Estimating Cost Efficiency among Maize Producers in Kenya and Uganda

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Introduction

Maize is a staple food to a large proportion of people in Kenya. About 3.5 million small-scale farmers are involved in maize production and produce about 75 percent of the total maize crop. Large-scale farms account for the remaining 25 percent of the production and are estimated to be just about 1000 farmers (CBS, 2001). In the recent past, there has been evidence of declining maize production and maize subsector competitiveness in the region (Nyoro, 2002).

In the early 1980s, maize yields started to increase following adoption of hybrid maize varieties and fertilizer use. By 1986, the average national yields were over 2 tons per hectare. However, this increase was not sustained. Maize yields started to fall gradually, stagnating at the current level of 1.8 tons per hectare. A new spurt of growth was expected to come from market liberalization, as a result of lower maize marketing and input costs. Reduction of these costs was viewed as an opportunity to improve farm production incentives.

But market liberalization had mixed effects on farm productivity, because it affected not only their incentives, but also their capacity constraints. The privatization of state corporations reduced the availability of many services used by farmers. The decline in the ability of marketing boards to play an important role in the industry, exposed farmers to increased price risks. Finally, farm credit and input supply constraints have resulted from high transaction costs, poor repayment rates, lax administrative procedures, corrupt practices, and inefficient accounts management by the publicly supported credit scheme, Agricultural Finance Corporation (AFC) and the input supply scheme of the Kenya Farmers' Association (KFA).

Recent research and policy debates have focused on the need to increase maize production levels and improve competitiveness of the subsector. Kenya's increasing gap between production and consumption of maize is bridged by imports, particularly from Uganda. Imported maize is usually cheaper than that produced locally, but import tariffs protect domestic producers, raising consumer maize prices. This situation creates a perfect food price dilemma: It protects those few maize producers who are net sellers, while imposing a heavy cost on low income maize consumers – both urban consumers and those rural net consumers who grow maize but are net buyers through the course of a year (Jayne *et al.* 2001). Public recognition of this phenomenon has increased policy-makers' interest in reducing production costs rather than raising maize prices, as the latter would compromise food security (Nyoro, 2002). The biggest challenge facing policy makers in the maize subsector is how to raise productivity through reduction of production and marketing costs and use of appropriate inputs. The strategy should ensure acceptable profitability for the producers and lower food prices for the consumers, mitigating the food price dilemma. It should also improve the competitiveness of the subsector, a particularly pressing challenge in the face of renewed regional integration under the Common Market for Eastern and Southern Africa Treaty (COMESA) and the East African Cooperation, (EAC).

Improving maize subsector competitiveness requires that Kenyan maize producers compete by achieving lower production costs and/or increased productivity rather than relying on protection from imports. One pathway toward lower production costs is to improve technical and allocative efficiency. Among Kenya's many maize farmers, some are more efficient than others at managing their productive resources. By understanding the magnitude and sources of maize production cost inefficiency, policies may be designed to help a wider cross-section of Kenyan farmers to achieve the management success of their more efficient peers.

The purpose of this paper is to assess the cost efficiency of maize producers in Kenya compared to Uganda, an important source of maize imports to the Kenyan market. A stochastic cost frontier analysis is used to determine the relative efficiency of household-level maize production systems in Kenya and Uganda. Estimates of the stochastic cost frontier and cost efficiency of each producer allow cost efficiency to be compared across three dimensions, 1) by nation (between Kenya and Uganda), 2) by agro-ecological zone, and 3) by farm size. If Kenyan maize farmers are operating on the cost frontier, the policy focus should be to increase output through access to appropriate technology and inputs. If they are not using currently available resources efficiently, then the focus should be threefold: First, to understand the origins of current inefficiencies, next to improve the efficiency of current resource use, and finally to expand access to appropriate technology and inputs.

Measuring Cost Efficiency with the Stochastic Cost Frontier Model

Production cost efficiency is comprised of two main components. Technical efficiency involves the ability of the producer to produce the maximum level of output from a given set of inputs. Allocative efficiency reflects the optimal choice of input levels and proportions (e.g., using an input at the level where its marginal physical product equals its input/output price ratio, or using inputs in such proportions that the marginal rate of substitution equals the inverse price ratio). Technical and allocative cost efficiency can be combined into a measure of total economic efficiency, referred to as cost efficiency. Technical and allocative inefficiency (excessive input use and misallocation of inputs) are costly, so it is desirable to be able to identify the sources of cost inefficiency.

Efficiency is defined relative to some notion of best practice at a particular point in time. This notion of best practice is referred to as the efficiency frontier. It is defined as the minimum cost of achieving a given output level at prevailing input prices with existing production technology. If a firm is operating on the frontier, it is defined as efficient; if it is operating away from the frontier, it is defined as inefficient. The level of inefficiency is measured relative to the frontier. Failure to attain the cost frontier implies the existence of technical or allocative inefficiency.

To measure the cost efficiency of individual producers, we use the stochastic efficiency frontier methodology of Aigner, Lovell, and Schmidt (1977). In this method, a producer's observed total cost is modeled to deviate from the cost-efficient frontier due to random noise and possibly cost inefficiency. For the ith firm,

$$\ln TC_i = f(\ln Y_i, \ln w_j) + \varepsilon_i \qquad (1)$$

where TC_i is the total cost, Y_i is output, and w_j are input prices. In equation (1), ε_i is a two-component disturbance term of the form:

$$\varepsilon_i = u_i + v_i \qquad (2)$$

where v_i represents a random uncontrollable factor and u_i is the controllable component of ε_i . In equation (2), v_i is independently and identically distributed with zero mean and σ_v standard deviation, i.e., $v_i \sim N(0,\sigma_v^2)$. The term u_i is distributed independently of v_i and has a half-normal distribution, i.e., u_i is the absolute value of a variable that is normally distributed with zero mean and standard deviation σ_u, $N^+(0, \sigma_u^2)$. Heteroscedasticity can appear in either error component, with the variance being positively correlated with size-related characteristics of the observations. This can affect inferences concerning cost function parameters as well as parameters of either error component. Consequently it can affect inferences concerning cost efficiency. Heteroscedasticity in v generates unbiased parameter estimates except for the intercept term but leads to biased estimates of cost efficiency. If u is heteroscedastic, parameter as well as efficiency estimates are biased in a stochastic frontier model.

The cost inefficiency of producer i, defined as c_i , can be expressed as the expected value of u_i conditional on ε_i (Jondrow *et al.* 1982):

$$c_i = E(u_i | \varepsilon_i) = [\sigma\lambda / (1 + \lambda^2)] [f(\varepsilon_i \lambda / \sigma) / F(\varepsilon_i \lambda / \sigma) + \varepsilon_i \lambda / \sigma)], \quad (3)$$

where λ is the ratio of the standard deviation of v_i to the standard deviation of u_i (i.e., σ_v/σ_u), $\sigma^2 = \sigma_u^2 \sigma_v^2 / \sigma^2$, F is the cumulative standard normal density function, and f is the standard normal density function. Estimates of c_i are obtained by evaluating equation (3) at the estimates of σ_u^2 and σ_v^2.

To specify the cost function in equation (1), we employ a translog cost function, which is a flexible functional form and places no *a priori* restrictions on the elasticity of substitution and allows economies of scale to vary with output level. This is specified as:

$$\ln TC = \beta_0 + \beta_y \ln y + \sum_j \alpha_j \ln p_j + ½ \beta_{yy} (\ln y_i)^2 + ½\sum_j \sum_h \alpha_{jh} \ln p_j \ln p_h + \sum_j \alpha_{yj} \ln y \ln p_j + \varepsilon_i$$

$$= \beta_0 + \beta_y \ln y + \sum_j \alpha_j \ln p_j + ½ \beta_{yy} (\ln y_i)^2 + ½\sum_j \sum_h \alpha_{jh} \ln p_j \ln p_h + \sum_j \alpha_{yj} \ln y \ln p_j$$

$$+ v_i + u_i, \quad (4)$$

where TC is the observed cost of production, y is the annual total output of maize in kilogrammes, and p_j is the unit cost of input j[3]. Three input costs are utilized: average cost of labor/acre, average price of fertilizer per kilogramme, average cost/acre of other variable inputs such as chemicals (pesticide and herbicide), land preparation inputs (tractor/oxen/hoe) and seeds. v_i and u_i are the random and the inefficiency components of the error term. The linear homogeneity restrictions,

$$\sum_j \alpha_j = 1, \quad \sum_h \alpha_{jh} = 0, \text{ for all j}, \ \sum_j \alpha_{yj} = 0,$$

are imposed by normalizing the total cost and the input prices by the price of fertilizer. Equation (4) is estimated using maximum likelihood techniques to obtain parameters of the stochastic frontier and the two error components ($\lambda = \sigma_u / \sigma_v$ and $\sigma^2 = \sigma_u^2 + \sigma_v^2$) and the firm-specific efficiency estimates.

One advantage of stochastic frontier estimation is the ability to obtain measures of the one-sided effects (c_i), which provide quantitative information on the level of cost inefficiency. Based on these measures, one can then calculate the cost efficiency index (CEI), which measures the magnitude of a producer's cost of production relative to the cost-efficient frontier level. This is defined as the ratio of observed costs to minimum costs (on the cost frontier). For a logarithmic dependent variable, the measure is given by

$$\text{CEI} = \exp(\ln \text{TC} | u_i) / \exp(\ln \text{TC} | u_i = 0) = \exp(u_i) \qquad (5)$$

This measure represents the increase in cost due to a producer's inefficiency: the perfectly efficient producer has a CEI equal to one. Efficiency indices greater than one

[3] The cost of fertilizer is an average cost that includes all cash costs paid by a producer for all types of fertilizer. Costs for seed and chemicals are computed in a similar way. Labor costs include hired and family labor.

indicate that the producer is above the frontier and thus a further proportional decrease in cost is feasible, given output level and technology.

Unexplained systematic cost differences are attributed to inefficiency and are captured by u_i. The variation in producer performance is associated with variation in variables characterizing the environment in which production occurs. Examples include input and output quality indicators, ownership form, and various managerial characteristics. These factors may influence the structure of the technology or the efficiency with which conventional inputs are converted to output. Thus heteroscedasticity of *u* is modeled as a function of exogenous variables that are neither inputs to the production process nor outputs of it but nevertheless exert an influence on producer performance (Kumbhakar and Lovell, 2000).

The variance of either cost inefficiency or the idiosyncratic component is modeled as $\sigma^2_i = \exp(Z_i \delta)$, where Z is a set of covariates affecting the error components. It is possible to simultaneously specify covariates for both components. In this paper, we model heteroscedasticity in *v* as a function of farm size while *u* is assumed to depend on farm size and technical knowledge as represented by type of seed used, planting time, intensity of fertilizer use and thoroughness in land preparation.

Data and Empirical Procedures

The data used for empirical analysis come from a survey of 581 maize-producing households in Kenya and Uganda during April-May 2003. This survey was designed and implemented under the Tegemeo Agricultural Monitoring and Policy Analysis Project (TAMPA), a collaboration among Egerton University/Tegemeo Institute, Michigan State

University, and the Kenya Agricultural Research Institute. Our analysis focuses on the 203 farmers who grew maize as a monocrop system.

To measure cost efficiency, a stochastic frontier is first estimated and then the approach introduced by Jondrow *et al.* (1982) is used to separate the deviations from the frontier into a random and an efficiency component. Maximum likelihood estimation is employed to estimate simultaneously the parameters of the stochastic translog cost frontier (equation (4)) and the cost inefficiency model. The translog function is specified as:

$$\ln (TC/fert) = \beta_0 + \beta_y \ln output + \sum_j \alpha_j \ln (p_j/fert) + \tfrac{1}{2} \beta_{yy} (\ln output)^2 + \tfrac{1}{2}\sum_j \sum_h \alpha_{jh} \ln (p_j/fert) * \ln (p_h/fert) + \sum_j \alpha_{yj} \ln output * \ln (p_j/fert) + v_i + u_i, \quad (6)$$

where *TC* is the actual total cost of production; *fert* is average price of fertilizer per kilogramme; the other input cost, p_j is as defined in equation (4). After normalizing the total cost and the input prices by the price of fertilizer and expressing all the variables in logarithms, the estimating equation becomes:

$$tcost = \beta_0 + \beta_y\, output + \alpha_1\, labor + \alpha_2\, other + \tfrac{1}{2} \beta_{yy}\, output^2 + \tfrac{1}{2}\alpha_{11}\, labor^2 + \alpha_{12}\, laboth + \tfrac{1}{2}\alpha_{22}\, other^2 + \alpha_{y1}\, labout + \alpha_{y2}\, otherout + v_i + u_i \quad (7)$$

These variables are described in Table 1.

Likelihood ratio tests are carried out to determine if the simpler Cobb-Douglas model is appropriate in this case, and to test for the presence of cost inefficiency. The latter is a test of the null hypothesis that there is no cost inefficiency component in the model, H_o: $\sigma^2_u = 0$, against the alternative hypothesis, H_1: $\sigma^2_u > 0$.

The variables that may potentially explain differences in the variance of the inefficiency error component in cost inefficiency model are *sized1, fertd1, prepd1, seedd1, recyd1, plantd1, plantd2* and *lcultv*, and are described in Table 1.

Results

Stochastic Frontier Cost Estimation

A translog cost function is estimated for farmers in Kenya and Uganda who grew maize as a monocrop system in the 2002/2003 cropping season. The test statistic for the hypothesis that all quadratic terms in the translog model are insignificant is: chi^2 (6) = 107.01. So we reject the hypothesis that a Cobb-Douglas function is an appropriate simplification of the translog cost function at the 1% level of significance. The results of the likelihood ratio test for cost inefficiency component are similarly robust, sigma_u=0: chibar2 (1) = 17.12. Again, the null hypothesis is rejected at the 1% level of significance, indicating that there ***is*** a statistically significant inefficiency term. The estimate of the ratio of standard deviation of the inefficiency component to the standard deviation of the random component, $\lambda = \sigma_u / \sigma_v$, = 3.96 (Table 2). This indicates that the one-sided error term *u* dominates the systematic error *v*.

Table 2 shows the maximum likelihood parameter estimates of the translog cost function and the λ parameter. All the variables are in logarithmic form and are as defined in Table 1. As expected, the results show that input prices have a positive effect on costs. The coefficients on *labor* and *other inputs* imply that an increase in the amount of labor and other variable inputs will increase total costs. However, the negative parameter estimate for *labor* x *other* indicates that labor and capital substitute for one another in production, so costs are reduced by mixing them. The coefficient for *output*^{2} shows that there are no economies of scale, as costs increase quadratically with output.

Cost Efficiency Estimation

The discrepancy between observed cost and the frontier cost is due both to technical and allocative inefficiencies. Table 3 and the corresponding histogram in Figure 1 show the frequency distribution of the estimates of the cost efficiencies of all households. The average cost efficiency index is 1.95 indicating that on average a producer's costs are 95% higher than the achievable efficient level. This implies that on average 95% of the costs incurred can be avoided without any loss in total output.

Table 3 shows that nearly 66% of the farm households achieve CEI levels equal to or less than the mean value of 1.95. It is also evident that there is a wide variation of cost efficiency across households. The most efficient household had a CEI of 1.12, almost on the frontier. By contrast, the least efficient household had a CEI of 6.71, implying costs of production over six times greater than the frontier efficiency level. Of the 66% of households at or below the mean CEI inefficiency level in Table 4, 56% are Kenyan and 10% are Ugandan, representing 63% of all Kenyan households and 83% of all Ugandan households sampled. The households in class 8 have very high costs of production, more than triple the minimum estimated cost attainable. All of these are Kenyan households.

Variation of efficiency across agricultural zones is as shown in Table 5. The results show that sampled households that achieve efficiency levels equal to or less than the mean efficiency level include nearly 60% of those in Kenya's high potential zone, 47% in western Kenya, 80% in Kenya's central highlands, 92% in Uganda's medium potential zone and 75% in Uganda's high potential zone. The largest proportion of households achieving the lowest efficiency levels (CEI ≥2.51) are in the high potential and western zones of Kenya. The inefficiency differentials across the zones again imply that Ugandan households are relatively more cost efficient than Kenyan households.

Some of the reasons for these key differences in cost efficiency between Kenya and Uganda are that the hybrids used in Kenya require greater use of fertilizer than the open pollinated maize varieties used in Uganda. Ugandan production systems have higher soil fertility and favorable weather conditions, conducive to maize production. However, the potential to raise maize productivity in Kenya does not lie in the open pollinated maize varieties. Indeed, the adoption rates for hybrid maize in Uganda are increasing. The secret to increasing maize productivity in Kenya thus lies in increasing the quantities and quality of the yield enhancing inputs like fertilizer and optimal land preparation (Nyoro *et al*., 2001)[4].

An examination of Table 6 reveals that there are efficiency differentials across farm size categories. Out of the 66% of households achieving efficiency levels less than or equal to the mean CEI, 30% are small-scale, 26% are medium-scale and 9% are large-scale producers. This translates to nearly 77% all small-scale, 68% of medium-scale and 40% large-scale producers. In addition, within sample results show that the largest proportion of the most inefficient households (CEI ≥2.51) is comprised of medium-scale farmers (7%), followed by the small-scale farmers (6%) and large-scale farmers (5%).

[4] In a 2004 draft Tegemeo Working Paper, "Competitiveness of Kenyan and Ugandan Maize Production: Challenges for the Future", J.K. Nyoro, L. Kirimi, and T.S. Jayne mention other factors that make the Ugandan maize production systems different from those of Kenya: Hybrid maize seed quality is lower in Kenya (reported by Kenyan farmers); Kenyan seed costs run three times those in Uganda; Average land rental rates in Kenya are double those in Uganda; Land preparation costs in Kenya are higher than in Uganda.

Equivalently, 38% of the most inefficient households are medium-scale while the small- and the large-scale farmers account for 33% and 27%, respectively. It is therefore evident that small-scale producers are relatively more efficient.

Determinants of Cost Inefficiency

Ordinary least squares regression analysis revealed three major determinants of cost inefficiency: recycled maize seed, late planting, and cultivated area (Table 7). Recycled local or hybrid seeds reduce yields due to inferior genetic material with less vigor giving lower yields. The quality of maize seed in Kenya has declined in recent years, despite the entry of many seed companies into the seed market following liberalization. Occasionally seed sold has poor germination rates (Nyoro, 2002); some packages even contain a variety different from what appears on the label. As a result, some farmers have lost confidence in hybrid seeds and have reverted to reliance on their own retained seeds. Seed quality, handling and packaging needs to be well monitored in order to win back farmers' confidence (Nyoro, 2002).

Late planting is another factor contributing to cost inefficiency. By reducing maize yields, delayed planting increases unit costs. Also, maize farms with more cultivated area are relatively less efficient than ones with less cultivated area. The underlying reasons for these sources of inefficiency need to be explored and understood if any meaningful policy changes can be instituted to increase efficiency of maize production.

Conclusion

The stochastic translog cost frontier analysis of Kenyan and Ugandan maize producers shows that many farmers in this sample are cost-inefficient. The Cost Efficiency Index ranges from 1.12 to 6.71 with an average of 1.95, implying that the average maize producer has costs 95% higher than the minimum cost frontier. Most Ugandan households achieve better-than-average efficiency levels, while Kenyan households dominate most inefficient category of farmers. The discrepancy between observed and frontier costs reveals considerable room to improve maize production cost efficiency, particularly among farmers in Kenya and those of medium- to large-scale. The potential cost savings from more efficient resource use could raise household incomes and enhance Kenya's balance of agricultural trade. Yield gains are particularly important, considering that opportunities to increase farm production by bringing additional land into cultivation have significantly diminished with population increases.

The key sources of cost inefficiency are late planting and use of recycled seed. There is also evidence that large-scale farmers are relatively less efficient. Since Kenyan farmers are not operating on the frontier, there is need to further research into reasons for observed inefficiency determinants. For example, the problem with recycled seed might be one or more of the following: a) recycled hybrid seed is less productive than open-pollinated seed, b) appropriate varieties are not available in the local markets (or farmers are poorly informed about them), c) hybrid seed arrives too late in local markets, d) hybrid seed is too expensive and credit is unavailable, e) farmers lack information and knowledge about how yield and seed vigor are related, f) hybrid seeds packed in large quantities (e.g., 25 kg bags) deter some farmers from purchasing hybrids. For example, if the size of hybrid seed packages were a cause of recycled seed use, then the feasibility of producing and selling smaller packages would deserve study.

Questions can also be asked about the determinants of late planting. Delayed planting may result from one or more the following: a) labor constraint, b) late arrival of imported fertilizer and hybrid seed in local markets, c) financial constraints that lead to late land preparation and purchase of inputs, d) recent changes in the weather pattern that have added to the farmers' uncertainty as to the right planting time, and e) inadequate tractor and oxen services for own use and hire.

The reasons that larger maize farms are relatively less efficient than small ones also need to be well understood. Is it the case that these farmers, a) face high fuel costs? b) lack finances to operate and maintain existing machinery or acquire new machinery? c) lack appropriate ploughing equipment to deal with land preparation problems (e.g., hard pans)? or d) lack sufficient tractor and oxen services for own use and hire?

There is need to determine if the Kenyan government has clearly defined its role in the input sector -- whether it is a regulator, a facilitator or a key player. When the government becomes a key player in the input supply system, it creates uncertainty for the private sector. This may lead to insufficient and untimely provision of inputs, causing farmers to be less efficient.

Since Kenyan producers have higher adoption rates for fertilizer and hybrid seed then their Ugandan counterparts, productivity gains should ensue from greater cost efficiency. While we have identified the direct determinants of cost inefficiency, additional research is needed to diagnose the causes of inefficiency determinants if well-informed policy changes are to be recommended.

Table1: Variable definitions and descriptive statistics, 203 maize farms, Kenya and Uganda, 2002-03.

Variable name	Definition	Mean	Standard deviation
tcost	total cost of production (Ksh)	120, 300.00	270,000.00
fert	average price of fertilizer per Kg (Ksh)	27.85	18.46
output	annual total output of maize in Kgs	15, 240.00	25, 560.00
labor	average cost of labor per acre (Ksh)	1, 825.00	2175.00
other	average cost of pesticides, herbicides, seeds and land preparation inputs (tractor/oxen/hoe) per acre (Ksh)	4, 230.00	2, 423.00
lcultv	cultivated land in acres	20.15	41.88
$other^2$	other x other		
$output^2$	output x output		
$labor^2$	labor x labor		
laboth	labor x other		
labout	labor x output		
otherout	other x output		
sized1	dummy variable equal to 1 if farm is small scale (≤ 5 acres)		
fertd1	dummy variable equal to 1 if low fertilizer use intensity (≤ 40 kg/acre)		
prepd1	dummy variable equal to 1 if only one tillage pass		
seedd1	dummy variable equal to1 if seed is open pollinated maize variety		
recyd1	dummy variable equal to 1 if seed is recycled		
plantd1	dummy variable equal to 1 if planting is done early		
plantd2	dummy variable equal to 1 if planting is done late		

Source: Tegemeo Maize Production Cost survey data, 2003.
Note: Descriptive statistics are in levels, not logarithms.

Table 2: Translog stochastic frontier cost function parameter estimates, 203 maize farms, Kenya and Uganda, 2002-03.

Variable	Coefficient	P value
labor	1.306	0.003
other inputs	1.607	0.001
output	0.4293	0.393
labor^2	0.02480	0.303
other^2	0.03682	0.370
output^2	0.04235	0.079
labor x other	-0.2329	0.000
labor x output	-0.02550	0.495
other x output	-0.06055	0.239
constant	-6.560	0.034
lambda	3.959	

Table 3: Frequency distribution of household-specific maize production cost efficiencies, 203 Kenyan and Ugandan maize farms, 2002-03.

Class	Cost Efficiency Index	Number of households	% of households
1	≤1.25	24	12
2	> 1.25 and <= 1.50	44	22
3	> 1.50 and <= 1.75	44	22
4	> 1.75 and <= 1.95	21	10
5	> 1.95 and <= 2.25	19	9
6	> 2.25 and <= 2.50	15	7
7	> 2.50 and <= 3.00	16	8
8	> 3.00	20	10
Minimum	1.12		
Maximum	6.71		
Mean	1.95		
Median	1.69		
Standard deviation	.85		

Table 4: Distribution of maize production Cost Efficiency Index by country (in percentages), 203 maize farms, Kenya and Uganda, 2002-03.

CEI	Kenya (n=179) within country	Kenya (n=179) within sample	Uganda (n=24) within country	Uganda (n=24) within sample
	--- percent --			
1.00-1.25	9	8	29	3
1.26-1.50	20	17	38	4
1.51-1.75	23	20	13	2
1.76-1.95	11	10	4	1
1.96-2.25	11	9		
2.26-2.50	8	7	4	1
2.51-3.00	7	7	12	1
>3.00	11	10		
Country totals	100	88	100	12

Table 5: Distribution of maize production Cost Efficiency Index by agricultural zone (in percent), 203 maize farms, Kenya and Uganda, 2002-03.

	Agricultural Zone				
CEI	High Potential -Kenya (n=114)	Western Kenya (n=21)	Central Highlands -Kenya (n=44)	Medium Potential - Uganda (n=12)	High Potential -Uganda (n=12)
		--	Percent	--	
1.00-1.25	4	5	27	25	33
1.26-1.50	20	14	21	42	33
1.51-1.75	24	14	25	17	9
1.76-1.95	12	14	7	8	
1.96-2.25	11	29	2		
2.26-2.50	10	5	2		8
2.51-3.00	6	9	9	8	17
>3.00	13	10	7		

Table 6: Distribution of maize production Cost Efficiency Index by farm size, 203 maize farms, Kenya and Uganda, 2002-03.

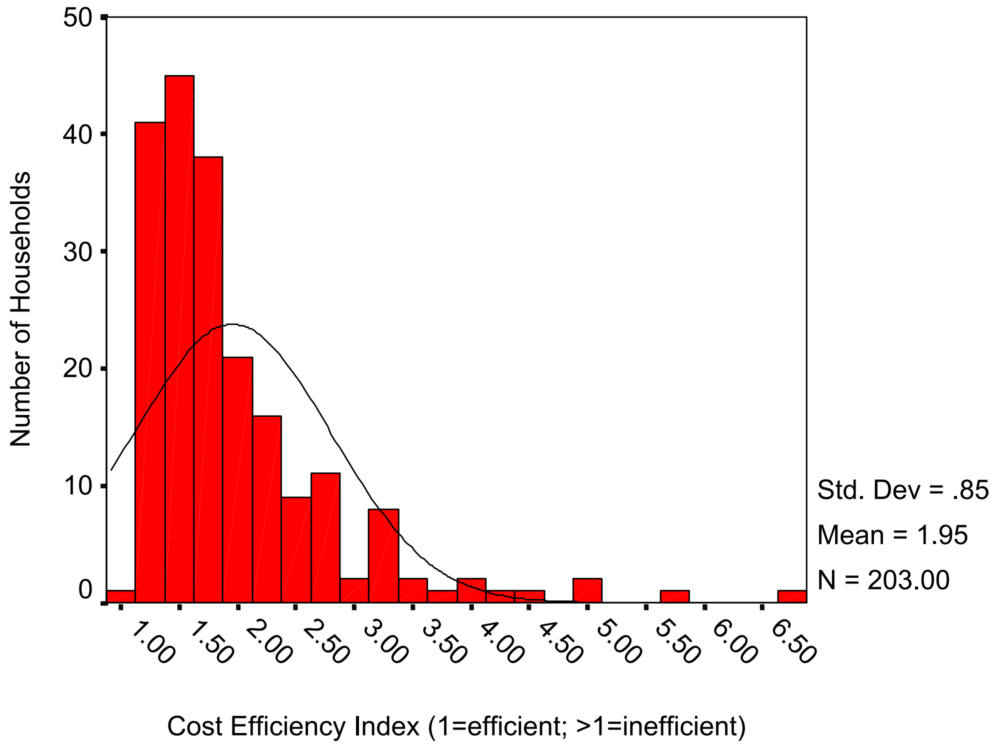
	Farm Size Category					
	Small (< 5 acres) (n= 81)		**Medium (5-20 acres) (n= 79)**		**Large (> 20 acres) (n= 43)**	
CEI	**within sample**	**within category**	**within sample**	**within category**	**within sample**	**within category**
1.00-1.25	7	17	5	13		
1.26-1.50	9	24	10	25	3	12
1.51-1.75	11	27	7	19	3	16
1.76-1.95	3	9	4	11	3	12
1.96-2.25	1	2	4	10	4	21
2.26-2.50	3	6	2	4	3	16
2.51-3.00	3	9	3	8	2	7
>3.00	3	6	4	10	3	16

Table 7: Determinants of maize production Cost Inefficiency Parameter (sigma_u) , 203 maize farms, Kenya and Uganda, 2002-03.

Variable	**Coefficient**	**P value**
Low fertilizer (1/0)	0.2088	0.748
Single tillage pass (1/0)	-0.1765	0.684
Open pollinated maize variety (1/0)	-0.8060	0.135
Recycled seed (1/0)	1.0641	0.039
Planting early (1/0)	0.7117	0.223
Planting late (1/0)	0.7009	0.081
Cultivated land in acres	0.01233	0.007
constant	-1.6470	0.006

Figure 1: Distribution of Cost Efficiency Index,

203 Kenyan and Ugandan maize farms, 2002-03



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