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Technical Efficiency in Cow Milk Production: The Case of Babile District of Eastern Hararghe Zone, Oromia National Regional State, Ethiopia

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Abstract
This study was aimed to examine the technical efficiency of cow milk production in the Babille district. Data were collected from 152 farmers those selected by randomly sampling technique and analysed using descriptive statistics and stochastic frontier production function. Accordingly, the return to scale (1.85) of the production function revealed that the farmers operated in the irrational zone of the production surface. The estimated gamma parameter (γ) for production function was 0.838, indicating that about 84%of the variation in the output of milk among the farmers differed due to their technical efficiencies. The estimated sampled household level technical efficiency ranged between 41 to 94% with a mean of 75.92%. It has been shown that farmers have potential to increase milk production by about 24% at the existing level of technological development. However, improvement in technical efficiency in milk production requires augmentation of feed and fodder resources as well as intervention with improved cow breed. There is a need for improving extension contact which had significant and positive impact on technical efficiency. The result also shows that rising age would lead to a decline in the efficiency means, and hence, the government policy should focus on ways to attract and encourage young people who are agile and aggressive in Dairy business.
Keywords: Babille district, Cow milk, stochastic frontier approach, Technical Efficiency

1. INTRODUCTION

The rural poverty reduction is associated with growth in agricultural productivity and maintaining agriculture as major source of economic growth (NPC, 2015). One way of increasing productivity is through improving efficiency (Thomas, 2007). The implication is that to bring about desirable changes in agriculture through introducing new technologies as well as increasing efficiency. Efficiency analysis in milk production becomes important in underdeveloped production environments of developing countries like Ethiopia which are basically low-input and low output environments. Dairy plays an important role in the Ethiopian agricultural sector and the national economy (Azage *et al*., 2013). The sector is a source of livelihoods for a vast majority of the rural population in terms of consumption, income and employment. The milk production in 2012/13 is 2.8 billion liters, of which 42.3% was used for household consumption (CSA, 2014). This shows that dairy production is an important agricultural activity in the country and provides livelihood for significant proportion of smallholders. However, dairy production has not been fully exploited and promoted in the country and its production is also low compared to its potential. According to the 2013 report of the Central Statistics Agency (CSA), from the 55.48 % female cattle, 12.5 % are dairy cows with about 63.64 % being in 3 years age category of the total estimated number of cattle population. According to FAO (2014), over the period 1993 - 2012 total annual milk production have been growing, but at a moderately slow rate. In line with this, Nathaniel *et al.* (2014) argue that since dairy inputs and services provisions are still at infant stage and the expansion of improved dairy cows is limited in the country. Increased milk production may have come mainly from increased number of cows rather than increased productivity. This calls questions for understanding the efficiency level of the dairy sector and identifying factors associated with inefficiency. The results of such analysis are expected to better development and policy decisions and also help to prioritize interventions in the sector. In this context, efficiency analysis assumes critical importance as technical efficiency improvement entails inefficient farmers adopting existing technologies and practices. Moreover, analysis of factors causing (in) efficiency offers crucial insights on key variables that might be worthy of consideration in policy making in order to ensure optimal capital and resource utilization. Although several studies are available on analysis of technical efficiency in farm production in the Ethiopia (Makombe *et al*., 2011; and Nisrane *et al*., 2011); but, efficiency in milk production is not adequately covered. In view of the above, the present study carried out to examine the technical efficiency in cow milk production along with influence of various factors on the efficiency in Babille district of Eastern Hararghe, Oromia region of Ethiopia.

2. RESEARCH METHODOLOGY

2.1. Area description, Sampling and Types of data

Babille district was purposively selected because the district is one of the most milk producing in the Eastern Hararghe of Oromia region. The study area has a huge potential in dairy production and livestock husbandry which is dominated by 56355 cattle, 122160 sheep, 23020 goats, 9704 camel, 7181 donkey, 21671 poultry, 208 modern hives, 5 transitional and 2522 traditional hive (Babille district DoARD, 2014). The livelihoods of the people based on livestock production complemented with crops production. Both primary and secondary data sources were used. The primary data collected using structured questionnaires that administered to households that were selected randomly as representative sample from the study area. The data collected from milk producing households includes input used and milk production along with socioeconomic and institutional elements. A total of 152 households were sampled. Descriptive statistics as well as Cobb-Douglas production function and stochastic frontier model were used to estimate production function and identify determining factors of efficiency levels simultaneously**.**

2.2. The stochastic frontier approach

The stochastic frontier approach preferred given the function in the model involves a composite error term that accounts both for the statistical noise in the data as well as the inefficiency in production (Erkoc, 2012). Once the individual inefficiency levels are estimated, the major factors causing the inefficiency can easily be identified from the inefficiency model. One of the drawbacks of this method is the imposition of restrictive assumptions about the functional form of the production function and the distribution of random errors. In addition, livestock in general and dairy production in particular in the study area can be characterized by poor method of production. The farmer may deviate from the frontier not only because of measurement error, statistical noise, or any other influence but also because of technical inefficiency. This divergence can be related to various factors. Therefore, it is necessary to identify factors which influence the technical efficiency of the dairy farmers to further intervene and increase milk production. To asses such conditions, the stochastic frontier production function model of Cobb-Douglas functional form is employed to estimate technical efficiencies of the farmers. Given the above specified model, the functional relationship between input and output in the production function was specified:

$Yi = f\,(Cows,\ Labour,\ Concentrate,\ Dry\ fodder,\ Green\ fodder,\ Health,\ \beta\ i) + \varepsilon i.$

Where:

Yi = Milk Output by the i^{th} household (litres) during the 2014/15 production year;

f (.) = Appropriate functional form (Cobb-Douglas);

βi = Vector of unknown variables to be estimated;

$\varepsilon i = Vi - Ui$

Where:

Ui = non-negative random variables which captures the technical inefficiency in production; Vi= a disturbance term which accounts for factors outside the control of the farmer

2.3. Technical Efficiency

Technical efficiency is the effectiveness with which a given set of input is used to produce an output. A firm is said to be technically efficient if a firm is producing the maximum output from the minimum quantity of inputs, such as labour, capital and technology. The concept of technical efficiency is also related to X-inefficiency. X-inefficiency is said to occur when a firm fails to be technically efficient because of an absence of competitive pressures. In other words, the farmer/firm wants to be as efficient as possible with as few inputs as possible, while still hitting its production goal. As far as factors determining technical efficiency are concerned, farmers have different characteristics that make them attain different levels of technical efficiency. Given a particular technology to transform physical inputs into outputs, some farmers are able to achieve maximum output while others are not. These factors need to be identified in order to define the problem of inefficiency and eventually search for remedial measures to solve the problem. Most of the time in the area of efficiency analysis the following variables are commonly used. So, to capture the possible effects of the exogenous variables that affect technical inefficiency, the following model is specified, after Battese and Coelli (1995). The model is expressed as: $\mu i= \delta\ 0+ \ldots\ \delta_{14}Z_{14} + \varepsilon i$

Where: Z are respectively: Age of household head, Household experience in dairying, Education level of household head, Household size, Landholding size, Extension contacts, Training in dairy production, Total livestock holding (TLU), Non/Off-farm income, Amount of Credit Utilized, Distance to the nearest market place, Distance to water source, Distance to veterinary clinic, and Breed type; δ 's are unknown coefficients of the inefficiency effect to be estimated corresponding to each exogenous Variables, εi is a stochastic error term that captures the effect of unaccounted household specific variables on technical inefficiency. These were the farm/farmers specific factors/exogenous/ explanatory variables included in the inefficiency model.

3. RESULTS AND DISCUSSION

3.1. Descriptive statistics of specific variables

The summary statistics for the output and input variables included in the stochastic production frontier and the inefficiency models, including the sample size, mean, standard deviation and a description for each variable are presented in Table 1. The average milk produced during the year 2014/15 per sampled household was 1645.69 liters and the average milk yield per cow was 781.53 liters. The average milk per cow per day is 2.58 and 6.69 for local and crossbred, respectively. The milk yield obtained from each breed is extremely different. Even though it is known as input difference between breed, the milk yield from crossbreed cow is 137% times higher than milk yield of local breed cow per year. The average dry and green fodder supplied to the milking cows per sampled household during the 2014/15 production year is 1494.01 and 1526.09 kg, respectively. Whereas the average dry and green fodders, fed per cow per year, appeared to be 782.2 and 799 kg, respectively. This indicates that sample households fed their cows equal proportions of green and dry fodder during the survey year. More feed sources consumption goes to crossbred cows. According to the sampled household responses, crossbreds prefer concentrate feed; however, availability of concentrate feed is less. The average concentrates supplemented to the milking cows during 2014/15 production year were 507.77 kg with high standard deviation of 717.41 kg. But, large portion of concentrates feed is offered to crossbred (133.9% times concentrated feed offered to local cow). This indicates that those households owning crossbred cows have used concentrate feed. The average amount of labour required for management of milking cows per sampled household were, 626.3 man-days with a standard deviation of 370.81 man-days. The labour used for lactating cows per sample households during the 2014/15 production year includes involvements in milking, watering, barn cleaning, herding, feeding and taking care of sick cows. The respondents indicates that labour requirement is high for crossbred cows because of the cows need more feed and continuously feeding, watering (usually fetch water from the sources and water at home), and cleaning barn frequently (at least three times per day). Even milking is consuming time and has handled by male household members. The labour consumed by crossbred is about 55% times the labour consumed by local cow.

Table 1. Descriptive statistics of Milk output and input used in (2014/15) per house hold

Variables	Local breed (N = 124)		Crossbred (N = 11)		Local and crossbred (N =17)		Total (N=152)	
	Mean	Std.	Mean	Std.	Mean	Std.	Mean	Std.
Milk output (L)	1216.2	1033.4	2882.7	2064.7	3977.9	2606.5	1645.7	1657.5
Dry fodder (kg)	1209.5	1003.3	2258.9	1160.7	3075.0	1866.4	1494.0	1291.8
Green fodder (kg)	1171.9	879.8	2503.4	1269.4	3482.4	1714.3	1526.1	1285.5
Concentrate (kg)	371.5	600.8	869.1	1039.9	1267.7	748.2	507.8	717.4
Number of milked cows	1.79	0.87	1.45	0.69	2.88	1.1	1.89	0.95
Labour (man-day)	550.2	302.1	852.4	397.5	1035.1	489.8	626.3	370.8
Veterinary cost (Birr)	189.8	150.6	223.1	167.0	226.1	167.3	196.28	153.2

3.2. Econometric Results

The test was carried out by estimating the stochastic frontier production function and conducting a Likelihood-ratio test assuming the null hypothesis of Technical efficiency effects are not present in the milk production and no efficiency difference among farmers. The test statistics were computed using STATA version11. Table (2) shows that the output elasticity for labour, green fodder, dry fodder and number of lactating cows significantly influence efficiency levels. Positive signs of variables indicate that lack of these inputs would lead to a decline in the milk output. In the present study, since Cobb- Douglas model was employed, the coefficients represent elasticity of milk production with regard to the respective inputs. Therefore, labour, number of lactating cows, green fodder and dry fodder which had the greatest overall coefficient (0.95, 0.64, 0.14, 0.13) respectively have the greatest contribution to milk production in the study area. The result of the study concurs with the finding of Lemma *et al.* (2013). For instance, Lemma and his colleagues found that dry fodder influence milk production levels statistically and significant. Nakanwagi and Hyuha (2015) reported that labour had positive and significant effect on milk output. Significance of labour and number of lactating cows is found to be in agreement with what has been reported by Mosisa (2014). A high value (0.838) of gamma (γ) estimate indicates the presence of significant inefficiencies in milk production (Table 2). That means about 83.8 percent of the differences between the observed and maximum production frontier outputs were due to farmers' inefficiencies which are in the control of the farmers and can be reduced to enhance technical efficiency of the farmers in the study area.

Table 2. Stochastic Frontier Estimation of Household Level Technical Efficiency

Variables	Coefficient	Std. Err.
ln of labour (man - days)	0.9528***	0.0500
ln of dry fodder in kg	0.13***	0.0401
ln of green fodder in kg	0.14***	0.0377
ln of concentrate in kg	0.002	0.0049
ln of number of lactating cows	0.64***	0.0562
ln of veterinary cost in Birr	-0.0133	0.0144
constant	-0.94***	0.2932
Sigma (u)	0.378	0.37
Lambda (λ)	2.274	0.08
Gamma (γ)	0.838	
Log likelihood	-19.700	
Wald ch2(6)	1213.01	
Number of observations	152.00	
Likelihood-ratio test of sigma=0:	6.42	
Prob>=chibar2 = 0.006		

** and *** represent significance at 5% and 1% levels respectively

3.3. Result of Hypothesis Test

With view to attaining meaningful result and to address the study objectives, the following null hypotheses were tested. As shown in Table (3), the first null hypothesis tested ($H_{01} = 0$) which states that there is no efficiency variation (households are efficient in resource use) in milk production that was represented by the model and at the same time it means that the technical efficiency effects are not random are rejected in favour of the alternative one. This indicates that there is statistically significant inefficiency in the data. The second null hypotheses ($H_{02}= \delta_1= \delta_2 = \ldots = \delta_{14} = 0$) was also rejected significantly, which states that as all the explanatory variables included in inefficiency effect model do not have an influence on technical efficiency variation. When test linear hypothesis imposed on stochastic frontier model, to that of the second null hypothesis, the LR test (chi2 (14)) was 32.35, but still significantly greater than the critical value and leads us to accept the alternative one. That is the joint effects of the explanatory variables included in the model are significantly influence technical efficiency of milk production although some variables are found to have individually statistically insignificant effects on technical inefficiency.

Table 3. GLR test of hypothesis for parameters of SPF and efficiency factors

Null hypothesis	LR Value	Degree of freedom	P value	Decision
H01: $\gamma= 0$	6.42	1	0.006	Reject Ho1
$H02 = \delta 1 = \delta 2 = \ldots = \delta 14 = 0$	32.35	14	0.0000	Reject Ho2

3.4. Technical efficiency scores

Given the functional form used, estimation procedure implemented, distributional assumption of the inefficient effect, Ui, the mean technical efficiency was estimated to be 75.92% (Table, 4). This value indicates that farmers are not technically efficient in producing milk in the study area. They can increase averagely the output by 24.08% without increasing the existing level of inputs. Conversely, farmers on average could decrease inputs by 24.08% to get the output they are currently getting if they use inputs efficiently.

Table 4. Estimated technical efficiencies at a household level

Description	TE estimates
Minimum	41
Maximum	94
Mean	75.92
Std. Deviation	12.7

Figure (1) show that most of the sample households in the study area have shown efficiency scores well above 80%. In fact, this figure shows that there is still a significant room for improving the productivity levels given the current level of technology. In other words, results further indicate that 39.5% of the households lie within 80% and 89% efficiency range. Moreover, there is a considerable difference in technical efficiency among farmers that ranged from a minimum of 0.41 to a maximum of 0.94. The results show that output could be increased given the present level of inputs farmers are using, if policy variables that are determining the level of TE of farmers are identified.

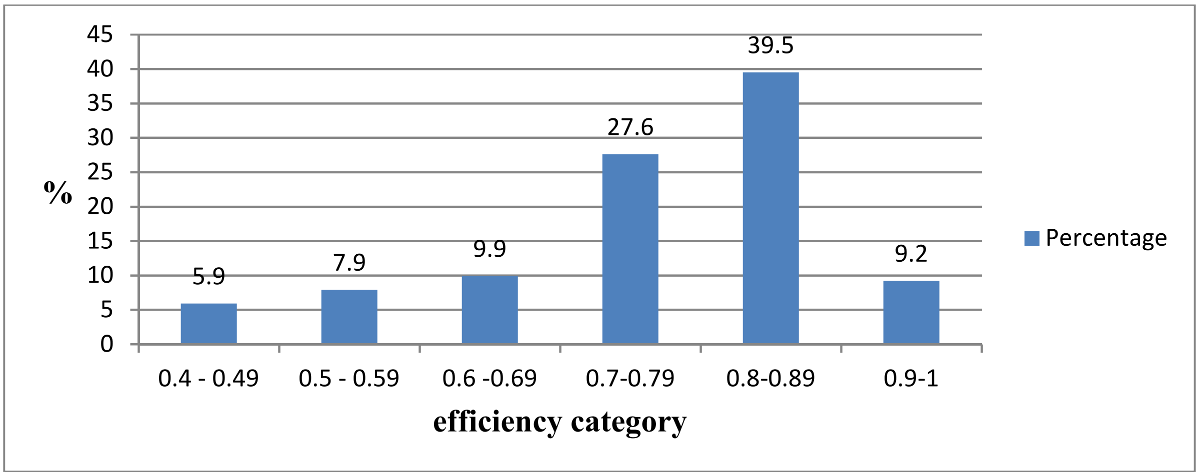

Figure 1. Frequency distribution of technical efficiency estimates for sample farm households
Source: Own computational result, 2016

3.5. Determinants of technical inefficiency

From Table 5, one can observe that age, household size, land allocated for crop production and frequency of extension contact have statistically significant effects on milk producers' technical inefficiency. Age of the producer may affect the technical efficiency negatively/inefficiency positively following the saying that "you cannot teach an old dog a new trick". Older producers may insist on sticking to old practices (Feng, 2008) or take long to accept new technologies that would improve operation efficiency as they tend to be risk averse. Singh and Sharma (2011) obtained results which favoured technical efficiency of young adult farmers. In this study, age of the sample households reveal that as age of the respondents increase, inefficiency in milk production also increases. This indicates that younger people are more efficient than older ones. It is in agreement with the findings of Lemma *et al*. (2013) that reported age of the farmers was negatively affecting technical efficiency of milk or positively for inefficiency. The authors further indicated that farmers with older age were found to be technically less efficient in producing milk. The findings of Bamlaku *et al*. (n.d.) also reveal that the sign for age is positive relating to milk production inefficiency, which indicates that younger people are more efficient than older ones. Household size is relevant in milk production. This may be due to the reason that as dairy farming is highly labour-intensive and cumbersome; sample households with higher family size are found to be more efficient than labour-constrained ones. It provides labour which constitutes the bulk of labour supply in developing countries. The regression coefficient of extension contact is found to be significantly negative (Table 5). It is expected that farmers who have contacts with extension workers will get timely suggestions that make themselves more efficient in the operation and milk production. This could be attributed to the fact that farmers who were using near optimal combinations of inputs based on the recommendation of the extension workers have achieved better technical efficiency. It is learned that extension advice on improved dairy husbandry could give a clear understanding on the improved practices to increase efficiency of milk production. Area of land allocated to crop production was a continuous variable indicating whether or not the producer owned enough land for crop production purpose. The result shows (Table 5) that ownership of land for crops determine the inefficiency significantly with negative sign as expected. Owning land where the cattle can scratch crop by- products may reduce expenses the farmer would have otherwise incurred in purchasing feed. Rahman and Umar (2009) found a positive and significant ($p > 0.005$) relationship between crop land size and technical efficiency. As cultivated land increases, dairy cows holder gets more by product from crop production (Stover of sorghum, maize, and groundnut hull) to feed their cows.

Table 5. Maximum Likelihood (ML) for inefficiency determinants

Explanatory Variables: Technical inefficiency part			
Variables	**Coefficients**	**Std. Err.**	**Z**
Age (years)	0.035**	0.019	1.80
Household size (number)	-0.160*	0.091	1.76
Schooling (1 if literate)	0.146	1.306	0.11
Experiences in dairying (years)	0.017	0.088	0.21
Area allocated to crop production (ha)	-1.221**	0.624	-1.95
Breed type of cow	-0.108	0.357	-0.30
Water point distance (Km)	0.177	0.141	1.25
Distance of the nearest milk market (Km)	-0.066	0.077	-0.85
Livestock clinic distance (Km)	0.018	0.0690	0.26
Non/Off-farm income (ETB)	0.00003	0.0003	0.11
Amount of credit utilized (ETB)	-0.0006	0.0020	-0.31
Frequency of extension contact	-0.448**	0.2240	-2.00
Training (1 if yes)	-0.443	0.814	-0.54
Livestock holding (TLU)	-0.0005	0.061	-0.01
Constant	-2.203	1.472	-1.50
Sigma	0.111	0.013	
Number of observation = 152			
Wald chi2(6) = 2407.34			
Log likelihood = 67.209	Prob> chi2 = 0.0000		

*, **and *** represent significance at 10%, 5% and 1% levels respectively

4. CONCLUSION AND RECOMMENDATIONS

Based on the findings of the study, one can safely argue that milk production is affected with different inputs to be used. This is because the summation of the partial elasticity (1.85) implies that increase in all inputs at the mean by one percent may lead to increased production by 1.85 percent, ceteris paribus. Another is that milk production in the study area is being operated at an increasing return to scale of production. It was observed that the elasticity of milk output with respect to labour, dry fodder, green fodder, concentrate and number of lactating cows was positive. This means that keeping all other factors constant, a unit increase in labour, dry fodder, green fodder, concentrate and number of lactating cows will result in an increase of 95%, 13%, 14%, 0.2% and 64% in milk yield, respectively. Based on the results of this study the following recommendations are made: First, there is a need for dairy producers to increase milk production by adjusting the existing level of inputs as suggested by the elasticity, but not only number of dairy cows. Thus, development practitioners can use the study to make effective adjustment and training packages in order to enhance profitability and efficiency of dairy production. Secondly, labour significantly affects milk production. In particular, the findings suggest that to stimulate efficiency if policy actors should enrolled unemployed youth come together and participate in dairy production activities. One possible explanation is that the current practical-oriented rural adult job creating programs seem to be appropriate interventions and move in the right direction, perhaps for dairy enterprise. Thirdly, dry and green fodder usages have significant effect on milk production. So, milk producers must care about roughage amounts used and act according to the ration blending proportions to overcome problems about roughage and to increase efficiency of milk production. Fourthly, frequency of extension contact has positive relationship and significant effect on efficiency of milk production. Therefore, results suggest that the services need to be strength on constant check with the programs clearly designed and being participatory in frequent. Further, strong and effective linkage of farmers to extension agents and strong motivation for the extensions would provide incentives towards increasing their efficiency in milk production and thus realize substantial cost savings. Fifthly, age of sampled households does negatively and significantly affect efficiency of milk production. The older the farmer becomes, the more he or she is unable to combine his or her resources in an optional manner given the available technology. These results call for policies aimed towards encouraging the rural youth to engage in dairy production. Sixthly, land allocated for crop production has a positive and significant effect on efficiency of milk production in the study area. Results clearly show that, in addition to dry fodder, the green fodder obtained through thinning of sorghum and maize highly affects milk production. Hence, ways of integrating cereal production with dairy production and efficient utilization of existing feed sources should be sought. Seventh, household size is found to have negative relation with technical inefficiency as observed from the study. It provides family labour which constitutes the bulk of labour supply in developing countries. This may indicates that labour dependent of the rural households' income generating activities. If policy actors intervene in providing different inputs (like crossbred in this case) those who has more family member, it can be easily managed and afford output efficiently.

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