

Full Length Research Paper

Economic efficiency of milk production in Khartoum state, Sudan

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The study was conducted at Khartoum state, Sudan during winter 2015 to measure the farmers' technical efficiency in producing milk and to define the main social-economic factor affecting farmers' technical efficiency of milk production. The stochastic production frontier model was utilized to achieve the study's objectives. The primary data was collected from random sample of 90 tenants through a questionnaire. The secondary data was collected from different relevant sources for example Ministry of Agriculture and Bank of Sudan. The study outcome revealed that the mean technical efficiency of milk production was 92% which indicates that milk production could have been increased by 8% at the same level of inputs, if resources had been efficiently utilized. The analysis of the determinants of technical efficiency indicated that area, education level, marital status, and experience were the most important factors affecting the technical inefficiency of farmers. To promote milk production technical efficiency, it is recommended improving the environment of cowshed and reduced the cost of feed. The results also show that area and education increase in the efficiency of milk production and recommended that Government policy should focus on ways to encourage young milk producer replacing aging farmers provide sufficient area for livestock keepers.

Key words: technical efficiency; milk production; stochastic frontier

Introduction

Sudan depends highly on agriculture which constitutes about 31.5 of the gross Domestic product (GDP). Animal wealth, being the major sub-sector of agriculture constitutes about 18.9 of the GDP, Annual report Bank of Sudan (2014). It is the main source of government revenue in the form of both direct and indirect taxes.

There are two main systems that supply milk to Khartoum State.

These are:

- 1 The modern dairy production system
- 2 The traditional dairy production system

The differences between these two production systems are reflected in the size of production milk unit, technology of production and the milk marketing and distribution channels followed.

The production of clean milk, under tropical conditions at a reasonable level of cost, presents a great technological challenge. It appeared to be a large increasing deficit in milk supply in Khartoum state as indicated by Table1.

This deficit is attributed to gaps between demand and domestic milk supplies. The demand has grown faster than supply. This was because of rapid population growth rate, rapid increase in per capita incomes and urbanization. On the supply side: low animal productivity, inappropriate technology, feeds and milk production costs are continuously increasing, unfavorable external conditions all together have contributed to poor performance of dairy production beside inefficiencies in resource utilization and consequently reduced returns. As a result there is need to produce milk more efficiently.

The major purpose of this paper was to measure the technical efficiency of milk production in Khartoum state, Sudan and the factors effecting in milk efficiency.

Table 1. Milk production trends for the past three years in Khartoum, Sudan

	2014	2015	2016
Expect production of milk by t	558340	541065	557294
Gap by t	250550	297614	305266

Source: Ministry of Agriculture Khartoum state (2014)

Materials and Methods

This study was conducted in Khartoum state, Sudan during winter 2015. The primary data was collected from random sample of 90 tenants through a questionnaire. The selection was based on proportional allocation (which is one of the methods of stratified sampling) with formula:

$$N_h = m \times \frac{N_n}{N}$$

N_h = Stratum size in sample

m = Sample size

N_n = Stratum size in population

N = Population size

The researcher selected from three strata, 35 producers of milk were of Khartoum, 31 producers of milk were of Omdurman and 24 milk producers from Khartoum north

The secondary data was collected from different relevant sources for example Ministry of Agriculture and Bank of Sudan.

The stochastic production frontier (SPF) model was utilized. The SPF functions have been the subject of large study during the last two decades (Farrell, 1957). Farrell (1957) proposed measure of firm efficiency consists of two components: technical efficiency, which demonstrates the capacity of a firm to get the maximal output from a given number of inputs, and the allocative efficiency, which demonstrates the capacity of a firm to utilize the inputs in optimal ratio, given their respective prices and the production technology. These two measures are then mixed to extend a measure of total economic efficiency. Aigner and Chu (1968) conceived the evaluation of a parametric frontier production function of Cobb-Douglas form, using data on a sample of N firms. The model is written as follows:

$$\ln(y_i) = X_i B - u_i \tag{1}$$

$i = 1, 2, \dots, N$

Where (y_i) is the logarithm of the (scalar) output for the

i -th firm.

X_i is a $(k+i)$ row vector; whose first element is i and the residual elements are the logarithms of the k -input quantities utilized by the i -th firm.

$B = B_0, B_1, \dots, B_k$ is a $(k+i)$ column vector of undefined factor to be evaluated.

u_i is non-negative random variable connected with technical inefficiency in production of firms in the industry implicated.

The proportion of the observed output for the i -th firm relative to the potential output known by the SPF function given the input vector x is utilized to define the technical efficiency (TE) for the i -th firm

$$TE = \frac{y_i}{\exp(x_i B)} = \frac{\exp(x_i B - u_i)}{\exp(x_i B)} = \exp(-u_i) \tag{2}$$

The above declared measure of technical efficiency is output-orientated. Farrell's measure of technical efficiency takes a value between zero and one.

Aigner et al., (1977) model suggested the SPF function in which an additional random error (v_i) is added to non-negative random variable u_i in equation (1) to provide

$$\ln(y_i) = X_i B + v_i - u_i \tag{3}$$

$i = 1, 2, \dots, N$

Algner et al., (1977) assumed that the v_i 's were independently and identically distributed (IID) normal variables with zero mean and constant variance independent of the u_i 's which were assumed to be IID. Exponential or have normal random variables.

The study objectives are attained through the estimation and analysis of the SFP model. The most commonly used package for estimation of SPF is Frontier 4-1 (Coelli, 1996). The model used is:

$$\ln(y_i) = \sum_{j=1}^4 B_j + B_{ij} X_{ij} + v_i - u_i \tag{4}$$

where

- \ln = natural logarithm
- y_i = annual milk production per farm
- X_1 = annual cost of feed consumption
- X_2 = annual cost of labour
- X_3 = annual cost of drug
- X_4 = annual cost of cow shed

Table 2. Tests of the stochastic production frontier hypothesis

Hypothesis	z-values	decision
$H_0 = u=0$	12.591***	H_0 : reject
LRH_0 No technical inefficiency	14.0698***	H_0 : reject

***significant at 1%

Table 3. Parameters estimates of the stochastic production frontier function

Variables	Parameters	Estimates
Constant	B_0	-0.1582 (0.3319)
Feed	B_1	0.86974*** (0.08462)
Labour	B_2	-0.049735 (0.0889)
Drug	B_3	0.04142 (0.0424)
Rent	B_4	0.1918*** (0.0611)
Sigma-squared	$v^2 = \sigma + \sigma_s \sigma$	0.0978 (0.0284)
Gamma	$\gamma = \sigma^2 / \sigma_s^2$	0.0826 (0.0656)
Mean efficiency		0.92
Log likelihood function		39.89

Note: Values between brackets are the standard errors of the parameters.
 ***significant at 1%

B_0 and B_i are undefined factor to be evaluated for the permanent variables.

v_i = Clarifies the statistical error and other parameters which are behind the farmers dominance like weather, and other factors which are not involved and may be positive, negative or zero.

u_i = is a non-negative random variable, associated with the tenants technical inefficiency in production and assumed to be independently distributed. For the technical inefficiency effect for the i th tenant, it will beget by truncation (at zero) of the normal distribution with mean, u_i and variance σ^2 . Such that:

$$U_i = \beta_0 + \sum_{s=1}^6 \beta_s Z_{si} \quad (5)$$

Where

- Z_1 = Location of area
- Z_2 = Age
- Z_3 = Education
- Z_4 = Martial status
- Z_5 = Experience
- Z_6 = Family size

Result and discussion:

Table 2 displays the z-values for the tests of the stochastic frontier hypothesis. It's clear from Table 2 both null hypotheses are rejected, which means that the deviations from normal are not entity due to noise and some technical inefficient factors are present in the model.

Table 3 display the parameter estimates of the stochastic production frontier function.

The mean technical efficiency of milk production was 92%. This indicated that respondents can rise their milk output by 8% from given combine of production input if the farmers are technically efficient.

An important outcome is that variance is considerable and has value of 0.82. This outcome expresses that around 82 percent of milk output deviations are caused by difference in farms level of technical efficiency as inverse to the traditional random variability. The significant estimate of γ and σ_s^2 for milk production indicates that the supposed distribution of u_i and v_i is acceptable.

Almost, all estimated B coefficient have the expected

Table 4. Milk production inefficiency model parameters

Variables	Parameters	Estimates
Constant	δ_0	-2.63** (1.45)
Area	δ_1	0.2889** (0.189)
Age	δ_2	0.00165 (0.00583)
Education	δ_3	0.28448** (0.1625)
Marital status	δ_4	0.3210* (0.222)
Experience	δ_5	0.0399** (0.0231)
Family size	δ_6	0.0019 (0.0107)
Mean efficiency		0.92
Log likelihood function		39.89

Note: Values between brackets are the standard errors of the parameters.

***significant at 1%

**significant at 5%

* Significant at 0.1%

sign. The coefficient of feed has positive sign and significantly at 0.01. That denotes feed is one of the major determinants of milk production in Khartoum state, similar outcome get by Ahmed (1998) and Bravo-Ureta et al., (1991).

The coefficient of labour cost has negative sign and insignificant. This results in contrary with the finding of Bravvo-Ureta et al., (1991). The result is contrary to expectation this may be attributed to small size of farm and that most of the work had been done by the farmer family.

The coefficient of drug has positive sign and insignificant.

The coefficient of cow shed cost (Rent) has positive sign and significant. This denotes when the cow shed has better quality in preparing and environment the productivity of milk increases.

The outcomes of the factors affecting tenants' technical inefficiency are present in Table 4.

The coefficient of family size has positive sign indicates that inefficiency reduces with the rise of family, as the additional family numbers are reflected as additional labour, identical outcome get by Moez (2008). The coefficient of age of farmers has positive sign, but it is not significant from zero, indicates that inefficiency increases with the increase of farmer age. The coefficient of experience has positive sign and has significant effect. That means the technical inefficiency of the tenants' increase with the increase of experience of farmer. The unexpected coefficient sign can be referred to the fact that, tenants with relatively higher number of years as a tenants are expected to be relatively old, similar result obtained by Ahmed (2007). The marital status has negative sign and insignificant. Negative sign means that

the increasing number of farmers who married reduces inefficiency. The coefficient of education level of farmers was positive and significant that means the technical inefficient increases with the increase in education level of farmers. One of the reasons may be that educated farmer were found alternative income sources Rahman (2002)

The coefficient of farm location has positive sign and significant effect; this means change from place to place has effect in inefficiency. From data, it is clear that the production of milk improves according to environment of place.

Conclusion

The outcome reveal that the mean technical efficiency of milk production was 92% which indicate that milk production could have been increased by 8% at the same level of inputs, had resources efficiency utilized. There was a significant technical inefficiency effects in milk production in Khartoum. Area, education level, marital status, experience had significant influence of the estimated farmers technical inefficient. The 82% of milk production deviation from normal is due to difference in farmers' level of technical efficiencies as inverse to the traditional random variability. In order to improve milk technical efficiency, it was recommended improving the environment of cow shed and reduce the cost of feed.

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