ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

THE SOCIO-ECONOMIC FACTORS IN MILK PRODUCTION AND THEIR CONTRIBUTION TO TRANSACTION COSTS IN MILK MARKETING IN KENYA'S NORTH RIFT

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Manuscript Info

Manuscript History:

Received: 22 November 2013
Final Accepted: 29 December 2013
Published Online: January 2014

Key words:
Socio-Economic Factors, Milk Production, Contribution, Transaction Costs, Milk Marketing, Kenya, North Rift.

Abstract

The study aimed at assessing marketing constraints faced by small-scale dairy farmers in Nandi North and Uasin Gishu districts. This paper examines the socio-economic factors that depress milk production in the two districts. A combination of multi-stage, simple random and systematic random sampling methods was used to select the district and small scale dairy farmers, where 270 respondents were interviewed using structured questionnaires and interview guides. The results indicated that a good education, more dairying experience, proximity to a cooler/milk collection centre, and ownership of a means of transport reduced transaction costs, enabling farmers to sell milk in more formal channels. Further, good roads, residing in Uasin Gishu rather than Nandi North, owning a bank account, cooperating with large-scale farmers, using a phone in dairying and access to electricity by a household were also associated with selling milk in more formal channels. Ordinary Least – Squares regression showed that the socio-economic factors that reduced milk production were poor animal breeds, lack of feed supplementation, and poor health care of the animals. It is recommended that due consideration be given to the development of a better physical and institutional infrastructure which would effectively link these producer areas to markets and improve market knowledge by providing relevant market information and farming skills. The study gives guidelines to serve as a point of reference for further research in the dairy industry in general, and any milk marketing in a particular.

Introduction

Several studies have dealt with the effects of transaction costs on market participation by farmers in developed and developing countries. According to Hirsh *et al.* (1996), there are two main approaches to assessing transaction costs. First, as explanatory (independent) variables explaining the behaviours of a certain production unit or form, as prescribed by Williamson (1985a), and secondly as a response variable affected by various factors, as explained by North (1997). Given the nature of transaction costs, which at times are unobservable, many studies dealing with these costs use household characteristics to assess their impact. This is possible because market failure is household-specific (Goetz, 1992) as well as commodity-specific (Delgado, 1999). Transaction costs revolve around market information and the institutional selling around it. These costs are thus associated with the lack of, or access to, various sources of market information.

A review of the studies on the effect and impact of transaction costs on households and the subsequent institutions adopted to lower them shows mixed results. This may be explained by the nature of transaction costs under investigation. On the basis of existing research, however, it is evident that market participation ultimately determines the level of income generated from trade and is influenced by various factors, including physical and institutional infrastructure, and household characteristics. Their effects may be positive or negative, and the actual level of income generated will depend on the level of transaction costs faced by a household. A number of studies in

various parts of the world reflect the relevance of this subject for the market integration of resource-limited subsistence farmers in order to uplift rural standards.

Transaction costs are dominant in input and output markets, whether the focus is on capital (credit), feeds or adopters of technology, land or labour, marketing channels or Market Information. Moreover, ownership of assets and access to market outlets influence the participation in such markets. In many developing countries, small-holder farmers account for the bulk of agricultural production and make up the largest segment of the rural population (Ruthenberg, 1985). The two main features that small-holder farms in the tropics have in common are:

(a) The agricultural work is carried out by the family rather than by hired labour.
(b) The better part of the subsistence requirements of the family are met directly from production on the farm.

These characteristics, combined with generally low levels of productivity, the absence of modern forms of mechanization and the low degree of specialization, imply that the output of small farms in the tropics is limited (Ruthenberg, 1985). Where there is no land scarcity, the lower limit, in terms of available land, is determined by the family's subsistence needs, at the minimum generally between one and two hectares of cultivated land. If development is to be sought in general economic terms and in terms of agricultural and food production, it is these small agricultural units that have to be mobilized on a massive scale. For the mobilization of this capacity, both technical and institutional changes are required (Ruthenberg, 1985).

Marketing studies are primarily geared towards identifying areas for improvement in marketing in order to foster economic development. The empirical finding that many households fail to participate in markets is explained by transaction costs (De Janvry *et al.,* 1994). These costs drive a wedge between household buying and selling prices, which is based on the concept of non-traded goods (Goetz, 1992). Dealing with financial constraints and access to credit by small-scale farmers, Ahmed (1989) has compared transaction costs of borrowing from formal and informal sources in rural Bangladesh. The study established that transaction costs resulting from loans lending were higher than those of loans from formal lenders. The study concluded that transaction cost per unit of loan decrease with loan size, and that this was much faster for formal than informal loans. These conclusions agree with the findings of Cuevas and Graham (1986) and Chung (1993), in which borrower transaction costs were found to be the primary reason in the choice of credit sources by farmers. Similar observations were also made in the study of the informal finance sector in Malawi (Chipeta & Nkendawire, 1996).

Zaibet and Dunn (1998), in looking at the use of fertilizer, mechanization and labour, have used size and ownership of land, number of plots, district location, and existence of annual crops as proxies for transaction costs. They investigated the assumption that larger family ownership systems, as opposed to restricted family ownership systems, and farm size are the main factors for increased risk aversion and transaction costs in market participation. The study found that only the nuclear family has a significant and positive correlation with the purchase of fertilizers. With respect to mechanization and labour hiring, the estimate of ownership was positive but not significant. A large farm size was found to significantly and positively correlate with mechanization and labour use. According to Strasberg *et al.* (1999), the use of fertilizer nutrients depends mainly on the distance to tarred road, assets such as the value of agricultural equipment owned, value of the livestock owned, and human resource factors.

Several studies have examined the effect of transaction costs on output markets in the sub-Saharan Africa. Goetz (1992) has studied household grain marketing behaviour in Senegal by separating the decision of whether or not to participate in markets from decision of how much to sell or buy, conditional or participation. The study identified important variables reflecting transaction costs which affected coarse grain marketing behaviour of rural households, in Senegal. Fixed transaction costs proxies included, among others, variables such as the ownership of a cart for transporting goods to the market, physical distance from the market, ethnicity and age of the household head. The study found that the probability of buying, and the quantity bought and sold are influenced by the grain price. However, other factors, such as better market information, significantly raise the probability of market participation of selling households, while access to coarse grain processing technology significantly increase quantities sold by sellers. In regions with thin markets, it is costly (time consuming) to discover trading opportunities. Similarly, poor market access due to lack of transport, distance and barriers such as ethnicity and languages, increase a household's cost of observing market prices to make transaction decisions (Goetz, 1992).

Adopting the same line of investigation as Goetz (1992), Key *et al.* (2000) have evaluated market participation for maize in Mexico. Fixed and proportional transaction costs were found to play a significant role in explaining household decisions. The proportional transaction costs were more determinant in the selling than the buying decisions, with selling through official outlets significantly increasing the production and selling capacity for the sellers. The study also shows that the ownership of a pick-up truck is associated with a lower production threshold, implying that ownership of assets tends to reduce entry obstacles into the market.

Holloway *et al.* (2000) have identified various techniques for an effective participation by peri-urban milk producers in the Ethiopian highlands. Their findings suggest that in order to promote entry into the market, institutional innovation should be accompanied by a mix of various factors, including improved physical infrastructure, knowledge and market information, and asset accumulation in the household. In addition, they suggest that by locating potential buyers, the time required to market milk could be minimized, thus increasing the number of participating producers and the level of marketable surplus. These findings are in line with what Staal *et al* (1996) have reported, that transaction costs increase with distance, most likely faster than could be expected from simple transportation costs. This is caused by the increased costs of information and risk of wastage or spoilage when a buyer is not found in time.

Staal *et al.* (2000) have used GIS-derived variables for distance and transport costs together with survey-derived variables for household characteristics to model market participation and the formation of farm level milk prices. Differences were made between the effects of roads by type and distance which pointed to the importance of milk production density and the state of market infrastructure.

A transaction cost approach has also been used by Omamo (1998) in determining that household devoted their resources to low-yielding food crops than to cash crops with higher market returns in Siaya district of Kenya. The results indicated that transport costs are the main determinants in the cropping and selling choice whereby relatively more land is devoted to cash crops and less to food crops when the households are closer to markets. Similar results have also been found by Fefchamps (1992) on food price volatility and rural market integration.

The study concluded that while better roads and transportation seem to equalize price movements across a larger regional market, the food prices are increasingly dissociated from local supply and demand conditions. Minot (1999) has also found that transaction costs, especially transportation costs, not only decrease market surplus but also substantially reduce the elasticity of supply and demand.

The transaction costs approach has also been applied in the choice of marketing channels in rural England (Hobbs, 1997). The study reported that transaction cost variables, including grade uncertainty, risk of not selling and time spent at auction, are the important factors determining the choice of either live-ring auction or direct-to-packer sales. Garbre-Madhin (1999) has assessed the output market by investigating transaction cost factors which determine the choice of market institutions, such as grain brokers in Ethiopia. Traders first determine where to trade and then choose whether to use a broker or search for customers. The study concluded that high transaction costs shown by traders' individual rationality in selecting brokerage is linked to increased broker use, while higher social capital reduced the use of brokers. Minten (1995) has examined the price transmission and transaction costs in a liberalized food marketing system in Zaire. The focus was on search and uncertainty as underlying causes of transactions. A model incorporating uncertainty of input costs in the marketing margins was used to explain why producer prices decrease faster than transportation costs increase for every kilometre travelled. Using a transportation cost and producer price share function for the trader, it was shown empirically that this effect holds especially on dirt roads and less on paved roads and rivers.

Frank and Henderson (1992) have analyzed vertical coordination in the United States food industries and their findings support the hypothesis that transaction costs are a primary motivation for vertically coordinating via non market arrangements. The authors concluded that the most influential transaction cost factors were related to uncertainty, input supplier concentration, assets specificity and scale economies. Comparing vertical coordination measures that only capture product flow inter dependencies with other specifications that incorporate coordinating methods as well, revealed the importance of non market exchange mechanisms in reducing transactional inefficiencies.

High value products in developing countries tend to be subject to very high transaction costs for market entry by small holder producers. These high transaction costs vary across rural households as they are based on differential access to assets and information (Delgado & Siamwalla, 1997). To some extent, Delgado and Siamwalla (ibid.) have noticed, this is true outside Africa as well, except that the institutional base for reducing these costs is especially weak in economies at early stages of agricultural transformation. Farm enterprise diversification through the process of investigating promising tradable agricultural outputs seems a necessity for both growth and equity, through agricultural research, infrastructure investment, and appropriate institutional development.

Coulter (1994) has examined the liberalization process in marketing cereals in sub-Saharan Africa and observes the following constraints: inadequate roads and vehicles, lack of availability of trade credit and storage for chemicals, lack of market information, unsupportive legal framework legal frameworks and unwillingness of influential sections (i.e. politicians, elite) to formally support market liberalization.

In most of the developing countries, many agricultural households produce a significant portion of the staple food that they consume. This is the case for a wide cross-section of geographical locations, levels of technological advancement, and land tenure arrangements. How these semi-subsistence households allocate output of staple foods

between home consumption and market sales is an issue that has received considerable attention from economists because of its important implications for aggregate market supply, food disappearance patterns, and the nutritional consequences for rural and urban dwellers (Renkow, 1990).

Critical Issues on Dairy Farming and Milk Marketing in Kenya

Nandi North and Uasin Gishu dairy farmers, like those in the rest of the country, can sell their surplus milk either in formal or informal channels. Informal channels include selling milk at the farm gate, to their neighbours or hawkers who visit the farmers. Formal channels include selling milk to cooperative societies, milk bars in town, and to milk processors. There are various patent benefits associated with selling milk formally rather than informally, such as higher milk prices, regular monthly incomes, and ability to obtain substantial credit. Despite clear advantages of selling milk via formal channels, it has been observed that a large proportion of dairy farmers in Uasin Gishu and Nandi North sell milk through informal channels. This paper hypothesizes that one of the explanations for this situation could be that the farmers selling milk informally could be facing huge transaction costs associated with selling milk in more formal channels. This is because one of the major problems arising is the cost of arranging exchange that may reduce or even prevent exchanges from occurring. Transaction costs include the costs of searching for and screening trading partners, bargaining with potential trading partners to reach an agreement, and transferring (transporting, processing, packaging and securing title) the exchanged products, monitoring the agreement to see that its conditions are fulfilled and enforcing the exchange agreement (Staal *et al.*, 1997). Hence, it is necessary to examine whether or not transaction costs could be preventing some farmers from selling milk in formal channels. Little is known about the effect of transaction costs on marketing of milk by the rural poor, their predisposition towards exchange, and the institutional framework that may impact on these costs. Given the necessary data, there is enormous scope for empirical inquiry around these themes and the use of modern techniques to derive sound policy conclusions.

Dairy farmers in Kenya produce milk under three main production systems: grazing, semi-zero grazing, and zero grazing systems (Karanja, 2003; Lanyasunya *et al.*, 2006; Staal *et al.*, 1998). These three systems have been noted to produce different volumes of milk per cow. Since milk is a highly perishable and bulky product, it implies that when its quantity increases, it also results in an increase in variable transaction costs associated with its marketing. In addition, for farmers to obtain good returns from selling their milk they must elevate the quantity of milk produced by their animals. This paper also hypothesizes that if farmers could sell more of their milk (because they are producing more), they could help reduce some of their transaction costs, such as those of transportation, by buying some means of transport, for example, motorcycles, tractors and trucks. Thus, it is crucial to investigate the socio-economic factors responsible for production of little amounts of milk in Kenya.

In summary, understanding the raw milk market structure in relation to transaction costs and the nature of the constraints limiting dairy production is a key policy issue which calls for in-depth research in this area, if the livelihood of small scale farmers in the area is to be improved. This paper, therefore, examines covariates representing factors affecting production, consumption and marketable surplus in order to establish the extent to which they influence milk marketing. The raw milk market structure was also established in order to understand the market opportunities available to small scale farmers.

MATERIALS AND METHODS

The study was conducted in Nandi North and Uasin Gishu Districts, situated in the western part of the Rift Valley Province of Kenya. The two districts are situated at an altitude that ranges from 1300 to 2200 metres above sea level. The districts are endowed with an abundant resource base in terms of arable and fertile soils, water and forestry. The area is classified as being of medium to high potential. The districts' fertile soil has considerable potential for livestock, food and cash crop production. The soil types and distribution vary according to the parent rock from which they were formed but most parts of the districts have predominantly deep soils with high organic matters.

This study employed a descriptive survey research design that enabled it collect requisite information about dairying variables, as they existed within the population. The target population was all the farmers living in Nandi North and Uasin Gishu Districts, who carry out dairy farming and produced marketable milk surplus, that is, farmers who sold at least some of the milk they produced. Multi-stage technique used to divide the research area into progressively smaller units from which respondents were sampled to be employed in the study. Based on the list of dairy farmers in the two districts used in the study, there were proportionately about 55% of farmers from Nandi North and 45% of farmers from Uasin Gishu. Proportionately, about 153 farmers and 125 farmers were randomly selected from Nandi North and Uasin Gishu districts respectively.

Primary data was collected mainly through administration of pre-tested structured questionnaire in the field. From the secondary sources, data such as districts' milk production, country's milk output and consumption patterns, yield per cow, human population size, number of dairy farmers, cattle population, producer and consumer prices as well as types of major milk markets and co-operative societies in the study area were obtained. Secondary data was used to provide background and supplementary information on milk production and markets in the study area. The secondary sources were subjected to general content analysis and provided updates and theoretical insights into the aspects which were studied. A lot of information was sourced from the Dairy Board records and manuals.

Descriptive statistics were used to analyse and present the data. How the socio-economic variables affect milk production and their contribution to transaction costs was analysed using an Ordinary Least Squares (OLS) regression which helped determine the socio-economic factors that could predict low milk production, and therefore, impact of transaction costs involved in the marketing of milk in the study area

RESULTS AND DISCUSSION

Socio-economic Factors causing Low Milk Production

Ordinary – Least Squares (OLS) regression was employed to determine the socio-economic factors that could be used to predict low milk production in the study area. The socio-economic factors conceptualized to affect milk production were the omnibus variable of the production system, farmer biographical factors (education, gender, and age), supplementary animal feeding variables (use additives, silage, Napier, and commercial feeds), and animal health variables (de-worming and tick control). Others were extension services, how animals were served, whether or not farmers were able to obtain credit, and the social factor of cooperating with large-scale farmers. The highest Cook's distance was 0.076 while the maximum leverage value was 0.145, which were less than one and two, respectively. This indicated that no single case exerted undue influence on regression coefficients, hence, there were likely to be no extreme outliers in the data. Thus, no case was deleted from the analysis. Homoscedasticity was examined via several scatter plots and these indicated reasonable consistency of spread through the distributions. Correlations amongst the independents were moderate (maximum 0.842), which indicated that multicollinearity was unlikely to be a problem. The predictors had either moderate or high correlation with the dependent variable, which indicated that the data was suitable for examination through multiple linear regression.

The Regression Model

Since no *a priori* hypotheses had been made to determine the order of entry of the predictor variables, the model was built by the forced entry of all the hypothesised independent variables. Table 1 shows the model summary that was obtained. R is the multiple correlation coefficient between all the predictors and milk production. Since its value ranges between 0 and 1, an R of 0.929 shows that the predictors in the model were highly correlated to the dependent variable. Therefore, the specification of the factors to be included in the model was appropriate.

Table 1: Summary Statistics of the Regression Model

Model					Change Statistics					
	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.929	.863	.855	4.47775	.863	114.441	14	255	.000	1.243

Source: Survey data, 2009

R squared (R^2) measures how much variability in the dependent variable the predictors account for. Of the 14 independent variables entered into the model, nine of them were found to be significant predictors at 5% significance level while the five were not. The R^2 in this model was found to be 0.863, which means that the nine predictors could explain about 86% of the variation in service quality. Since R^2 values above 40% are considered high, this model could therefore explain a lot of the variation in the dependent variable. In other words, we can

predict, to a great degree, milk production in the area by using the nine independent variables. The remaining unexplained variation in milk production could be attributed to the error term in the regression equation.
Adjusted R square provides information on how well a model can be generalized in the population. If this model had been derived from the population rather than the sample, then it would have accounted for approximately 85.5% of the variance in the dependent variable, which is just about 0.8% less than what the model explains.
The standard error of the estimate, also known as the standard deviation of Y about the regression line, was 4.48. Since its value was small, it means that the observed Y-values in this study did not differ greatly from the values on the regression line. The change statistics show the effect of adding or removing independent variables from the regression model. Since the variables in the model were all entered at once (by forced entry), the R square change is equal to the final R square given above. The effect of this change is significant [F (14, 255) = 114.4, $p<0.001$].

The Durbin-Watson statistic shows whether or not the assumption of independent errors is tenable. The value should not be less than 1 or greater than 3. In this model, it was 1.243, meaning that the errors were independent. Table 2 shows the estimated regression coefficients.

Table 2: Estimated Regression Coefficients

Variable (n = 270)	**B**	**SE B**	**B**	**t-value**
Constant	19.804	3.728		5.312***
Production system	-6.098	0.865	-.358	-7.054***
Household education level	0.249	0.072	.114	3.454***
Cooperate with large-scale farmers	2.792	0.947	.118	2.949***
De-worm dairy animals	3.076	0.995	.101	3.092***
Use additives	5.280	1.099	.205	4.802***
Use silage	5.507	1.049	.194	5.252***
Land under Napier	2.003	0.725	.085	2.762***
Use commercial feeds	2.549	1.124	.104	2.269**
How ticks are controlled	2.918	1.270	.124	2.297**
How cows are served	-0.335	0.444	-.021	-0.755
Visited by extension officer	-0.856	0.899	-.026	-0.952
Gender of household head	0.590	0.646	.022	0.912
Age of household head	-0.065	0.041	-.046	-1.586

*****, **** significant at the one and five significant levels, respectively; SE=standard error

Source: Survey data, 2009

Hence, using the constant and the B coefficients for the significant predictors of production system (X_1), education (X_2), cooperation (X_3), de-worming (X_4), additives (X_5), silage (X_6), Napier (X_7), commercial feeds (X_8), and tick control (X_9), an estimated prediction (regression) equation for this model can be written as follows:

$$\hat{Y} = 19.804 - 6.098X_1 + 0.249X_2 + 2.792X_3 + 3.076X_4 + 5.280X_5 + 5.507X_6 + 2.003X_7 + 2.549X_8 - 2.918X_9$$

The partial regression coefficient (B coefficient) indicates the individual contribution of a predictor to a model. The partial coefficient for a variable shows how much the value of the dependent variable changes when the value of that independent variable increases by 1, when other independent variables are held constant. A positive coefficient means that the predicted value of the dependent variable increases when the value of the independent variable increases. The standard partial regression coefficients (β), also known as b-primes, beta coefficients, or beta weights were all measured in standard deviation units and are therefore not dependent on the units of measurement of the variables. The advantage of the standard partial regression coefficients then is that their magnitudes can be compared directly to show the relative standardized strengths of the effects of several independent variables on the same dependent variable. A standardized partial regression coefficient gives the rate of change in standard deviation units of Y per one standard deviation unit of X_k (when all other X variables are kept constant). According to β, the most important factor that determined milk production was the production system employed by a farmer, followed by use of additives, silage, and tick control. The least important appeared to be land under Napier.
The production system had been coded as 0 for zero grazing, 1 for semi zero grazing and 2 for grazing. The partial regression coefficient for production system was -6.098, which is a sample estimate of the population parameter. Since the sign of the coefficient was negative, it implied that when production system increases by one unit (such as moving from semi zero grazing to grazing, assuming constant scale), milk production was likely to reduce by roughly 61%, *ceteris paribus*. Production system was the single most important predictor of milk production, with

the highest milk produced in zero grazing systems, followed by semi zero grazing systems, and lastly, in grazing systems. The likely explanation for the primacy of the production system was that it was an omnibus variable, which subsumed several other variables, such as animal breed, lactation period, food supplementation, land size and herd size. The study revealed that milk yields were the highest in high-grade cows, followed by cross breeds and lastly, local breeds. On the other hand it was found that zero grazing systems were mainly populated by high-grade cows, semi zero grazing systems had a mixture of cross breeds and high-grade animals while grazing systems had predominantly local breeds. Thus, one explanation for the low milk production among some farmers was because they kept local breeds under grazing only systems. Further, the lactation period of the local breeds were found to be the lowest, followed by that of the cross breeds while that of the high-grade cows was the highest, suggesting that keeping more of the local breeds will significantly reduce milk production in a year.

Land and herd size were greatest in semi zero grazing system, followed by grazing system, and lastly, in zero grazing. Ironically, this appeared to suggest that high milk production was associated with less land and herd, typically found in zero grazing systems. These variables appear confounding because from the foregoing arguments, it is not the land or herd size *per se* that matter. What appears to matter is the type of breed comprising the herd and the intensity of care to the animals (which is highest in zero grazing that does not require too much land). This appears to be good news for dairy farmers. Even with the sub-division of land that is occurring in the study area as parents bequeath this resource to the offspring, they can still produce a lot of milk by keeping the right animal breeds and adopting superior husbandry technologies.

For the biographical variables of education, gender and age, only education was found to be a significant predictor of milk production. Like for transaction costs, this suggested that a farmer's education is likely to be more beneficial to a dairy farmer in milk production than their mere chronological age or gender. This salutary role of education in improving milk production mirrors what Matungul *et al*. (2002) found for improving farmer incomes in Kwazulu-Natal, South Africa. This implied that education likely predisposed farmers to be able to learn and apply the best technologies in milk production.

Since its coefficient was positive, cooperating with large-scale farmers improved milk production. In terms of milk production, this cooperation mainly involved observing and learning what the big farmers did. This suggested that low milk production could be caused because of ignorance amongst some farmers of the best technologies of producing milk. This was reinforced by a large proportion of farmers who said that they had never attended any form of agricultural training (61.9%) compared to those who said they had (38.1%).

Perhaps surprising was the finding that being visited by extension officers was not found to be significantly related to milk production ($p > .05$). However, when a univariate ANOVA was conducted to test whether the means of milk production differed among the various categories of 'extension' variables (know name of extension officer, visited by extension officer and consult extension officer), it was found to be significant. The results of the tests were: know name of extension officer, $F(1, 266), 23.85, p < .001$; visited by extension officer, $F(1, 266), 4.24, p < .05$; and consult extension officer, $F(1, 266), 103.22, p < .001$

This suggested that knowing the name of the extension officer, visiting them, and being visited by them was likely to increase milk production. This is because the extension officers could help to improve the technology with which farmers use in dairy industry. The explanation as to why OLS found no relationship between visited by extension officer and milk production was possibly because about 85.2% of the farmers had never been visited by extension officers compared to 14.8% who had. Thus, some farmers produced a lot of milk in spite of the absence of advice by extension officers. However, the ANOVA results above suggest that milk production among farmers could be improved with more advice from these crucial officers.

When milk production was regressed on how cows were served alone, the simple linear regression failed to establish a relationship between the two variables [$F(1,268), 0.195, p > .05$] which confirmed the results from multiple regression in Table 2. However, when a curvilinear regression using a quadratic function was attempted, the relationship between the two variables was found to be significant. This showed that the relationship between how cows were served and milk production was not linear but rather quadratic.

To visualize the relationship between milk production and how cows are served, the means of milk production are shown in Table3.

Table 3: Milk Production and how Cows were served

How cow was served	n	Percentage	Milk produced in litres/day	
			Mean	Standard error
Owned bull	107	39.6	9.16[a]	0.475
AI service	109	40.4	25.96[b]	0.99
Borrowed bull	54	20	4.59[c]	0.39

Means with different letters in a column are significantly different at $p < .05$ by Bonferroni test. n = number of farmers

Source: Survey data, 2009

Thus, farmers who used artificial insemination (AI) produced more than twice the milk produced by those who used their own bulls. Even less milk was produced in cows where the farmers borrowed bulls. AI technology has been found to improve dairy productivity, shortening calving intervals, and improving herd fertility by minimizing breeding diseases while eliminating the costs of keeping a bull (Karanja, 2003). The method used to serve cows was also found to be significantly related with the production system, χ^2 (4, n=270), 195.86, $p < .05$. AI was used exclusively in zero grazing system. In semi zero grazing system, 80% of the farmers used AI, with 17% and 2% using their own bull or borrowing the bull, respectively. In grazing system, about two-thirds of the farmers used their own bulls with another third borrowing the bull. Only two percent of the farmers in this system used AI.

The health variables' coefficients were both significant and positive (de-worm animals, 3.076; and how ticks are controlled, 2.918). De-worming animals had been coded 0 for no and 1 for yes while 'how ticks are controlled' was coded 1 for using community cattle dip and 2 for using an own spray. Thus de-worming animals as opposed to not de-worming and using an own spray to control ticks rather than using a community cattle dip increased milk production by 30% and 29% respectively. Community heath dips may be less effective in controlling ticks because sometimes the acaricide may not be changed as frequently as required, hence failing to kill some ticks. This finding indicates that the good health of the animals is crucial in improving milk production.

A large proportion (81.9%) of the farmers in the study area de-wormed their animals compared to only 18.1% who did not. However, 41.2% carried it out only once a year compared to 21.7% and 37.1% who de-wormed their animals twice a year and once every three months respectively. A significant and positive relationship was also found between the frequency of de-worming and milk production, $F(1, 219)$, 489.9, $p < .001$. Thus, when the number of de-worming times in a year was increased, there was also an increase in the amount of milk produced. Specifically, the means of milk production when de-worming was done once, twice and every three months were 7.9, 15.76 and 29.50 litres/day/farmer respectively. This suggested that the animals were prone to multiple infections or that a single dose of the drug may not be effective in killing the worms, hence, the need for manifold de-worming. The cost of de-worming each animal at any given time was about Ksh 100 and hence the cost can spiral with a large herd size, especially for farmers who keep large local breeds that yield little milk. Thus, not surprising, the frequency of de-worming was found to be correlated to the production system.

Thus, farmers who practiced zero grazing were likely to have the highest frequency of de-worming their animals as opposed to those to farmers who practiced grazing.

The study found 51.5% of the farmers who used community cattle dip to control ticks compared to 48.5% who used their own sprays. The cost of tick control was found to be higher in community cattle dips (about Ksh 15 per cow per session) compared to using an own spray (about Ksh 8 per cow per session). The method of tick control was also found to depend on the production system, with 100% and 98.9% of the farmers practicing zero and semi zero grazing systems using sprays, respectively while 93.9% of farmers in grazing systems using community dips. The study found that farmers in grazing systems were not using sprays either because of the inability to raise the capital to buy the sprays or due to downright ignorance of the ultimate benefits. The latter reason is a sad indictment of the extension services department, whose ability to disseminate pertinent information to farmers appeared to be lacking.

The supplementary animal feeding variables (use additives, use silage, land under Napier, and use commercial feeds) had all positive coefficients, which were significant. Thus, when farmers supplemented the feeding of the animals (the default feeding was grazing on natural pastures) milk production in animals also improved. The vital role that supplementation plays in improving milk production has been found in studies by Karanja (2003), Ongadi *et al*. (2007) and Lanyasunya *et al*. (2006). An average 92.2% of the farmers in the study area were found to use supplementation as opposed to only 7.8% who did not, with Napier being the most prevalent supplement. However, the land devoted to growing Napier ranged from 0.2 acres to 3.20 acres. Commercial feeds such as wheat and maize bran, bone meal, fish meal, blood meal and maize germ were found to be used by only 35.9% of the farmers

compared to 64.1% who did not. Additives, such as molasses and silage, were used by only 29.3% and 21.9% of the farmers. The low usage of supplements, especially commercial feeds, could be ascribed to their high price, which ranged from Ksh 20 to Ksh 50 per cow per feeding session. Again, supplementation was significantly related to the production system. A greater proportion of land was dedicated to Napier growing in zero and semi zero grazing systems compared to grazing systems. A total of 93.5% of farmers in zero grazing system were found to use commercial feeds compared to 72.8% and 0.7% in semi zero and grazing systems. For additives, the percentage of farmers using them was 71, 90.9 and 0.7 in zero, semi zero, and grazing systems respectively. This again demonstrated that farmers in zero grazing systems treated dairying as more of a commercial enterprise and were willing to invest more in it to increase the output of milk production.

The foregoing presentation shows that various socio-economic factors contribute to low level of milk production. Thus, the null hypothesis that socio-economic factors do not contribute to low level of milk production in the study area was rejected.

CONCLUSION AND RECOMMENDATIONS

Dairy farmers in Uasin Gishu and Nandi North districts face considerable variable and fixed transaction costs during the marketing of their milk. This is because variable transaction costs arise from transportation of the bulky and highly perishable milk to the market. The provenance of fixed transaction costs are information costs, the costs of searching for markets, negotiation, bargaining, monitoring and enforcement costs. This is because the milk market is characterized by uncertain prices, opportunistic milk hawkers, infrequency in the participation the market, making farmers have bounded rationality when making decisions

Liquidity constraints were also mentioned as obstacles to farming in the study areas. Income generation through non-farm activities is crucial for investment in agriculture. Employment policies as strategies, therefore, should pay special attention to the factors that permit increased participation in non-farm income activities by at least some members of the households since they would then revisit, or bring in extra income which can be invested in dairy.

To compensate for the lack of formal financial institutions around them most respondents relied on informal sources of credit such as neighbours, relatives and friends. However, some farmers would have preferred to have formal financial institutions as their services of credit. Obviously, this calls for microfinance institutions with programmes to extend loans to resource limited farmers. These farmers do not have the collateral needed to access the financial services in the formal banking sector. Programmes combining savings, business development training, networking and farmer support would be needed.

Further research may also seek to measure returns from investments in physical and institutional infrastructure. This would help clarify even much better the role of transaction costs in influencing the marketing of milk. Such studies can also seek to test more unequivocally the role of some variables that appeared to give confounding results in this study such as the effects of having access to postal services and ability of the farmer to apply for credit.

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