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Factor Substitution in Integrated Maize-Dairy Farming System inUasinGishu District

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Abstract

This study looked at the existence of jointedness in production, cost complementarity and factor substitution in small hold mixed maize and dairy production system. The smallholder farmers in UasinGishu County practise mixed dairy and maize farming as a strategy to mitigate against production risks. Maizeis a commercial crop whose price has been directed by the government rather than the market; dairy farming also faced market challenges with increasing imports due to inefficient pricing in the market. However, farmers allocate more land to maize farming than dairy. The study hypothesized that Maizewas found to be an increasing cost industry while dairy was a decreasing cost industry. Expansion of dairy farming enterprises would lead to cost reduction while expanding maize would increase the cost. The study thus recommended that farmers practise integrated mixed farming system due to cost complementarityand the government to facilitate access to credit for farmers access expensive farm inputs.

In trying to shed light on this, a survey was carried out amongst mixed dairy and maize famers in UasinGishu County and the results showed The production of maize in UasinGishu County in Kenya These group of farmers rely much on subsidized maize production annually. They however allocate more land to maize than dairy. It has been observed that farmers in UasinGishu County allocate more land to maize farming than dairy farming. Culturally, most farmers who dot keep animals are considered poor and therefore dairy farming is an integral part of any farming practice in the region.

Key words; *Dairy, Complementarity,Cost, Maize, Scale economies*,*Substitution*

Introduction

Farming is a business and farmers'objective is to maximize profits. This objective aims to increase farmers' incomes and assets. It also fulfils the achievement of the second objective of sustainable development goal where farmers must post more returns over cost in all their investments. Smallholder farmers in Kenya face a lot of challenges in many areas including low soil fertility, climate change, water shortages, dysfunctional input output markets, and weak extension system. In an uncertain production environment, this requires trade-offs where gains and losses are made depending on the pattern of resource allocation.This ties the farmers to a poverty status. The only strategy they have is to diversity. Diversification refers to mixing crop and non crop activities in a field. Like in this case, we consider diversification from livestock crop perspective. Farmers use this strategy to maximize returns fromestablished diversified production system. Such scenarios characterize mixed production systems in Western Kenya where farmers integrate livestock and crop production under their holdings.

The selection criteria that underpin the complexity of integrated mixed farming system of enterprise combination depend on whether the enterprises are complementary or supplementary. While highreturns are the driving force to commercial farming, unequal costs of production may make it difficult for farmers to decide on the optimum enterprise mix based on resource allocation. Complementary activities work together to enhance the production of enterprises while supplementary activities provide additional income to the main enterprise.

By juggling between complementary and supplementary activities, famers aim to improve the profitability of theirbusinesses even after achieving their goals. However, when they fail, they revise their aspiration levelsand align them with their resource capability as they search for investment options that will fulfil their targeted objectives. These are futuristic strategies that inform and determine farmers decision criteria and enterprise performance.Satisficing profit margins do not guarantee maximum profits. Recognizing their inability to maximize profit due to risks and uncertainty, rationalfarmers chose enterprise combinations that give the highest possible profits.This approach gives an output level that is commensurate with the level of risk taken by the farmer.

Farmers in UasinGishuapply this strategy in when allocating resources to dairy and maize enterprises. They operate in an uncertain production environment and their resilience is dependent on integrated crop-dairy production to maximize profits subject to resource constraint. This strategic production system characterizes smallholder production system and their livelihoods in Kenya with livestock cushioning the farmer in case of crop lose and vice versa.

In this study, we explore the positive and negative synergy in the interaction between crop and livestock activities. Crop enterprise meet immediate household consumption needs while livestock act as astore of wealth and provide the long term cash requirements. In an integrated crop-livestock system the enterprises complement one another through space and time. The backbone of an integrated system is the herd of ruminants which graze a pasture building up the soil and improving the soil health making it useful for crop production. Also, the proceeds from livestock farming can be invested in crop farming (Mohammed and Parton, 1992).

Problem

In Kenya ,dairy industry accounts for about 3.5% of the national GDP and about 14% of the agricultural GDP (ROK, 2008). It employs 12% of the agricultural labour force and is a primary source of livelihood for about 625,000 smallholders who produce over 70% of the country's marketed milk (Karanja, 2003). The average milk output level is 20 litres daily though the potential productivity of dairy animals in the high potential areas is about 30 litres daily.

Maize on the other hand is Kenya's main staple food and a major source of daily calories for the country's population. Its production occupies the largest cultivated area and the widest variety of agro-ecological zones in Kenya. It contributes about 3% of Kenya's GDP and 12% of the agricultural GDP (Wangia, et al., 2001). The maize sub-sector employs one quarter of the agricultural labour force and accounts for about 20% of the value of agricultural production in Kenya (Republic of Kenya, 2004). Maize production faces a number of problem key among them are low producer prices and unreliable input supply system. UasinGishuCountyis the rain basket in Kenya and a productivity average of 20 bags per acre.

Maizeproduction in Kenya peaked in the mid-1980s but has since stagnated with the country facing frequent structural maize deficits. The area under maize cultivation in Kenya has stabilized at around 2 million hectares, producing about 3.5 million tonnes per annum against an estimated consumption of 3.612 million tonnes.The average yields rane between 1.6-1.8 tonnes per hectare lower than the potential output of 6 tonnes per hectare. Rift Valleyproduces about 50% of the total maize output in Kenya's annually with the main areas being Trans Nzoia, UasinGishu, Nandi, Narok, Nakuru and Bomet districts (Economic Survey, 2003). The average output for these areas is 3.56 tonnes /ha which is lower than the expected yield of 4.95 tones /ha. While continued production of maize and dairy from the farms in UasinGishu areas would imply the enterprises are profitable, it does not necessarily mean high productivity. During the 2005/2009 period, the returns for dairy and maize grew by 56.4% and 49.6% respectively yet the maize enterprise posted higher returns.From the foregoing, it would be expected that dairy sector would be allocated more resources thanmaize. However, this was not observed. It thus begs a question of what factor relationship do farmers consider when allocating resources to competingenterprises? To answer this questions, this study was carried out with the aim of determining the trade-offs in competitive dairy and maize farmingsystem inUasinGishucounty. It was hypothesized that that there was no scale economies and cost complementarity between dairy and maizeenterprises.

Region

UasinGishuCounty lies between longitudes 34 ^{o} 50' and 35 ^{o} 37' east and 0 ^{o} 03' and 0 ^{o} 55' north. The county shares a common border with Trans Nzoia district to the North, Marakwet and Keiyo districts to the east, Koibatek district to the South and Nandi North and Nandi South to the West and Lugari to the northwest. It covers an area of 3,327 km2. Arable land covers 2,995 km2, water mass covers 23.4 km2 and urban area covers 186.9 km2.On average the county receives 900-1200mm of rainfall per annum. The average annual temperature ranges from 8.4^{0}C to 26.1^{0}C with a mean of 18^{0}C. The district is described as highland plateau with gently undulating plains that range in altitude from 2700 m.a.s.l at Timboroa in the east to about the sea level at Kipkaren in the west.Thecounty has a population of 882,342 as at 2015 having increased.

Materails and methods.

Sampling and Samples Design

The study used a combination of multistage, systematic and purposive sampling technique to select 135 famers from three divisions that were selected randomly. The three divisions were wereAinabkoi, Kesses and Kapseret. From the divisions, 45 sub-locations and three, 3 households from each were selected randomly with the help of frontline agricultural extension officers. Data was then collected using pretested questionnaires. The data collected focused on monthly factor requirements and production for mixed dairy and maize enterprises over a whole production year. The information required included quantities and costs of all variable inputs, production levels for maize, other crops and dairy practices. Separate summary forms were developed to record all capital items including human capitals for each firm. In addition to cross sectional data, time series data was used. Actual price and yield information for the study area was sought from the local district agricultural offices i.e. farm management section. Additional information was obtained from the farm management division of the Ministry of Agriculture and existing publications and journals. All these helped in ensuring that the data used for analysis was accurate and could be easily compared after developing both input and output price indices.

Data Analysis

Model Specification

This study assumed that decision-makers minimize a well-defined but unobserved shadow cost function subject to unobserved shadow input prices. The inputs are defined as variable factor X_1, labour X_2 capital $X_3$and land $X_4$are variable. The cost function C is assumed to be a function of shadow prices.

$$\ln C = a_0 + \sum_{r=1}^{2} a_r \ln Y_r + \sum_{k=1}^{4} b_i \ln W_I + \frac{1}{2}\sum_{r=1}^{2}\sum_{s=1}^{2} d_{rs} \ln Y_r \ln Y_s +$$

$$\frac{1}{2}\sum_{j=1}^{4}\sum_{k=1}^{4} f_{ij} \ln W_i \ln W_j + \sum_{r=1}^{2} \sum_{i=11}^{4} g_{ri} \ln Y_r \ln W_{ii}^{t} \quad \text{……………………….. 1}$$

Where C is cost, $Y_r$or (Y_s) is output of r (or s), W_i (Wj) is the price of input I (or j) and t is an index of time.

Trans-logarithmic cost function approach is used in this analysis. Factor use was normalized by one output maize and this improved the function making it a better approximation of the distance cost function. The limitation of the improved cost function are high degree of collinearity, it is an approximation over a non-specified region and has weak econometric properties of the Taylor series. The function is however flexible, twice differentiable and gives robust results. Production trade-offs were obtained by evaluating the resulting parameters relative to the output prices of 2007/2008. The relationship between the output levels and the returns from the two enterprises was evaluated when the factors responsible for productivity are changed. The impact of the resultant changes on the indicators of production trade-offs gives an insight about the gained and lost opportunities which are the proxies for economic trade-offs. t-statistics was used to evaluate the significance of these changes when different factors influencing productivity growth are altered.

Thecross partials derivatives of the cost function must be equal. This implies the symmetry restrictions.

$$d_{rs} = d_{sr} and \;\; f_{ij} = f_{ji} \quad \text{…………………………………………………….. 2}$$

Moreover, as a Taylor's series approximation to an arbitrary cost function is defined relative to a specific point of expansion, the cost function was approximated by defining all variables around their 2007/2008 values.

The cost function is constrained to be homogeneous of degree one input prices so as to ensure that, when all input prices are changed by k per cent. For the translog cost function, this requires the restrictions

$$\sum_{i=1}^{4} b_i = 1; \sum_{i=1}^{4} f_{ij} = 0(j = 1,....,4); \sum_{i=1}^{4} g_{rii} = 0(r = 1,2); \quad \text{……………………….. 3}$$

If (1) is estimated on its own it is likely that parameter estimates are not be efficient due to the high correlation between many of the cross-products among explanatory variables. Hence, to reduce this problem and to use additional information without introducing new parameters, the cost function is estimated jointly with the cost-share equations for each input and the revenue share equation for each output.

Assuming cost minimizing input levels (X) are chosen to produce the observed output volumes (and using Shepherd's Lemma) whereby $\partial C/\partial W_I = X_I$ and thus $\partial \ln C/\partial \ln W_I = (\partial C/\partial W_I(W_I/C) = W_I X_I/C = S_I$, where S_i denotes the cost share of input i), partial differentiation of (1) with respect to in W_i yields the cost share equations:

$$S_I = b_i + \sum_{i=1}^{4} f_{ij} \ln W_J + \sum_{i=1}^{2} g_{rii} \ln Y_R (I = 1,...,4) \quad \text{………………………….. 4}$$

Since the sun of Si =1, which requires the same restrictions given in 3.12 above as does linear homogeneity of the cost function in input prices, only three of the four cost share equations in (4) are linearly independent.
Assuming profit maximizing behaviour with marginal –cost pricing for the products (so that $\partial C/\partial Y_r = P_r$ and thus that $\partial \ln C/\partial \ln Y_r = (\partial C/\partial Y_r)(Y_r/C) = P_r Y_r/C = R_r$ where R_r denotes the revenue share of product r), partial differential of natural log of cost with respect to $\ln Y_r$ yields the revenue share equations.

$$R_r = a_r + \sum_{i=1}^{2} d_{rs} \ln Y_s + \sum_{i=1}^{4} g_{rii} \ln W_i (r = 1,2) \quad \text{……………………………………….. 5}$$

The revenues share equation does not need to add up to unity since revenue may differ from cost in the short run.

Results and Discussion

Gross Margin Analysis

Gross Margin analysis was done to determine the returns to resources invested in the dairy industry in the study area. The elements included in the Gross margin analysis are shown in Table 16 shows the results of Gross Margin Analysis in the study area.

Table 1: Gross Margin Analysis at sample mean US $)

Enterprise	Dairy	Maize
Total Revenue	1319.	810.
Total Variable Cost	360.	222
Gross Margin	959.	727.
Total Fixed Cost	539.	284.
GM/Labour	7.2	9.2
GM/Variable Cost	2.7	3.2
Profit	599.	505.
Profit	13,9*	9,0.**

* Profits per cow per year and *** yield per acre per year.

Source: Author's Data 2009

The Gross Margin figures in dairy is higher than Maize. The returns to investments do not show the same trend. The Gross margin per unit of labour in Maize is higher than that in Dairy while GM/unit of variable cost is greater than that in dairy. This result is an indicator that there could a significant difference in the returns realized each enterprise. The efficiency of input use could also be different in the two enterprises. From Table 1 it is clear that the variable costs incurred by farmers in Maize are lower than that in dairy. This resultant difference in gross margins and profit levels thus depends on the efficiency of resource use. Similar results had been presented in earlier studies Otieno (2009).

Looking at Returns per animal in Table1, the expected mean annual returns per cow/year of in Dairy (US$. 13. 9) higher than that in Maize (US$ 90). This shows that dairy is a more lucrative enterprise than Maize enterprise and it is an incentive for increased allocation of more resources to it.

Production Structure

The marginal costs of the aggregated factors of production and the goodness of fit of the parameters involved were determined. In addition to the levels of maize and dairy output, land, labour, intermediate factors and capital are estimated. The coefficients of the factors and inputs are used to determine factor flows between the two enterprises as well as their expansion potential (Glass and McKillop 1978; Forsund et al, 2005).
Using OLS technique, the coefficients of the variable cost function were estimated using the logarithmic form of the Cobb-Douglas production function. The coefficients derived were used as proxies for the correlation evaluations.

Table 1.18 Estimates of Cost structure using a Cobb Douglass function in UasinGishu

INDEPENDENT VARIABLES	COEFFICIENTS	STANDARD ERRORS	T-RATIOS
CONSTANT	2.499	0.854	2.926
ln w_1	0.043***	0.02	2.199
ln w_2	0.019***	0.01	1.966
ln w_3	0.22***	0.022	10.128
ln w_4	0.614***	0.056	10.878
lny_1	0.07	0.116	0.599
lny_2	-0.07	0.145	-0.482
R	0.898		
Adj R	0.787		
R^2	0.806		
F STATISTIC	42.829		0

Where ln natural logarithm,Y_2Dairy output,Y_1 Maize output,W_1 land, W_2labor input, W_3variable factor and W_4 capital. *** significant at 10%.

The results show that the marginal costs of the factors of production are all significantly related to the costs of production with the factors explaining 89.9% of the total cost. An increase in the level of use of all the above variables except for the level of dairy output would lead to increases in the total cost of production. All the variables except the levels of output of dairy and maize have a significant impact on costs of production. While the both enterprises show homotheticity in functions with the estimated marginal costs showing that maize production is elastic and dairy is inelastic. The second stage involve the generation of the parameters of the cost function.

Table 1.19

	Unstandardized		Standardized		
	B	Std Error	Beta	t	Sig P
constant	-1.806	8.095		-0.223	0.824
ln W_1	0.172	0.232	0.519	0.74	0.463
ln W_2	-0.082	0.123	-0.495	-0.666	0.509
ln W_3	0.139	0.234	0.371	0.592	0.557
ln W_4	-0.1	0.488	-0.111	-0.206	0.838
ln Y_1	0.707	1.108	0.862	0.638	0.527
ln Y_2	0.648	1.746	0.634	0.371	0.712
lnW_1lnW_1	0.023	0.011	0.45	2.004	.051***
lnW_1lnW_2	0.01	0.006	0.3	1.842	0.072
lnW_1lnW_3	0.055	0.015	-0.911	-3.617	.001***
lnW_1lnW_4	0.028	0.044	-0.487	-0.64	0.526
lnW_2lnW_2	0.023	0.003	0.664	7.341	.000***
lnW_2lnW_3	0.001	0.005	-0.034	-0.245	0.807
lnW_2lnW_4	-0.014	0.018	-0.466	-0.801	0.428
lnW_3lnW_3	0.128	0.013	3.188	9.92	.000***
lnW_3lnW_4	-0.185	0.034	-0.2744	-.5.492	0
lnW_4lnW_4	0.148	0.048	1.788	3.07	.004***
lnY_1lnW_1	0.018	0.032	0.322	0.555	0.582
lnY_1lnW_2	-0.014	0.032	-0.502	-0.439	0.663
lnY_1lnW_3	-0.006	0.063	-0.1	-0.093	0.927
lnY_1lnW_4	-0.204	0.187	-2.118	-1.091	0.281
lnY_2lnW_2	0.019	0.041	0.718	0.479	0.635
lnY_2lnW_3	0.026	0.078	0.446	0.333	0.743
lnY_2lnW_4	0.208	0.202	2.049	1.028	0.309
lnY_1lnY_2	0.038	0.087	0.548	0.438	0.664

Key. W_1Land , W_2Labour, W_3Variables , W_4 Capital , Y_2 Maize ,Y_1Dairy

The cost function model consisting of equations 1, 4, 5 with restrictions 2, and 3 imposed acrossthe equations was estimated using annual data for the production period 2006/2007. As noted, in the estimating model, the cost share equation for the land was deleted. The economic significance of the parameter estimates lie in the fact that they enable the extraction of measures of elasticities of factor substitution, elasticity of factor demand, economies of scale and technical change. The b_{ij} have no explicit economic interpretation.

In order for the translog function to be adequate representation of the underlying production structure, the estimated cost function must be monotonically non-decreasing in input prices, and outputs and it should be concave in input prices over the range of observation. Monotonicity is satisfied if the fitted cost share and the fitted revenue share s are positive. Concavity is satisfied if the Hessian matrix is negative semi definite.

Computation of cost share equations using parameters in Table 1.19 and following the approach of Glass and McKillop (1978) indicated that monotonicity and concavity was satisfied for all observations. In addition to the above regularity conditions being satisfied, the model fitted the data quite well, as measured by the appropriate R2 and F statistics for the system of equations with an R^2 =0.982 and $F_{25,43}$=95.6 respectively. The R^2 for individual equations are 0.73, 0.51, 0.81, and 0.93 for S_1, S_2, S_3, S_4, and 0.97 for R^1 and 0.789 for R^2. These results are quite encouraging as the translog models often yield very poor fits for cost share equations (Glass and Mckillop 1991).

The Table 3 also shows that 7 of the 25 interactions are statistically significant at 10% in explaining the cost of production in the mixed farms with 5 being significant at 5%.these estimates imply that the f_{ij} have a unitary elasticity of substitution. However, the t-values in the table may be exaggerated due to interdependence of the error term over time.

Table 4 shows the Allen partial elasticity of substitution is defined as the % change in the ratio of inputs that arise following a 1% change in the ratio of prices (Thomson, 1996).

Table 4 Allen partial elasticity of substitution.

	Land	**Labour**	**Variables**	**Capital**
Land	-5.8441222	0.7153248	-1.0878428	0.9363901
Labour		-2.3034052	0.8090593	0.8914094
Variables			-5.401067	-0.400383
Capital				-1.8682217

Source; authors data 2009

As shown by Binswanger, (1974), Thomson (1996) and Chirsters and Featherstone (2007), the Allen partial elasticities of substitution between inputs i and j can be obtained directly from the parameters of the cost function by the equations below.

$$s_{ij} = [(\partial^2 C / \partial W_i \partial W_j)(C)] / [(\partial C / \partial W_i)(C(\partial C / \partial W_j)(C))] \ldots\ldots\ldots 6$$

which in the translog case yields

$$\hat{s}_{ij} = \left[\left(\hat{f}_{ij}\right) / \left(\hat{S}_{ij} \bullet \hat{S}_{ij}\right)\right] + 1 \qquad (i \neq j) \ldots\ldots\ldots 7$$

The hats indicate the estimated values. In the case where i=j

$$s_{ii} = \left[\hat{f}_{ii} + \hat{S}_i\left(\hat{S}_i - 1\right)\right] / \hat{S}_i^2 \ldots\ldots\ldots 8$$

In equation 7 above, the elasticities are symmetric and the s_{ij} are positive for substitutes and negative for complements. These equations were utilized to compute partial elasticities between inputs. Table 5 shows the estimated elasticities at the sample means. The degree of substitutability between the factors whelps to determine the potential factor flows and the best production strategy is one of the least cost of production.

Table 5 Factor Relationship.

Factor combination	Fij	Factor share	Factor share	Partial elasticity of substitution	Factor relationship
Labor-land	-0.01	0.134281	0.314428	1,243	Substitutes
Labor-capital	- 0.014	0.134281	0.199973	0.48	Substitutes
Labor –variable fa.	- 0.001	0.134281	0.351623	0.98	Substitutes
Land-capital	- 0.028	0.314428	0.199973	0.568	Substitutes
Land-variable fa	0.055	0.314428	0.351623	1.59	Substitutes
Capital –variable fa	- 0.185	0.199973	0.351623	-1.63	Complements

Source Authors data 2009

The Table 5 shows substitutability between labor and land, labor and variable factors, capital and land, while complementarity is observed in the relation between and capital and variable factors. These observations are valid for cross sectional data and can be explained by the fact that as land becomes small, labor is normally used to harvest fodder, silage and feed supplements for the farmers with dairy animals. Equally, large tracts of land require that more labor. Increasing population, pressure on land has made the number of agricultural activities on them to decrease. This makes labor intensive means of production have become quite important particularly in dairy farming. The maize farms on the other hand are decreasing in size and the once large tracts of land under maize have become fewer in UasinGishu. Where farm households experience shortage of manpower, they use machinery. The shelling, transportation, and harrowing in addition to the handling of the large outputs of maize require that manual labor work hand in hand with machinery. As such, it is important to note that increased productivity and use of machinery is associated with high labour cost. Capital and labor thus become complements this is further supported by the inverse relationship that exists where small pieces of land have fewer people to work on them intensively leading to high productivity while large tracts of land have a smaller family membership to oversee the work on the farm.

The use of herbicides and pesticides in the study area greatly reduces the need to hire casual laborers to weed. This illustrates elements of substitution to a great extent. Herbicides and pesticides fall under the variable factor category and are thus substitutes for labour. This is well supported by the study results.

In the study region, there has been an increase in land area for cultivation and rearing animals. This has resulted in higher output levels for both maize and dairy. There was a marked increase in the level of output maize were unlike for dairy. This could be attributed to availability of fertile land that was originally under tree crop. Alternatively, overused land requires that more of the fertilizer be used to replenish fertility of the soils. Production land thus becomes a substitute for the variable production factors. Capital can be used alongside variable factors and as such they are complements.

The observed relationship holds for UasinGishu since land is owned by the farm families whose working owners providing most of the labor input. The ownership structure explains the high levels of investment in UasinGishu where farming is treated as a commercial enterprise. Increasing factor costs has also made the investment in factor use to be low and this accounts for the low proportion of the total cost attributed to variable factors, high proportion of capital on farm.

Table 6. OWN AND CROSS PRICE OF FACTOR DEMAND BETWEEN INPUTS

	Labor	Land	Capital	Variables
Labor	-0.69522	0.21307	-0.091392	0.284308
Lad	0.236973	-0.69641	0.231098	0.353916
Capitaln	0.064128	0.138853	-0.2242	-0.32544
Variables	0.105043	0.111969	-0.17136	-0.22058

Source author's data 2009

Depending on the model used, it is possible to derive elasticities both in the long run and short situations (Johansen *et al* 2001), Fare and Primont, 2001, De Koning*et al* 2003, Nerlove 1956, and Lovel 2001). Own price elasticities and cross price elasticities of input demand at sample mean are presented in the table above. The e_{ij} are positive for substitutes and negative for complements.

$$\hat{e}_{ii} = s_{ii} \hat{\bullet} \hat{S}_i \text{ and } \hat{e}_{ij} = s_{ij} \hat{\bullet} \hat{S}_j \quad \text{----------- } 9$$

Where the e e_{ii} and e_{ij} are own and cross price elasticities
Table 6 shows that all the e_{ii} have the correct negative sign. They are all less than one and statistically significant. All point estimates of elasticity of demand for labor are less than unity and the absolute value lies between 0.21 and 0.7. The demand for capital is all inelastic. This shows that farmers always require these factors for improved production. The same pattern of substitution is portrayed by the relative factor shares. The demand for variable factors was quite inelastic during the period of study. This means that farmers in UasinGishu cannot do without fertilizer in their farms.

Economies of Scale and Cost Complementarity

The overall economies of scale exist if an increase in all output by some λ per cent leads to a cost increase less than λ per cent. The overall scale economies can be measured by the inverse of the sum of elasticities with respect to outputs. Scaling models had been used in studies using derivatives from the translog functional form, by Hansen and Jones (2008). They expressed scale economies as

$$SE = \left[\sum_{r=1}^{2} (\partial \ln C)/(\partial \ln Y_r)\right]^{-1} = \left[\sum_{r=1}^{2} R_r\right]^{-1} \quad \text{……………….} \quad 10$$

SE= Scale economies, C= cost, Y=output Y, R = revenue

Using this approach, this study found the existence of scale economies in mixed dairy and maize farms. The implication is that output levels can be increased with the benefits of the associated decrease in the cost of production. The overall economies of scale worked out to be less than one and were significant. The average value worked out to be 0.79524. This implies that if all outputs are increased by 1% the cost will increase by 1.8%. This result is expected since the production system in UasinGishu where farms are small and with high levels of input use resources are wasted. Based on the specific enterprises, the overall scale economies are 1.3 for dairy and 0.55 for Maize. This implies that there is a potential to increase dairy output by increasing the factor use levels while in maize farming increase in output is associated with increased use of more factors will lead to increase in the production costs. A 1% increase in output for dairy farming will be associated with a 0.77% increase in costs of inputs. This in actual sense is beneficial to the farmers. For maize farming a 1% increase in output level will lead to a 1.92% increase in the costs of inputs. From this it can be concluded the potential to increase dairy productivity is a better option for a farmer faced with a choice between dairying and maize farming. Comparing the relative costs of production, there is a high cost involved in the establishment of the dairy enterprise while the recurrent costs are much lower. The annual variable cost in maize production is higher than the recurrent costs in dairy farming and over a long period of time, the dairy farming might be a paying enterprise for small hold farmers since the structure of farming in UasinGishu area is changing with increased influx of settlers in the area. Further to this maize farming has a high requirement for labor a factor that contributes to high levels of consumption of maize products in the farm as well as a significant increase in the cost of production. This is evident in the regression results for the relationship between the cost of production and the factor use levels which shows that a 1% increase in the use of additional labor leads to a 4.3% increase in the cost of production

Based on the foregoing discussion, the study estimated the potential to increase production for both dairy and maize using their revenue share equations. The results imply that the potential to increase dairy output is almost 2.5 times that of maize. For rational farmers, dairy enterprise is more paying than maize and as such, there is need to use more resources in this enterprise assuming perfect factor substitutability,

Cost complementarity was evaluated using equation 11 below. Complementarity between two products is defined as the extent to which the marginal cost (MC) of one product is influenced by the output levels of the other product. Mathematically, this is expressed as the derivative of the second order cross partial of the cost with respect to the two outputs.

$$CC_{dm} = \partial MC / \partial Y_{M2} = \partial^2 C / \partial Y_1 \partial Y_2 \quad \ldots\ldots\ldots\ldots 11$$

With no cost complementarity between the two products the equation yields

$$CC_{dm} = \partial C / \partial Y_1 \partial Y_2 = 0 \quad \ldots\ldots\ldots\ldots 12$$

This can be presented in the translog function as

$$CC_{12} = C.(d_{12} + R_1 R_2) / Y_1 Y_2 = 0 \quad \ldots\ldots\ldots\ldots 13$$

Thus with the equation below and at

$$CC_{12}=0 \text{ when } d_{12} = -R_1R_2 \quad \ldots\ldots\ldots\ldots 14$$

At 95% confidence interval, d_{12} was found to be -3.244 (0.694). Compared with R_1R_2, the two figures are significantly different from zero therefore there exists a cost complementarity between the two enterprises. With R_1R_2 being 1.797, its sum with d_{12} is less than zero. This would imply that as the marginal cost of dairy production increases, the output levels for maize declines. The implication of this is that there is jointed ness in production between these two enterprises. Resource use under joint production is evaluated for aggregated data Stoovgel et al 2002). Farmers with multi input multi output production portfolios aim to lower risks and obtain higher returns Omamo 1998, Tew*et al* 1992Binghan 1992, Gesimba

2005, Nyangito 1996, Otieno, 2011) Resources can either be used to produce one product which could in turn be used to produce another one e.g silage from maize products can be used to produce dairy products and the manure from dairy can be used to fertilize the fields. However, if more resources are used to produce dairy, limited will be available for maize production and hence the decline in output.

Conclusion and Recommendation

This study explored the competition between dairy and maize farming for the factors of production in a rapidly changing production environment and farmers production decisions based on potential benefits and losses which they have to accept. The study found that maize is an increasing cost industry while dairy is a decreasing cost industry implying that expansion of the dairy farming is associated with a substantial decline in production cost suggesting the existence of scale economies signifying the existence of a significant potential to increase dairy farming through reduction of land. The estimated elasticities of substitution indicate that there is scope of substitution between labour and land. Capital and variable factors, land and capital and variable factors and finally capital and variable factors. Estimated own and cross partial elasticity of substitution are statistically less than unity implying that the demand for capital, variable factors and land are highly inelastic over the sample. The overall scale economies shows that that costs will increase more than increase in output implying diseconomies of scale. However, there is scope to expand dairy production which has higher returns to farmers' objective of revenue maximization relative to maize whose contribution is much lower. The risk levels in maize are much higher than those of dairy although when the two enterprises are combined, their risk levels reduce. This implies jointedness in production.

On the policy front, this study recommends

1. The integration of dairy and maize as a cost reduction strategy. This is because of the high degree of factor substitution in the enterprises and complementarity where the costs are high. Like most of the expensive factors capital and the variable category are complements while the other factors are substitutes.

2. Facilitate the access to farm capital factors like machinery and farm chemical by promoting increased access to cheap credit by the farmers. While dairy is a reducing cost industry, maize is an increasing cost industry. It is also notable that the high degree of factor substitutability would also favour integration since resource can interchangeably be used in the two enterprises without high additional costs.

3. However, it is suggested that the precise rate of factor flow between the two sectors be established so as to assist farmers in estimating the anticipated returns at any point in time.

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