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Full Length Research Paper

Profit efficiency among Kenyan smallholders milk producers: A case study of Meru-South district, Kenya

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Production inefficiency is usually analyzed by economical efficiency, which is composed of two components-technical and allocative efficiencies. This study provided a direct measure of production efficiency of the smallholder milk producers in Kenya using a stochastic profit frontier and inefficiency model. The primary data were collected, using IMPACT (intergrated modeling platform for mixed animal crops systems) structured questionnaire and includes four conventional inputs and socio-economic factors affecting production. The result showed that profit efficiencies of the sampled farmers varied widely between 26 and 73% with a mean of 60% suggesting that an estimated 40% of the profit is lost due to a combination of both technical and allocative inefficiencies in the smallholder dairy milk production. This study further observed that level of education, experience, and the size of the farm influenced profit efficiency positively while profit efficiency decreased with age. This implies that profit inefficiency among smallholder dairy milk producers can be reduced significantly with improvement in the level of education of sampled farmers.

Key words: Profit, efficiency, smallholder, farmers, socio-economic factors.

INTRODUCTION

Agriculture plays an important role in the economic development of Kenya. It provides not only food for the growing population but also employment to over 70% of the population, raw materials for industries and foreign exchange earning (CBS, 2007). It therefore has potential to improve the Kenyan economy, if well harnessed. This however, will depend, to a large extent, on the efficiency in agricultural production.

The Kenyan population growth and urbanisation continues to fuel the local demand for food of which there is already apparent disparity between the rate of food production and demand in Kenya (FAO, 2003; SDP, 1996). One of the major causes of food disparity is the inability to provide the required amount of animal protein in the diets of the populace, especially those in the rural areas which constitute about 80% of the population (Kenya Census, 1999). In addition, the elasticity of demand for livestock products is three to five times higher than that of cereals (FAO, 2003).

However, dairy which accounts for 14% of agricultural gross domestic product (GDP), could play an important role in effectively reducing the inadequacy of animal protein in the diets through milk production. This is because milk is a complete protein and dairy milk constitutes 84% of total milk consumed in the country (KDDP, 2000).

This industry, like other agricultural sub sectors, is dominated mainly by smallholder farmers (Staal et al., 1999). Several factors such as importance of milk in the diet, suitable climate and policy and institutional environment have been contributing to the success of dairy milk production by the smallholders (Connelly, 1998; Thorpe et al., 2000). Smallholder dairy farms have concentrated

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the high potential areas and constitute about 60 and 80% of total milk produced and marketed, respectively (Staal et al., 1999).

Central province of Kenya is one such area where smallholder dairy milk production is more developed. Apart from providing employment and livelihood to thousands of people, it also provides remarkably high quality milk for consumption. Even though in these area feed supply and disease control are much better. This area has been marked by declining farm size, upgrading of dairy breeds and an increasing reliance on purchased feeds, both concentrates and forage (Staal et al., 1997). As such, purchased feeds have become very important. For example, the area planted with fodder for sale is equal to the area planted with maize, the staple food crop. Due to the declining land sizes, farms are small; cattle are confined and fed through a cut-and-carry system in which feed materials are brought to the animals (Baltenweck et al., 1998; Staal et al., 1999).

Assuming small improvements in reproductive performance and milk yield for the dairy herd, milk off take could be sufficient to meet the high population growth rate and demand for dairy product. Thus presenting an opportunity for farmers. However, there is a concern among the development agencies and policy makers over the efficiency of the smallholder milk producer in the midst of increasing competition with intensive livestock producers in both urban and peri urban areas (FAO, 2003).

To gain insights on the prospects on performance efficiency among smallholder milk producers, a study to estimate profit efficiency and identified farm-specific characteristics which might be causing variation was done.

The objective of this study is to estimate the economic efficiency of smallholder dairy milk producers/farmers in Kenya using data from Meru-south district of the central province. This study analyses the profit efficiency among sampled smallholder dairy farmers and identifies farm-specific characteristics that explain variation in efficiency. The hypotheses were:

1. The farmer's milk production decisions are consistent with profit maximization.
2. Profit inefficiency differs across households and it is related to farmers' socio-economic characteristics.

The measurement of efficiency remains an important area of research both in developing and developed countries. The measurement of efficiency goes a long way to determine the profitability of an enterprise and agricultural growth is linked to profit (Abdulai and Huffman, 2000). The relationships between efficiency, market indicators and the household characteristics have not been well studied in Kenya. An understanding of these relationships could provide the policy makers with information to design programmes that can contribute to measures needed to expand the food production potential of a country (Rahman, 2002) and better measures that can enhance agricultural efficiency can be implemented. The significance of such policies in the face of increasing competition between domestic and imported agricultural products cannot be overemphasised (Abdulai and Huffman, 2000). The measurement of efficiency has received considerable attention in economic literature. Farrell (1957) defines efficiency as the ability to produce a given level of output at a lower cost. This traditional definition of efficiency as defined by Farrell has three components: technical, allocative and economic. Technical efficiency is defined as the ability to achieve a higher level of output, given similar levels of inputs. Allocative efficiency deals with the extent to which farmers make efficient decisions by using inputs up to the level at which their marginal contribution to production value is equal to the factor cost. Technical and allocative efficiencies are components of economic efficiency. It is possible for a firm to exhibit either technical or allocative efficiency without having economic efficiency. Therefore, both technical and allocative efficiencies are necessary conditions for economic efficiency. Economic efficiency is equal to the product of technical and allocative efficiencies. According to Farrell (1957), technical efficiency is associated with the ability to produce on the frontier isoquant, while allocative efficiency refers to the ability to produce at a given level of output using the cost minimizing input ratios. Alternatively, technical ineffi-ciency is related to deviations from the frontier isoquant and allocative inefficiency reflects deviations from the minimum cost input ratios. Thus, economic efficiency is also defined as the capacity of a firm to produce a predetermined quantity of output at minimum cost for a given level of technology. Production functions have traditionally been used to examine efficiency of farmers in many developing countries (Parikh and Shah, 1995; Battese et al., 1996; Battese and Coelli, 1995; Sharma and Singh, 1993; Bindlish and Evenson, 1993; Ojo, 2003; Ajibefun and Daramola, 1998).

However, Yotopoulos and others argued that a production function approach to measure efficiency may not be appropriate when farmers face different prices and have different factor endowments (Ali and Flinn, 1989). This led to the application of stochastic profit function models to estimate farm specific efficiency directly (Ali and Flinn, 1989; Kumbhakhar and Battacharya, 1992; Ali et al., 1994; Wang et al., 1996).

MATERIALS AND METHODS

This survey was carried out in Meru south district of central province of Kenya. Central province is one of the eight provinces of Kenya. Meru south district lies on the south eastern slope of Mt. Kenya at 0014' S, 39038'E at an altitude of 1480 m. According to Jaetzold et al. (1983), the area is in upper midlands 2 and 3 (UM2-UM3) agroecological zones. The soils are typic palehumult. Coffee, Tea and dairy are the main land use systems (LUS). The population density averages over 750 persons Km-2(CBS, 2005).

The survey was carried out during the months of September 2006 to October 2008. Data were collected from sampled farmers in the Meru south district. There were 40 farmers selected, 34 of which were livestock keepers. The multistage sampling technique was utilised. The first stage involved purposive selection of Meru south district. Meru south district was selected based on the fact that it had other research project targeting crop and livestock farmer going on in the area. The second stage involved a random selection of 40 farms. The third stage involved purposive selection of small-holder dairy farmers from a population of forty. The data used in the survey were obtained from the selected farmers using integrated modelling platform for mixed animal crops systems (IMPACT) structured questionnaires. Data on the socio-economic characteristics of the respondents and on the prices and quantities of input and output were collected.

The stochastic profit frontier function

Production inefficiency is usually analyzed by its two components-technical and allocative efficiency. Recent developments combine both measures into one system, which enables more efficient estimates to be obtained by simultaneous estimation of the system (Wang et al., 1996). The popular approach to measure efficiency – the technical efficiency component – is the use of frontier production function (Wadud and White, 2000). However, it has been argued that a production function approach to measure efficiency may not be appropriate when farmers face different prices and have different factor endowments (Ali and Flinn, 1989). This led to the application of stochastic profit function models to estimate farm specific efficiency directly (Ali and Flin, 1989; Wang et al., 1996).

The profit function approach combines the concepts of technical and allocative efficiency in the profit relationship and any errors in the production decision are assumed to be translated into lower profits or revenue for the producer (Ali et al., 1984). Profit efficiency, therefore, is defined as the ability of a farm to achieve highest possible profit given the prices and levels of fixed factors of that farm. Profit inefficiency in this context is defined as the loss of profit for not operating on the frontier (Ali and Flin, 1989). Battese and Coelli (1995) extended the stochastic production frontier model by suggesting that the inefficiency effects can be expressed as a linear function of explanatory variables, reflecting farm-specific characteristics. The advantage of this model is that it allows the estimation of farm specific efficiency scores and the factors explaining the efficiency differentials among farmers in a single stage estimation procedure. Following Rahman (2002), this study utilizes the Battese and Coelli (1995) model by postulating a profit function, which is assumed to behave in a manner consistent with the stochastic frontier concept. The stochastic profit function is defined as

$$\pi_j = f(P_{ij}, Z_{kj}).\ \mathrm{Exp}\ e_j \tag{1}$$

Where, π_j = normalized profit of the jth farm and it is computed as gross revenue less variable cost divided by the farm specific output price P; P_{ij} = price of j_{th} variable input faced by the i_{th} farm divided by output price; Z_{ik} = level of the k_{th} fixed factor on the i_{th} farm; e_i = an error term; i = 1, ….., n, = number of farms in the sample.

The error term e_i is assumed to behave in a manner consistent with the frontier concept (see equation 6), that is,

$$e_i = v_i - u_i \tag{2}$$

Where, vi = symmetric error term and it is assumed that it is an independently and identically distributed two sided error term representing the random effects, measurement errors, omitted explanatory variables and statistical noise; u_i = the one sided error term.

It is a non-negative one sided error term representing the inefficiency of the farm. Thus, it represents the profit shortfall from its maximum possible value that will be given by the stochastic profit frontier.

In the inefficiency effects model, the u_i terms in equation (2) are assumed to be a function of a set of non-negative random variables that reflect the efficiency of the farm. They are assumed to be independently distributed, such that efficiency measures are obtained by truncation of the normal distribution with mean, μ = δ_o + $\Sigma_d \delta_d Z_{di}$ and variance σ_μ^2 where Z_{di} is the dth explanatory variable associated with inefficiencies on farm i and σ_o and σ_i and are the unknown parameters.

The profit efficiency of the farm *i* in the context of the stochastic frontier profit function is defined as

$$EFF = E\left[\exp(-u_i)/_{e_i}\right] = E\left[\exp\left\{(-\delta_0 - \textstyle\sum_{d=1}^{D} \delta_d Z_{di})/_{e_i}\right\}\right] \tag{3}$$

Where, E is the expectation operator. The method of maximum likelihood is used to estimate the unknown parameters, with the stochastic frontier and the inefficiency effects functions estimated simultaneously. The likelihood function is expressed in terms of the variance parameters,

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \text{ and } \gamma = \left(\sigma_v^2/(\sigma_u^2 + \sigma_v^2)\right)$$

Empirical model specification

The functional form of the stochastic profit frontier was determined by testing the adequacy of the Cobb–Douglas (highly restrictive) by fitting it the less restrictive translog. The frontier models estimated was defined as follows:

$$y_i = \beta_0 + \textstyle\sum_{i=1} \beta_i X_i + V_i - U_i \tag{4}$$

$$y_i = \beta_0 + \textstyle\sum_{i=1}^{4} \beta_i X_i + \sum_{i=1}^{4} \sum_{i=1}^{4} \beta_{ij} XX_{ji} + V_i - U_i \tag{5}$$

$$u_i = \delta_0 + \textstyle\sum_{d=1d}^{D} \delta_d Z_{di} + e_i \tag{6}$$

In these equations, Y = Normalized profit (gross margin); X_1= Normalised wage rate; X_2= Nomalised feed cost per kg; X_3= Farm size (Head of milking cows); X_4= Drugs; u_i = Farmer specific characteristic related to production efficiency; V_i = statistical disturbance term;

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6. \tag{7}$$

Where, Z_1= Age of the farmer (years); Z_2= Formal education, Measured in years; Z_3= Household size; Z_4= Non farm income;

Table 1. Summary statistics of the descriptive variables.

Parameters	Minimum	Maximum	Mean	Standard deviation
Farm gross margin per	69.00	116360.00	16362.29	26580.79
Feed cost (Kshs)	11.40	66278.00	8685.90	12769.60
Drugs cost(Kshs)	45.00	2520.00	382.00	478.20
Wage in (Kshs)	140.00	471.00	169.10	111.70
Herd size	1.00	3.00	1.50	0.80
Age H head	30.00	67.00	44.51	9.62
Milk price/litre	20.00	25.00	22.35	1.72
Education(yrs)	4.00	18.00	12.96	4.20
Experience(yrs)	5.00	42.00	19.51	9.62
Farm size (Ha)	0.21	5.90	1.86	1.83
Household size	1.00	7.00	4.00	1.00
Non-farm income	0.00	960000	186946.50	242683.40

Source: Survey, 2007.

Z_5 = Experience in milk production (measured in years); Z_6 = Farm size (number of milking cows).

The parameters to be estimated are β_o, β_i, δ_o, δ_i. In all farming activities, human physical energy is required. The level of active involvement by individuals in their farms to a large extent determines their production output levels. The age of the farmer is an important factor in agriculture because it may affect the level of efficiency at the farm level. Influencing efficiency also is the farmer education level. This is because efficiency in agriculture production, that is, in terms of quality and quantity, speed of new technology adoption and rationalizing of input, may boost the output. Education represents human capital and it is hypothesised to have a positive impact on efficiency (Lockheed at al., 1980). As expected, experience has positive influence on efficiency. For farmers with a lot of experience, higher profit efficiency is expected. The expectation of the farmers with no off farm income will be that of reduced efficiency. Although this is not always the case as argued by Huffman (1980) that increased off farm income reduces financial constraint, particularly for the resource-poor farmer and thus enables them to purchase productivity enhancing inputs. Access to large farms provides the farmers with a means of expanding and the ease of improving dairy enterprise (that is planting several types of feeds such as Napier grass as well as food-feed crops such as maize). It also determines the ease with which he could expand his dairy enterprise by acquisition of resources needed to expand the dairy enterprise such as fixed inputs (that is through loan by land acting as collateral).

The maximum likelihood estimates of the parameters in the Cobb-Douglas and translog stochastic frontier production function defined by Equation 4 and 5 respectively, given the specification for the technical inefficiency effects defined in equation 6, were obtained using FRONTIER 4.1

The unknown parameters of the stochastic frontier and inefficiency effects were estimated concurrently. To select the lead functional form, hypothesis test base on the generalized likelihood ratio (LR) test was conducted.

The following formula was used to carry out the likelihood ratio test.

$$\lambda=-2(l_R - l_U)$$

Where, l_R = log likelihood of the restricted equation (Cobb-Douglas model); l_U = log likelihood of the unrestricted equation (Translog model).

But λ has a χ^2 distribution with h degrees of freedom. h is the number of restrictions in this case the number of restrictions imposed on the Cobb-Douglas model.

The null hypothesis is that the Cobb-Douglas is an adequate representation of the data. The LR test indicates that the null hypothesis could not be rejected because the value of λ was less than the critical value of χ^2 at the 0.05 level of significance with 9 degrees of freedom. This means that the Cobb-Douglas form fits these data better.

The description of the quantitative variables included in both profit and inefficiency function are presented in Table 1.

RESULTS AND DISCUSSION

Maximum likelihood values (MLE) values for stochastic function profit frontier

The relative importance of the variable inputs in milk production is presented in Table 1. The coefficient of the variables X_1, X_2, X_3 and X_4 are the estimates from profit function maximum likelihood and are interpreted as the elasticities of the variables. The coefficients are all properly signed.

The elasticities estimates of the drug and feed cost were statistically significant at 5 and 1% level respectively; while the estimate of wage rate and herd size were not significant at all conventional levels. The cost of the feed was the most important variable determining profit efficiency. This means that for a 10% increase in the cost incurred through feed purchases, the profit obtained from the milk production will increase by 6.3%. The estimated coefficient for the mean profit with respect to cost of feeds X_2 and drugs X_4 were 0.636 and 0.763, respectively. This also implies a 10% increase in the profit of 7.6%.

The inefficiency function

Equation (7) defines the relationship between profit efficiency

Table 2. Maximum likelihood estimates (MLE) of the stochastic frontier profit function.

Variable	Parameter	Coefficient	t-ratio
Constant	β_0	3.641	1.532
Wage rate	β_1	-0.119	-0.367
Feed cost	β_2	0.636	6.317***
Herd size	β_3	0.225	0.624
Drugs	β_4	0.763	1.521**
	Inefficient function		
Intercept	δ_0	1.216	1.323
Age	δ_1	0.851	2.377***
Education in years	δ_2	-0.126	-2.290***
Household size	δ_3	0.002	0.016
Non farm income	δ_4	0.003	0.269
Experience	δ_5	-0.452	-2.795***
Farm size	δ_6	-0.091	-2.800***
	Diagnostic statistics		
Sigma square	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.0790	6.532***
Gamma	$\gamma = \sigma_u^2/\sigma_v^2$	0.999	6.826***
Log likelihood		-12.08	
LR test		15.83	
Average efficiency		0.60	

*, **, *** Significant at 10, 5, 1% level respectively. Source: Author survey, 2007.
A negative sign of the parameters in the inefficiency function means that the associated variable has a positive effect on the economic efficiency and vice versa.

Table 3. Frequency distribution of farmer specific profit efficiency estimates.

Efficiency estimate (%)	Frequency	Percent	Cumulative percent
00>29.99	1	3.70	3.70
30>39.99	0	0.00	3.70
40>49.99	7	25.93	29.63
50>59.99	8	29.63	59.26
60>69.99	8	29.63	88.89
70>79.99	3	11.11	100.00
80>89.99	0	0.00	
90>99.99	0	0.00	

Source: Author survey, 2007.

and farm household characteristics, the parameters estimates of are shown under the inefficiency function section of Table 2.

As can be seen from the results, the level of education measured in year's age of farmer, experience measured in years and farm size have a significant effect on the profit inefficiency. The negative and significant coefficient of education variable indicates that higher education reduces profit inefficiency. This finding is consistent with findings of Huffman (2000), Ali and Flinn (1989) as well as the review by Lockheed et al. (1980). A negative and significant coefficient of farm size and experience was also found and indicates that farmers who have more experience and farm size tend to exhibit higher levels of profit efficiency. However, completely in line with a priori expectation, a positive and statistically significant relationship was found between age of the farmer and profit inefficiency. This indicates that old tend to exhibit higher levels of profit inefficiency.

Table 3 shows that farm profit inefficiencies moderately increased from a minimum of 26 to a maximum of 73%. The average efficiency estimates was 60% and this suggests that, on the average, about 40% of the profit is lost to economic inefficiency. This value of the 40% represents the gap that can be made by the farmers if they improve both their technical and allocative efficiencies.

Conclusion

The study used stochastic profit frontier function to analyse the efficiency of sampled milk producing farmers in the Meru south district of Central Kenya. Using detailed survey data obtained from 27 milk producing farms, the study showed that profit inefficiency varied moderately among the sampled farmers. It ranged from 26 to 73% with a mean of 60%. The mean level of efficiency indicates that there exist some room to increase profit by improving the technical and allocative efficiency. The farm specific variable used to explain inefficiency indicates that those farmers who have a higher level of education, more experience and larger farm size tend to be more efficient while those who are aged tend to be less efficient. The policy implication in dairy milk production of these finding is that inefficiency in dairy milk production can be reduced significantly by improving the level of education amongst the farmers.

REFERENCES

Abdulai A, Huffman W (2000). Structural Adjustment and Economic Efficiency of Rice Farmers in Northern Ghana. Econ. Dev. Cult. Change 48: 503-520.

Ajibefun IA (1998). An investigation of technical inefficiency of production of farmers under the National Directorate of Employment in Ondo State, Niger. Appl. Trop. Agric. 3: 15-21.

Ali F, Parikh A, Shah MK (1994). Measurement of Profit Efficiency Using Behavioural and Stochastic Frontier Approaches. Appl. Econ. 26: 181-188.

Ali M, Flinn JC (1989). Profit Efficiency among Basmati Rice Producers in Pakistan Punjab. Am. J. Agric. Econ. 71: 303-310

Battese GE, Coelli TJ (1995), "A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data", Empir. Econ. 20 325-332.

Coelli TJ (1996). A guide to FRONTIER Version 4.1: A computer Program for Stochastic Frontier Production and Cost Function Estimation. CEPA. University of New England, Armidale, NSW, 2351, Australia.

Herrero M, Gonzalez E, Thornton P, Quiros C, Waithaka. M, Ruiz R, Hoogenboom G IMPACT (2005). Generic household level databases and diagnostics tools for integrated crop-livestock systems analysis.

Huffman WE (1980). Farm and Off-Farm Decisions: The Role Human Capital. Rev. Econ. Stat. 62: 14-23.

Lockheed ME, Jamison DT, Lau LJ (1980). Farmer Education and Farm Efficiency: A survey. Econ. Dev. Cult. Change 29: 37-76.

Ojo SO (2003). Productivity and Technical Efficiency of Poultry Egg Production in Nigeria. Int. J. Poult. Sci. 2: 459-464.

Rahman S (2002). Profit Efficiency among Bangladeshi Rice Farmers. School of Economic Studies. The University of Manchester Oxford Road Manchester, M13 9PL England, UK.

Smallholder Dairy Project (2005). The Uncertainty of Cattle Numbers in Kenya. Policy Brief Number 10. Smallholder Dairy Project. Nairobi.

SDP (Smallholder Dairy Project). ILRI/KARI/MoALDM, 1996. PilotSurvey of Household and Dairy Production Systems Ch aracteristics in Kiambu District, Kenya.

Wadud A, White B (2000). Farm Household Efficiency in Bangladesh: A Comparison of Stochastic Frontier and DEA Methods. Appl. Econ. 32: 1665-1673.

Wang JC, Wailes EJ (1996). Production Efficiency of Chinese Agriculture: Evidence from Rural Household Survey Data. Agric. Econ. 15: 17-28.