Will Small-Scale Dairy Producers in Kenya Disappear Due to Economies of Scale in Production?

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1. Introduction

Dairy production is a major farm activity in Kenya, where it is regarded as a major smallholder success story, incorporating over 1.8 million smallholder farm households, who produce over 70% of all milk marketed (SDP, 2005). Dairy accounts for about 14% of agricultural GDP and contributes to the livelihoods of many small-scale farmers in Kenya through income, employment and food. Smallholder dairy production has thrived since independence in 1963 owing to supportive subsidized services, and guaranteed milk markets and prices for farmers. Liberalization of the industry in 1992 led to more competitive milk markets, but also reduced access to public livestock services. It also led to growth in informal milk marketing in urban areas, who now account for over 80% of marketed milk. On the demand side, local markets for milk and other dairy products continue to rise, fuelled by rapid population growth and the process of urbanization. . It is projected that by 2010 demand for milk in Kenya will rise to about 5.8 billion metric liters, 15% higher than the projected supply of about 5 billion liters (SDP, 1996). While the increased demand presents an opportunity for farmers, there is concern among development agencies and policy-makers over the ability of the small-scale milk producers to survive the increasing competition with intensive large-scale livestock producers in the urban and peri-urban areas.. To gain insight on the prospects for continued viability of smallholder dairy production activities, a study of the effects of scale and policy factors on dairy production was conducted..

2. Methodology

2.1 Econometric Model

This study adopted an analytical approach in the tradition of Ali and Flynn (1988), Battese and Coelli (1995) and Delgado *et al* (2003)., by estimating stochastic profit frontiers from farm level data with second round estimation of technical efficiency effects that explain the distance of individual farms below the frontier.. The prospects for small-scale dairy producers to remain in business mainly depend on their competitiveness, which may be measured as the ability to produce at a lower unit cost than competitors. Small-scale farmers with relatively high unit costs of production (hence thin profit margins) compared to large-scale competitors may still be uncompetitive, because large-scale firms with thin profit margins can capture adequate returns to labour and investment through greater volume. Higher unit profit is thus a necessary but not a sufficient condition for competitiveness. To circumvent this problem when assessing the impacts of scale on the competitiveness of a farmer, we look at the farmer's efficiency in securing profit per unit of output.

The traditional way of assessing relative efficiency is to estimate a profit frontier across farms and then measure how each farm in the sample lies below the frontier. Conceptually, such a frontier can be thought of as a function mapping profits per unit to relative input and output prices and quantities of non-traded factors of production, where each point on the frontier is the maximum profits per unit that a firm can achieve given those relative prices and access to resources. While numerous methods could be used to estimate the frontier (Fried, Lovell and Schmidt, 1993), the use of a stochastic profit frontier model with technical inefficiency effects following Battese and Coelli (1995) is attractive, as it provides information on how to help improve the market-orientation and competitiveness of small-scale producers, which is thought to be positive for poverty alleviation in rural

areas.. When the locus of the frontier is estimated, the actual performance of a farmer in terms of unit profit can be compared to an ideal unit profit for that farmer given the level of resource endowments and also the prevailing input and output prices. The difference between the ideal and the actual profit is the firms' inefficiency. The estimated levels of inefficiency in dairy farms can then be regressed against a set of explanatory variables including policy and scale factors and also other characteristics of the farmer.

While the usefulness of stochastic frontier models to relate estimated efficiencies of firms to sets of explanatory variables has been recognized, Coeli (1996) notes that the traditional 2-stage estimation procedure such as used by Ali and Flinn (1988) gives parameters that are inefficient because it violates the assumption of independence of the inefficiency effects during the two estimation stages. The current study therefore used the alternative single-stage stochastic frontier model estimation procedure proposed by Coeli (1996). The stochastic profit frontier model was specified as:

$$\mathrm{Ln}\pi_n = \beta X_k - u + v$$

Where:

Lnp_n = natural log of profits per litre of milk produced in the n^{th} farm

β= a vector of unknown parameters

X_k= a matrix of the factors determining profitability including natural logs of fixed factors.

v = a measure of the usual idiosyncratic effects and is independent and normally distributed with mean=0 and variance=σ^2_v, that is, v=Niid $(0, \sigma^2_v)$;

u = non-negative inefficiency term and it measures the deviation of profits from the most efficient point. u has a mean m_i and variance= σ^2_u. The mean of u is expressed as: $m_i=z_i\delta$ where: z_i is a vector of variables which may influence

efficiency. This included scale, policy related factors, and also farm and farmer specific characteristics. δ is a vector of parameters to be estimated.

The estimation of the parameters β and z_i is done using the maximum likelihood technique. Following Battese and Corra (1977), the variance parameters are estimated as $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \frac{\sigma_u^2}{(\sigma_v^2 + \sigma_u^2)}$. The Stochastic frontier model was run using the FRONTIER 4.1 computer package developed by Battese and Coelli (1995).

2.2 Data sources

A survey of dairy farms was conducted in two rural districts of Kiambu and Thika, and urban areas of Nairobi. The survey covered a random sample of 204 dairy farmers drawn from a sampling frame of 762 dairy farmers obtained from livestock extension offices. A structured questionnaire was administered in two rounds during the dry and wet seasons to obtain information on the size of their dairy operations, expenditure, incomes, and other farm and farmer characteristics. The sample farms were also digitized to obtain their location with reference to major market centers and road infrastructure, based on GIS-derived measures.

Based on the number of cows kept, the sample dairy farms were grouped into three contrasting categories, that is, small-scale dairy farms (SSDF) ($\leq$2cows), medium-scale dairy farms (MSDF) (3-6cows) and large-scale dairy farms (LSDF) ($\geq$7cows). The surveyed farms included 105, 71 and 28 small, medium, and large-scale dairy farms, respectively.

3. Results

3.1 Characteristics of varying scale categories of dairy farms

Table 1 shows the summary characteristics of the surveyed dairy farms. A small-scale dairy producer kept an average of 1.4 cows compared to 3.7 and 13.6 in medium and large-scale, respectively. Land size in acres averaged 2.8 and 4.8 in SSDF and MSDF, respectively compared to 37.4 in LSDF, among which however, exhibited wide variability.

Dairy farming was often integrated with other farming activities, both crop and livestock. Most of the SSDF and also MSDF (nearly 70%) had commercial poultry activities compared to about 40% of the LSDF. The poultry activities supplied poultry waste, which was a popular feed for cattle. Food and horticultural crops, on average, accounted for the largest proportion of land in the SSDF (36%) but this fell to 33% in MSDF and 20% in LSDF. Fodder crops (elephant grass and pastures) accounted for about 25 % of the total land in SSDF compared to 34 and 37 percents in medium and large scale, respectively. Food crop residues, especially maize stover are however often a primary feed for livestock in Kenya. Owners of LSDF tended to be more educated and possessed more years of experience in dairy farming.

Cost of milk production averaged K.Sh.15 (US$0.21) per liter with no significant variation across the contrasting scale categories of dairy farms (Figure 1). Feed expenses accounted for the largest proportion of the total cost of variable inputs across scale (71-74%) with purchased fodder accounting for the most of this (about 67%). Most dairy farmers across scale used concentrates especially commercial dairy meal (82-88%) and maize bran (49-54%). Feed prices showed no significant variation across scale contrary to expectations that large-scale operators may obtain price discounts or pay lower transport costs per unit due to bulk purchases.

Annual milk productivity increased from 2300 liters per cow in SSDF to 3000 and 3200 liters in MSDF and LSDF, respectively. Milk producer prices increased from an average of K.Sh.20 (US$0.29) and K.Sh.21 (US$0.30) in SSDF and MSDF, respectively K.Sh.24 (US$0.34) in LSDF. The apparently higher milk prices in large-scale farms were however largely attributable to a high positive correlation between a dairy farm being in Nairobi and scale (number of cows kept) (partial correlation coefficient=0.46). To investigate this issue further, a price formation equation was estimated and the effect of location of dairy farms on the milk producer prices controlled by including a dummy variable for Nairobi location. The variables included in the price formation model accounted for 61% of the variability in milk producer prices across dairy farms (Table 2). Scale had no significant effect on price. The dummy variable on location was however positive and significant indicating higher prices for dairy producers in Nairobi. In addition, the milk prices related positively to selling in units of 0.5 liters or less and negatively to buyer types, that is, dairy co-operative societies and private processors.

Profitability ranged K.Sh.7.9 (US$0.11) to K.Sh.8.5 (US$0.12) per liter of milk produced and the variation was not significant across scale. The mean profitability in the entire set of LSDF including those in Nairobi however seemed higher (K.Sh.10.6 (US$0.15)) owing to the higher milk producer prices in Nairobi. Even then however the variability in profitability with scale remained not significant.

3.2 Econometric results of the determinants of profitability and Efficiency

Table 3 presents frontier MLE results of the determinants of profitability and inefficiency in all dairy farms pooled together and also in SSDF and also medium and large-scale farms (M&LSDF), collectively.. Sigma squared was significant in all the three models indicating a significant variation in profitability across dairy farms. Gamma was also significant in all the models indicating that inefficiency was an important cause of reduced profitability.

In the pooled data model, profitability related positively to milk price received, as anticipated. The quantity of concentrate feeds used per liter of milk and also the weighted price of concentrate feeds had negative effects on profitability which demonstrates the important effect of concentrate feeds on the cost of milk production. Efficiency in profitability averaged 82% implying an average loss in potential profitability of about 18%. The number of cows in a dairy farm had no significant effect on efficiency suggesting that small-scale dairy producers were just as competitive in securing profitability as their large-scale counterparts. Nevertheless, the results showed that horizontal coordination through dairy co-operative societies (which mainly helped farmers in milk marketing and also procurement of inputs and services) increased efficiency.

Commercial poultry activities in dairy farms had a positive effect on efficiency which suggests some economies of scope in producing dairy jointly with commercial poultry.. Distance by main road (tarmac) from farms to Nairobi was associated with greater efficiency. Rather than a market access issue, this is very likely simply a measure of rural location. In those areas, there is likely to be greater availability of fodder, either cut and carried or grazed, from public lands, thus leading to greater efficiency in terms of purchased inputs . Older dairy farmers tended to be less efficient probably because such farmers tend to be less innovative. Similarly, farmers with more years of formal education tended to be efficient perhaps because education enhanced their managerial skills.

The frontier results in SSDF and also M&LSDF were highly similar to the results of the pooled data model. Profitability in both cases increased with the milk price received. As in the pooled case, profitability in M&LSDF fell with the increasing quantities of concentrate feed per liter of milk produced. By the same token, weighted price of concentrate feeds had a negative effect on profitability in SSDF although the variable was not significant in M&LSDF. This result perhaps relates to the diversity of feed results utilized by the

contrasting scale categories of dairy operators. More of the medium and large-scale producers tended to use industrial by products such as cotton seed cake, fish meal, and brewers waste which gave them a wide rage of substitutes to the commercial concentrates when the concentrate prices were high. Use of the industrial by products by the small-scale farmers was often constrained by local non-availability, lack of knowledge on how to use them, procurement logistics and also the scale necessary for the transport of these products to be economical.

Levels of efficiency in profitability were just about the same in the two models (83% in SSDF and 81% in M&LSDF). The set of determinants of efficiency showed similarities and also differences in the two contrasting scale categories of dairy farms. As in the pooled data model, active membership in dairy co-operative societies and also commercial poultry had positive effects on efficiency in both cases. By the same token, distance to Nairobi by main tarmac roads was associated with greater efficiency in both models. Levels of formal education of dairy producers and also access to extension had a positive effect on efficiency in SSDF but these were not significant in M&LSDF. On the other hand, age of farmer had a negative effect on efficiency in M&LSDF but not in SSDF. In addition, medium and large scale dairy farmers with more years of experience in the activity tended to be more efficient.

4. Conclusions

Evidence from this study has shown that relative profit inefficiencies can be observed across farms at all levels of scale, and that small-scale farmers are not more prone to inefficiency than large farms. Within classes of farm, there are indications of what can be done to improve the fficincy of less efficient members of the class.. The results show little ground for pessimism about small farms on the grounds of alleged economies of scale in production. On th e contrary, small farms make better use per unit of output of low cost

family labor and of economies of scope with other farm activities, such as poultry raising. Thus those who seek to help alleviate rural poverty in Kenya through continued development of the small-scale dairy sector should be encouraged. On the other hand, this study did not investigate possible economies of scale in procurement, processing and retailing, which are also relevant to the future of smallholder dairy farming.

Prices received for milk and paid for feed were an important determinant of relative farm profitability, as is to be expected, and preliminary results suggest that feed prices tend to decline with scale. There is no evidence that milk prices differ with scale other than due to location..

Results from analysis of the second stage efficiency effects support the view that the profit efficiency of smallholder dairy farms in Kenya can be further strengthened by: (a) upgrading roads linking dairy producing areas with major urban centers such as Nairobi ; (b) strengthening of farmers' co-operative societies/self-help groups that improve access to quality inputs; (c) promoting use of cheaper by-products for dairy feed .

Tables

Table 1 : Farm and farmer characteristics in dairy farms

Characteristic		Small-scale (1-2 cows)	Medium-scale (3-6 cows)	Large scale (≥cows)	All farms
Sample and herd sizes	Number of dairy farms	105	71	28	204
	Mean number of cows	1.4 (0.7)	3.7 (0.9)	13.6 (8.1)	3.9 (5.0)
Percent of dairy farms with commercial poultry		67	69	39	64
Size of farm land and utilisation	Mean (acres)	3.3 (3.5)	5.5 (6.5)	39.2 (94.3)	9.0 (36.7)
	% land under food crops	36	33	20	33
	% land under cash crops	16	15	21	16
	% land under fodder crops	25	34	37	29
	% land under other use e.g. forests	23	19	22	22
Gender of managers of Dairy farms	% managed by husbands	47	61	21	48
	% managed by Women	46	37	50	43
	% managed by a hired manager	2	0	25	4
	% managed by Others e.g. siblings	6	3	4	4
Experience	Mean number of years in dairy	15 (11)	16 (10)	17 (10)	16 (11)
Education of owner	% with no formal education	9	4	0	37
	% with just primary school education	28	24	11	33
	% with just secondary school education	30	32	22	20
	% with post secondary school education	33	39	66	10

NB: Numbers in parenthesis are standard errors

Source: Authors Survey, 2001

Table 2: Determinants of milk producer prices in dairy farms

	Coefficient	Std. Error	t-ratio
Constant	34.08***	3.17	10.76
Index of potential evapo-transpiration	-11.12***	2.59	-4.29
Location (1=Nairobi; 0 if otherwise)	2.96*	1.54	1.92
Number of cows (count)	0.06	0.06	0.96
Buyer types			
Dairy co-operative (0,1)	-4.86**	2.34	-2.08
Trader/Hawker (0,1)	-2.63	2.28	-1.15
Farmer group (0,1)	-3.09	2.37	-1.31
Local bar/restaurant (0,1)	0.25	2.43	0.10
Local household (0,1)	0.02	2.37	0.01
Private processors (0,1)	-5.16**	2.35	-2.19
General shop (0,1)	-1.84	2.61	-0.70
Farm labourers (0,1)	-1.33	2.69	-0.50
Measurement unit when Selling Milk (Control ≥750ml)			
Half Liter or less (0,1)	3.25**	1.67	1.94
GIS Distances from dairy farms to Nairobi			
Distance from the farm to Nairobi on tarmac (Km)	-0.07***	0.01	-4.72
Distance from the farm to Nairobi on murum road (Km)	-0.13	0.08	-1.60
Distance from the farm to Nairobi earth road (Km)	-0.20*	0.11	-1.89
R-squared = 61%			

***, **, and * indicates significance at 1 percent, 5 percent and 10 percent respectively

Source: Authors survey, 2001

Table 3: Frontier Results of Determinants of profitability in dairy

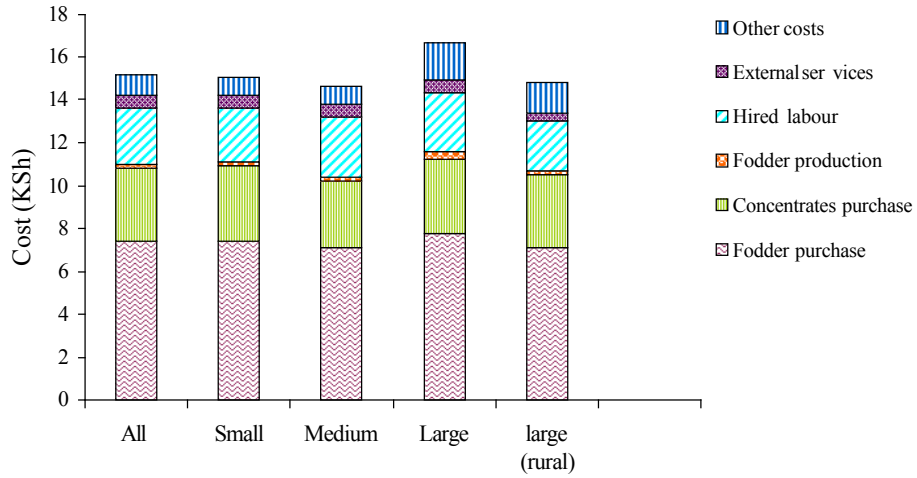
Determinants of Profitability		All Dairy farms (N=192)			Small-Scale dairy farms N=94			Medium and large-scale dairy farms, collectively (N=98)		
		Coefficient	Std-error	t-ratio	Coefficient	Std-error	t-ratio	Coefficient	Std-error	t-ratio
	Constant	2.3***	0.3	9.6	3.3***	0.20	16.5	2.04***	0.5	4.4
Resources	Log acres of land per L of milk	-0.01	0.01	-0.5	-0.03*	0.02	-1.8	-0.01	0.01	-0.8
	Log CRC of buildings & equipment / L of milk	-0.01	0.02	-0.7	-0.01	0.02	-0.6	0.01	0.03	0.4
	Log Man-days of family labour available/L of milk/year	-0.001	0.004	-0.3	0.003	0.01	0.5	-0.01	0.01	-1.03
Technology	Log percentage of high-grade dairy animal in the herd	-0.01	0.01	-0.7	-0.01	0.01	-0.9	0.02	0.08	0.3
	Log quantity of concentrate feeds per litre of milk	-0.05***	0.02	-3.6	-0.0003	0.01	-0.02	-0.08***	0.02	-3.6
Input and out put prices	Log weighted milk price	0.4***	0.06	7.4	0.19***	0.06	3.0	0.5***	0.08	6.1
	Log price of concentrate feeds	-0.03**	0.01	-2.1	-0.08***	0.02	-3.7	-0.02	0.02	-1.3
	Log wage	0.04	0.05	0.8				0.03	0.06	0.5
	Log of weighted price of purchased fodder	-0.003	0.04	-0.08	-0.03	0.03	-1.02	-0.03	0.05	-0.6
	Log capital/L of milk X concentrate feeds/ L of milk	-0.01	0.02	-0.97	0.01	0.01	1.3	-0.02	0.02	-0.8
Determinants of Inefficiency										
	Constant	-2.77**	1.1	-2.5	-1.8	1.0	-0.9	-0.5	0.6	-0.9
Access to support services	Farmer has long term credit (0,1)	-0.3	0.7	-0.4	0.4	0.4	0.9	0.2	0.2	0.8
	Access to concentrate feeds on credit (0,1)	-0.4	0.6	-0.8	-1.08	0.6	-1.9	0.05	0.2	0.3
	Access to extension (0,1)	-0.01	0.03	-0.4	-0.11**	0.04	-2.6	0.001	0.01	0.06
Road Infrastructure	Distance from the farm to Nairobi on tarmac	-0.05***	0.01	-3. 8	-0.07***	0.03	-2.8	-0.01**	0.01	-2.04
	Distance from the farm to Nairobi on murum road	-0.01	0.07	-0.1	0.10	0.1	0.9	0.002	0.04	0.06
	Distance from the farm to Nairobi earth road	0.09	0.09	1.04	0.13	0.2	0.8	-0.03	0.05	-0.6
	Age of farm manager (Years)	0.05***	0.02	3.07	0.01	0.03	0.4	0.02**	0.01	2.2
	Number of years of experience in dairy of the manager	-0.02	0.02	-0.9	-0.01	0.03	-0.3	-0.03*	0.01	-1.8
	Number of years of formal education of the farmer	-0.4**	0.2	-2.1	-0.71**	0.6	-2.04	-0.2	0.1	-1.4
	Number of cows kept	-0.05	0.04	-1.3						
	Commercial poultry activity (’00 birds)	-0.01***	0.001	-6.8	-0.04**	0.02	-2.3	-0.004***	0.001	-5.4
	Active membership to a dairy coop (0,1)	-2.9***	0.8	-3.6	-3.5***	0.6	-6.3	-0.7**	0.3	-2.5
	Sigma-squared	0.99***	0.2	5.8	1.7***	0.4	3.9	0.3**	0.1	2.5
	Gamma	0.997***	0.001	836.7	0.99***	0.001	1722.0	0.99***	0.01	191.6
	Mean Efficiency	82%			83%			81%		

***, **, and * indicates significance at 1 percent, 5 percent and 10 percent respectively

Source: Authors survey, 2001

Figures

Figure 1: Composition of Costs per Liter of Milk Produced



Source: Authors survey, 2001

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