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Determination of Cost Efficiency Level of Production among Sugarcane Farmers in Nyanza Region, Kenya

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Abstract
In agricultural production, labour, capital and land are critical ingredients in increasing output levels. In sugarcane and food crops production, farmers always experience competing requirements on production inputs. In Kenya, farmers are uprooting sugarcane to compensate for food deficits without due regard to the possibility that these two crops can coexist in case production inputs are in short supply. Based on production theory, this study established the cost efficiency level and the possible likelihoods sugarcane farmers, in Nyanza region, can make given the production inputs. Cross sectional data and Stratified random sampling was used. Stochastic Frontier and Multinomial Logit regressions obtained the results which showed that sugarcane farmers were cost inefficient; the significant determinant of choices that farmers make were the cost of labour and the cost of land. However, they were positive and negative respectively. This paper recommended for the betterment of wages and cost of land controls if efficiency and sugarcane output is to be increased.
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1. Introduction

A critical factor that determines an enterprise level of competitiveness, whether big or small is the level of efficiency which can be classified into cost, technical or allocative efficiencies. These efficiencies work together to lower per unit cost of production thereby enabling enterprises to supply their commodities at a reasonably lower cost. In this paper, cost efficiency was addressed. The definition of cost efficiency was defined in two ways i.e. the ability of a firm to produce a predetermined level of output at least cost or conversely, the ability to produce the same output with minimal cost for a given input, (Karagiannis, Katranidis, & Tzouvelekas, 2008). Because Kenya is a developing country, expansion of efficiency is critical in order to assure economic development (Fatima & Yasmin, 2016).

In the context of this paper, the study area comprised of sugarcane growing counties in Nyanza region, Kenya namely Kisumu, Homabay and Migori and the study focused only on sugarcane farmers who either dealt with sugarcane "only", or mixed farming i.e. sugarcane and food crops and investigated the sole factors of production namely labour (Narayan, 2004); capital (FAO, 2008) and land (Watson, Garland, Purchase, Dercas, Griffee, & Johnson, 2008). According to Livingston, Schonberger, & Delaney, (2011), smallholder farmers have limited access to credit to acquire farm inputs, farm and processing equipment. Once farmers have struggle to acquire these inputs, and given the myriad problems facing the sugarcane farmers, Africa Times, (2015), attempts are made by the said farmers to practice mixed farming in order to mitigate the adverse effects of sugarcane productivity, (Farmbiz Africa, 2018). Supporting this opinion was Monroy, Mulinge, & Witwe, (2012) who contended that sugar industry in Kenya cannot meet national demand or even compete with other producers in the international market because of cost inefficiencies in the region. This observation was also supported by (Ogada, Muchai, Mwabu, & Mathenge, (2014) who also upheld that Kenya's smallholder crop farmers were technically inefficient.

Based upon the aforementioned debates, this paper investigated, in terms of the factor inputs; the probable reasons regarding the inclination towards sugarcane "only" farming or mixed farming. It also endeavored to establish the percentage of the variances due to factor input inefficiencies as well as cost efficiency levels determination since such studies are limited within the study area.

2. Literature review

The importance of sugarcane in the production of sugar, alcohol, yeast and other derivatives cannot be understated (Ramashala, 2012). However, its production requires huge parcels of land (Watson, 2011). Where land is inadequate, other natural resources like forests have been cleared to facilitate their expansion, (Schneider, 2010) . While supporting this claim, De Sa, Palmer, & Di Falco, (2013) confirmed a negative and statistically significant correlation between sugarcane expansion and deforestation. As was established by Garside, Bell, & Magarey, (2001), long term sugarcane cultivation also affects soil properties and crop productivity negatively. This increase in production also leads to increased soil acidification, nutrient depletion and reduced soil microbial activity as well as biomass, if compared to other agricultural land uses or natural vegetation (Mardamootoo, Ng Kee, Kwong, & Preez, 2010). Gitau, (2015), pointed out that the factors promoting sugarcane farming in Western Kenya were

land, labour, markets and good pay.

Sugarcane requires operating capital, replacement of equipment and also non -land capital (Shapouri, Salassi, & Fairbanks, 2006). The presence of these capitals has made positive contributions to sugarcane production both in the short- and long-run, (Narayan, 2004). However, even though there are farmers with sufficient land for sugarcane cultivation, these farmers may not be able to farm all their land if capital is insufficient (FAO, 2008). This is because the crop requires huge costs of production at various stages of production (Rao, 2014). Hussein & Khattak (2011) also assessed that capital employment is closely related to sugarcane production especially on preparation of land, water management, weed control and insecticides.

Labor defines the work done by people whose value depends on workers' education, skills, motivation and productivity and whose reward is wages (Amadeo, 2017). In India, Rao, (2014) established that labour costs formed the greatest cost in sugar cane production, an observation supported also by Hussain & Khattak, (2011) in Pakistan. In Kigali, Lankhorst & Veldman, (2011) contended that it is strenuous to work in a sugar cane plantation since the wage rates are low compared to other forms of employment.

With regards to food security (proxied by food production), there is a potential to increase food production without increasing agricultural area in developing countries (UN, 2012). One such method of increasing food security is through agriculture intensification, which is, moving from growing one crop per year to two crops per year, (Khaleed, 2000). In Kenya, there is competition for land use among different crops but which favored sugarcane and maize at the expense of other indigenous food crops such as onions, tomatoes, cassava and sweet potatoes resulting in the persistent food insecurity (Waswa, Mcharo, & Netondo, 2009).

With reference to food security, agricultural, ecological, micro and macro-economic policies as well as international trade are important. Zepeda, (2001) established that there is a weak relationship between food security and physical capital. Because of this, Mozumdar, (2012) proposed that human capital, research and technological development are critical in the analysis of food security.

Contrary to the popular belief, NEPAD,(2013) established that agricultural production in Africa has increased steadily but there has been very little improvement in labour since this huge production is only achieved by mobilizing a larger agricultural labour force. UN, (2013) opined that to obtain permanent economic access to food, sustainable agricultural intensification must be done only if families make optimal use of land and labour on their small land sizes and because labour is a key input in agricultural production, its loss by whatever means may lead to the reduction in the area of land under cultivation and declining yields resulting in reduced food production and food insecurity, (un.org, n.d).

3. Methodology

This paper used correlational research design adopted and adopted Stochastic Frontier Analysis and Multinomial Logistic Regression to establish the cost efficiency level and likelihood effects the factors of production had upon the various agricultural practices among farmers in Nyanza region, Kenya. Stratified random sampling was used and the stratas identifies from the sugarcane growing zones in Chemelil, Muhoroni, Ndhiwa and Awendo. This study sampled 190 farmers and used primary data collected through questionnaires whose reliability and validity were tested. Heteroscedasticy was tested using the Levene's test.

Using a one-step approach with a truncated normal distribution, this study incorporated the Battesse – Coeli (BC) model and the crop type to generate the cost efficiency model. The cost efficiencies are captured in Table 2 and 3.

The econometric model for the Stochastic Frontier cost efficiency model was specified as;

$$\ln TC_i = \alpha_0 + \alpha_{1i} \ln L + \alpha_{2i} \ln K + \alpha_{3i} \ln D + \varepsilon_i \quad \text{.....(1)}$$

Where;

$\ln TC$ = Total cost of output

$\ln L, \ln K, \ln D$ = Cost of labour, cost of capital and cost of land, respectively

$\alpha_1, \alpha_2, \alpha_3$ = Random coefficients of cost of labour, cost of capital and cost of land

α_0 = Constant

i = Cross sectional individual farmer subscript.

$\varepsilon_i \sim N(0, \sigma^2)$

In order to analyze how the cost efficiency varied across the farmer type, the multinomial logistics regression econometric model was used. It was specified in equation 2 and the results captured in Table 4;

$$\ln FT_i = \alpha_0 + \alpha_{1i} \ln L + \alpha_{2i} \ln K + \alpha_{3i} \ln D + \varepsilon_i \quad \text{.....(2)}$$

Where;

$\ln FT$ = The farmer type (either sugarcane producer or a mixed crop producer)

$\ln L, \ln K, \ln D =$ Cost of labour, cost of capital and cost of land, respectively

$\alpha_1, \alpha_2, \alpha_3 =$ Random coefficients of cost of labour, cost of capital and cost of land

$\alpha_0 =$ Constant

$i =$ Cross sectional individual farmer subscript.

$\varepsilon_i \sim N(0, \sigma^2)$

3.1 Farm inputs on Crop or farmer type choice

In this paper, there were two types of sugarcane farmers. Those who practices sugarcane "only" farming and those who practiced mixed farming, namely sugarcane and other food crops. The distribution was as follows;

Table 1: Frequencies of the Farmers

Crop type	Freq.	Percent	Cum. %
Sugarcane only	33	16.75	16.75
Mixed farming	164	83.25	100.00
Total	197	100.00	

From Table 1, sugarcane "only" farmers (type 1) were 33 representing 16.75% of the total sample while mixed crop farmers (type 2) were 164 representing 83.25% of the total farmers.

3.2 Determination of Cost of Efficiency of Output

The results on the variations on cost efficiency of output were presented in the Table 2.

Table 2: Variations in Total Cost of Output due to Farm Inputs

Stoc. frontier normal/tnormal model				Number of obs = 190 Wald chi2 (3) = 65.61 Prob > chi2 = 0.0000 Log likelihood = -70.5459		
LnTC	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
Frontier						
lnL	.0809959	.0970674	0.83	0.404	-.1092527	.2712446
lnK	.0456622	.0299973	1.52	0.128	-.0131314	.1044558
lnD	.3015204	.1024616	2.94	0.003	.1006994	.5023414
cons	8.084448	.528299	15.30	0.000	7.049001	9.119895
Mu						
Crop type	41.42182	272.0129	0.15	0.879	-491.7137	574.5574
cons	-114.998	754.5377	-0.15	0.879	-1593.865	1363.869
Usigma						
cons	2.030693	6.460588	0.31	0.753	-10.63183	14.69321
Vsigma						
cons	-2.522028	.1855023	-13.60	0.000	-2.885606	-2.15845
sigma_u	2.76032	8.916645	0.31	0.757	.0049128	1550.924
sigma_v	.2833665	.0262826	10.78	0.000	.2362646	.3398587
lambda	9.741165	8.915355	1.09	0.275	-7.732609	27.21494

From Table 2 above, the probability of the chi-square were significant hence an indicator of a good model. From the frontier, a unit increase in the cost of land significantly increased the cost inefficiency in output production by 0.3015204 $(\alpha_3 = 0.3015204; p = 0.003)$, otherwise, the cost of labour, the cost of capital and the farmer's decision were all insignificant. The standard deviation of inefficient and the random component were shown by sigma u and sigma v respectively.

Given that inefficiency component = 2.76032 and the random component = 0.2833665, the variance (standard deviation squared) were 7.61937 and 0.08029 respectively. Therefore the effect of the inefficiency component on the overall output was given by;

$$\frac{VoI}{TV} = \frac{2.76032}{2.76032 + 0.2833665} = \frac{2.76032}{7.69966} = 0.35849$$

Where;

VoI = The variance of inefficiency

TV = The total variance.

This calculation implied that the total variance on the cost of outputs as a result of inefficiencies was 35.849%. According to (Battese & Coelli, 1995), a stochastic frontier functions suggests the existence of technical inefficiencies for firms producing outputs. In this paper, the cost efficiency was investigated and the results of Battese –Coelli's coefficient was tabled below;

Table 3: Battesse & Coelli coefficient

Variable	Obs	Mean	Std. Dev.	Min	Max
bc	190	.8181486	.1081179	.3595672	.9419181

From Table 3, the results indicated that the mean BC coefficient was 0.8181486. This meant that the farmers cost efficiency level was at 81.81486%. However, this efficiency was bounded between 18.8315% - 93.25745%. Assuming a Cobb Douglas production function, the summation of the elasticity of the production factors $0.0809959 + 0.0456622 + 0.3015204$=0.4281785 which signified a decreasing returns to scale.

3.3 Likelihood adoption of a farming type given production inputs

From Table 2, considering mixed farming (type 2) as the base/reference group, labour and land are elastic and significant with respect to the choice of the crop/farmer type $(\alpha_1 = 2.140552; p = 0.024)$ and $(\alpha_3 = -23.942629; p = 0.000)$. This implies that a unit increase in the cost of labour is likely to increase the cost of sugarcane production by 2.140552 relative to the cost of mixed production while a unit increase in the cost of land is likely to reduce the cost of sugarcane production by 3.942629 relative to the cost of mixed production. Although cost of capital was inelastic and insignificant $(\alpha_2 = 0.3457222; p = 0.185)$, a unit increase on it results into 0.3457222 increases in the cost of sugarcane production relative to the cost of mixed cropping.

Table 4: Farmer/crop type

Multinomial logistic regression			Number of obs = 190		
			LR chi2(3) = 29.45		
			Prob > chi2 = 0.0000		
Log likelihood = -71.413741			Pseudo R2 = 0.1710		
Crop type	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
Sugarcane					
LnL	2.140552	.9461295	2.26	0.024	.2861719 3.994931
LnD	-3.942629	.9883203	-3.99	0.000	-5.879701 -2.005557
LnK	.3457222	.2606575	1.33	0.185	-.1651571 .8566014
Cons	12.9378	4.257262	3.04	0.002	4.593718 21.28188
Mixed farming		(base outcome)			

From Table 4, different signs were exhibited upon the costs of inputs. Labour and capital are positive while land is negative. The coefficients on labour and land were significant $(\alpha_1 = 2.140552; p = 0.024); (\alpha_2 = -3.942629; p = 0.000)$. This implies that cost of labour was significantly more likely to influence a farmer to adopt sugarcane "only" production as opposed to going for mixed farming while the cost of land was significantly less likely to encourage farmers to adopt sugarcane production at the expense of mixed production. With regards to the cost of capital, the results were insignificant.

4. Conclusion and Recommendations

Given that this paper intended to establish the cost efficiency level of production among sugarcane farmers and to also examine the likelihood of choice of a given production line, given the factors of production namely land labour and capital, the results indicated that the farmers still suffered from cost inefficiencies in output production and the greatest factor contributing significantly to this cost inefficiency in output production was the cost of land. Therefore, this study recommended for the reduction in the cost of land within the region.

With reference to the cost of the factor/ inputs in production, this study concluded that the cost of labour was more likely to influence the adoption of sugarcane farming at the expense of mixed farming while cost of land was less likely to influence the adoption of sugarcane farming at the expense of mixed farming. Hence this paper recommends for an increase in the wage levels and a reduction in the cost of land if the region is to increase its capacity in sugarcane production.

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