

Sources of Technical Inefficiency of Smallholder Cow Milk Producers in Yabelo District of Oromia Region, Ethiopia

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Abstract – This study investigates source of technical inefficiency of smallholder cow milk producers using tobit regression after identification of inefficiency level using stochastic production approach of Cobb-Douglas production form. The data collected from 177 sample household randomly selected from pastoral and agro pastoral Kebeles of Yabelo district. The result indicated producers producing on average 28.56% below their potential production level. This means if producers are producing in fully efficient way, they can save on average of their current input to produce their current output or increase their current milk output by 28.56% without additional inputs requirement. The gamma parameter, γ , was found to be 0.70 showing 70% of the deviation of actual output from potential output was due to technical inefficiency. The result of Tobit regression model shows that family size, size of livestock holding, extension contact, distance to veterinary clinic, distance to water positively and significantly contributed to inefficiency while age and education level of household head negatively and significantly affecting inefficiency of milk producers. Evidently intervention on access to water source, veterinary clinic, education, family planning and productivity oriented livestock holding will improve technical efficiency of cow milk producer of the study area.

Keywords – Technical Inefficiency, Tobit Regression, Yabello District.

I. INTRODUCTION

The major species used for milk production in Ethiopia is cattle which 97% of the cow milk comes from indigenous cattle breeds (MOARD, 2004). The overall milk production potential of the country is from rural small holder dairy system which includes pastoral, agro-pastoral and mixed crop livestock system, while the pre-urban and urban including the commercial dairy farms produce insignificant of total milk production (Care-Ethiopia 2009; Land O'lakes, 2010).

Rapidly increase population size, urbanization, and change in lifestyle and consumption behaviors result in growing domestic demand for dairy products (Francesconi *et al.*, 2010; Moti *et al.*, 2013). Rural smallholder households, being large share of dairy products supply, expected to benefit from dairy growing demand. However, neither the dairy sector is able to produce adequate milk to satisfy this demand and benefit producers mainly due to low productivity of dairy animals (Kebebe, 2015). Low productivity of agriculture output arise due to technology or inefficiency. Now days, despite large livestock and dairy population of the country, Ethiopia is importing milk from outside for domestic consumption demand (Staal *et al.*, 2008).

There is increasing market demand milk due to Ethio-Kenya border trade and high liquid milk consumption behavior at Borena area with increasing population. Fresh milk is traded along the road Addis Abeba to Moyale at available rural market. Despite relatively emerging market demand for milk from this area, productivity of livestock particularly dairy is decreasing over time (Tache and Oba, 2010; Bekele *et al.*, 2013). Increasing dairy production and productivity has significant role in benefiting smallholder rural dairy producers particularly in the dry areas of the country representing 65% of domestic milk output (FAO, 2011). Hence, identification of

technical inefficiency and contributing factors important for policy makers and development initiatives intended to work on rural dairy especially like Yabello pastoral milk shade areas.

II. MATERIALS AND METHODS

2.1. Description of the Study Area

Yabello is the capital town of the Borana zone. Yabello found at 567km south of Ababa (Finfine) has a total of 13 peasant associations and two urban dweller associations (El-way and Haro Bake). The altitude of this Woreda ranges from 350 to 2200 meters above sea level. There are no rivers and streams in Yabello or rivers crossing it except traditional wells and ponds. Obda highland and El-way lowland are the major features in the district.

The mean annual temperature ranges from 12 °c to 24 °c and a prominent feature of the ecosystem is the erratic and variable nature of rainfall, with most areas receiving 238 mm and 989 mm annually, with a high coefficient of variability from 18% to 69%. The total rural population of the district was 63,648 out of which 36,382 were men and 27,266 were female. The total households of rural peasant associations of the district were 10048 out of which 7880 were male and 2168 were female.

The district has bimodal rainfall pattern. The main rainy season extends from March to May whereas the short rainy season lasts from October to November followed by the long dry season. The short rains are unreliable. Variable rainfall results in greater variability in forage productivity. Seasonal distribution of rainfall is more important than the annual total rainfall in influencing forage production from rangelands. During the years of high rainfall, surplus forage is being produced and vice versa. As a result livestock productivity and production losses are expected during the years of below average rainfall (Cossins and Upton (1988). According to the Woreda Pastoral Development Office (2015; unpublished), the district's total livestock population is estimated to be 637,314 out of which cattle 265897, goats 222,779, sheep 97,011, horses 106, mule 833, donkeys 6646 and camels 44042.

2.2. Sampling Technique and Sample Size

According to data from pastoral development office Yabelo district was classified under agro-pastoral district of Borana zone. However, Peasant associations (Kebeles) classified into two homogeneous groups, namely agro-pastoral and pastoral. Households from each stratum as well as from each *kebele* were randomly selected. The sample size from each category and each kebele were based on the proportion sample allocation formula given as $n_i = \frac{nN_i}{N}$ (Pandey and Verma, 2008). According to data from Pastoral development office, about 2775 households were under pastoral while 7273 households in agro pastoral peasant associations. $n = n_i = \frac{nN_i}{N} + \frac{nN_j}{N}$ Where, N_i and N_j number of pastoral and agropastoral households respectively. This study was based on 177 households selected from the district.

III. METHODS OF DATA ANALYSIS

3.1. Descriptive Statistics

This method of data analysis goes to the use of ratios, percentages, means, range, and standard deviation employed in examining and describing farm household, demographic and socio economic characteristics, produ-

...tion and resource use allocation in cow milk production.

3.2. Econometric Model Specification

This study follows two stage analysis of in identifying source of technical inefficiency of producers similar with other studies (Mosisa and Belaine 2016; Mwangi *et al*, 2020). First stochastic production function was used to estimate the technical inefficiencies of cow milk producer in the study area.

$$Y_i = \beta' X_i + \varepsilon_j, \quad (i = 1, 2, \dots, n) \quad (1)$$

Where, $\varepsilon_j = v_i - u_i$, y_i = output of farmer i , $x_i = (k+1)$ row vector whose first element is 1 and remaining 'x' elements are 'k' input quantities used by i^{th} , $\beta = (\beta_0, \beta_1, \dots, \beta_k)$, is a $(k + 1)$ column vector of unknown parameters to be estimated. Y_i is milk output in liters of milk produced by i^{th} household, X_1 is grazing land available to the i^{th} household; X_2 is amount of crop residue of household from own production (Kg); X_3 amount of forage feed supplied for dairy cows of the household per year in Kg; and X_4 amount of labor (family and hired labor) per household (expressed in equivalent man-days). β_0 is the level of milk output from cows without any inputs and the other β_i 's constitutes a vector of parameters to be estimated (they are the partial elasticity coefficients of the production function). v_i is a symmetric error term, independently and identically distributed normal random variables with zero means and variances σ^2 , i.e. $v_i \sim \text{iid } N(0, \sigma^2_v)$, accounting for the deviation from the frontier because of factors which are beyond the control of the farmer (such as variation in weather, measurement error and other statistical noise), and u_i , is a one sided error term accounting for the deviation because of inefficiency effects. Second, tobit regression function was used to estimate the source of technical inefficiency specified as:

$$Y_i^* = \sum \beta_i x_i + v_i$$

$$Y_i^* = \{Y_i\} \text{ if } Y_i > 0, Y_i^* = 0 \text{ if } Y_i \leq 0,$$

$$Y_i = 1 - \beta_0 + \beta_i x_i + u_i \quad (2)$$

Where, x_i constitutes proposed inefficiency variables; age of household, education level, family size, distance to market, distance to veterinary clinics, distance to water source, family land size, total livestock unit excluding cows, extension contact, credit use, training, non/off farm income, and farming system. Y_i Technical inefficiency is the latent dependent variable, $i = 1$ to n independent variables, u_i = error term.

IV. RESULTS AND DISCUSSION

4.1. Descriptive Statics of Selected Variables

From the total respondent of the sample survey 80.80% were illiterate while 19.20% were literate. From the women involved in the survey only 6.67% of them were educated while 93.33% women were illiterate. Among all the educated respondents female shared about 11.67% only.

Table 1. Marital status and sex of sample households.

Variables	Mean values							
	Pastoral	Agropastoral	Both	T-Ratio	Male	Female	Both	T-Ration
Age	43.97	41.09	41.70	1.02	42.30	40.50	41.70	0.75

Variables	Mean values							
	Pastoral	Agropastoral	Both	T-Ratio	Male	Female	Both	T-Ration
Education/year	0.98	0.92	0.94	0.70	1.23	0.38	0.94	0.57

Source: own survey result (2018).

There was significant difference between male and female households in their education level at 5% significance level.

Table 2. Summary statistics of inputs and output variables.

Variable	Units	Mean Value			
		Agro Pastoral	Pastoral	Both	t-ratio
Milk yield/year	Litre	375.03	355.75	365.51	0.62
Labor/year	Man-day	474.93	464.09	468.80	0.33
Grazing land/year	Hectare	6.92	9.43	8.34	12.93
Hay Forage/year	Kg	269.15	260.00	264.00	0.26
Crop residue/year	Kg	684.27	541.27	603.50	1.81

Source: Own survey result (2018).

4.2. Econometric Analysis

This paper follows a two-step estimation model. The first step involves the specification and estimation of the stochastic frontier production function and the prediction of the technical efficiency in the smallholder cow milk production. The second step involves the specification of a regression model for the predicted technical inefficiency effects.

4.2.1. Estimation of Stochastic Production Function

Table 3. ML Estimates for SFA parameters and for CD model.

Variables	Coefficient	Std. Error	Diagnostic statics	Value	Std. Error
Ln of labor	0.62 ***	0.071	$\lambda = \sigma_u / \sigma_v$	1.510	0.154
Ln of grazing land	0.46***	0.135	σ^2	0.314***	0.074
Ln of hay forage	0.02***	0.005	$\gamma = \lambda^2 / (1 + \lambda^2)$	0.700***	
Ln of crop residue	0.01	0.010	Log likelihood	-95.64	
Constant	1.68***	0.510			

Significance codes: 1% *** 0.05% ** 10% * significance level. Source: own computation, 2018.

From the above input output function, all four inputs for milk production showed the expected positive sign to milk production. Among four inputs assumed as the function of cow milk production grazing land, labor inputs and forage turned to contribute in milk production at 1% significant level. The γ value show that about 70% variation in milk output from frontier production is due to inefficiency problems of milk producers.

There is a wide variation of actual output from frontier output where about 70% ($\gamma = 0.70$) of this deviation is

due to technical efficiency problems (inefficiency). In this result case, through technical efficiency improvement, producers on average could increase milk output/ cow by 28.56% of what they are producing without requiring additional input with existing technology.

4.2.2. Source of Technical Inefficiency of Cow Milk Producers

The technical inefficiency determinants estimated showed age of household, family size, livestock ownership, distance to water, distance to veterinary clinic and distance to milk market was significant in determining inefficiency among the hypothesized determinant variables. Except distance to milk market, all significant coefficients of explanatory variables determined inefficiency with expected direction of influence. The variables significantly determining inefficiency in milk production was significant at 1% significance level except distance to veterinary clinic, livestock holding and extension contact which are significant at 5%, 10% and 10% level respectively.

Table 4. Source of technical inefficiency.

Variables	Coefficients	Robust Std. Error
Age	-0.14***	0.04
Education level	-0.90***	0.24
Family size	0.70***	0.30
Distance to market	-0.036	0.07
Distance to veterinary clinic	0.30**	0.15
Distance to water for livestock	0.80***	0.17
Farm land size	0.30	0.50
Total livestock holding	0.2*	0.10
Nom/off farm income	0.002	0.07
Farming system	2.46	1.60
Extension contact	2.45*	1.42
Dairy training	1.52	2.01
Credit use	3.50	2.30
constant	2.000	3.20
Right censored observation	1	
Left censored observation	0	

Codes: significance 0.01*** 0.05** 0.1*. Source: own computation, 2018.

Age of Household:

Age of household was proposed to have positive or negative contribution to inefficiency based on the argument that elders households may attach to the existing technology by resisting the new one or were more experienced in production will help to produce more. In this study age of household has significantly contributed to decrease in inefficiency. A year increase in age of a household on an average, holding other

factors constant, significantly contributed to decrease in household inefficiency by 0.14% at 1% significance level. This showed elder were more technically efficient than younger. Effective pastoral natural resource management is based on a sound knowledge of local user groups of their environment, referred to as pastoralists' indigenous knowledge as stated in Homann (2005). The increase in age of cow producer might help to understand more the environment and existing indigenous knowledge to manage their herd. Selection of cow with important trait characteristics may also took long period of production time. This finding agrees with the work of others including Hassen *et al.*(2012), Amlaku *et al.*(2013) Lemma *et al.*(2013) who found significant contribution of increase in age to technical efficiency in milk production while it disagrees with Madau *et al.*(2017).

Family Size:

It refers to all the total family size of the household during the survey period. The number of people in the household had used whether to contribute to household inefficiency or help to improve their technical efficiency. The result showed that the household size had significant and positive contribution to inefficiency of milk producers in the study area. As the number of household increase at a fixed technology it is natural that labor productivity will decrease after a certain point in a given activity of production. The areas of pastoralist depend on their fixed technology for a number of periods where the household size thus might fall at diminishing productivity (less efficient use of existing input) with existing technology. This finding showed a unit increase in family size on average, holding other factors constant, contributed to an increase in inefficiency by 0.70% at 1% significance level. This finding disagrees with Nakanwagi and Hyuha (2015) and Ajabush *et al.* (2018) who found increase in family size significantly contributed to technical efficiency of households.

Total Livestock Holding:

It is the total number of livestock owned by a household excluding dairy cows and measured in tropical livestock unit. Livestock ownership was used as proxy variable for wealth of producer and expected to contribute to efficiency of producer's technical efficiency. The result showed opposite as expected and unit increase in tropical livestock unit on average, keeping other determinant variables constant, increase technical inefficiency of producer by 0.2% at 10% significance level. Increase in livestock ownership might put producers on wealthy status of those who largely do not depend on milk production for both income and consumption purpose but they may depend on livestock sell. Thus, they might pay less attention for livestock products output management rather than for live animal. This finding disagree with the work of Hassen *et al.* (2012) who found livestock size contribute to technical efficiency and Adane *et al.* (2016) who found negative relationship of total household wealth with technical inefficiency during his study.

Extension Contact:

This variable was dummy variable whether household has contacted with extension agent or not during production period. In this result, apart from expected effects of extension contact on inefficiency, having contact with extension worker, at citrus paribus, contributed to increase inefficiency of household by 2.45% probability at 10% significance level. This disagrees with the work of Mosisa (2014), Saptati (2016) and Ajabush *et al.* (2018) who found extension contact has significant contribution in reducing technical inefficiency. Borana pastoral area, intervention was mainly disregarded the pastoral farming system and extension services favored

crop cultivation on valuable grazing areas claiming key resources from the pastoral production (Homman *et al.*, (2008). Kena *et al.* (2018) found access to extension has positive contribution in diversifying livelihood strategy of pastoralist that might drive labor for other activities reducing milk production management activities. This biased intervention might made pastoralist's contact with extension service provider less efficient in milk production.

Education Level of Household Head:

Education level of household measured in years of schooling showed negative effect on inefficiency of milk producers. According to this result, an increase in one year of schooling of household contributed to decrease household inefficiency by 0.9% at 5% significance level. This results agrees with other works including Mosisa (2014), Adane *et al.* (2016), Mehmood *et al.* (2018) and Mareth *et al.* (2019) who found positive and significant contribution of education to technical efficiency in milk production.

Distance to Veterinary Clinic:

It is the closeness of the households homestead to the veterinary clinic measured in kilometers. A household relatively nearer to veterinary clinic expected to have less animal health management problem than household far from animal health posts. Animal health care could have an implication to human health as consumption of raw milk is the most preferred diet for producers of the area. As a household's distance to veterinary clinic increase, by one Kilometer on an average citrus paribus, contributed to increase in inefficiency by 0.30% at 5% significance level. Household access to health post help households to manage milking cows' health easily, in turn contribute to technical efficiency.

Distance to Water Point:

Water for milking cow requirement is high to produce milk. Thus, as watering is the time consuming activity, the nearer the household to water source the more time saved for watering. Hence, households nearer to water source might be more frequently water their cow compared to household far from water source. Increase in distance of household home from water point in kilometers on an average, holding other factors constant, contributed to increase in inefficient by 0.80% at 1% significance level. This finding is consistent with Mosisa (2014) who found distance to water source significantly contributed to inefficiency in milk production.

V. CONCLUSIONS

The study intended two stage analysis of technical efficiency of smallholder cow milk producers in study area. The first stage analysis was conducted to identify the household level of technical efficiency in milk production and the second stage analysis was to identify the potential factor for the inefficiency of milk producers in the study area. Four inputs variables were used in inputs function (Cobb-Douglas) in milk production in the study.

Among four input variables used by households, the result of this work revealed labor input, size of grazing land and grass forage were found significant factor in milk production. Crop residue used as additional input in milk production found insignificant factor in milk production. From the elasticity of input, milk production in the area was found to be at an increasing scale of production stage. This result indicated there still exist to increase milk output by proper use of labor, hay forage and grazing land in study area. The gamma parameter

value ($\eta = 0.70$) shows that variation of actual output from potential output due to inefficiency was accounted to about 70%. Milk production of the study area was found to be an increasing return to scale of production of about 1.1 showed 1% increment in all over inputs would proportionally increase output by 1.1%. Among variables assumed to be the cause for inefficiency, age of household head, education level of household head were negatively and significantly contributed to decrease inefficiency while size of livestock holding, family size, extension contact, distance to veterinary clinic and distance to water point from respondent's home found to be positively and significant contributed to inefficiency of cow milk producers.

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