysis.

The estimation of the production function parameters of stochastic frontier and inefficiency function was conducted simultaneously through a frontier 4.1c program (Coelli, 1996). The estimation of the entire parameters and variances was conducted by using Maximum Likelihood Estimation (MLE) with Technical Efficiency as the selected model to estimate the entire parameters of production and intercept factors of both v_i and u_i error components. The estimation equation model of frontier production functions of beef cattle fattening business of self-ownership and partnership systems can be described as follows:

$$\ln Y_{man} = \ln a + a_1\ln X_1 + a_2\ln X_2 + a_3\ln X_3 + a_4\ln X_4 + a_5\ln X_5 + a_6\ln X_6 + a_7\ln X_7 + d_1D_1 + d_2D_2 + (v_i - u_i) \quad (3)$$

$$\ln Y_{gad} = \ln b + b_1\ln X_1 + b_2\ln X_2 + b_3\ln X_3 + b_4\ln X_4 + b_5\ln X_5 + b_6\ln X_6 + b_7\ln X_7 + d_1D_1 + d_2D_2 + (v_i - u_i) \quad (4)$$

where: Y_{man} = The production of beef cattle livestock business of self-ownership system (kg); Y_{gad} = The production of beef cattle livestock business of partnership system (kg); X_1 = Weaned cow-calf (AU/period); X_2 = Forage feed (kg/period); X_3 = Concentrate feed (kg/period); X_4 = Livestock medicines (gr/period); X_5= Supplement feed (gr/period); X_6 = Numbers of labor (man-days/period); X_7 = Extension frequency (times/period); D_1 = Dummy of cattle type, Non-Local Cattle = 1, Local Cattle (PO) = 0; D_2 = Dummy of the membership of livestock group, if joined = 1, if not joined = 0; a,b = Constant/ intercept; ai,bi = The regression coefficient of estimation parameter (i = 1,2,3,...,7); d_i = The coefficient of dummy variable (i = 1); and $v_i - u_i$ = error term, (u_i) technical inefficiency effect in the model.

3.2 *Technical inefficiency analysis*

The technical inefficiency method used in this research was referring to the effects of technical inefficiency which developed by Battese and Coelli (1995) that also adopted in the study aimed to analyse the technical inefficiency on small-scale beef cattle fattening in Tanzania (Mlote *et al.* 2013), West Java, Indonesia (Isyanto *et al.* 2013), and Jambi Province (Pramusintho *et al.* 2015). The u_i variable used to measure the technical inefficiency is assumed as independent, and the distribution is normally-truncated towards N (u_i, a_2). The following formulation was used to determine the value of the distribution parameter (ui) of technical inefficiency

in this research:

$$u_i = \delta_0 + \delta_1 lnZ_1 + \delta_2 lnZ_2 + \delta_3 lnZ_3 + \delta_4 lnZ_4 \quad (5)$$

where:ui = technical inefficiency effect; δ_0 = intercept; $\delta_{1\text{-}4}$ = the predictor parameter coefficient of technical inefficiency; Z_1 = age of farmers (years old); Z_2 = formal education of farmers (years); Z_3 = the business experience in beef cattle livestock (years); and Z_4 = the number of family member of farmers (person).

The parameter tests of a stochastic frontier and technical inefficiency effect were conducted in two phases. The first phase was an estimation of β_i parameter by using the OLS method. The second phase was the estimation of the entire intercept parameters (β_0), production factors (β_i) and the variances of both error components (u_i and v_i) by using the method of MLE. The processing results of the Frontier 4.1c program according to Aigner *et al.* (1977) and Jondrow *et al.* (1982) will provide the estimation value of variances in the form of parameterisation as follows:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \quad (6)$$

$$\gamma = \frac{\sigma^2_u}{\sigma^2_v} \quad (7)$$

The parameter of this variances can determine the γ value; therefore, the value of γ is $0 \leq \gamma \leq 1$. The parameter is the contribution of technical inefficiency on total residual effect. The amount which approaching to 1 indicates that error term is only resulted from inefficiency effect (u_i) and not resulted from noise (v_i). As the opposite, if the value is approaching 0 (zero), it means that the entire error terms are the results caused by noise (v_i), including climate/ weather, cattle disease, and others.

4. Result and Discussion

4.1 Factors that are affecting production

The average of input quantities used and the production yield between self-ownership and partnership systems are presented in Table 1. The average of forage feed from self-ownership system was lesser than that of the partnership system. The average of production, cow-calf, concentrate feed, livestock medicine, supplement feed, number of labour, and extension frequency of self-ownership system was slightly larger than that of the partnership system.

The estimation results of the production function of the stochastic frontier are presented in Table 2. The log likelihood values of the production function method of MLE in self-ownership and partnership systems are 45.5 and 49.03 which bigger than the log-likelihood values of the OLS method that generate 30.71 and 32.76 which indicate that the production function of the stochastic frontier with MLE method is useful and in accordance with the field condition.

The sigma squared (σ^2) values in self-ownership and partnership systems are 0.225 and 0.239 respectively that found significant at $\alpha = 0.01$ which show that the variation of production is caused by the 22.5% and 23.9% influences of technical inefficiency (ui). The gamma (γ) values in self-ownership and partnership systems are 0.944 and 0.963 that found significant at $\alpha = 0.01$ which show that 94.4% and 96.3% of the result variation of beef cattle livestock business is caused by the difference in technical efficiency and the rest 0.56% and 0.37% have resulted from stochastic effects (vi), such as the impacts of disaster, climate, livestock disease attack, and the error in modeling.

Table 1. Production Yield and Inputs Used of Self-ownership and Partnership Systems

Variables	Self-ownership System		Partnership System	
	Mean	Standard deviation	Mean	Standard deviation
Production (kg)	481.4	249.93	394	199.95
Weaned Cow-Calf (AU)	1.69	0.63	1.53	0.47
Forage Feed (kg)	7.524,99	1.898,53	7.595,71	2.500,36
Concentrate Feed (kg)	757.80	557.10	696.71	379.80
Livestock Medicine (gram)	89.29	94.79	77.55	56.02
Supplement Feed (gram)	344.28	335.57	248.77	175.48
Numbers of Labor (man-days)	120.30	49.61	116.64	30.73
Extension Frequency (times)	2.76	1.44	2.58	1.12

According to Table 2, it is known that almost the entire variables are having real influences towards the production of beef cattle. All estimation parameters on the production function of self-ownership system marked as positive, except for cow-calf. In the production function on the partnership system, the entire coefficients marked as positive, except for cow-calf and the dummy of cattle type. The negative parameter indicates that 1% addition of cow-calf will decrease the 1% production of beef cattle for self-ownership systems, and 5% for the partnership system. The entire labour is derived from the families, therefore, along with the increasing number of livestock, labour from families will have more burden in finding the forage with limited working hours. In the beef cattle livestock business of the community, the management is running almost the entire time with high labour input performed by the families; therefore, the distribution of quite high families labour is required

(Suherman, 2001).

Table 2. The Estimation of a Function of Stochastic Frontier Production on Beef Cattle Livestock Business Through Maximum Likelihood Estimates (MLE) Method

Variables	Self-ownership System		Partnership System	
	Coefficient	t-ratio	Coefficient	t-ratio
Constant (C)	1.545*	1.973	3.701***	5.003
ln Weaned Cow-Calf (X_1)	-0.010*	-1.692	-0.05***	-6.099
ln Forage Feed (X_2)	0.73***	9.132	0.98***	6.737
ln Concentrate Feed (X_3)	0.26***	3.392	0.553***	5.833
ln Livestock Medicine (X_4)	0.52***	5.639	0.552***	5.349
ln Supplement Feed (X_5)	0.057***	4.693	0.03**	2.280
ln Numbers of Labor (X_6)	0.34***	8.453	0.17***	3.381
ln Extension Frequency (X_7)	0.022***	3.108	0.024***	3.713
***Dummy* of Cattle Type**	0.012*	1.973	-0.084	-1.397
***Dummy* Membership Group**	0.086***	3.236	0.046	1.478
Sigma-squared	0.225***	2.224	0.239***	6.941
Gamma	0.944***	3.079	0.963***	10.302
Log-likelihood MLE		45.594		49.034
Log-likelihood OLS		30.71		32.76
LR Test		29.763		32.531

Remarks: *** significant at α = 1% (P<0.01), ** significant at α = 5% (P<0.05), and * significant at α = 10% (P<0.1)

The variables of production function of self-ownership system that have significant influence towards the frontier of livestock business at the level of α = 0.01 are forage, concentrate, medicine, supplement, labor, frequency of extension, and the dummy of livestock group with cow-calf and the dummy of cattle type at the level of α = 0.10 which having regression coefficients that amounted to 2.017 in accumulation. The variables of production function of beef cattle in partnership system that have a significant influence towards frontier of livestock business at the level of α = 0.01 are cow-calf, forage, concentrate, medicines, labor, frequency of extension, the dummy of livestock group, and supplement (at the level of α = 0.05). The function has regression coefficients that amounted to 2.017 and 2.221 in accumulation, and these values show that the scale of beef cattle livestock business in self-ownership and partnership systems is at the increasing return to scale (IRS).

In the beef cattle livestock business of self-ownership and partnership systems, the variable of forage feed has 0.73 and 0.98 coefficient values as the highest elasticity. This condition indicates that the variable of forage feeds the variable that generates most response towards the production of beef cattle compared to the other inputs. The forage feed that frequently used by the farmers in the Special Region of Yogyakarta are rice straw, and field grass as the primary input, while the concentrate feed is not provided routinely depend on the availability of cost to purchase them, these conditions are linear with study conducted by Dung et al (2013) in Vietnam which mentioned that the forage feed were provided more in the community beef cattle fattening compared to the concentrate feed and rough proteins.

Table 3. The Frequency Distribution of Technical Efficiency

Technical Efficiency Distribution	Self-Ownership System		Partnership System	
	Number of Farmers	Percentage (%)	Number of Farmers	Percentage (%)
0.00 – 0.20	-	-	-	-
0.21 – 0.30	-	-	-	-
0.31 – 0.40	-	-	1	0.83
0.41 – 0.50	1	0.83	-	-
0.51 – 0.60	6	5	4	3.33
0.61 – 0.70	5	4.17	7	5.83
0.71 – 0.80	4	3.34	11	9.17
0.81 – 0.90	41	34.16	35	29.17
0.91 – 1.00	63	52.5	62	51.67
Total	120	100	120	100
Mean		0.87		0.86
Minimum		0.50		0.39
Maximum		0.96		0.97
Standard deviation		0.105		0.107

According to the distribution value of technical efficiency distribution in Table, it can be seen that the

technical efficiency of farmers of self-ownership beef cattle livestock is around 0.50-0.96 with 0.87 average value of technical efficiency, while on the partnership system is ranged between 0.39 to 0.97 with 0.86 average value. This result indicated that in short period context, the production of beef cattle could be enhanced about 13% for self-ownership system and 14% for partnership system through the application of cultivation strategies and best technologies. The technical efficiency values of self-ownership and partnership systems farmers in the Special Region of Yogyakarta are included in the efficient category due to the average values that following the standard value of Coelli et al. (1998) which higher than 0.8.

The research results with regard to calculation of technical efficiency value is higher than the research of Indrayani et al. (2012) on the beef cattle fattening in West Sumatra-Indonesia with the average score of 0.764, however, the results are lower than the score acquired by Cehyan and Hazneci (2010) about the research in Turkey which generated 0.92 average value with the range between 0.67 to 1, and Mlote et al. (2013) about the analysis of beef cattle in Tanzania which made 0.91 average value. The other studies regarding technical efficiency of beef cattle were conducted by Otieno et al. (2014) which expressed that the score of technical efficiency of beef cattle in Kenya is 0.69, and Temoso et al. (2016) who proposed the result of average value of technical efficiency of commercial beef cattle farmers in Botswana is 0.74 and 0.71 for traditional farmers.

4.2 The factors of technical inefficiency source

The factors that influence the technical efficiency of beef cattle farmers with self-ownership and partnership systems in the research location are estimated/ predicted by using the model of technical inefficiency effect which determined by the other factors outside the input associated with farmers managerial aspect. The estimation results of technical inefficiency function are the simultaneous results which were analysed together with the production function through the utilisation of Cobb Douglass model of the stochastic frontier with MLE method. The estimation results of the production function of beef cattle livestock with self-ownership and partnership systems are presented in Table 4.

Table 4. The Factors that Influence the Technical Inefficiency of Beef Cattle Farmers Through MLE Method

Variables	Self-Ownership System		Partnership System	
	Coefficient	t-ratio	Coefficient	t-ratio
Constant (C)	6.745	1.575	11.756	7.156
Age	-0.237*	-1.682	-0.527**	-2.141
Formal Education	-1.658	-1.511	-2.965***	-7.114
Livestock Business Experience	-0.068	-1.610	-1.297***	-4.712
Numbers of Family Member	0.389	1.590	0.120	0.926

Remarks: *** significant at α = 1%, ** significant at α = 5%, and * significant at α = 10%

The estimation results of technical inefficiency effect indicate that the variable of farmers age generates a significant influence in explaining the technical inefficiency on production process of beef cattle farmers of self-ownership system at the level of $\alpha = 0.10$, while the variables of education, livestock experience, and the family member who also supports the business activity of livestock/ breeding are having non-significant influence towards technical inefficiency. On beef cattle farmers of partnership system, the variables that have significant impact are the variable of age ($\alpha = 0.05$), as well as the variables of formal education level and livestock business experience ($\alpha = 0.10$). The variable of the number of family member has non-significant influence.

The variable of age has a significant influence towards the technical efficiency of beef cattle livestock business in self-ownership and partnership systems with the negative-signed coefficients, which are -0.237 and -0.527. It means that the older the farmers become, thus, it would be more efficient in conducting the beef cattle livestock business. The average ages of farmers in the research location are 52.5 years old for self-ownership system and 53.4 years old for beef cattle farmers of partnership system. In line with the increasing age of farmers, the possibilities of their experiences and skills will also improve. These conditions are linear with several studies that age is valued as negative and influencing towards the improvement of technical efficiency (Indrayani et al. 2012; Mlote et al. 2013; Pramusintho, 2015).

The variables of education and livestock experience in self-ownership and partnership systems are both valued as negative, although in self-ownership system those variables are not significant. This condition indicates that the higher education and the long experience in livestock, the livestock business will be more conducted efficiently. The education level and farmers experience will provide essential knowledge and skills in managing the herd. This argument is linear with the research of Isyanto et al. (2013) which expressed that education and experience influenced on the improvement of farmers technical experience of beef cattle livestock.

The numbers of a family member either in self-ownership or partnership systems are valued as positive (0.389 and 0.120) but not significant, it means that the more family member involved in the maintenance of beef cattle, thus, the farmers will be more inefficient in producing or utilising production inputs. These conditions are following the research of Isyanto et al. (2013) which mentioned that the more family member of farmers, thus, it will decrease the technical efficiency.

5. Conclusion

The factors that significantly influence to the production improvement of self-ownership beef cattle livestock system are forage, concentrate, medicines, supplement, labour, a frequency of extension, the dummy of cattle type, and the dummy of livestock group. The factors that significantly influence to the production improvement of partnership system are forage feed, concentrate feed, medicines, supplement feed, labour, and the frequency of extension while the factor that can reduce the production of beef cattle both in self-ownership and partnership systems is the variable of cow-calf. The farmers of beef cattle livestock in self-ownership and partnership systems in the Special Region of Yogyakarta are categorised as efficient with 0.87 and 0.86 average values of technical efficiency.

The factor that has a significant influence in decreasing the technical inefficiency on farmers of beef cattle with self-ownership system is the age of farmers, while the factors that have a significant impact on the farmers of beef cattle with partnership system are the age of farmers, formal education of farmers, and livestock business experience.

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