The cost of producing milk in the KwaZulu-Natal Midlands of South Africa: a cost-curve approach

T Mkhabela[1] & SH Mndeme[2]

Abstract

The cost of producing a unit of output is a critical management aspect in the dairy industry, particularly in South Africa. The ability of minimise unit costs of producing milk, while not curtailing output levels, is often a determining factor of the long-term survival of dairy farms in South Africa. In this study, average cost curves showing the variation of unit cost with output are estimated for dairy production in the KwaZulu-Natal Midlands of South Africa, using a panel of 37 farms for the period 1999 to 2007. The results show that economies of size exist, with larger farms able to produce any given level of output at lower costs compared to their smaller counterparts. The study found that the long-run average cost curve (LAC) for the sample of dairy farms is L-shaped rather than U-shaped. The best farmers, in terms of average costs of producing a litre of milk, are found between the 100 000 to about 170 000 litres of milk per year output range and these were found to spend less than R1 per litre.

Keywords: Cost curve; milk; economies of size; KwaZulu-Natal; South Africa

1. Introduction

The future of the small dairy farm in South Africa (SA) is a topical issue among dairy farmers, agricultural economists and policy makers alike. This discussion is sustained by the fact that a large number of small dairy farms are exiting the industry in traditional dairy areas each year, and there is tacit agreement that this exodus is likely to continue. This is not a welcome trend in South Africa, as it seems to fly in the face of the desired trajectory in agriculture, given the reforms in the sector and the desire to see new entrants in the dairy industry. There are those in the agricultural industry that hold the view that there is no future for the small dairy farm in SA agriculture, since its unit cost of production is perceived to be higher than that of its larger counterpart. This scenario is not unique to SA. Tauer and Mishra (2003) reported similar arguments in the US, where engineering cost studies of dairy production have shown lower unit costs with larger production units (see

---

[1] *Senior researcher, Department of Agricultural Economics, University of Stellenbosch. E-mail: thula@sun.ac.za.*

[2] *MSc student, Department of Agricultural Economics, University of Stellenbosch. E-mail: smndeme@gmail.com.*

Matulich, 1980). The SA dairy industry is deregulated, rendering the milk market competitive, with the implication that the survival of dairy farms (particularly small farms) depends on their competitiveness. Thus, the long-run survival of dairy farms in the country relies on lowering cost of production, as no individual farm can influence the amount received for the milk produced.

The dairy industry is the fourth largest agricultural industry in South Africa, representing 5.6% of the gross value of all agricultural production. The coastal regions of the Western, Southern and Eastern Cape and KwaZulu-Natal contribute more than 42% of national milk production, with the largest number of dairy producers found in the Free State (24.9%) and the Western Cape (21.5%) (Department of Agriculture, 2003). There has been a substantial shift of production from inland to coastal areas as farmers move to the coast due to better pasturage, among other reasons. This trend is clearly shown in Table 1.

Table 1:   Geographical distribution of milk production, 1997 and 2007

Province	Percentage of production	
	1997	**2007**
Western Cape	22.9	25.3
Eastern Cape	13.8	21.8
Northern Cape	1.2	0.7
KwaZulu-Natal	15.7	21.1
Free State	18.0	12.8
Northwest	12.6	7.1
Gauteng	4.4	3.1
Mpumalanga	11.0	7.6
Limpopo	0.4	0.5
Coastal areas	52.4	68.2
Inland areas	47.7	31.8
Total	**100**	**100**

Source: MPO (2008) estimates

The dairy industry is important to South Africa's job market, with some 4 300 milk producers employing about 60 000 farm workers, and indirectly providing jobs for 40 000 people, (Statistics South Africa, 2001, 2003). Milk is bought and processed by over 300 processors and manufacturers, while some 500 producer-distributors also market liquid milk and fresh dairy products. Large dairy companies represent a very small percentage of all processors, but process over 80% of the total milk delivered to dairies, producing a large range of mainly commodity dairy products.

South Africa produces some 2.37 billion litres of milk per annum, as was the case in 2007 (Milk Producers' Organisation, 2008). More than 64% of all the milk produced in South Africa is produced on pasture-based systems in the

Western Cape, Eastern Cape and KwaZulu-Natal, with KwaZulu-Natal producing 21.1% of South Africa's milk (500 million litres). Above South Africa's own production, the country imported 4 529 679 litres of milk and 9 852 949 kg of concentrated milk and powdered milk in 2007 (Milk Producers' Organisation, 2007). There was a reduction of 2% on the total milk to market from 2006 to 2007. The reasons for this reduction in production were the drought in the summer rainfall areas, which resulted in less silage being produced, and the high prices of maize and other grains (Milk Producers' Organisation, 2008). This is an indication that there is capacity to expand within the country.

There are also numerous small operations processing less than 2 000 litres of milk a day, often supplying on a regional basis. Following agricultural deregulation in the early 1990s, there has been substantial restructuring of both the dairy production and processing sectors in an effort to improve global competitiveness. A significant confidence indicator in the restructuring of the processing sector, in particular, has been the recent heavy investment of multinationals like Parmalat and Danone in large South African dairy companies, and the continuing presence of Nestlé and Clover.

The small dairy farms in South Africa have higher unit costs of producing milk than larger farms (Coetzee, 2002: 46; Botha, 2007: 30-32; Coetzee, 2007: 35-37). Engineering cost studies of dairy production have shown lower unit costs with larger production units (Matulich, 1980). In a competitive market like milk, the survival of the small dairy farm hinges upon whether these farms are competitive with larger dairy farms, and their long-run survival depends upon having a low cost of production. A discussion of the continued existence of the small farm is not limited to dairy or to South Africa, but is a worldwide issue in both developed and developing countries.

The key question that arises is whether these higher costs are due to technology or inefficiency? If high cost of production on smaller farms is due to a higher cost frontier, then to make small farms competitive would require research to devise and design technology that is suitable for small farms. If, instead, the high cost is due to inefficiency, then educational approaches are needed to ensure small dairy farms use technology efficiently.

Since low cost of production is critical for dairy farm survival in a competitive market, this study proposes to estimate the cost of milk production by farm size, using individual farm production data for 37 farms in the KwaZulu-Natal Midlands from 1999 to 2007, obtained mainly from Tammac Consultants cc in Ixopo (Southern KwaZulu-Natal). In order to best understand the production

system for milk, it is important to look at the cost of production and its components.

There are two components to the cost of production for an individual farm that are proposed in this study. The first is the lowest cost for the specific technology and practices that a farmer can use for a given farm size. This can be referred to as the best practice or frontier cost curve (Short, 2004). The second component of cost is how efficient an individual farm is in using the techniques available for a given farm size. Costs greater than the best practice costs can occur if a farmer is inefficient in using best practice techniques. In this study, both of these cost components are modelled and estimated for each farm, taking into consideration the herd size. The modelling procedure proposed will allow for both frontier and efficiency cost components to vary by farm size. It is worth a brief discussion here that, although in most cases farm size is generally measured in terms of hectares (physical area), a consensus is gradually emerging that in the dairy industry herd size (number of milking cows) is a better proxy for farm size.

The intention is to find the curve that best represents the relationship between average cost and level of output. This could be done by relating average cost to actual output, but it is more appropriate to relate average cost to planned output, on the basis that costs are more likely to reflect what the farmer expects output to be (Dawson & Hubbard, 1987; Hubbard *et al.*, 2007). As a result, a pragmatic two-step procedure will be adopted. In the first step, the farmer's planned output will be determined by estimating a production function based on the farmer's actual use of inputs (such as area, labour, fertiliser, etc). In the second step, the long-term average cost (LAC) curve will be estimated, where average cost is calculated as total cost divided by planned output, and this is then related to the level of planned output.

In all endeavours to assess production costs in dairy, it is important to ensure that all relevant costs are accounted for. Like in any production system, some of the production costs are explicit, thus easily accounted for and duly recorded. A good example of such explicit costs is the fact that farms that purchase feed record feed expenses and quantities. Hired labour is another example of explicit cost in dairy farm operations, in that the farmer incurs a specific expense (cost) for the people employed and, by extension, the hours worked during any time period.

However, not all the costs incurred by dairy farms are obvious. These not-so-obvious expenses are also harder to measure and account for, and these will be dubbed implicit costs in this paper. Notwithstanding the difficulty of

measuring these, it must be acknowledged that these costs are often substantial and significant, thus omitting them invariably leads to valuable cost information being lost. An example of implicit cost would be family labour. Commonly, farmers and their families work on the farm, thus contributing to the labour compliment of the dairy enterprise. The cost of the family labour should still be recognised, even in cases where there are no direct payments made for such. The farmer and/or family members could have worked off the farm and earned income, and their foregone potential earnings is the opportunity cost of the farm's unpaid labour.

Dairy farms in South Africa, in the main, often incur two other important implicit costs, namely for farm-produced feed and for capital equipment and structures. Farm-produced feeds and forage represent implicit costs because the farmer could have sold the feeds, the land supporting their production, or the labour and use of machinery expended. All dairy farms own equipment and structures (milking parlours, sheds, etc.), and often do not record an explicit annual cost for their use. Capital use is viewed as an implicit cost for the farm because the farmer could have invested the money elsewhere and earned a return on it.

There two additional issues that are pertinent in developing cost estimates for dairy production, and these are joint production and common costs. This notion will be discussed in more details later on it the paper, but a brief introduction is warranted here. A simplistic look at dairy farming reveals that dairying yields a joint product in milk and livestock (and sometimes surplus feed). There are dairy animals that are culled from the herd and these are sold, including male calves that are produced from the breeding process. If the foregoing argument is sustained and the joint products are truly joint, then the costs of producing them cannot be attributed separately to each product, and attempts to do so may simply underestimate the costs of the farming entity as a whole. To further complicate the issue, some costs, such as taxes, administrative overheads and energy expenses (electricity and fuel – diesel and petrol) are incurred at the level of the whole farm. That is to say, they are common to all commodities produced on a farm. Thus the modelling approach adopted has a bearing on the results that will be obtained. Suffice to say that different analytical approaches may have different means of accounting for joint products and common costs, and this may lead to different estimates.

The price of milk (R/L) is an important consideration for dairy farmers, as this gives an indication of whether farmers will break even or not. By and large, revenue, and consequently profit and loss, are a function of the difference

between unit costs of production and the price of a litre of milk. Having said the above, a brief discussion of milk price would suffice in setting the scene. Economic theory on price formation postulates that, in a free and competitive marketing environment, prices are formed as a result of market demand and supply. So, following the preceding postulation, it is logical to expect that prices increase when there is a shortage of milk. Farmers, being rational economic players, then produce more milk at the higher producer prices and, as a result, a surplus of milk develops, with a subsequent decrease in producer prices.

In South Africa, producer prices showed an increasing trend from March 1999 because of a shortage of milk (Department of Agriculture, 2007). However, this did not result in any corresponding increase in production, because producers were still suffering from the combined effects of declining producer prices, escalating input costs and higher interest rates during the previous two years. The foregoing prevalent situation can be dubbed as a 'cost-price squeeze', where input costs rise faster than the product (milk) prices received by the producers. Due to the nature of dairying, producers can only absorb lower producer prices for a short period of time. If milk prices decline to a level lower than variable cost, and remain at that level for a long time, this will invariably lead to the liquidation of dairy herds (selling of herds for cash). This is a plausible explanation for why such a high number of producers exit the industry each year in South Africa, as shown in Table 2.

Table 2:   Number of producers per province, 1997 and 2008

Province	Number of producers					Percentage change 1997-2008
	1997	2003	2006	2007	2008	
Western Cape	1 577	973	878	827	815	-48.3
Eastern Cape	717	481	422	420	407	-43.2
Northern Cape	133	67	39	37	34	-74.4
KwaZulu-Natal	648	449	402	385	373	-42.4
Free State	1 204	1 250	1067	987	919	-23.7
Northwest	1 502	819	649	596	549	-63.4
Gauteng	356	282	275	245	228	-36
Mpumalanga	866	477	407	357	302	-56.1
Northern Province	74	58	45	45	38	-48.6
Total	**7 916**	**4 856**	**4 184**	**3 899**	**3 665**	**-48.2**

Own calculation from MPO statistics

Although the variable cost of producing milk from pastures in the coastal areas is lower, the extra cost to transport milk from the coastal areas to the markets should be taken into account. Despite the fact that the variable cost of producing milk from pastures is lower in the coastal areas, there still are dairy

farmers that are less efficient in their milk production, and thus are struggling to break even. It is this dichotomy in the cost of production efficiency in the KwaZulu-Natal dairy industry that is of particular interest and begs research to establish the determinants of unit and total cost production. The size distribution of milk producers for South Africa as a whole is shown in Table 3. The number of smaller milk producers is declining, while the share of larger producers in the total milk production is growing. The average milk producer now produces 1 380 litres per day, up 20% from 2001. Given the current trend of few and larger farms surviving, it is likely that there are increasing returns to scale (or economies of size) that need to be taken into consideration in estimating the cost of production in the dairy industry.

Table 3:   Size distribution of milk producers, 1995 and 2001

Daily production (litre/day)	Percentage of producers		Percentage of production	
	1995	**2001**	**1995**	**2001**
0 – 500	58	45	19	9
501 – 1 000	21	17	20	9
1 001 – 2 000	13	17	24	19
2 001 – 4 000	6	11	22	24
4 001 – 6 000	2	5	5	15
> 6 000	0	5	10	24

Source: MPO estimate

2.   Background to the KwaZulu-Natal dairy industry

There are 381 milk producers registered with the milk producers' organisation of KwaZulu-Natal (KZNMPO) at present, dramatically lower than the 648 of 1997 (Milk Producers' Organisation, 2007). This is an indication of the small margins to be made out of dairying, with fewer producers producing a lot more milk from more cows to stay economically viable. Of the milk producers in KwaZulu-Natal, one from a previously disadvantaged background is registered with the KZNMPO, four with the national milk recording scheme and an estimated 20 other producers in the informal market.

Most farms within the midlands of KwaZulu-Natal are predominantly grazing farms, mostly irrigated ryegrass (predominantly annual ryegrass, but some perennial ryegrass) and dryland kikuyu, with maize silage and hay (*Eragrostis curvula* or veld) being fed at strategic times. Dairy meal is fed at the rate of an average of 6.5 to 7.5 kg per cow in milk daily, ranging from zero to 10 kg of meal per head daily (Penderis, 2004).

In KwaZulu-Natal, most of the milk is produced in the Mooi River, Howick, Boston, Bulwer, Underberg and Ixopo areas, and all of these areas fall within the Midlands region, making it the most important milk-producing region in

the province. Interestingly, the sample falls within this region, from Ixopo in the south to the Mooi River area further north. This concentration of dairy farms in the Midlands is due to more conducive climatic and soil conditions, such as lower temperatures and higher rainfall, which promote the growth of kikuyu in summer and ryegrass under irrigation in winter, making the region suitable for quality grazing.

3.   Conceptualisation, estimation and data

The primary intention of the study was to find the curve that best captures the relationship between average cost and level of output. Following the approach adopted by Hubbard *et al.* (2007), this could be done by relating average cost to actual output, but it is more appropriate to relate average cost to planned output, on the basis that costs are more likely to reflect what the farmer expects output to be (Hubbard *et al.*, 2007; Dawson & Hubbard, 1987). As a result, a pragmatic two-step procedure will be adopted. In the first step, the farmer's planned output will be determined by estimating a production function based on the farmer's actual use of inputs (such as land, labour, capital, fertiliser, veterinary expenses, etc.). In the second step, the long-term average cost (LAC) curve will be estimated, where average cost is calculated as total cost divided by planned output, and this is then related to the level of planned output.

The data used in this study were obtained from Allan Penderis of Tammac Consultants cc., based in Ixopo (Southern KwaZulu-Natal). The farms that were selected are highly specialised dairy producers, deriving more than 90% of their income from dairying. The dataset is comprised of 37 dairy farms in the KwaZulu-Natal Midlands area, and this figure represents approximately 10% of the number of dairy farms in the area in 2007 (381 farms).

The dataset is dairy financial management data covering a maximum of 37 farms for the nine years from 1999 to 2007. If it were a balanced panel it would comprise 333 observations, but there are only 25 farms for the first two years. Then the sample was increased to 37, but one farm dropped out in 2006 and only 22 farms had reported for 2007 at the point in time when the data were handed over. This gives an unbalanced panel, with a total of 293 observations. The original data are all in terms of current prices, which does not allow for comparisons across time. The current price data is used first to investigate the cross sections for the individual years, as using deflators is bound to introduce some amount of random error, but then the variables all need to be transformed to constant prices. A note on how deflation was done is warranted and this is provided below.

It is always possible to pool several years of data to increase the sample size and thereby increase the number of significant variables, but this raises complications. There are statistical tests to determine if pooling is a valid approach, and these will be undertaken in due course. But, before pooling data with a time dimension, the variables have to be made inter-temporally comparable by deflating the current values to give constant price variables. This needs to be done for all the variables expressed in value terms, in order for the changes in the physical quantities of outputs and inputs, which are what the production function models, to be separated from changes in prices.[3] The current price data from Tammac Consultants does not include appropriate deflators, therefore the most suitable deflator available must be used to deflate each variable. The source of deflators is the Abstract of Agricultural Statistics (Department of Agriculture, 2007), and even when a variable such as fertiliser can be deflated with the fertiliser price index from the Annual Agricultural Statistics, the process is a new source of errors. This is inevitable, as the national prices may not be the same as the local prices in the Midlands and because the deflator is for a fertiliser mixture that is probably different from that used by dairy farmers. With aggregates for items like farm machinery, this problem is obviously more serious, and there really is no appropriate deflator available for some items.

3.1 A brief conceptual framework

Before any analysis can be done, an understanding of how the dairy industry operates is a prerequisite as it suffices to present how the South African dairy industry can be pictured at farm level. It would be foolhardy to assume that the dairy industry is identical to industrial firms and other sectors in SA agriculture. A conceptualisation of the dairy industry will facilitate an appropriate modelling of production, thereby making it possible to select the most important variables and cost drivers. The dairy farm produces its own replacement stock (herd) through breeding and rearing heifers, and it disposes of male calves produced, while old and unproductive cows are culled and sold off. The farm also produces its own feed, mainly roughage (grass, maize for silage and some legumes) and, in times of excess feed being produced, this is

---

[3] *Suppose that all the outputs and inputs are measured in value terms. If inflation affected all at exactly the same rate, deflation would not be necessary as the relationship between inputs and outputs would be unchanged. But suppose that all the prices and hence values stayed the same from year t to year t+1, except that the government doubled the wage by administrative fiat. Supposing too that the farms could not employ less labour, the labour cost input would double and production would appear to have decreased in efficiency as twice as much labour is needed. Obviously, the wage bill needs to be deflated by a wage index that has doubled, in order that the true unchanged production relationship can be identified.*

Deflation is a necessary evil in the generation of variables that are the equivalent of physical quantities and these are the requirement for fitting production functions. Note too, that the intention is to model the production process from the viewpoint of the decision-makers, who in this case are the farmers.

sold off to adjacent farms. Although what has been presented is an over-simplification of the system, life is a bit more complicated than this simple model. Cows therefore are both an input and an output at some stage of the farm's cycle. Feed also is an input in the production of milk, but the bulk of the feed is produced on the farm and thus can be viewed as an output. The cows produced on the farm go on to produce milk (the ultimate output for dairying) and some more cows (herd building and production of replacement heifers). Cull cows and bull calves that are sold off can also be viewed as products from cows. Figure 1 provides a schematic presentation of the farm system as conceptualised thus far.
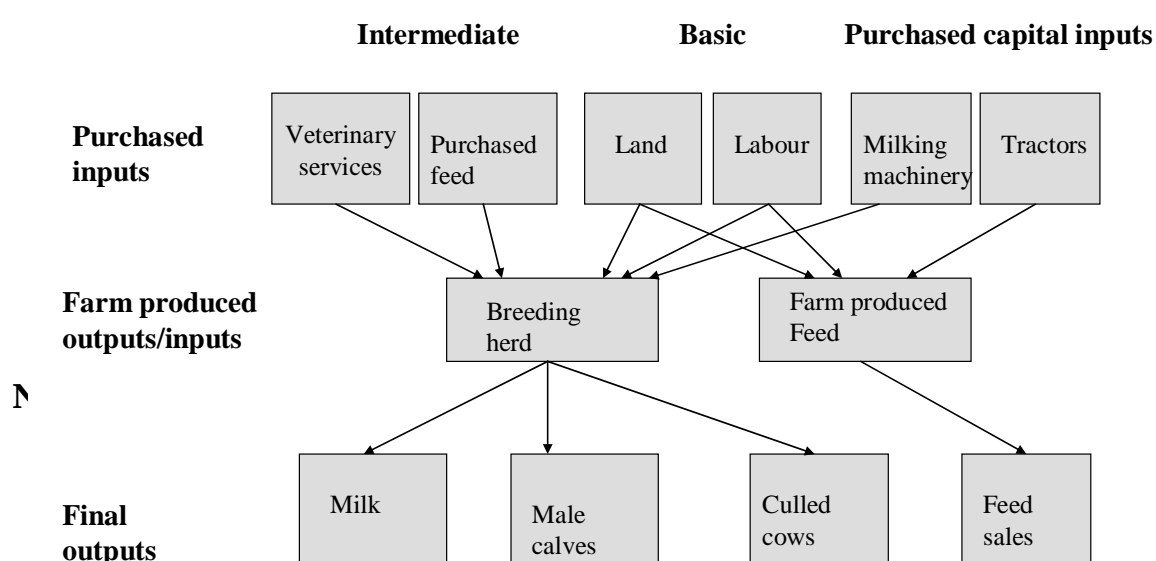
Figure 1:   **A conceptual model for dairy farming**

The gross value of production generated by the dairy enterprise includes payments from milk production, from sales of dairy animals, and from other sources (such as sale of cull animals or lease of farm space, dairy co-op patronage dividends, or the value of excess feed produced). Net returns are the difference between the gross value of production and total costs. Enterprises with positive net returns cover all costs, including costs of capital recovery.

The picture presented in Figure 1 can be expanded further to show, in detail, what the cost drivers are for a typical dairy farm. This expansion is given in Figure 2.
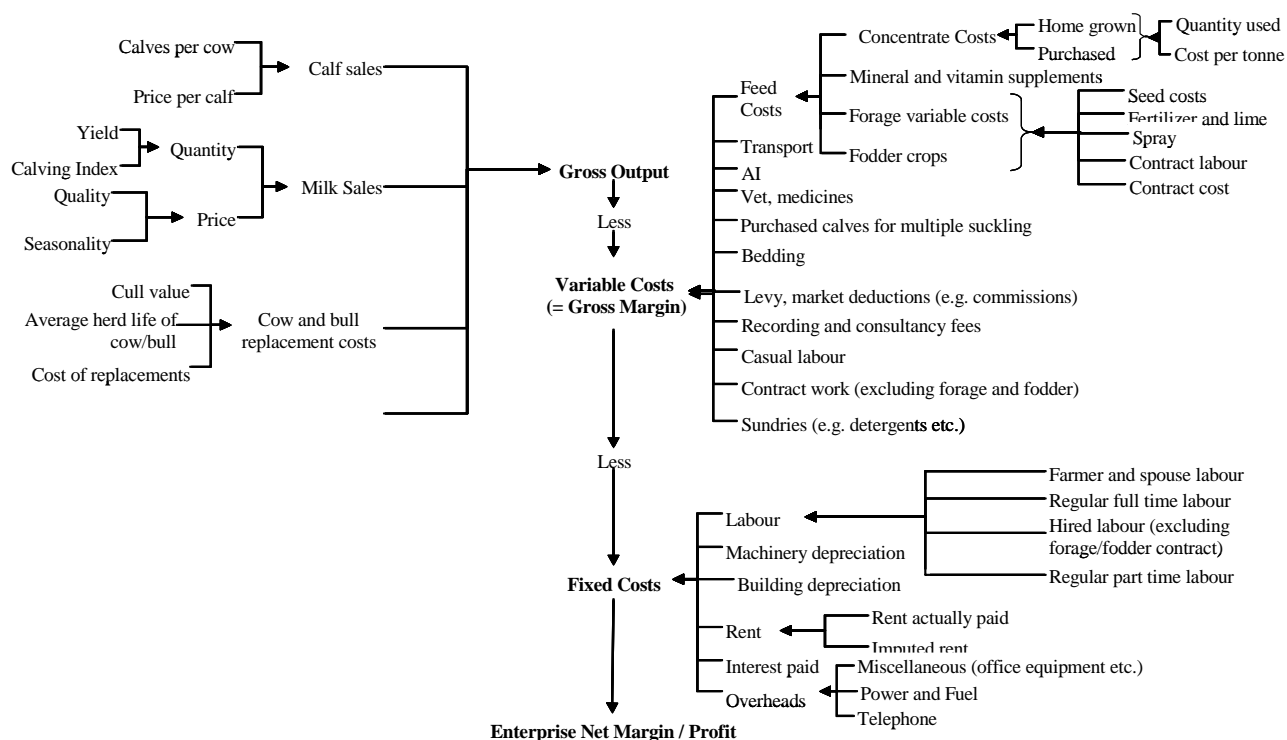
Figure 2:   A detailed schematic representation of a typical dairy farm

4.   Results

Table 4 shows the descriptive statistics for the dairy farms under study. Average milk production per farm per year is 196 113 litres (L) and ranges from 59 755 to 630 921 L. This range, as well as the standard deviation of production, indicates that there is considerable variation among farms. The average herd size for the sample is 278 cows, ranging from 100 to 669 cows. The average land area is 205.5 hectares, with a minimum of 76 and a maximum size of 455 hectares. The average use of other inputs per farm, *i.e.* *LW* (labour wage) and *PF* (purchased feed), is R866 per worker per month and R62 668 per farm per annum respectively. The average cost across the sample was R2/L of milk, but the minimum and maximum values, as shown in Table 3, display a wide range between farms, from R1/L to R10/L. However, the wide variation in average cost between farms has to taken with a pinch of salt, because some costs are imputed and this may mask actual differences between farms.

Table 4:   Descriptive statistics for South African dairy farms from KwaZulu-Natal Midlands

Variable	Observation	Mean	Standard deviation	Minimum value	Maximum value
Total cost (R)	293	227 380	176 003	51 127	1 195 397
Average cost (R/L)	293	2	1.33	1	10
Milk (L year^{-1})	293	196 113	83 875	59 755	630 921
Cows (Numbers)	293	278	101	100	669
Land (ha)	293	205.5	76	84	455
Labour wage (R)	293	866	327	117	2 169
Purchased feed (R)	293	62 668	44 886	272	571 756
Veterinary expenses (R)	293	26 592	34 949	899	214 704
Milking equipment(R)	293	93 705	136 362	0	296 045
Other equipment (R)	293	1 236 162	1 977 730	36	4 180 243

The next step in elucidating further understanding of the relationship between cost and output is doing scatter plots of variable, fixed and total costs per litre against actual milk yield per hectare, as depicted in Figure 3. Variable costs here comprise of total feed (sum of purchased and farm-produced feed) and veterinary costs (artificial insemination, disease vaccination and treatment, etc.). Farm-produced feed further comprises of seeds, fertiliser and sprays, while purchased feed refers to all feedstuff procured off the farm, such as licks, concentrates and supplementary roughage (silage and hay). Fixed costs are made up of labour, machinery, buildings and land, and total cost is the sum of variable and fixed costs. A look at the scatter plot for fixed costs against output (litres/ha) reveals that fixed costs stay relatively constant, by and large. This finding is not revelatory, thus not surprising, because machinery accounts for a large portion of fixed cost and machinery has a limited observed relationship with output, even though it does change with change in farm size. A somewhat unexpected aspect is the positive yet statistically insignificant relationship shown by the scatter plot of variable costs per hectare and yield.
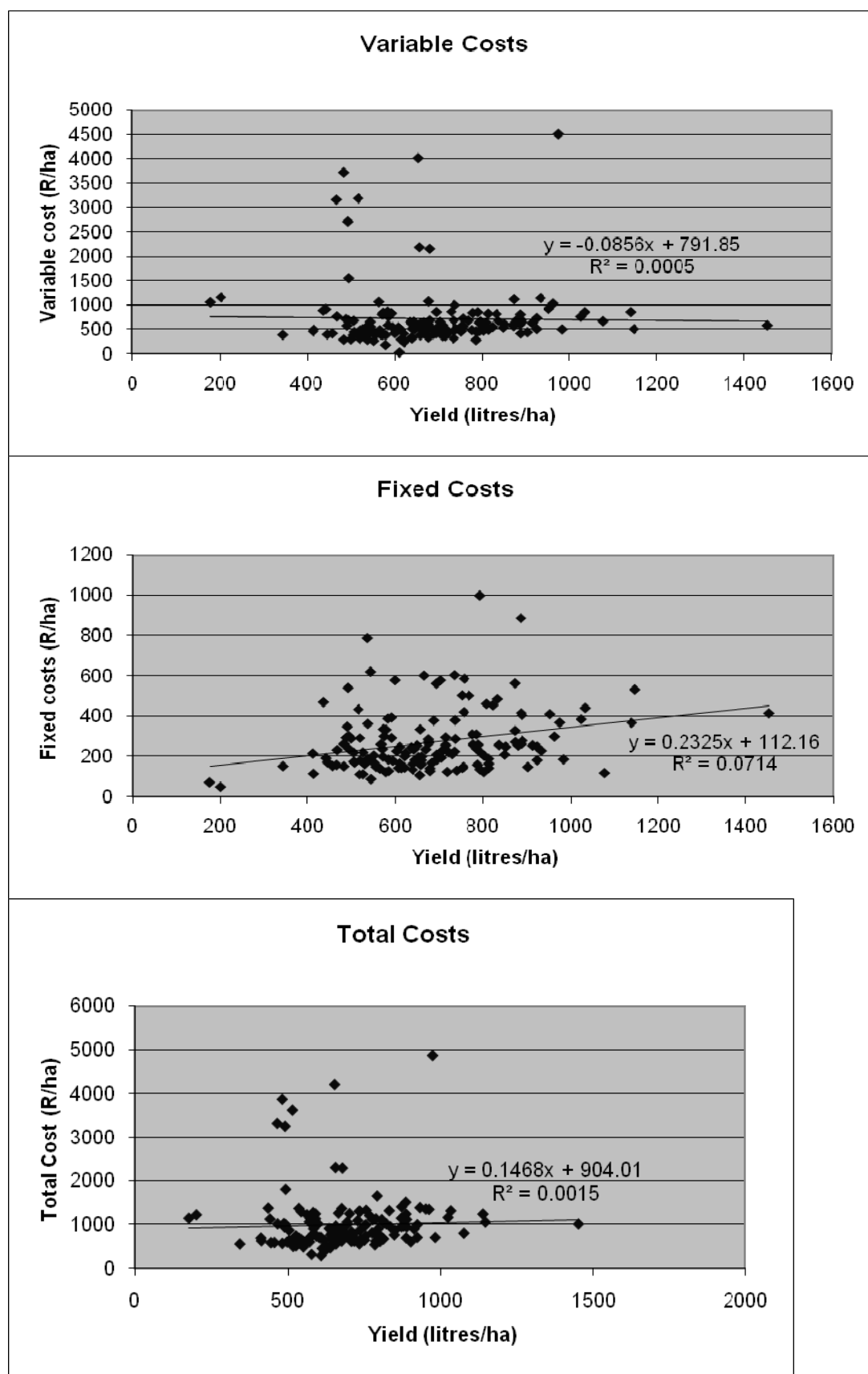
Variable Costs

y = -0.0856x + 791.85
R² = 0.0005

Fixed Costs

y = 0.2325x + 112.16
R² = 0.0714

Total Costs

y = 0.1468x + 904.01
R² = 0.0015

Figure 3: **Variable, fixed and total cost curves**

Next, attention is given to the relationship between actual average cost and the levels of actual output, and this is shown in Figure 4. Actual average cost is defined as the total cost of producing and delivering the milk to the market, divided by the actual output of milk. The picture depicted in Figure 4 shows that average costs of production on some smaller farms are higher than those of their larger counterparts. Another interesting observation is that rising average costs, otherwise known as diseconomies of size, do not set in at higher levels of output within the sample. This finding falls within the school of thought that purports that the long-run average cost curve (LAC) is L-shaped rather than U-shaped. Be that as it may, one needs to be alert to the pitfalls of attempting to derive the shape of the LAC curve based on a two-dimensional scatter plot that does not take into account the vital influence that management exerts on production and thus on the attendant costs. This cautionary note is echoed by Dawson and Hubbard (1987) in the dairy industry in England, and Hubbard *et al*. (2007) in the oilseed rape production in England. It is axiomatic that better managerial acumen enables a farmer to produce any given output at a lower cost, and it should be realised that each point on the scatter plot shown in Figure 4 typifies a given level of managerial ability and/or practice. Due to the nature of management being unobservable, and thus difficult to measure, it is often ignored when estimating either the determinants of efficiency or the cost of production. Needless to say, the omission of management invariably leads to biased estimates.
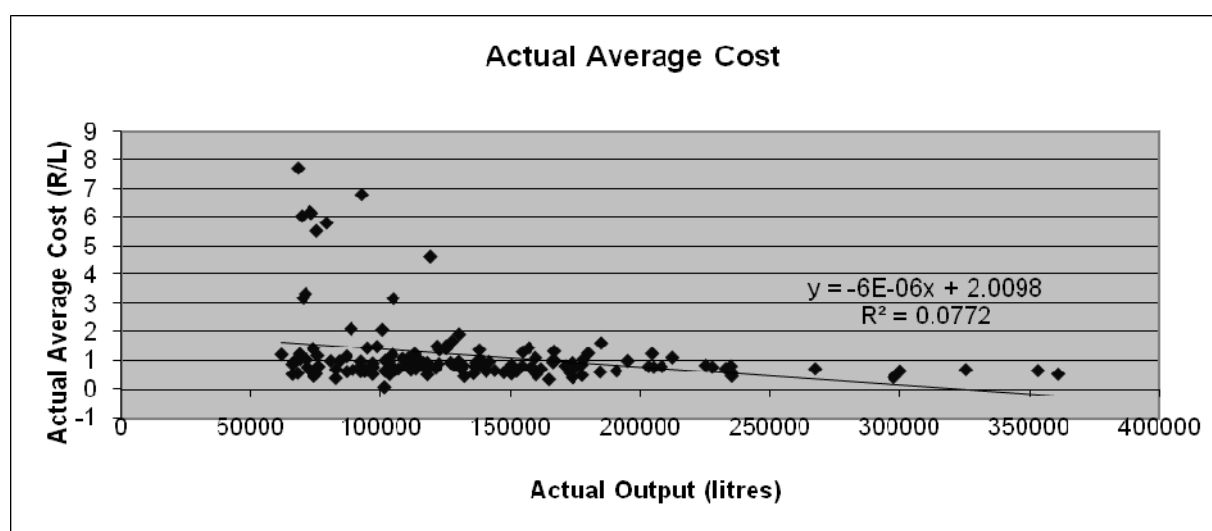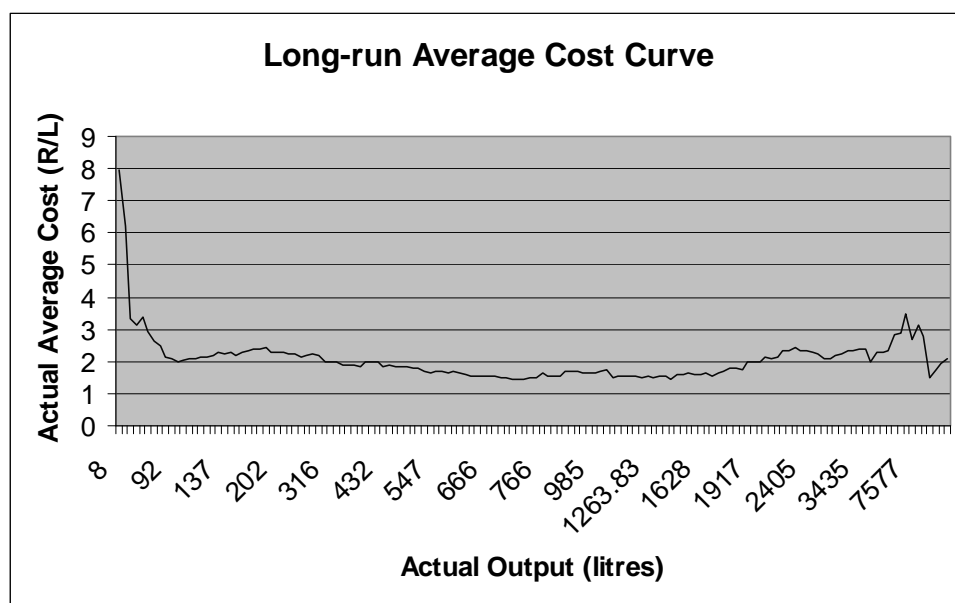

Figure 4:   Actual average costs

Figure 5:   Long-run average cost curve

Following the approach adopted by Short (2004) in the US, estimated costs of production were ranked from lowest to highest in order to form a cumulative distribution on farms, and this is illustrated in Figure 6. In order to put the unit cost of production into perspective, the costs are juxtaposed with the average price of milk received by the farmers in the Midlands. Such a comparison gives an approximation of the number of farmers breaking even (number of producers who sell their milk at a price equal to or more than what it costs to produce a litre of milk). The average price of milk over the period under review was R1.72/L. It has to be remembered that all the variables used were deflated to facilitate inter-temporal comparison, thus it is possible to take an average price over the period. Approximately 84% of the dairy farmers in the sample were able to compensate for costs of production. Of the 84%, 39 observations (representing 25% of the sample) can be classified as low-cost producers that were consistently able to produce a litre of milk for less than R1. Fifteen percent of the farmers can be classified as high-cost producers, incurring costs exceeding the revenue accruing from the sale of their milk. Cognisance has to taken of the fact that prices received by farmers for milk vary considerably, due to milk quality, season and contractual agreements with retailers, but the cost of production (prices for inputs) are relatively comparable among farmers in the region.
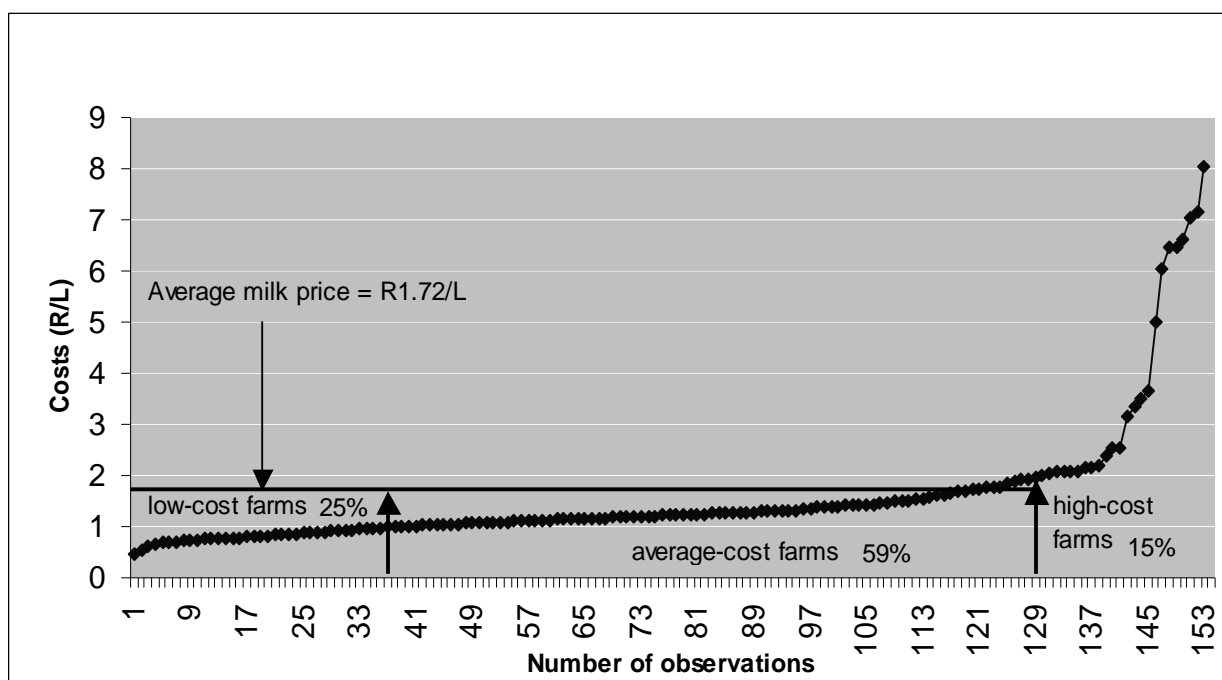
Figure 6: **Cumulative distribution of unit costs of producing milk (1999 to 2007).**

5.   Discussion

The first step in the estimation procedure was estimating a production function using the actual input data for each farm in the sample. An estimate of planned output was derived from the first step, and this, in turn, was used to estimate the LAC curve in the second step. The estimated planned output is synonymous with the milk variable in the second step (second equation). The estimation of the LAC curve was done by using a reciprocal function (e.g. Hubbard, 1993(1); Hubbard, 1993(2); Burton *et al.*, 1993a). This reciprocal function allows for continuously falling average cost, which is consistent with an L-shaped curve. Since no spatial data were available and the sample was treated as being geographically and spatially homogenous, a straightforward cost function was estimated and this yielded good econometric results.

In the first estimation step, a Cobb-Douglas production function was estimated, and this is shown in Table 5. Notwithstanding the restrictiveness of the Cobb-Douglas production function, the results obtained were quite insightful. No further general functions are reported, as these did not give any significantly different estimates of planned output, so we stick with the Cobb-Douglas production function. Number of cows was the dominant input and this is to be expected, because cows are the most important resource in dairy production (they produce the milk). The inputs elasticities for cows and land are high, implying that, on average, additional use of these inputs increases

output. In other words, production of milk can be increased by increasing the number of cows in the herd (herd size) and land under dairy production or both. These findings are hardly surprising, as cows are the most important input in milk production. The small elasticities of both the machinery inputs (milking and other equipment) seem to imply that machinery is relatively fixed, thus not highly dependent on the amount of output being produced. This, in turn, has the connotation that increasing machinery is unlikely to result in increased milk production, but will invariably increase the unit cost of producing milk.

Table 5:   Production function estimates

Variable	Coefficient
Constant	5.59 (11.27)
Cows	0.432 (4.78)
Land	0.248 (3.36)
Labour wage	0.183 (3.4)
Purchased feed	0.15 (4.48)
Veterinary expenses	0.068 (2.71)
Milking equipment	0.093 (3.43)
Other equipment	0.034 (1.07)
R^2	0.49
Sample size	37

All variables in natural logarithms; equation estimated by robust errors; t-statistics in parenthesis

The statistical properties of this function are satisfactory, given the panel data used for the analysis. The important coefficients relating to planned output and management are significant, and the R^2 value is reasonable. Forty-nine percent of the variation in output is explained by variation in inputs. The findings of the current study are similar to those of Burton *et al*. (1993b), who reported R^2 values of 0.34 and 0.45 in a study of long-run average costs curves in the England and Wales dairy industry.

Table 6 shows the cost function estimates, and these are quite interesting in that the R^2 is quite high (0.89), implying that the variables selected actually explain 89% of the costs incurred in producing milk in the sample. Purchased feed, as expected, accounted for the bulk of the costs, followed by labour cost. Table 7 simply shows the correlations between the cost variables. Again, purchased feed had the highest correlation with total cost, followed by milk

and land. Interestingly, there also were high correlations between land and milk, and this also is consistent with prior expectations.

Table 6:   Cost function estimates

Variable	Coefficient
Constant	7.33 (5.57)
Milk	0.47 (10.67)
Labour Cost	0.53 (9.26)
Purchased Feed	0.703 (15.31)
Veterinary expenses	0.068 (2.71)
R^2	0.89
Sample size	37

Table 7:   Correlation between the total cost variables

	Total cost	Milk	Labour cost	Land	Purchased feed
Total cost	1				
Milk	0.8741	1			
Labour cost	0.2323	0.3165	1		
Land	0.8232	0.9242	0.2592	1	
Purchased feed	0.9057	0.9252	0.3244	0.8699	1

6.   Conclusion

Unit costs of production estimates clearly show that average costs decline as herd sizes increase, and they provide some useful information for assessing the sources of the cost advantage. This implies that there area economies of size at play in milk production in the KwaZulu-Natal Midlands, and these persist even at relatively high levels of output. Diseconomies of size were not evident in the sample. The implication here is that farmers, on average, can still increase production and farm size without incurring increasing cost per unit of milk produced.

A conceivable hunch to explain the finding that economies of size are persistent with higher output levels is that pasture-based dairy production is efficient in terms of costs per unit of output. This hypothesis lends credibility to the observed trend of dairy farms moving away from inland to coastal areas, where pasturage is better. It is worth repeating here that dairy production in South Africa is largely pasture based, and this receives backing from the findings of the study. However, the usefulness of these findings is not without limit. One the most striking limitations is that it is not possible to

determine whether a cost advantage derives from more efficient input use or from lower prices paid, because the estimates do not distinguish between input quantity and input price. The second limitation is that the unit costs of production estimates reflect the average performance of farms in each size class. In reality, farms differ in efficiency, thus some are best-practice efficient farms while others may be poor performers, even within size classes. Consequently, costs can fall as herd sizes increase, either because larger enterprises tend to be more efficient or because technology creates scale economies that allow large enterprises to realise lower costs than equally efficient smaller enterprises.

The level of managerial ability, as proxied by margin over materials, has an important effect on the average costs of production. Consequently, farmers with better managerial abilities incur conspicuously lower production costs. A nuance to be gleaned here is that margin over materials is a good proxy to use for managerial ability.

The study showed that many small dairy farms in the area operate near the margin of viability. These small marginal farms can benefit from improved revenues. Possible sources of enhanced revenue are higher product prices, and value-added activities such as agri-tourism or cheese making, and these may go a long way in sustaining these farm operations. Other small farms may be able to adopt production technologies, such as managed (sometimes called controlled) grazing, which invariably leads to lower gross returns but substantially lower costs. Still other farms may turn to organic milk production, which offers higher milk prices (niche market) but has higher feed costs attendant to it. Regardless, continued shifts of production to larger enterprises will place downward pressure on conventional milk production costs and prices, and that will impose powerful competitive pressures on small farms and on alternative products and production technologies.

Caution would have be exercised in using these findings in a generalised manner, as the data used were taken from a small sample of 37 farms in one particular area without accounting for heterogeneity that might exist between the farms. In this study, heterogeneity was assumed because all the farms were located within the same geographical area. However, it is possible that there may be marked differences between the farms in terms of resource endowment, such as soil fertility, acidity, etc., which are factors that are known to vary within short distances. Notwithstanding the foregoing cautionary remarks, the findings are quite useful in that they provide a good basis for further and more detailed analyses to properly understand the dairy industry in South Africa.

7.   Acknowledgements

The authors would firstly like to express their unreserved gratitude to Allan Penderis of Tammac Consultants cc in Ixopo, for his invaluable assistance in providing the data used. Secondly, the authors are indebted to participants at the 43rd AEASA Conference held in Windhoek, Namibia in September 2008 for their useful comments and suggestions during a presentation of an earlier version of this paper. Last but by no means least, the authors would like to acknowledge, with gratitude, the contributions of Professors Colin Thirtle and Jennifer Piesse in analysing the data and the use of STATA.

References

Botha T (2007). Produksiekoste kniehalter SA melkboere. *Landbouweekblad* 1496:30-32.

Burton GW, Gates RN & Hill GM (1993a). Registration of 'Tifton 85' Bermuda grass. *Crop Science* 33:644–645.

Burton MP, Ozanne A & Collinson C (1993b). Long-run average cost curves in the England and Wales dairy industry – comment. *Journal of Agricultural Economics* 44(3):502–506.

Coetzee K (2002). Low producer prices could cause long term decline. *The Dairy Mail* (January):88.

Coetzee K (2007). The squeeze is on. *The Dairy Mail* 14(2): 35-37.

Dawson PJ & Hubbard LJ (1987). Management and size economics in the England and Wales dairy sector. *Journal of Agricultural Economics* 38:27-37.

Department of Agriculture (2003). *Abstracts of agricultural statistics* (AAS). Pretoria: Department of Agriculture.

Department of Agriculture (2007). *Dairy Marketing.* Paper No. 6 [Online]. www.nda.agric.za/docs/MarketExtension/6Dairy.pdf   (Accessed 12/06/2008).

Hubbard LJ (1993). Long-run average cost curves in England and Wales dairy sector. *Journal of Agricultural Economics* 44:144-148.

Hubbard LJ, Dawson PJ & Scott CR (2007). Estimating the unit costs of producing oilseed rape in England. *Journal of Farm Management* 12(11):709-718.

Matulich SC (1980). Efficiencies in large-scale dairying: incentives for future structural change. *American Journal of Agricultural Economics* 60:642-647.

Milk Producers' Organisation (2007). The primary industry. *Lacto Data|Statistics* 12(1):3-5.

Milk Producers' Organisation (2008). *Lacto data: Statistics*. A service to the dairy industry by the Milk Producers' Organisation [Online], www.dairyconnect.co.za (Accessed June 2008).

Penderis A (2004). *Historical dairy financial management results* [Online]. www.tammac.co.za (Accessed 05/06/2008).

Short S (2004). *Characteristics and production costs of US dairy operations.* Statistical Bulletin No. SB974-6. Washington DC: United States Department of Agriculture, Economic Research Service.

Statistics South Africa (StatsSA) (2001). *Census* [Online]. www.statssa.org.za (Accessed August 2008).

Statistics South Africa (StatsSA) (2003). *Census* [Online]. www.statssa.org.za (Accessed August 2008).

Tauer LW & Mishra AK (2003). *Can the small dairy farm remain competitive in US agriculture?* Working Paper 2003-28. Department of Applied Economics and Management, Cornell University, Ithaca, New York.