AN ECONOMETRIC APPROACH TO ESTIMATING THE UNIT COST OF PRODUCING MILK IN THE SOUTH AFRICAN DAIRY INDUSTRY

BY

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THESIS

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DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work (unless stated otherwise) and that I have not previously submitted it, in its entirety or in part, to any university for a degree

Signature.. Date.....................................

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ABSTRACT

Small dairy farms in South Africa are observed to have higher costs than larger farms, and whether those higher costs are due to technology or inefficiency has implications for policy. This research focused on finding the curve that best represents the relationship between average cost and level of output. That was done by relating average cost to actual output. However, it was found to be 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. As a result, a pragmatic two-step procedure was adopted. In the first step, the farmer's planned output was determined by estimating a production function based on the farmer's actual use of inputs, i.e., land, number of cows in the herd, labour, feed and veterinary costs. In the second step, the long-run average cost (LAC) curve was estimated where average cost is calculated as total cost divided by planned output and this is then related to the level of planned output. To identify the determinants of production cost thus the drivers of higher costs on small farms, the cost of milk production by farm size was decomposed into frontier and efficiency components with a stochastic cost curve and long run cost curve using data from dairy farms in KwaZulu-Natal (South Africa). Financial data of 37 farms for the period 1999 to 2007 were used in econometrics estimation of long run average cost curve (LAC) function for different level of production (as a proxy of planned output). Results show that average cost curves exhibiting variation in unit cost with output thus suggesting the existence of economies of size with larger farms being able to produce any given level of output at lower costs compared to their smaller counterparts. The study found that long-run average cost curve (LAC) for the sample of dairy farms is L-shaped rather than U-shaped.

List of Abbreviations

AAS	Abstract of Annual Statistics
APP	Average Physical Product
L	litres
LAC	Long-run Average Cost Curve
MPO	Milk Production Organisation
MPOSA	Milk Producers Organisation of South Africa
MPP	Marginal Physical Product
NAMC	National Agricultural Marketing Council
NCD	Natal Cooperative Dairies
OLS	Ordinary Least Squares
PPC	The production possibility curve
PPF	The production possibility frontier
R	South African currency (Rand)
SA	South Africa
UIF	Unemployment Insurance Fund

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CHAPTER 1 : INTRODUCTION

1.1 Introduction

The dairy industry is the fourth largest agricultural industry in South Africa, representing 5.6percent of the gross value of all agricultural production. The coastal regions of the Western, Southern and Eastern Cape and KwaZulu-Natal contribute more than 42percent of national milk production, with the largest number of dairy producers found in the Free State 24.9percent and the Western Cape 21.5percent (National Department of Agricultural Pretoria, 2003).

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 to 40 000 people (National Department of Agricultural Census 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 80percent of the total milk delivered to dairies, producing a large range of mainly commodity dairy products.

Deregulation in the South African agricultural sector led to the abolishment of the Dairy Marketing Board and the quota system. A number of new organisations developed to represent the interest of the diverse industry, particularly that of the broad range of milk producers. Low-volume producers (averaging less than 250 litres of milk per day) constitute 18percent of all dairy producers and deliver 9percent of the total production. Farms that average more than 5 000 litres of milk per day (1percent of all milk producers) produce 11percent of raw milk deliveries to dairies.

There are also numerous small operations processing less than 2 000 litres of milk a day and often supply on a regional basis. Following agricultural deregulation in the mid 1980s, 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 multi-nationals like Parmalat and Danone in large South African dairy companies, and the continuing presence of Nestlé and Clover.

The small commercial dairy farms in South Africa have higher unit costs of producing milk than larger farms (Coetzee, 2007: 35-37; Botha, 2007: 30-32; Nofal, 2002: 46). 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 those farms are competitive with larger dairy farms, and their long-run survival depends upon having 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 high cost is due to inefficiency, then educational approaches are needed to ensure small dairy farms use appropriate technology efficiently.

1.2 Statement of the problem and objectives

This research proposes to estimate the unit cost of producing milk for the South African dairy farmers. The main objectives are:

- To describe the dairy farms in South Africa using a sample from the KwaZulu-Natal Midlands
- To estimate the milk production function of dairy farmers by farm size
- To estimate and interpret the long-run average cost curve of dairy farming

1.3 Rationalization of the study

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 the KwaZulu-Natal midlands from the year 1999 to 2007 obtained from Tammac Consultants 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 at 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 as a function of the number of cows. The modelling procedure proposed will allow for both frontier and efficiency cost components to vary by 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 (Hubbard *et al*., 2007; Dawson and 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, area, labour, fertilizer, 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.

1.4 Delimitations

The low output may be resulting from low quality feed, poor genetics, disease, or poor cow comfort among many other reasons. This study however will not further investigate these issues.

1.5 Significance of the study

Understanding the reasons behind the high cost of production for small dairy producers has important policy implications. For instance, if high costs of production on smaller farms are 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 commercial farms.

If instead high cost is due to inefficiency, and not a high cost frontier, then current technology exists that would allow small farms to be competitive with larger farms. Educational programs would be necessary to ensure that small farms use more efficiently the technology currently available to them at their respective size.

1.6 Layout of the thesis

This thesis consists of six chapters. Chapter one provides the introduction of the research study, statement of the problem, objective, and rationale of the study delimitations and significance of the study. Chapter two provide a general description of the South African dairy industry. Chapter three provide a survey of the available literature and research conducted on economies and diseconomies of scale and size, the theoretical framework of theory of concept of production function, efficiency modelling and concepts of long-run average cost curve (LAC), mainly focus on identifying what has been done concern LAC on estimating unit cost on production of milk as per the literature. Chapter four mainly deals with data, research design, methods and techniques used. Chapter five provides results and discussion from econometrics estimation and give the shape of the long run average cost curve from data analyses that were estimated using the ordinary least squares (OLS) method using STATA version 10 (StataCorp, 2008). Chapter six provide the overall conclusions drawn from the research findings, recommendation and suggestions for further research.

CHAPTER 2 : THE SOUTH AFRICAN DAIRY INDUSTRY

2.1 Introduction

The dairy industry in South Africa is large and complex, and provides an ideal case study to unpack the structural factors that could influence production. The primary industry is undergoing a number of structural changes at present. The total number of commercial milk producers in South Africa has been declining and there has been a remarkable move of dairy operations from inland to coastal areas (MPO, 2002; MPO, 2007).

2.2 The structure of the dairy industry

The structure of the dairy industry has changed with the developments that have taken place in South African agriculture, such as deregulation and the inherent liberalization of the industry. Factors such as changes on the technological front, infrastructure, consumer preferences and product development have contributed to this change. From the establishment of the first factory in 1890, large changes have taken place with regard to the number of factories and milk producers. A large amount of small factories and milk producers have been gradually replaced with smaller numbers of larger factories and milk producers. In 1976 there was approximately 27 000 industrial milk, 20 000 cream and 3 500 fresh milk producers in South Africa (De Jong, 1994). This is a total of 50 500 primary milk producers. These farmers represented 63percent of the South African farmers. In 1993 the estimated number of milk producers was 7 200 of which 6 496 rendered a return to the Dairy Board (De Jong, 1994). Although there has been a drastic decline in the numbers of milk producers, the quantity of milk produced exhibited only a marginal decline. In the period July 1975 to June 1976 there was 2 407 000 tons milk produced compared to the 1 934 479 tons for the period July 1992 to June 1993 (Dairy Board, 1993: 3).

In 1976 there were 30 cheese factories, 22 butter factories and 22 milk powder and condensed milk factories. There were also 25 bigger and a large number of small fresh milk factories. There are approximately 15 large cheese factories, 15 milk powder and condensed milk factories, five long life milk factories, four large butter factories and a large number of large and small fresh milk factories (Repshold, 1993:31). The scenario depicted above yields five interest groups identified in the dairy industry, namely the producers, producer distributors, manufacturers, consumer and policy makers.

2.3 The control and origin of dairy industry

During the slump in 1922 the dairy industry faced a serious setback due to low and fluctuating prices causing a build up of surpluses. Consequently the Board of Trade and Industries was instructed by the government to investigate the position. Their findings were that excessively high manufacturing costs were preventing successful competition in overseas markets and that there was a lack of coordination of supply, manufacturing and distribution. On their recommendation the Dairy Industry Control Board was established in 1930, under the Dairy Control Act No. 35. The Board's functions were as follows (Dairy Industry Control Board, 1946:3):

- To impose levies on butter and cheese.
- To manage and control export of butter and cheese.
- To prescribe subsidies on exports of butter and cheese
- To promote the consumption of dairy industry products.
- To co-ordinate the production, manufacture and marketing of dairy products
- To fix minimum prices for the primary production if the prices sunk unduly low

In 1937 the Marketing Act was announced and the Board of supervision for the dairy industry was established. On the 4 March 1962 a control scheme came into effect in certain metropolitan areas. Due to this the Milk Board was introduced and its objectives were to bring stability to the fresh milk industry. The Board of supervision was converted into the Dairy Board, which merged with the Milk Board on first of March 1979 to form the Dairy Control Board. The name of this board was changed to the Dairy Board on June 1982 and the main objectives of the Dairy Board were:

- To stimulate growth in the dairy industry
- To render and service to the dairy industry
- To accomplish stability within the dairy industry

2.4 Production, processing and consumption

Milk is "harvested" normally twice a day, 365 days a year. The production of milk requires specialised milk cows, buildings according to specified regulations, equipment and management. Great demands are made on the modern dairy farmer, not only as regards a large capital investment in a herd, milking stables and milking equipment and a high operating expensive structure, but also regard knowledge and entrepreneurial acumen. These factors especially with regard to capital investment have led to the increase in herd size while the number of producers has declined dramatically. Average milk production per cow has also increased over time due to improved nutritional, breeding programmes and management. Milk production can in the short-term only be marginally adjusted by controlling the amount and type of feed fed to the cows (nutrition). Large changes in milk production can only be accomplished by changing the numbers of cows or by applying a long term breeding program (Korsten, 1992).

The four most important dairy cattle breeds in South Africa are Friesian (Holstein-Friesian), Jersey, Ayrshire and Guernsey. Other dual-purpose breeds like the Simmentaler are also used. The production structure of the milk industry is characterised by the 80:20 principle, where 66.2percent of the milk producers produce about 24.6percent of the milk. This production is relatively spread throughout the country and is currently divided into six milk producing regions, namely Western Cape, Free State, Kwazulu-Natal, Eastern Cape and Northern Cape (AgriReview, 1993).

Milk is produced in nearly all regions of South Africa. However, the coastal areas are more suitable because of mild temperatures and good rainfall which ensures good-quality pastures. In 2007, the Western Cape Province contributed 25.3percent to total production, Eastern Cape 21.8percent, Free State 12.8percent, Mpumalanga 7.6percent, North West 7.1percent and the remaining three provinces 4.3percent. South Africa produces some 2.37 billion litres of milk per annum (MPO, 2008). More than 64 percent of all the milk produced in South Africa is produced in the Western Cape, Eastern Cape and KwaZulu-Natal on pasture based systems, with only KwaZulu-Natal producing 21.1 percent of South Africa's milk which is equal to (500 million litres). There has been 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.

According to the Milk Producers' Organisation, the estimated number of commercial milk producers in the country in July 2007 was 3 727, as against 4 039 in July 2006. Milk production in South Africa makes a very small contribution to world milk production (approximately 0.5percent); however, in terms of the value of agricultural production in South Africa, it is the fourth largest agricultural industry in the country. The gross value of milk produced during 2006, including milk for own consumption and on-farm usage, is approximately R5 629 million. In South Africa, traditionally, milk surpluses are produced and severe shortages are seldom reported. Production during 2007 is expected to be approximately 2 373 million litres, which is 2.1percent lower than the 2 425 million litres produced in 2006 and 4.5percent lower than the expected consumption of 2 480 million litres in 2007. Above South Africa's own production South Africa imported 4 529 679 litre of milk and 9 852 949 kg of concentrated milk and powdered milk in 2007 (MPO, 2007).

Table 1: **Geographical distribution of milk production in South Africa, 1997 and 2007**

Region	**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	12.5	7.1
Gauteng	4.4	3.1
Mpumalanga	11.0	7.6
Limpopo	0.4	0.5
Total	**100**	**100**
Coastal areas	52.4	68.2
Inland areas	47.6	31.8
Total	**100**	**100**

Source: MPO 2008

There was a reduction of two percent on the total milk to market from 2006 to 2007. The reasons for this reduction in production were the drought in the summer rainfall area, which resulted in less silage being produced, and the high prices of maize and other grains (MPO, 2008). The trends of the price ratio between average monthly SAFEX maize price and the producer price of raw milk is illustrated in figure 1.

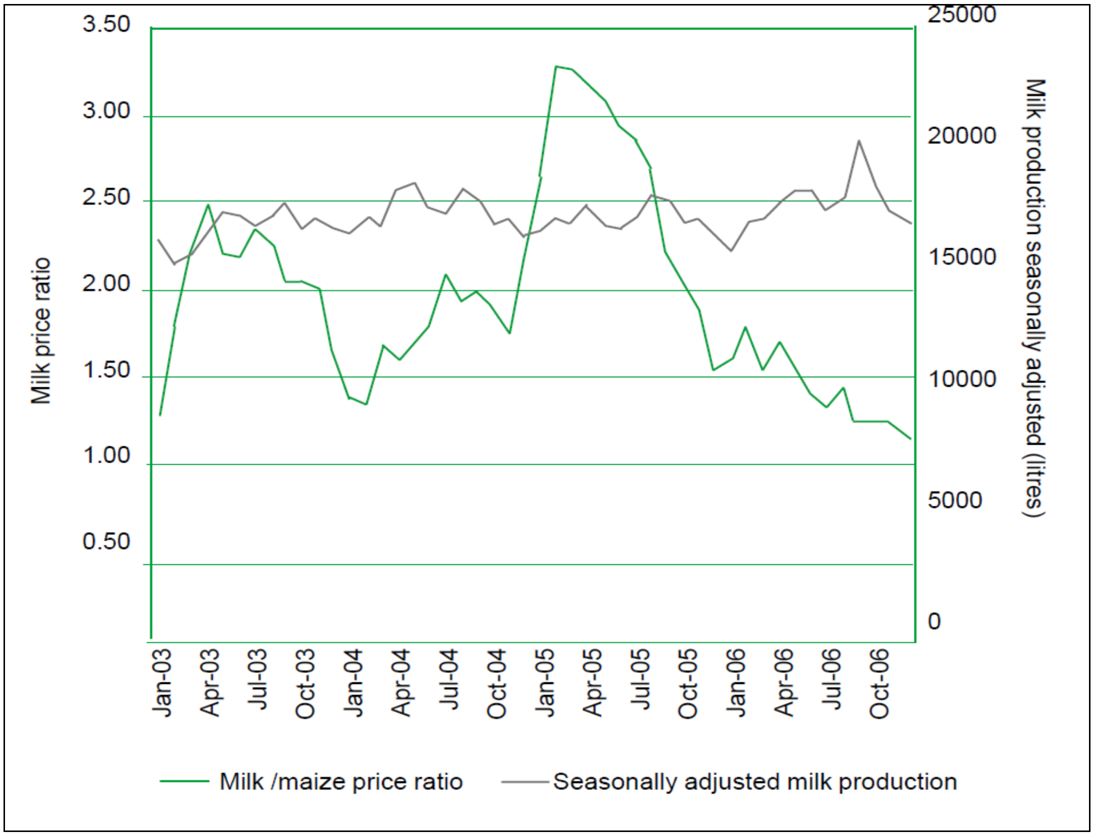

Figure 1: **Trends in the milk/maize price ratio and the seasonally adjusted milk production**

Source: MPO (2007).

Figure 1 clearly shows that the producer price of milk has not kept up with the average SAFEX yellow maize price. The milk/maize price ratio, depicted in Figure 1, indicates a strong downward trend during 2006. This shows that the price of maize, which is the main feed input for milk production, increased at a faster rate than the increases in the producer price of milk. The ratio averaged 1.44 during 2006, decreasing from a high of 1.77 in February to 1.18 in December. The seasonally adjusted monthly milk production averaged 178 400 million litres in 2006, peaking at 203 000 million litres in September 2006.

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 multi-nationals like Parmalat and Danone in large South African dairy companies, and the continuing presence of Nestlé and Clover.

The South African dairy industry is, however, in the process of structural change that is reminiscent of the changes that took place in other industrialised agricultural economies such as the USA, Australia and New Zealand. Of particular interest is the decline in the number of smaller producers along with a decline in their share of production. Structural changes are also occurring in the processing industry responsible for the manufacturing of dairy products. In the aftermath of deregulation there has been a marked increase in the number of small milk producer-distributors using non-traditional distribution channels, including bulk milk tanks in greengrocers, butcheries and bakeries (Vink and Kirsten, 2002).

At the end of 1997 milk was bought and processed by some 350 milk processors and manufacturers in South Africa (see Table 2) below. Apart from regular processors and manufacturers, approximately 522 producer-distributors were actively involved in the marketing of liquid milk and fresh dairy products in 1997. There is a general perception in the industry that the number of producer-distributors grew substantially after deregulation, while the volume of milk processed by medium sized processors increased both nominally and relatively (Vink and Kirsten, 2002).

Table 2: The number of buyers and producer-distributors registered with the Milk Board, 1997

Province	Milk buyers		Producer-distributors	
	Number	**percent**	**Number**	**percent**
Western Cape	**42**	**12**	**59**	**11**
Eastern Cape	**29**	**8**	**62**	**13**
Northern Cape	**9**	**3**	**33**	**6**
Kwazulu-Natal	**29**	**8**	**72**	**14**
Free State	**39**	**11**	**75**	**15**
North West	**32**	**9**	**49**	**9**
Gauteng	**122**	**35**	**64**	**12**
Mpumalanga	**37**	**11**	**64**	**12**
Northern Province	**10**	**3**	**44**	**8**
Total	**349**	**100**	**522**	**100**

Source: Milk Board, 1997

Approximately 88percent of processors and producer-distributors account approximately for 3.5percent of total milk processed. These processors are mainly small entrepreneurs involved in processing liquid milk and to some extent fresh dairy products in rural areas. Individually they process less than 2 000 litres milk per day. The Agricultural Research Council is prominent in supporting small dairy processors (Keller, 1999). The four largest dairy company's process between 74percent and 78percent of total commercial milk delivered to dairies (Theron, 2000). An interesting aspect of the dairy industry has been shifting rivalry following deregulation when a large well established Italian dairy company, Parmalat entered the South African dairy industry at high cost and fierce rivalry.

The immediate effect of Parmalat's entrance was an intensification of competition by way of a price war in cheese and butter from beginning 1998, lasting until the first quarter of 2000. Parmalat has a leading research system and has available technology and products "from the shelf". As such it is stepping up competition with a wide variety of products, appealing to young and old but with relation to South African consumer and market conditions, it is on a steep learning curve (Theron, 2000).

Medium sized dairy processors, knowledgeable of such conditions and with excellent products are at present growing their market share via strong competitive positions and at the expense of larger dairy processors. In the long run large dairy companies might revert to their standard tactic of growing market share in a slow growing national market by buying out medium sized processors with well established niche markets. However, this suggested move by large processors is unlikely given that the dairy market and companies are at present under financial duress. The long-term effect of Parmalat's entrance can be that competition will move from intense to less intense price battles, with more focus on novel and quality dairy products. Medium sized dairy processors will endeavour to entrench their position in their immediate market domains, expanding slowly into other areas, as high transport cost is a deterrent to aggressive expansion to other areas further away from the production plant.

2.5 Farm value and dairy products

The raw milk producer price, as recorded by the Milk Producers Organisation of South Africa (MPOSA), averaged R1.89 per litre in 2006 and increased by 10.1percent year-on-year from December 2005 to December 2006 at farm level there exists near perfect competition. Farmers are numerous; largely price takers selling a homogenous product, example butter, fat, cheese, etc and are subsequently subject to a perpetual cost price squeeze, while on the input and output side farmers are faced with companies operating under oligopolistic market environment. This means that farmers are quite bound to the prices that they receive and they can only bargain prices to a very limited extent with either input suppliers or milk buyers.

The most plausible recourse that farmers have is to intensify their production processes and to improve productivity. The formation of more functional cooperatives to increase farmers' bargaining power is another alternative available to them. Milk buyers, on the other hand, operate in an oligopolistic market. The industry is still dominated by four large buyers/processors. These dairy companies process approximately 74percent to 78percent of the total milk delivered to dairies. More recent estimates reveal that between 60percent and 70percent of the total delivered milk is processed by the four large companies. There are a few rounds of negotiations between milk buyers and producers that precede the formal notification of the buyers' price decision. Milk buyers prefer to negotiate the prices during autumn when milk flow is low. There is a wide variety of products that are processed from milk. These products impose different demands for milk solids and volume. These product specifications are included in the negotiations and vary according to the market segment in which the buyer finds him/herself (Department of Agriculture and NAMC, 2006).

Farm to retail price spread and farm value share of products contained in the South African food basket are important concepts. The farm-to-retail price spread is the difference between the farm value and the retail price. It represents the payments for all assembling, processing, transporting and retailing charges added to the value of the products after they leave the farm. Price spreads are sometimes confused with marketing margins. Marketing margins represent the difference between the sales of a given firm and the cost of goods sold. There is often a time lag between the receipts and the final sale of merchandise. Spreads, on the other hand, represent the difference between the retail and farm prices of a specific product at a given point in time (Elitzak, 1997).

2.6 Milk price and marketing trends

Theoretically and on the surface prices are formed as a result of market demand and supply. There is no uniform payment system on which producer price of milk is based. The inclusion of for instance butterfat and protein in the payment system depends on the type of milk buyer. A milk buyer who processes butter and cheese will include butterfat and protein in the price they offer, while a buyer that processes and distributes fresh milk is only interested in milk volume. The price of farm requisites increased steadily at nearly 10percent per year over the period September 1995 to July 2001. Since then, the weakening of the rand has resulted in an accelerated increase in input prices largely because a number of the inputs use imported ingredients, such as fertiliser and veterinary medicines (MPO, 2002). When there is a shortage of milk, prices increase. Farmers 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.

Producer prices showed an increasing trend from March 1999 because of a shortage of milk that year. However, this did not result in any corresponding increase in production because producers were still suffering from the combined effects of declining producer prices and higher interest rates during the previous two years. Due to the nature of dairying, producers can only absorb lower producer prices for only 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, (MPO, 2002).

Although the variable cost of producing milk from pastures in the coastal areas is lower, the extra cost to transport milk from coastal areas to the markets should be taken into account. Despite the fact that variable cost of producing milk from pastures is lower in the coastal areas, there are still dairy farmers that are less efficient in their milk production, and are thus struggling to break even. It is this dichotomy in 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 of 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, as previously stated, while the share of larger producers in the total milk production is growing. The average milk producer now easily produces 1 380 litres per day, up 20 percent on 2001. Given the current trend of many small farms exiting the market and large farms increasing or persisting, it is likely that there are increasing returns to scale (or economies of size) which need to be taken into consideration in estimating the cost of production in the dairy industry.

Table 3: Size distribution of milk producers in South Africa, 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

2.7 Problems experienced within the dairy industry

The Dairy Board (1991:20) stated that with deregulation, free enterprise and competition amongst milk buyer, processors and manufacturers, will result in the South African consumer being assured of a regular supply of milk and dairy products at a reasonable price. Even with partial deregulation that had already taken place, the dairy industry found itself in a difficult situation. In 1991 the Dairy Board suffered an export loss of R108 million, and was faced with a 9 300t butter mountain and a 22 600t pile of skim milk powder in 1992 (De Villiers, 1992:49). However, the main point of contention revolved around the payment of the special levy which the Dairy Board claimed from all milk buyers. Non-manufacturing dairies claimed that the surplus disposal control favoured large manufacturers at their expense, due to the fact that they received no benefits from the subsidy but still had to pay the levy.

Finally the fresh milk distributor's battle against the payment of the levy reached the courts in June 1992 in the well-known Homestead independent Dairy case. The judgement in the Cape Supreme Court rejected an application by the Dairy Board for the payment of levies by the Homestead Dairies. The judgement resulted in levies amounting to R361 million collected since February 1987 being invalid (Harrison, 1992: 38). Consequently the future of the Dairy Board was in jeopardy.

On the 18th June 1993 the chairman of the Dairy Board announced that the board would drastically reduce its functions and staff following the recommendations made by the industry task group. The task group recommendation specifically excluded any compulsory industry stabilisation for the Board. The Dairy Board was to directly administer its own affairs and personnel rather than rely on the Dairy Services Organisation, which was disbanded. The primary function of the Board would be to provide statistics, marketing and other services that promote the industry on a budget R 9 million (Financial Mail, 1993).

CHAPTER 3 : LITERATURE REVIEW

3.1 Introduction

The main focus of this chapter is identifying what has been done and reported in the literature on estimating unit cost of producing milk in the studies of long-run average cost curve. This chapter will provide a survey of the available literature and research conducted on the theoretical framework on the concept production function, economies and diseconomies of scale and size and concepts of long-run average cost curve of the dairy industry in South Africa and elsewhere.

3.2 Economies and Diseconomies of scale

An age-old question that has baffled economists and producers alike is what happens to unit costs of production when all inputs categories are increased. If the increase in all inputs results in a directly proportional increase or decrease in output then no economies or diseconomies of scale are said to exist (constant returns to scale). If output increases more than in proportion to inputs then economies of scale are said to exist. If output increases less than in proportion to inputs, then diseconomies of scale are said to exist. For economies or diseconomies of size to take place, all that is required is that average costs of production change as a result of a change in the scale of production. Note should be taken that not all inputs need to change proportionately. However, if economies or diseconomies of scale are to take place not only must output change but each of the inputs must change in a fixed proportion to the others (Debertin, 1986).

The term scale implies a proportionate increase in all inputs, not just those treated as variable over a production season, but also other agricultural inputs such as land, labour, capital and other farm machinery. Furthermore, many of these inputs can be increased or decreased only in discrete amounts. The scale of farm is much more restrictive than the term size of farm. A farm uses land, labour, capital, and management as inputs to the production process. If the scale of a farm is to increase, each input, fixed as well as variable, must also increase proportionately. Moreover, a complete and practical definition of scale should imply that the level of management should also increase, albeit the difficulty of quantifying management as an input. However, there is a common practice of distorting the strict definition of , thus glibly using the term. According to Debertin (1986), the most common misuse of the scale concept is using it under circumstances where an increase in one or more of the input categories such as land without a corresponding increase in all other input categories.

3.3 Scale economies and structure in dairy farming

Herman (1996) recognized that economies of scale in production are only a part of the explanation of structural change. Strong structural changes, specifically the ongoing shift of production to larger operations suggest that there may be significant economies of scale in dairy production, in the form of cost advantages accruing to increased herd sizes (MacDonald *et al* 2007:5). It is also interesting to note that this move to fewer and larger operations is happing in the South African dairy industry as explained in Chapter 2 under the discussion of the dairy industry in South Africa. Whether or not this is an axiomatic implication of economies of scale in the South African dairy is an interesting question that will be tackled in this study.

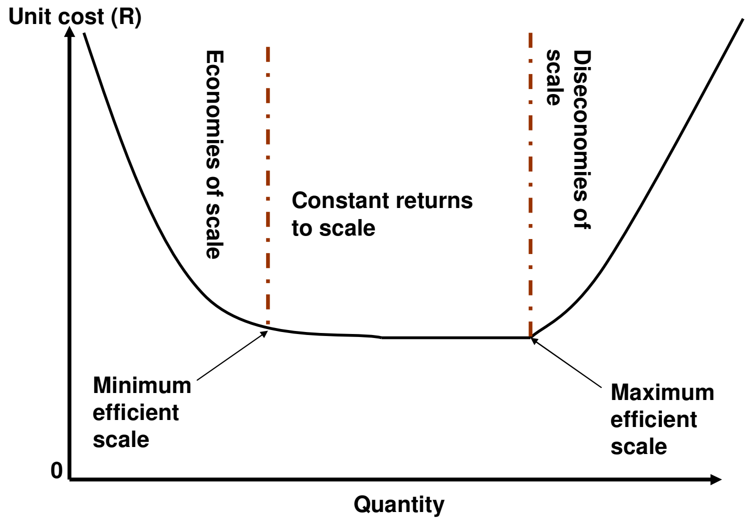

Figure 2: Reflection of scale economies

Source: MacDonald *et al* (2007).

Figure 2 portrays the long-run average cost curve and its three sections namely: increasing returns to scale (IRS), constant return to scale (CRS) and diminishing returns to scale (DRS). Returns to scale, as a concept, is concerned with the change in unit costs as levels of production change. All long-run cost curves are derived from long-run production functions. The shape of the long-run production function depends entirely upon the technology and biological characteristics of the production process under consideration thus any change in these factors, including price, possibly will shift the position and shape of the curve (Doll and Orazem, 1984). To minimize the cost of production in the long run, each level of output must be produced with the least cost combination of inputs (Upton, 1979).

Long-run average cost curve express cost as a function of output and expansion of output usually increases efficiency as average costs per unit of output tend fall and this particularly true when the farm is small. The reasons usually cited for the decrease in cost include an increased degree of specialization of labour and capital. It seems logical that a farmer with more cows has more reason and motivation to improve on management than a farmer with fewer cows and the cost of learning and adopting such technologies relatively cheaper for larger farms (in terms of unit cost). Samuel and Shaw (1983:3) referred to economies of size as the "tendency for unit costs of operation to fall as the size of farm increases". The theoretical underpinnings of the declining production cost with increasing level of operation (farm size) are that there are savings from better use of own labour (farmer), ability to use larger equipment, discounts from bulk purchases of inputs and sale of milk, amongst others (Samuel and Shaw, 1983).

MacDonald *et al* (2007:5) suggested that any attempts at modelling or assessing how cost-scale relationships affect the size and structure of farms the following elements should be considered and these elements are derived Figure 2. The fist element that was postulated was the firm's minimum efficient scale. The firm's minimum efficient scale has been defined as the level of output at which scale economies are just exhausted, that is, the point at which constant returns set in. The second nuance to be considered is how much higher are the costs of small firms that are unable to realize minimum efficient scale. This should be viewed as the cost penalty for small-scale operation. In other words this refers to the cost of a plethora of small purchases of inputs as opposed to bulk buying and its often concomitant savings.

The maximum efficient scale is the third point that should be considered in cost-scale discourse in dairy farming. The maximum efficient scale is the level which diseconomies set in and it refers to the largest firm size that can be achieved while still realizing all scale economies (MacDonald *et al*, 2007). The fourth point is diseconomies of scale which are particularly important in agriculture because even the largest farms are still fairly small businesses by comparison to their counterparts in other industries. However, where farm businesses are typically small, they are unlikely to suffer diseconomies of scale. This is the level of output where it is no longer economically justifiable to increase scale, that is, when a unit increase in output is not met with a corresponding decrease in unit cost. Lastly, it should be realised that cost curves are efficiency frontiers because they reflect the minimum costs that a firm can achieve, given available technology and prices paid for inputs.

In practice and as often is the case, actual costs could exceed frontier costs and in such cases the farm is considered to be inefficient. The reasons for such inefficiencies could be many and varied. To begin with, some inputs are in fixed supply and cannot easily be adjusted to the level needed to attain the efficiency frontier due to poor operating environment (less than favourable) such weather, soil fertility and topography. The reason for inefficiency could be simply the operator being less effective than other operators in the industry because frontier efficiency is a relative measures and is determined by the sample under consideration. Summarily, a cost curve reflects a given set of input prices thus changes in input prices would shift the curve, but could also alter scale relationships and therefore the shape of the curve.

The following quotation encapsulates the essence of the cost-scale relationship discussion, “Minimum and maximum efficient scales drive the potential range of farm sizes and, coupled with product demand, largely determine how many farm operations will be in business in the long run. The cost penalty from small scale affects the likely survival of smaller operations that cannot realize minimum efficient scale. The efficiency of operations affects survival and the actual industry wide cost changes from structural change. Relative price changes could alter the existing pattern of scale advantages. Increases in prices paid for hired labour, purchased feed, or manure transportation will be, all else being equal, raise average costs more for large dairy farms than for small since they use those inputs more intensively" MacDonald *et al* (2007:5).

Cigno (1971) described economies of scale and industrial location using a linear programming approach and based his postulations on the simple assumption that unit plant costs decline as the size of the plant (scale of production) is increased, while unit transportation costs increase with distance. The views expressed by Cigno (1971) are echoed in many classical textbooks on agricultural market analysis (Tomek and Robinson, 1994; Goodwin, 1994; Ferris, 2005). Also the results of the study by Cigno (1971) showed that, up to a point, the average total cost falls as the size of the plants is increased, because the saving in plant costs more than compensates for the rise in the cost of collecting raw materials from, and distributing the products to a wider area. However, there is a limit to the geographical dispersion beyond which the critical plant size transportation costs rise very steeply and so does the average total cost (Cigno, 1971).

3.4 Economies and diseconomies of size

The term could be used to describe what happens to per unit costs of production when output is doubled or tripled, but input levels do not necessarily increase in the same proportionate amounts. The term also is used to describe a situation in which as farm expands output, the cost per unit of output decreases. There a number of reasons why costs per unit of output might decrease as output levels increase: (a) the farm may be able to spread its fixed costs over a larger amount of output as the size of operation increases; (b) it may be possible to do more field work with the same set of machinery and equipment; (c) the larger producer may be able to take advantage of pecuniary economies; and (d) as the size of the operation increases, the farmer might pay less per unit of variable input because inputs can be bought in larger quantities. Such pecuniary economies might be possible for inputs such as seed, feeds, fertilizers and veterinary costs (Debertin, 1986).

The expression "diseconomy of size" is used to refer to increases per unit cost of production arising from an increase in output. There exist reasons why diseconomies of size might occur as the farm is expanded. As output increases, the manager's skills must be spread over the larger farm, (Debertin, 1986). The long-run average cost curve represents a planning curve for the farmer as increases or decreases the size of the operation by expanding or contracting output over a long period of time, for an increase in the price of a particular agricultural commodity will cause the size of the farm producing the commodity to increase. The inflation that results in a general increase in the prices for all agricultural commodities will cause this measure of farm size to increase, despite the fact that the physical quantity of output may not have increased (Doll and Orazem, 1984).

Economies of size have been an important field of research in agricultural economics for some time now. The economies of size surveys Castle (1989) and Hallam (1991) claim that in agriculture, economies of size exist for a certain range of output but after some level they disappear and average costs tend to become constant thus there is often a levelling out. There are also different shapes of the average cost curve depicting different scenarios. For most industries the average cost curves are either L-shaped on U-shaped. The L-shaped average cost curve in agriculture has been found to persist in the livestock sectors of the industry (McLemore *et al*, 1983:79-83). However, other studies have also found diseconomies of size, a finding typically consistent with the U-shaped long-run average cost (LAC) curve displayed in most microeconomic textbooks. In particular, this finding has been commonplace in studies of dairy farms (for examples see Hoch, 1976; Dawson and Hubbard, 1985; Loyland and Ringstad, 2001). However, other studies in the dairy industry have found the long-run average cost curve to be U-shaped. For example, Samuel and Shaw (1983) found the average cost curve to be U-shaped for the dairy industry in Australia with majority of the farms (78percent) being low-cost producers.

3.5 Herd size and production costs: scale economies or inefficiency?

The cost curve, as depicted in Figure 2, illustrates how costs vary among producers who have cost minimisation as their objective in the manner in which they choose and use inputs. The fact that such producers choose combinations of inputs that allow them to minimize the costs of producing a given level of output renders them allocatively efficient. These producers are also productively efficient because they reap the most from the inputs employed in the production process (MacDonald *et al*, 2007).

In that case, the declining cost curve represents scale economies that allow costs for efficient producers to decline as output expands. Due the nature of scale economies being a technological concept, particularly in dairy production, there may be several sources of any observed scale economies. The determinants of scale economies in dairy farming include milking systems, housing, feed management, and herd size**.** In principle, inefficient enterprises would have costs above the unit cost line, while efficient dairy enterprises would be on the line, often referred to as the cost frontier. "Actual data points can fall above or below the line for other reasons, such as measurement errors in the data or an inability to control for other factors that affect costs. These are called random or stochastic errors. In trying to identify the unit cost line (scale economies) in the data, and to identify the extent of inefficient production, assumptions are made about the nature of the stochastic errors and about the nature of the technology that drives the shape of the line" (MacDonald *et al*, 2007:18).

Costs per unit of output begin to increase as output is expanded; ultimately, the long-run average cost curve will turn up; why? Because; commonly advanced for increasing inefficiencies are managerial limitations/poor decision making by the operator. As firm size increases, the manager encounters increasing difficulty in maintaining control organization/firm, communications and coordination become more difficult, and mistakes are both more frequent and more costly. This causes costs to increase. When the long-run average cost curve is falling, the firm is said to be experiencing economies of size. The minimum point on the long-run average cost curve defines the optimum farm size. A farm of this size will produce the product at the lowest possible cost per unit. Diseconomies of size set in when the long-run average cost curve begin to rise.

3.6 Explicit and implicit costs in dairy production

Any attempt at assessing production costs should ensure that care is taken in accounting for all relevant costs. The dairy industry is particularly a difficult one to analyse in terms of production costs because it is a complex and multiple input-output system (Premakumar and Chaudhary, 1996). The dairy industry is further complicated by the fact that, on the one hand, some costs are explicit and easy to record: for example, purchased feed is recorded in terms of expenses and quantities. Hired labour is another explicit cost to the dairy enterprise as this item can easily be captured as a specific expense incurred for the hours worked during any given time period (Short, 2004). On the other, however, significant implicit costs are also incurred on dairy farms and are much harder to measure. For example, the farmer and sometimes the some members of the family contribute labour to the dairy farm activities. Sometimes this labour is unpaid but this does not detract from the fact that the cost of the family labour should still be recognized and somehow captured. The economic rationale behind recognising this contribution is that the farmer and/or other family members could have earned income by working off the farm, thus their working on the farm comes at a cost in terms of foregone labour earnings often referred to in literature as the opportunity cost of the farm's unpaid labour (Upton, 1979; Short, 2004; MacDonald *et al*, 2007:6).

In dairy farming there two other important implicit costs often incurred and these are farm-produced feed and capital equipment and structures. Farm-produced feeds and forage represent implicit costs because these could have been sold and the land used for their production could have been sold, rented out or used for some other activities. All dairy farms own equipment and structures but often do not record an explicit annual expense for their use - often known as depreciation (MacDonald *et al*, 2007).

Two other issues are pertinent in developing cost estimates and these are joint production and common costs. Dairy production yields joint product milk and livestock, the dairy animals that are culled from the herd and sold (Premakumar and Chaudhary, 1996; Rojko, 1957). If 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 enterprise (MacDonald *et al*, 2007). Next, some costs such as taxes, administrative overhead, and some energy expenses are borne at the level of the whole farm (they are common to all commodities produced on a farm). “Different analytical approaches may have different means of accounting for joint products and common costs, and this may lead to different estimates” (MacDonald et al, 2007:6).

Joint products are the products that result from the same production process. In the extreme case, the two are combined in fixed proportions and production of one without the other is impossible. Conceptually, joint products produced in fixed proportions can be handled in the same manner as single-output production situations. Most of agricultural examples of joint products fall in second category: Joint products with variable proportions, introduction of new varieties breeds in livestock may affect the proportions in which the joint products are produced (Doll and Orazem, 1984).

3.7 Summary

The farmer is able to change the size of the business in long run thus the farmer will seek to make changes that increase the efficiency of farming operation to achieve their goals. Actually, the manager will always change the amount of an input to increase profit through striving for increased efficiency by adjusting the so-called fixed inputs. Production planning in the long run consists of two factor firstly; Enumerating and secondly; Evaluating all the production possibilities the farmer could produce when have the flexibility to consider all amounts and combinations of inputs, through utilisation of the best technologies for each level of output. Many industries exhibit increasing return to scale it is typically the case that efficiency increases with the size of the firm/Industry.

The existence of increasing return to scale means that a percentage increase in inputs will result in a larger percentage increase in outputs. Differences in the way in which reduction in average production costs are achieved highlight an important distinction concerning economies of scale. Efficiency gains can be achieved through economies of scale in two ways: External economies of scale occur when the cost of production depends on size of the industry. Internal economies of scale occur when the cost of production depends on the size of the firm.

Economies and diseconomies of scale, which produce a long- run cost curve which is sometime U shaped, have long fascinated economists (Doll and Orazem 1984). Despite the fact that it is possible for diseconomies of scale to occur, empirical studies conducted for various agricultural economics enterprises have revealed very little hard evidence supporting the existence of significant diseconomies of scale within agriculture. Rather, per unit costs of production usually form an L-shaped curve. However, it is very difficult to verify as that true change in scale has taken place as the output for farm to increases or decreases.

3.8 Production functions

Costs of production studies have a long tradition in the agricultural economics literature. Through the years the cost of production by farm size has been estimated for various commodities and regions of the US (Stefanou and Madden, 1988). Recent cost studies of dairy production have found lower unit costs with larger production units in US (Bailey *et al.*, 1997). These procedures estimate average cost of production by farm output or size without estimating the distribution of costs around these averages by farm size. Their research model estimates the distribution of costs around the means by farm size. The deviations are assumed to be due to inefficiency and data error. Inefficiency is estimated as a function of farm size, and a frontier cost function of efficient farms is simultaneously estimated as a function of farm size.

Tauer (2001) used this approach to estimate the cost of production for New York dairy farms for the production year 1999 and estimated that farms with an average of 50 cows had average costs of $16.95 per hundredweight ($0.36 per kilogram), but $3.34 ($0.07 per kilogram) of that was due to inefficiency. If those farms had all been operated as efficiently as the most efficient 50-cow farm, average costs would have been much lower at $13.61 ($0.30 per kilogram). However, this was still $0.58 ($0.01 per kilogram) higher than the average costs for the efficient 500-cow farm. Although efficient small farms had lower costs than did the average large farm, the efficient large farm still had slightly lower costs. These results clearly show that most of the observed high cost on New York small dairy farms is due to inefficiency rather than purely economies of scale.

Alvarez and Arias (2003) estimated economies of size of Spanish dairy farms assuming fixed managerial ability of each farm operator. These Spanish dairy farms were smaller than many dairy farms in the US. They modelled and estimated managerial ability as the technical efficiency of individual farms, with managerial ability and farm size separately impacting the average cost curve. Since they had panel data, they were able to determine unique farm results. Size elasticity averaged -0.28 with a minimum value of -0.60 and a maximum value of 0.15. The elasticity of managerial ability on average cost averaged -0.26 with a range from -1.12 to 0.82.

3.9 Concept of production function

For a long time now economists attempted to have all theoretical analyses of economic organization grounded in an appreciation of the nature of real production activity (Winter, 2002). Historically theory of production has been concerned with the problem of distribution of the factors of production, that is, land, labour, and capital. There has been a shift in focus production economics literature. Recently the focus of theory of production has been the analysis of the role of production possibilities in the determination of relative prices. However, most recently the efficient allocation of resources has gained more importance and is receiving unprecedented attention in neoclassical economics. In classical economics, it was the marginal productivity schedule, and not the production function or the cost function that was the focus of attention**.** The question was not how much output can be obtained, at a maximum, from any given set of inputs but rather by how much will output increase if the amount of this particular input is increased some, with all other inputs held constant **(**Winter, 2002).

To summarize on the notion of the marginal productivity of an input in a productive process is a particularly important idea in economic analysis, because under competitive conditions, the equilibrium price of a factor of production such as land, labour, capital including wages and interest will tend toward equality with its marginal productivity **(**Winter, 2002). Marginal productivity is the increase in the value of output that can be produced by adding in one more unit of the particular input while holding other inputs constant. Thus the higher the productivity of a factor of production, the higher the income that may be expected to accrue to its supplier and anything that raises overall levels of productivity within a civilization may be expected to increase the average overall wealth of the civilization.

3.9.1 Production possibility frontier

According to Gillespie (2007:16), the production possibility frontier or curve (PPF or PPC) demonstrate the maximum output that can be produced in an economy at any given moment and given the resources available, If an economy is fully utilising its resources then it will be producing on the production possibility frontier or curve. The production possibilities curve represents the amount of each output that can be produced given that the available resources or inputs are taken as fixed and given. The production possibilities curve is usually drawn bowed outward, or concave to the origin of the graph, rather than convex to the origin of the graph because it is the boundary that is of interest.

Herrero and Pascoe (2002:1) described the level of technical efficiency of a particular firm as characterised by the relationship between observed production and some ideal or potential production. The measurement of firm-specific technical efficiency is based upon deviations of observed output from the best production or efficient production frontier. If a firm's actual production point lies on the frontier it is said to be efficient but if it lies below the frontier then it is technically inefficient. Thus the level of efficiency of the individual firm is the ratio of the actual to potential production. The production possibilities curve has been used in economics as a fundamental tool for understanding the possible alternative efficient sets of outputs from a given set of resources.

According to Worthington (2008) economists have developed three main measures of efficiency for cost estimation in this regard. The first is technical efficiency which refers to the use of production resources in the most technologically efficient manner. Conversely, technical efficiency implies the maximum possible output from a given set of inputs. Within the context of dairy production in the estimation of unit cost of producing milk, technical efficiency may then refer to the physical relationship between average cost according to inputs allocation and level of output. The second measure is allocative efficiency pertains to the ability of an organisation to use its inputs in optimal proportions, given their respective prices and the available production technology. In other words, allocative efficiency is concerned with choosing between the different technically efficient combinations of inputs used to produce the maximum possible outputs. Since different combinations of inputs are used the choice of combination is then based on the relative costs (price-driven) of these different inputs The third and final measure, is a combination of allocative and technical efficiency to determine the degree of production efficiency and this is known as total economic efficiency or simply economic efficiency.

3.9.2 Stochastic production frontier software

Herrero and Pascoe (2002) in their review paper described a different range of multi-purpose econometric software that can be adapted and used for the desired estimation of stochastic frontiers. The two most common statistical packages used for the estimation of stochastic production frontiers and inefficiency is the FRONTIER 4.1 (Coelli 1996a) and LIMDEP (Greene 1995). Recently STATA (Statacorp, 2008) has gained popularity due to its user-friendly nature and versatility. However in this study STATA and FRONTIER 4.1 were used. For a more comprehensive review of stochastic frontier estimation and the associated packages Sena (1999) is recommended.

The FRONTIER 4.1 (Coelli 1996a) incorporates the maximum likelihood estimation of the parameters and the estimation process consists of several important steps. The first step of Ordinary Least Squares (OLS) is applied to estimate the production function and this stage provides unbiased estimators for the β s (parameters being estimated) except for the intercept term and the variance estimate (Herrero and Pascoe, 2002).

According to Herrero and Pascoe (2002), FRONTIER 4.1 has been created specifically for the estimation of production frontiers and the following are the advantages that were highlighted in their paper;

- It is a relatively easy tool to use in estimating stochastic frontier models.
- It is flexible in the way that it can be used to estimate both production and cost functions.
- It can estimate both time-varying and invariant efficiencies, or when panel data is available, and it can be used when the functional form have the dependent variable both in logged or in original units.

Stata is a general-purpose statistical software package created in 1985 by StataCorp. It is used by many businesses and academic institutions around the world. It’s capable for statistical analysis, Data management, Graphics and Simulation. Most of its users work in research, especially in the fields of economics, sociology and political science. The name "Stata" was formed by blending "statistics" and "data". The dataset is always rectangular in format, that is, all variables hold the same number of observations (in more mathematical terms, all vectors have the same length, although some entries may be missing). Stata's file formats are platform independent, so users of different operating systems can easily exchange datasets and programs.

3.9.3 Cobb-Douglas Production function

This has been used to refer to nearly any simple multiplicative production function, The original production function contained only two inputs, capital (K) and labour (L) Moreover, the function was assumed to be homogeneous of degree 1 in capital and labour, or constant returns to scale. Economists of this period, while recognizing that the law of diminishing returns (or the law of variable proportions) applied when units of a variable factor were added to units of a fixed factor, were fascinated with the possibility of constant returns to scale, when all factors of production were increased or decreased proportionately (Cobb and Douglas, 1928 as cited in Debertin, 2002:172). They probably believed that as the scale of the operation changed, it was no longer possible to divide inputs into the categories fixed and variable. In the long run, the marginal product of the bundle of inputs that comprise the resources or factors of production for the society should be proportionate to the change in the size of the bundle, or the amount of resources available to the society (Cobb and Douglas, 1928 as cited in Debertin, 2002).

It is important to understand how the Cobb-Douglas method works and a review of its history is the most logical entry point. In the 1920s the economist Paul Douglas was working on solving a problem of relating inputs and output at the national aggregate level. A survey by the National Bureau of Economic Research found that during the decade 1909-1918, the share of output paid to labour was fairly constant at about 74percent despite the fact that the capital/labour ratio was not constant. Douglas consulted a friend and colleague Charles Cobb, a mathematician, if any particular production function might account for this. This gave birth to the original Cobb-Douglas production function $y = AX_1^{\alpha} X_2^{1-\alpha}$; which they postulated in a paper published in 1928 titled "A Theory of Production" (Cobb and Douglas, 1928). In order to understand how these authors arrived at their conclusion it is imperative to identify and understand the problem. Mathematically stated the problem is as follows: Assume that the function $y = f(K;L)$ determines the relationship between outputs Y, capital (K), and labour (L). Further assume that (f) is continuously differentiable. For every output price level p, wage rate w, and capital rental rate r the function proposed in the 1928 article had three characteristics viewed at that time as desirable as described in Debertin, 2002: Firstly, the function was homogeneous of degree 1 with respect to the input bundle which was consistent with the economics of the day that stressed that production functions for a society Y should have constant returns to scale. Secondly, the function exhibited diminishing marginal returns to both capital and labour when the other was treated as the fixed input, so the law of variable proportions held. The parameter *A* was thought to represent the technology of the society that generated the observations upon which the parameters of the function were to be estimated. Third and lastly, the function was easily estimated with the tools of the day. Both sides of the function could be transformed to logarithms in base 10 or natural logarithms in base e(2.71828)

$$\log y = \log A + \alpha \log x_1 + (1-\alpha) \log x_2 \qquad \text{.... (1)}$$

The resulting equation is referred to as linear in the parameters or linear in the coefficients. In other words, log y is a linear function of log x_1 and log x_2 the transformed function is the equation for a simple two-variable regression line in which all observations in the data set used for estimating the regression line has been transformed into base 10 or natural logs

$$\log y = b_0 + b_1 \log x_1 + b_2 \log x_2 + \varepsilon \qquad \text{...... (2)}$$

Where $A = e^{bo}$ if the transformation is to natural logarithms, or 10^{bo} if the transformation is to base 10 logs, $b_1 = \alpha$, $b_2 = 1-\alpha$, ε = regression error term (Debertin, 2002:172).

In this study the term Cobb-Douglas function or true Cobb-Douglas function is used only in the reference to the two inputs multiplicative function in which the sum of the individual production elasticity's is equal to 1, and also where the elasticity's of production sum to a number other than 1 or in a case where there are more than two inputs or factors of production. It has some of the characteristics:

- The term Cobb-Douglas type of function is homogeneous of degree $\sum \beta_i$. The return to scale parameter or function coefficient is equal to the sum of the β values on the individual inputs, assuming that all inputs are treated explicitly as variable. The β values represents the elasticity of production with respect to the corresponding inputs and are constants
- The practical elasticity's of production for each are simply the β parameter for the input, the ratio of MPP to APP is constant, which is very unlike the neoclassical three stage of production function
- Moreover, MPP and APP for each input never intersect, but stay at the fixed ratio relative to each other as determined by the partial elasticity of production
- There is no finite output maximum at a finite level of input use, the function increase up to the expansion path at the rate that corresponds to the value of the function coefficient. In agricultural production function of the Cobb-Douglas type when estimated usually has function coefficient of less than 1, which means that function will increase at a decreasing rate.
- For a given set of parameters, the function can represent only one stage of production for each input and ridgelines do not exist. If the elasticity's of production are for each input less than 1, the function will depict stage (region) II of production curve everywhere, which is constant return to scale and normally Cobb-Douglas feat only on region I and II of production curve.

- If the function coefficient is less than 1 there will normally be a point of global profit maximisation at a finite level of input use. Pseudo scale lines exist and will intersect on the expansion path at this finite level (Debertin, 2002:174-5).

3.10 Efficiency modelling

The study scrutinizes the efficiency levels on the cost of producing milk by using stochastic production frontiers. The study uses panel data from Kwazulu-Natal provided by Tammac consultancy. The measurement of efficiency using production frontiers approach can be deterministic, that is all deviations from the frontier are attributed to inefficiency, or stochastic, that is random errors are distinguished from inefficiency differences. Relative efficiency can be measured by applying stochastic frontier techniques to the individual annual samples, and to the total sample as a panel, but in many cases efficiency differences are a function of inadequate models and data even when the frontier is stochastic. This approach allows the use of panel data and technical inefficiency effects are specified as factors that interact with the input variables of the frontier function (Battese and Coelli, 1995).

Ordinary least squares (OLS) estimation takes the average line of best fit through the observations and tacitly assumes that all the farms are efficient, which may be misleading if there are considerable differences in efficiency levels. Tests are conducted to determine whether a production frontier is the appropriate model and efficiency levels are estimated (Battese and Coelli, 1995).

The frontier model identifies the farms that represent best practice and inefficiencies are explained using the method of maximum likelihood to estimate the unknown parameters. The stochastic frontier and the inefficiency effects are estimated simultaneously. The theory is described in Battese and Coelli (1995), and many applications are discussed in Bravo-Ureta and Pinheiro (1993). The estimating equation is:

$$y_{it} = f(x_{j,it}, t, \beta) + \varepsilon_{it} \quad where\ \varepsilon_i = V_{it} - U_{it}$$
$$with \quad U_{it} \sim |N(\mu_{it}, \sigma_U^2)| \quad and \quad V_{it} \sim N(0, \sigma_V^2), \qquad \text{…. (3)}$$

Where $f(x_{j,it}t, \beta) + U_{it}$ is a suitable functional form, y_{it} is an output measure of farm i at time t, $x_{j,it}$ is the corresponding level of input j, and β is a vector of parameters to be estimated. The V_{it}'s are independently and identically distributed random error terms that are uncorrelated with the regressors and the U_{it}'s are non-negative random variables associated with the technical inefficiency of the farm. In the second part of the model, this inefficiency term, U_{it}, is made into an explicit function of k explanatory variables, z_{kit}, that represent farmers.

The U_{it}s are independently but not identically distributed as non-negative truncations of the normal distribution given by:

$$U_{it} \sim N\left[\delta_0 + \sum_{k=1}^{M} \delta_k z_{k,it}, \sigma^2\right]. \qquad \text{….. (4)}$$

The technical efficiency of an individual farm is defined in terms of the ratio of the observed output to the corresponding frontier output, conditional on the levels of inputs used by that farm. Thus, the technical efficiency of farmers i at time t using the stochastic frontier production function can be expressed in terms of the errors as:

$$TE_{it} = E\ [\exp(-U_{it}) \mid (V_{it} - U_{it})], \qquad \text{…….. (5)}$$

This is the expectation of the exponential technical inefficiencies conditional on the error, ε_{it}. Since U_{it} is a non-negative random variable, these technical efficiencies lie between zero and unity, with unity indicating that farmers are technically efficient.

3.11 Long run average cost curve

Dawson and Hubbard (1987) and Mukhatar and Dawson (1990) made use of popular translog functional form to investigate economies of size, while Hubbard (1993) estimate both translog LAC functional with an improved definition of total cost and an alternative 'recipropcal' specification which may be written in the form:

$$LAC = \alpha_1 + \alpha_2 / \mathrm{q} \qquad \text{...... (6)}$$

A rather more attractive approach is to estimate the unit cost of milk production in South Africa (Kwazulu-Natal), by specifying an LAC function that will either be U or L-shaped, depending on the data. Such a functional form was suggested by Davis (1941:125) and used extensively for the cost analysis in the 1950s and 1960s (examples in Johnston, 1960; Gupta, 1968). A modified version of the Davis function may be written as:

$$LAC = \alpha_1 + \alpha_2 /(\mathrm{q} + \alpha_3) + \alpha_4 \mathrm{q} \qquad \text{..... (7)}$$

For which corresponding to total cost (c) function is:

$$C = \alpha_1 \mathrm{q} + \alpha_2 \mathrm{q} /(\mathrm{q} + \alpha_3) + \alpha_4 \mathrm{q} \qquad \text{....... (8)}$$

The LAC function represented by equation (7) is sketched in Figure 3. A LAC is essentially described as a hyperbola with (dashed) asymptotes represented by line pair (Davis 1941).

$$L\bar{A}C = \alpha_1 + \alpha_4 \mathrm{q} \qquad \text{..... (9)}$$

$$Q + \alpha_3 = 0 \qquad \text{…... (10)}$$

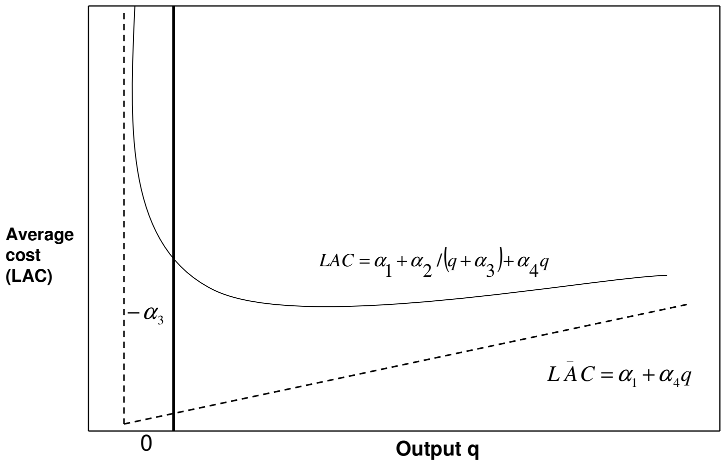

Figure 3: Model for Long-run average cost curve
Adapted from Davis (1941)

The Hubbard reciprocal function is obtained by setting both α_3 and α_4 equal to zero. If α_4 = 0, first asymptote equation (4) is constrained to be horizontal; that is the LAC curve is L-shaped, exhibiting no minimum point and no diseconomies of size. If α_4<0, then the LAC curve declines monotonically. If α_4>0, the first asymptote has a positive slope, the LAC curve is U- shaped with a minimum at q= $-\alpha_3 + \sqrt{(\alpha_2/\alpha_4)}$, and diseconomies of scale exist at higher levels of output. As with the translog form given in equation (7) therefore provide a basis for a simple statistical test of whether LAC curve are U-shaped or L-shaped.

The estimation equation is based on equation (7) with all variables measured in levels. Following Hubbard (1993), a variable (m) used as a proxy for management ability is introduced. In this study expected milk yield per cow (define as herd size, litres/cow) as a proxy for management input will be used, rather than the margin over feed cost per litre. This is to avoid the potentially redundant situation of explaining average cost per litre (of which approximately 50percent is accounted for by feed) and using a variable that will be dominated by the feed cost component.

The use of milk yield (output) as an alternative proxy of level of production rather than income is a viable option and McInerney *et al* (1992) have supported this approach. McInerney *et al* (1992) suggested that the conclusion that markedly higher yields, better milk price, better calf values and lower replacement costs are all largely consequences of good technical dairy management and overall control of the complexities of an intensive livestock enterprise could not be dispensed. The management variable is introduced as a shifter on both the intercept and the reciprocal variable giving an estimating equation of the form:

$$LAC = (\alpha_1 + \alpha_5 M) + (\alpha_2 + \alpha_6 M)/(q + \alpha_3) \qquad \text{....... (11)}$$

According to Dawson and Hubbard (1987) the LAC is shown to be a function of planned output (q*) and management (m), assuming that input price to be constant and the same for all farms. Planned output is unobservable and a two-stage procedure is employed whereby a production function is used to provide estimate of planned output, which are then used as input into the LAC function.

Estimation of LAC curve itself is done using a translog function, which usually generates a U-shaped curve in a cost output space, and is not constrained to be asymmetric. Thus economies of size in the downward part of the LAC are not restricted to be of similar magnitude to diseconomies of scale on the upward- sloping section. To obtain estimates of planned output, it is necessary to itemise costs (inputs) for the use in estimating the production function Mukhatar and Dawson (1990) explain that, following Dawson and Hubbard (1987:14) they restrict the variables inputs to the broad aggregates of feed costs, labour costs, machinery cost and rent of land.

The reasons for the decreasing part of the LAC curve are well known. If the industry is characterized by important input indivisibilities, the LAC curve is expected to have a negative slope in a substantial part of the output range. Also, productivity gains from specialization of labour and management are expected to occur when firms grow, since they can subdivide tasks and become more efficient. Another factor that can also explain increasing returns to size is pecuniary externalities. Due to volume discounts on large purchases larger farms may face lower input prices and, therefore, average cost may decline. The rising part of LAC can be explained by the following factors. A number of researchers have adopted the explanation stance that purports managerial ability to be fixed. For example, Sloman (1997) asserted that increasing average costs may show up if, at some point, the managerial problems of running a large organization outweighs the production and financial economies.

Following this logic, the main reason the existence of diseconomies of size would then be, by and large, that firms increase size without increasing or improving managerial ability. Taking this thought a bit further would imply that firms are actually increasing variable inputs in the presence of a fixed input (managerial ability) thus playing into the hands of the law of diminishing returns which implies that eventually average cost starts rising.

Acknowledgement is given here that this point of managerial fixity is not novel and has been recognized previously in the literature. In Robinson's (1953) novel textbook, the problems associated with the growth of firms was raised and special attention given to what was termed diseconomies of management as the determinants of the upper limit of the optimum size of the firm. Years later this important issue was again tackled by Lund and Hill (1979:148). They postulated that in keeping with expectation that the skill of the farm management on a small farm may not be sufficient to manage a much larger farm, it would be envisaged that an increase in the farm size would be accompanied by a decrease in relative efficiency. The empirical literature has also paid attention to this problem. The exclusion or omission of this managerial variable from any efficiency analysis often produces biased estimates of the parameters of the model if any of the included explanatory variables is correlated with managerial ability because firms may have different quantities of unobserved managerial ability.

Consequently, it is not unreasonable to purport that managerial ability is an important issue when studying (dis)economies of size. This issue has been considered in several studies using varied analytical approaches. Some of these studies use a production function approach (for example, Griliches, 1957; Mundlak, 1961; Dawson, 1985) and other studies have adopted the cost function approach (for example, Dawson and Hubbard, 1985; Mukhtar and Dawson, 1990). It must be conceded, however, that managerial ability is a difficult concept to define and measure, and its inclusion in empirical analysis is not a trivial task and consequently its often omitted. Dawson and Hubbard (1985) estimated an average cost function that includes margin over feed cost per litre as a proxy for managerial ability. However, they recognize that there is no obvious candidate for a proxy for managerial ability and that this choice is central to the estimation of diseconomies of size. The internationalisation of dairy markets seems to favour scale economies, yet the changes in food consumption patterns and consumer expectations induce continuous changes in these international markets (Dawson, 1994). Producers adjust the size of their operations accordingly to reap the benefits of the scale economies.

Empirical studies on production efficiency and the treatment of management as an input in the production process are limited in the South African context. The author of this research is only aware of one study that has been conducted in South Africa. According to Beyers (2001:09), the IDF (International Dairy Federation) official figures of 1996, reported that a total volume of 2 215 million litres of raw milk to the value of R 2, 62 million produced with a cow stock of 562 000 cows in milk. Data on the cost structures of 394 South African dairy farming operations was obtained from an annual production cost survey, conducted by SAMO (South African Milk Organisation) in 1997. This set of cross sectional data is used in the econometric estimation of long run average cost curves (LAC) for the dairy sector.
From the LAC function, inferences are made regarding the prevailing economies of size. Despite the variability of nearly all inputs in the long run, management as a production input is assumed fixed. It represents the one input that co-ordinates the use of all other inputs, and frequently the management is in the hands of one person or a small number of people. Thus, an upper bound is placed on the farm's long run expansion opportunities. However,

management is rarely measurable and therefore a proxy of managerial ability, namely the efficiency in allocating the most substantial other input (feed), is employed (Dawson and Hubbard, 1987).

It must be stated that the study reported by Beyers (2001) had limitations and the most glaring one is the typical problem often faced in the collection of cost data is the absence of price and quantity information. Yet, with a cross-sectional study, in one year, the assumption was made that farmers face the same market prices, and that observed differences were ascribed to transaction cost (transportation cost or savings when buying inputs in bulk). These inter-farm differences are (assumed) negligible. The problem of lacking price and quantity information can be bridged through the application of duality theory, by which the indirect cost function can be estimated (for the evaluation of size economies).

Beyers (2001) analysis focuses on the wider concept of economies of size, which encompasses economies of scale. However, size economies evaluates the unit cost variation associated with changes in some (one or more) or all inputs, as opposed to scale economies that measure the changes in production (output) due to a proportionate changes in all inputs. The former concept seems more realistic, since it is unlikely that proportionate changes will simultaneously occur in all inputs.

The LAC function, which shows the minimum production cost per unit, for every feasible level of output, is of interest in the analysis of size economies. Traditionally, the LAC-curve is assumed to be U-shaped due to the combination of average fixed- and average variable cost. Kaldor (1934) assumed that management, as a factor of production is fixed and that it fulfils a co-ordinating role between all other inputs. Dawson and Hubbard (1987) refer to studies in which L-shaped LAC-curves were inferred, based on the assumption that management and output is positively correlated, i.e. that larger farms also imply better management.

Such an assumption ignores the impact of management, since better management should be associated with lower average production cost, at any level of output, not necessarily with large farms. Given this (fixed) level of managerial input, any firm's relative position to that of all other firms in the industry is represented on the LAC-curve.

The specific functional form of the LAC-curve depends on the researcher's assumptions regarding firms' economic behaviour and output. In Beyers (2001) study, typical profit-maximising behaviour is assumed for all farms. Profit maximisation is achieved at the point of cost minimisation, for any given level of output (Varian, 1996; Chambers and Robert, 1991) and therefore the LAC-function should follow from a model in which output is given for each observation (Dawson and Hubbard, 1987).

A further assumption is that of a single, non-negative output (milk, measured in litres per year), denoted as Q. Output is produced through the combination of non-negative, homogenous and infinitely divisible flows of variable inputs, denoted as Xi (i = 1, n), together with one strictly positive fixed input – management, denoted as Xm. A stochastic production function is assumed, in which the error term captures the effects of unpredictable variability (due to transaction cost, climatic differences, disease, etc.). The production function is also assumed to be twice differentiable, strictly quasi concave and the marginal product for each input is positive over the range of the function (Varian, 1996; Chambers and Robert, 1991).

In Beyers (2001) article the data for the 1997 production year was used to analyse the relationship between the scale of operations and the level of management, through estimated long run average cost functions (LAC). The theory developed by Dawson and Hubbard (1987) was applied to deal with situations of output uncertainty by minimising cost with respect to planned or expected output. The estimated LAC function has as its arguments planned output and managerial ability, but both are unobservable. Thus, proxies were constructed for each of the variables.

In the case of management the margin above feed cost was used, while output was substituted with estimated planned output from a production function approach. The results indicate that substantial economies of size exist in the South African dairy sector, and these outweigh the diseconomies of size, as is evident from the highly skewed U-shaped LAC curves. It was argued that the shape and position of the curve depends on the level of managerial ability and the results confirmed that better management was associated with lower average cost, higher levels of optimal output and larger optimal herd sizes (defined by cows in milk) over the whole range of farm sizes.

For example, average management levels are associated with a break-even herd size of four cows in milk and that can expand to 58 cows in milk before diseconomies come into play.
Nevertheless, diseconomies are very small, allowing profit to be made over the whole range of farm sizes. This probably justifies the large number of firms that are operating beyond the

optimum level of output. It does not hold for the low management level firms – they operate at average cost levels that are 24percent higher than the average milk returns (Beyers, 2001). The lack of available time series data for the South African dairy sector makes it impossible to verify at this stage whether dairy farms are moving toward optimum levels of production or whether other forces than managerial ability dictates expansion decisions.

In another study of the sector, done with data for the 1998 year, compensated and uncompensated elasticities of input demand and output supply was calculated for a smaller sample of dairy enterprises (Beyers, 2000). The results indicated that milk production is likely to contract over time and that milk price support measures would not induce expansion of the sector. Combined with the findings of the research presented in this article, it appears all the more essential to analyse the trends in the dairy production sector over homogenous farms, production regions and over time to determine which factors play the most marked role in shifting production, profitability and efficiency and what the extent of these changes are. If South African dairy producers truly strive to compete in the global market place, they too have to employ the benefits of similar analysis that has formed the basis of progress in the European and American markets.

CHAPTER 4 : DATA, RESEARCH METHODS AND TECHNIQUES

4.1 Introduction

Bless and Higson-Smith (1995) asserts that data can be classified under different aspects depending in the way in which it has been collected or to some of intrinsic properties. They argue, on one hand, that when researchers collect their own data for the particular purpose of their research, such data is known as primary data. On the other hand, researchers use data collected by other investigators in connection with other researcher problems and this constitutes secondary data.

According to Mouton (1996) data collection involves applying a measuring instrument to the sample or cases selected for investigation. If properly constructed and validated over time, these measuring instrument such as questionnaires and observation schedules can be used to collect data that are more likely to be reliable than they would be had instruments not been used. During data collection the researcher collects various types of empirical information or data, for instance historical, statistical or documentary data. This accomplished through various methods and techniques. Creswell (1994) argues that the data collection step involves:

- Setting the boundaries for the study
- Collect information through observations, interviews, documents and visual materials
- Establishment the protocol for recording information

4.2 Data used

The data used in this study were obtained from Alan Penderis of Tammac Consultants cc. Tammac Consultants cc is a consultancy firm located in Ixopo (Southern KwaZulu-Natal), which assists dairy farmers in KwaZulu-Natal Midlands with production and marketing services. The farms that were selected are highly specialised dairy producers deriving more than 90 percent of their income from dairying. The dataset is comprised of 37 dairy farms within the KwaZulu-Natal Midlands area and this figure represents approximately 10 percent of the number of dairy farms in the area in 2007 (381 farms).

The dairy financial management data covers a maximum of 37 farms for 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. The deflators are explained below, after the variables have been discussed.

The variables used in the analysis of dairy production are a small subset of the data supplied. The cost functions explain a single composite cost with all the important inputs. The costs thus have to be aggregated and so do the inputs, as there are far too many to include and they tend to be collinear.

The farms sell milk (product income), other milk products and some farm produced fodder (other income), but they also buy and sell animals (trading income), so these are the three components of the output variable. The variable product income is the net income for all milk sold, including cash sales (milk sold informally), after deducting transport charges, all levies and monthly shares deductions. The price that farmers normally receive from processors depends on a number of milk characteristics and these include butterfat and protein content and somatic cell count. Price differences between farmers are, therefore, the result of milk quality and component composition. Thus, using revenues for total output provides additional information. Other income includes bags sold; levies repaid; dividend and bonus received; surplus grain sales; grazing let; land lease income: Lease charges for cattle must be deducted from cost centre. Trading income, by definition, is gross income (inclusive of levies, transport etc) for the sale of cull cows, breeding cows, heifers, bull calves and oxen. Cattle purchases and hire purchase (charges for purchase) redemption for cattle purchases are entered in parenthesis (as a negative value) next to the cattle sales figures.

Inputs begin with the original factors of production, which are land in hectares and labour which is measured both as a physical quantity, as number of workers and as a cost, when measured by the wage bill. The cost of labour includes wages, cost of rations given to the workers, and other labour costs (for example, medical expenses, clothing, workers' compensation and Unemployment Insurance Fund (UIF)). The cost approach is generally preferable as it does quality adjust the labour input. The first intermediate input is total feed, which has both purchased and farm produced components. The purchased feed is the aggregate of feeds bought for cows, heifers and calves. The farm produced feed is not actually measured but is accounted for by aggregating the inputs used to produce it.

These inputs for farm-produced feed include items such as fertiliser, seed, herbicides and pesticides, and transport from source to the field. Land has already been counted, so the intermediate inputs of seed, fertiliser, herbicides, pesticides and other costs (including transport) are included here. The other intermediate input is total veterinary cost, which is made up of the cost of veterinary visits, medicines, artificial insemination costs, dips, semen purchases, milk recording charges and other miscellaneous costs (these include semen flasks, artificial vaginas, surgical gloves, sheaths and semen straws).

The capital inputs always present more of a problem. Since the inputs of land, labour and intermediate inputs are flows per unit of time, while capital items are stocks, the service flows emanating from the capital stocks should be calculated. These are the depreciation on the capital stocks plus the running costs. The data includes investment expenditures on capital items but does not give information that allows the capital stocks to be calculated, so depreciation cannot be estimated. From an accounting viewpoint this is a difficulty, but in production, the level of capacity utilisation is too variable, so unless this is known it is usually true that the running costs have more explanatory power. These are reported and are aggregated to give an input of total running costs of milking machinery, buildings and equipment. The items included are electricity, repairs and maintenance of fixed improvements (such as milking sheds), sundry cots, insurance and other miscellaneous costs. The other capital item is for other machinery running costs and it is comprised of the costs of fuel, lubricants, tractor repairs and maintenance, implements repair and maintenance, and other miscellaneous running costs.

4.3 Research methods

According to Mouton (1996) the methodological dimension refers to the ‘knowledge of how` or ‘know-how` to do things or the total set of ‘means` which scientists employ in reaching their goal of valid knowledge. Mouton identified three levels of methodological dimension, which is as follows:

4.3.1 Methodological paradigms

This is the highest level of complexity of the methodological dimension. It includes both the actual methods and techniques and underlying philosophy regarding their use. A philosophy would include a ‘theory` of when and why to apply**.** The procedure used in this study is typically referred to as a stochastic cost function. Aigner *et al* (1977), Battese and Corra (1977) and Meeusen and Van den Broeck (1977) are credited with the introduction of stochastic frontier production functions. The authors cited above decomposed the typical error term of a regression model into an efficiency component plus a measurement error, and used maximum likelihood estimation to estimate simultaneously the parameters of the production function as well as efficiency and measurement error. The approach is now routinely used to estimate not only production but also profit and cost functions as stated by Tauer and Mishra (2006).

4.3.2 Research techniques and methods

This is defined as the specific and the concrete means that the researcher uses to execute specific tasks. Such tasks are of course related to a specific stage in the research process, such as sampling, measurement, data collection and data analysis. Methods refer to the means required to execute a certain stage in the research process and includes: Methods of identification, sampling methods, measurement methods, data collection method, and data analysis methods.

The distinction between techniques and methods is one of the degree and scope. Methods include classes of techniques, skills and instruments. Research involves application of variety of standardized methods and techniques in the pursuit of valid knowledge. This is underpinned by the need of scientists to generate truthful knowledge (verifiable body of knowledge), thus they are committed to the use of objective methods and procedures that increase the likelihood of attaining validity (Mouton 1996). In this study, both the frontier and the efficiency components were modelled and estimated as a function of dairy farm size in order to decompose cost of production by size into both frontier cost and inefficiency components. This contrasts to the typical approach of estimating cost as a function of output and input prices. Following Tauer and Mishra (2006), an average cost curve across dairy farms is estimated as a function of cow numbers on the farm and an error term,

$$Cost/cwt_1 = f(cows_i) + \varepsilon_i \qquad \text{...... (12)}$$

where $Cost/cwt_1$ is the cost of production per litre of milk on farm i, $cows_i$ are the number of cows on farm i, and the ε_i is the error term for a single farm observation i, can be broken into a stochastic term, v, due to data error, and an efficiency term, u, such that $\varepsilon_i = v_i + u_i$.

The efficiency term, u, is further specified as a function of cow numbers,

$$u_1 = g(cows_i)_i \qquad \text{...... (13)}$$

The stochastic term, v, is modelled as a normal distribution, N $(0, \sigma^2)$, while the efficiency term, u, were modelled as a truncated positive half-normal distribution with mean specified by $N^{\pm}(g\ (cows_i), \sigma^2)$. This allows the stochastic term for an individual farm observation to be either negative or positive, but the expected efficiency term will be greater than equal or to zero. Estimation of this model is by maximum likelihood simultaneously estimating the f and g functions specified in equations (12) and (13) with the specified error and efficiency structures stated above.

The number of cows on the farm will serve as a latent variable to represent cost and efficiency components, which change as the number of cows increase on the farm. Some of these components will be incorporated into either the cost frontier or efficiency segment of the specification. A case in point is milk production per cow. Low milk production per cow may lead to higher costs per unit or output (Jondrow *et al*, 1982). The low output may be resulting from low quality feed, poor genetics, disease, or poor cow comfort among many other reasons, this study however will not further investigate these issues.

4.4 Brief production background

A milk production unit is an activity of a diversified farming business, in which milk products are produced. Milk production involves the dynamics of the dairy herds, which requires replacement, culling, nourishment and improvement. In addition to milk, trade in livestock form an important part of the production process, although a secondary activity the animal products are fluid milk and butter fat.

The processing of milk and butterfat into other consumables (butter, milk powder, low fat and full cream milk, etc) is regarded as dairy production, but classifies as dairy processing. Furthermore, for the purpose of this study, the estimation of a unit cost from KwaZulu-Natal Midlands is taken into account. This is due to the availability of information on dairy cattle (Dairy Development Initiative, 1999).

4.5 Input technical efficiency

In principle, one can distinguish between two notions of technical efficiency: output oriented, which reflects the capability of producing maximal output from a given set of inputs, and input oriented, which corresponds to producing a given output using a minimum amount of inputs. The two coincide if and only if constant returns to scale prevail (Fare and Lovell, 1978). In the present case, this correspondence disappears, with important empirical implications. For example, the input oriented measure of technical efficiency does not enter the derived demands, but rather appears in the restricted cost function alone. The individual frontier can then be written as $(1/\mathrm{bf})G_f$, where $(1/\mathrm{bf}), 0 < \mathrm{bf} = 1$, reflects the cost of radial over-utilisation of inputs (Bauer, 1990; Atkinson and Cornwell, 1994) on the *f*th farm.

Recent developments in parametric frontier modelling can be found in Fried *et al* (1993) and Kumbhakar and Lovell (2000), among others. As no single approach seems to prevail in terms of theoretical properties and/or empirical advantages, the fixed effect model was opted for (Schmidt and Sickles, 1984). This panel estimator is distribution-free, allows for correlation between efficiency and regressors, and becomes consistent as the temporal dimension approaches infinity (Nickell, 1981). Individual effects are accounted for by specific intercepts, which may be interpreted as reflecting unobserved structural heterogeneity such as input quality and/or managerial skill. Time-varying fixed effects seems a realistic assumption, which can be represented either according to parameterised functions of time or discretely by means of temporal dummies (for example see, Cornwell et al, (1990); Kumbhakar and Hjalmarsson, 1993; Ahmad and Bravo-Ureta, 1995; Ahmad and Bravo-Ureta, 1996). In this thesis, time-varying efficiency is approximated by a flexible second-degree polynomial.

A two-step estimator is considered (Ahmad and Bravo-Ureta, 1995; Cornwell *et al*, 1990; Kumbhakar and Heshmati, 1995 and Kumbhakar and Hjalmarsson, 1993). First, the minimised variable cost is obtained using the parameter estimates of the demand system (5.6). Observed and fitted variable costs are related as follows:

$$\ln G_{ft} = \ln \hat{G}_{ft} + \varepsilon_{ft}, \qquad \ldots (14)$$

where

$\hat{G}_{ft} = \sum_i W_{ift} X_{ift}$. The first-step estimated residual, ε_{ft}, is composed of two terms:

$$\varepsilon_{ft} = \mu_{ft} + \nu_{ft}, \qquad \ldots (15)$$

where

$\mu_{ft}=\ln(1/b_{ft})$, which is restricted to be non-negative, includes both the farm-specific effect and technical efficiency, and v_{ft} is the statistical noise, which is heteroskedastic by construction. In the second-step, individual effects and time-varying efficiencies can be estimated by the least squares procedure, as

$$\varepsilon_{ft} = \sum_f \left(\mu_f + \mu_{1ft} + \mu_{2ft}{}^2\right) D_f + \nu_{ft}, \qquad \ldots (16)$$

where

μ_f, μ_{1f}, and μ_{2f} are unknown parameters, D_f is a dummy whose value is 1 for the fth farm and 0 otherwise, and v_{ft} is assumed iid normal with mean zero and finite covariance matrix. The predicted value $m_{ft}=(m_f+m_{1f}t+m_{2f}t^2)$ is the basis for calculating efficiency scores at the farm level:

$$TE_{ft} = \frac{\left[\min f \ \exp\left(m_{ft}\right)\right]}{\exp\left(m_{ft}\right)}, \qquad \dots (17)$$

The numerator of (10) is the least predicted value in each cross-section of the panel, i.e. the best practice or the reference against which all others are compared in that year.

CHAPTER 5 : RESULTS AND DISCUSSIONS

5.1 Introduction

The main objective of this chapter is to find the curve that best represents the relationship between average cost and level of 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 systems 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 to 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 in this paper be dubbed implicit costs. Notwithstanding the difficulty of measuring these, it must be acknowledged that these costs are often substantial and significant thus omitting them invariable lead 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 recognized, 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, 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 to 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 the 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 overhead, and energy expenses (electricity and fuel- diesel and petrol) are incurred at the level of the whole farm. That is to say that 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 functions 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 when there is a shortage of milk, prices increase. 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. 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 as discussed can be dubbed as a 'cost-price squeeze' where input costs rise faster than product (milk) prices received by the producers. Due to the nature of dairying, producers can only absorb lower producer prices for only 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 plausible explanation of why such a high number of producers exit the industry each in South Africa as shown in Table 4.

Table 4: Number of producers per province, 1997 and 2008

Province	Number of producers					percent 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**

Source: Own calculation from MPO statistics

5.2 Estimation and data

Data and choice of variables, the farm production data are drawn from production and financial records and consists of annual observations on 37 specialised dairy farms as stated in chapter 5. The Midlands region provides more than one-third of the milk supply in KwaZulu-Natal province. The investigation period covers the years from 1999 to 2007 and the panel is unbalanced. The analysis was restricted to a single region in order to ensure as much homogeneity as possible in input quality as well as technological and structural conditions. Of course, the availability of data is always a constraint, and this was also true for the study reported in this thesis. Accordingly, only farms with hired labour and located in the Midlands were considered. The observed farms are medium to large in size by South African standards.

The data set does not provide farm gate prices of variable inputs or outputs, with the exception of hired labour and milk; hence, the relevant information is provided by farm requisite data obtained by aggregating prices of the elementary components weighted by farm-specific cost (revenue) shares. The resulting series are farm-specific due to differences in input and output compositions. Quantities are obtained by dividing the values of output and variable inputs by the farm-specific price index.

Variable costs consist of three input categories: (1) purchased feeds; (2) other intermediate inputs; and (3) hired labour. Feed costs include aggregate outlays on concentrates, forages, licks, supplementary and roughage (silage and hay). The second group consists of the remaining intermediate inputs (mainly fertiliser, pesticides, seed, fuel, energy, veterinary costs, as well as overheads, i.e. the costs of repair and maintenance of capital equipment.

A note on how deflation was done is warranted and this is rendered 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 described 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 that the changes in the physical quantities of outputs and inputs, which is what the production function models, can be separated from changes in prices. 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.

The current price data from Tammac Consultants does not include appropriate deflators, so each variable must be deflated by the most suitable deflator available. The source of deflators is the Abstract of Agricultural Statistics (AAS, 2007) and even when a variable such as fertiliser can be deflated with the fertiliser price index from the AAS, 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 Kwazulu-Natal Midlands and because the deflator is for a fertiliser mix, which is probably different from that used by dairy farmers. With aggregates for items like farm machinery, this problem is obviously more serious and for some items there really is no appropriate deflator available.

Table 5 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 5, display a wide range between farms from R1/L to R10/L. However, the wide variation in average cost between farms has to be taken with a pinch of salt because some costs are imputed and this may mask actual differences between farms.

Table 5: Descriptive statistics for 37 dairy farms from KwaZulu-Natal Midlands (1999-2007)

Variable	**Number of 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	2169
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

Source: Own calculations based on data from Tammac Consultancy (1999-2007)

The next step in elucidating further understanding of 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 4. 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, fertilizer 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, 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 cost 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 limited observed relationship with output, even though it does change with change in farm size. A somewhat unexpected result is the positive yet statistically insignificant relationship shown by the scatter plot of variable costs per hectare and yield.

Next attention moves to the relationship between actual average cost and the levels of actual output and this is shown in Figure 5. 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 per farm. The picture depicted in Figure 5 shows that average costs of production on most smaller farms are higher than those of 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 as shown in Figure 6.

Be that as it may, one needs to be alerted to the pitfalls of attempting to derive the shape of the LAC curve based on a two-dimensional scatter plot which does not take into cognisance the vital influence management exerts on production and thus 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 5 typifies a given level of managerial ability and/or practice. Due to the nature of management being unobservable thus difficult to measure, it is often ignored when estimating either determinants of efficiency or cost of production. Needless to say that the omission of management invariably leads to biased estimates.

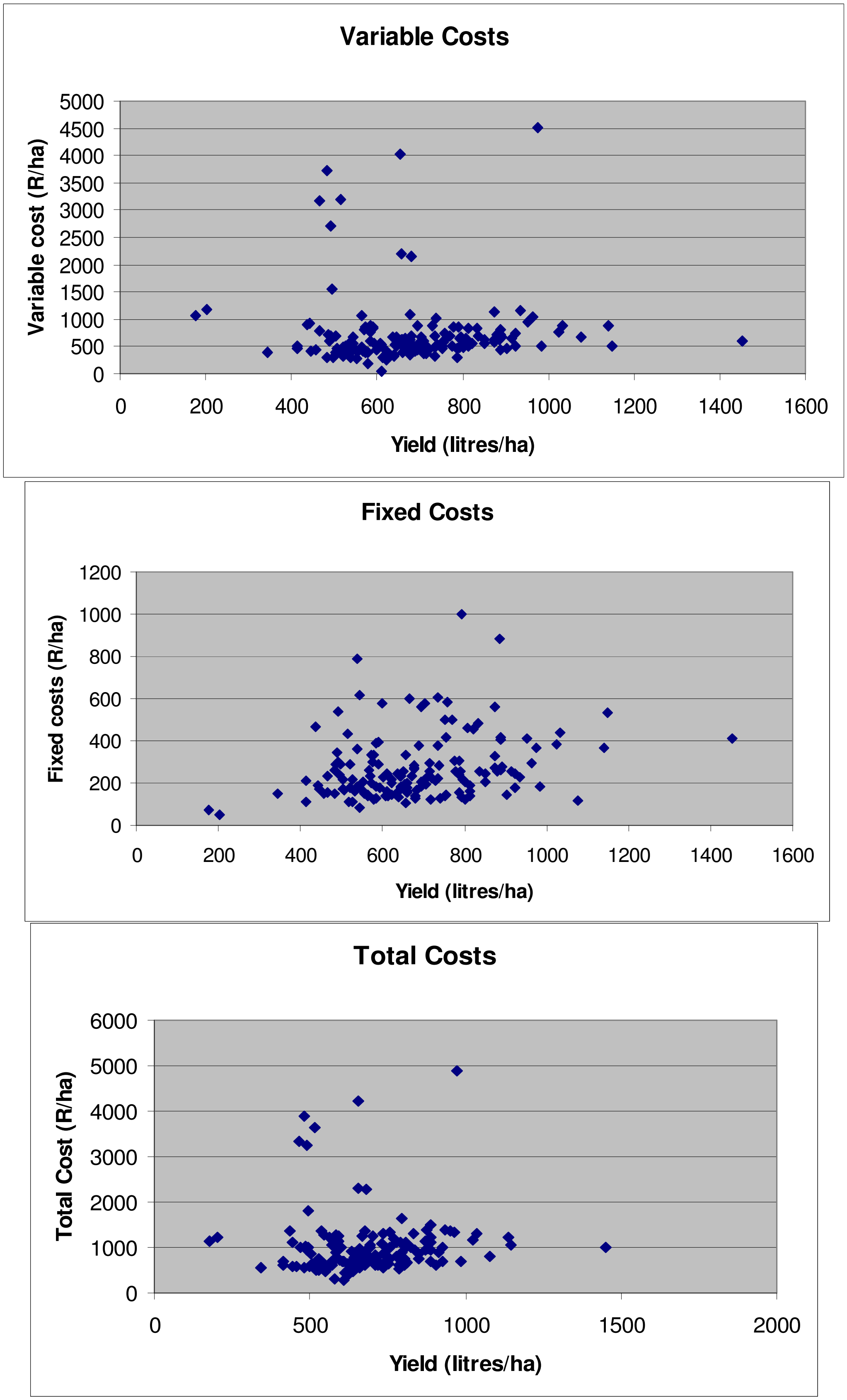

Figure 4: Variable, Fixed and Total Cost Curves for 37 dairy farms from KwaZulu-Natal Midlands, 1999-2007

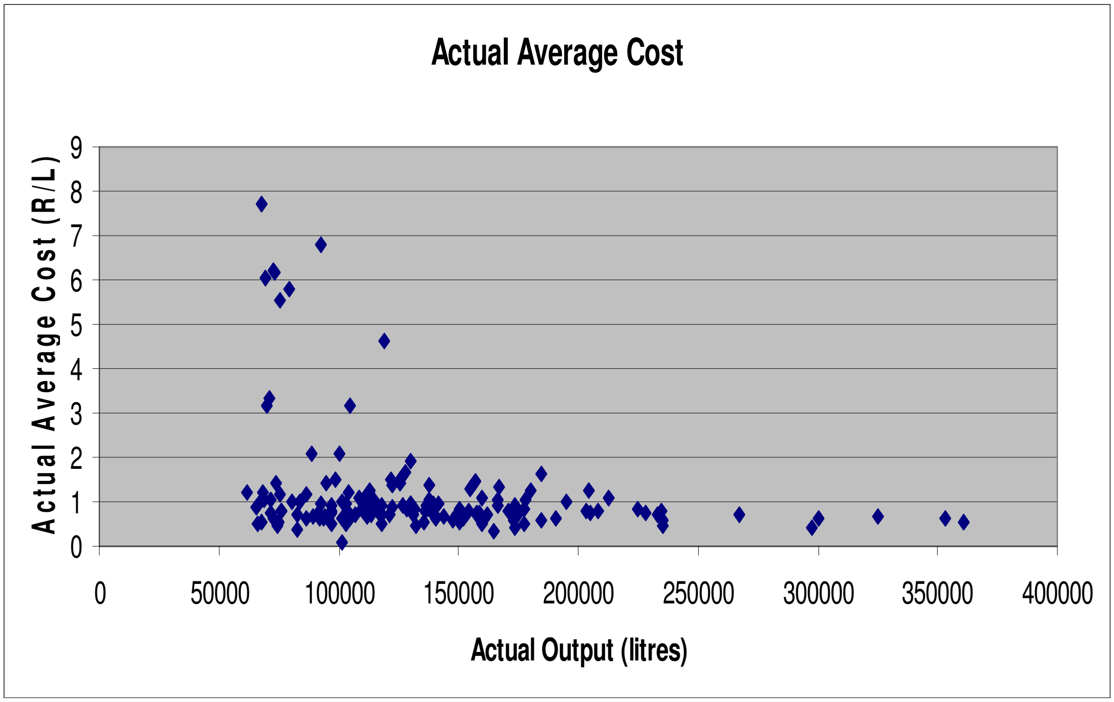

Figure 5: Actual Average Costs for 37 dairy farms from KwaZulu-Natal Midlands, 1999-2007

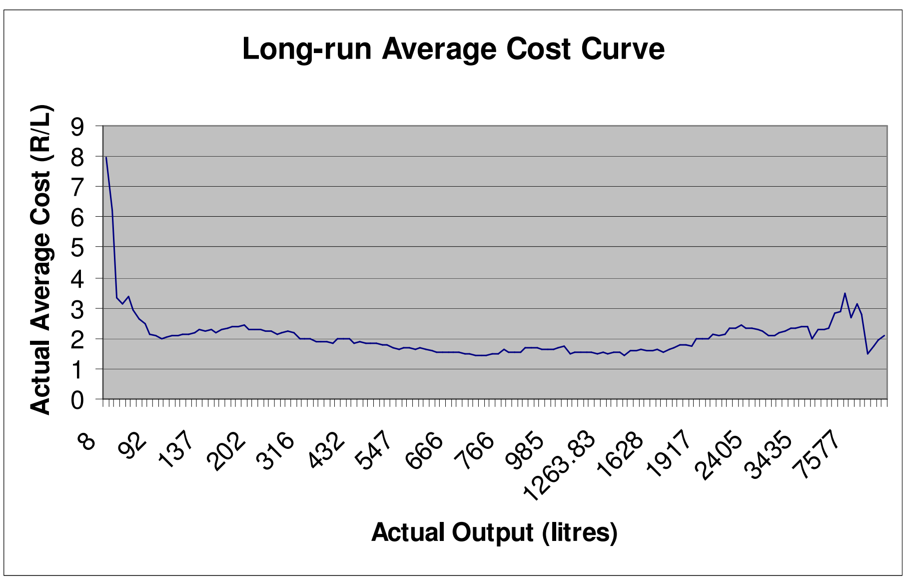

Figure 6: Long-run Average Cost Curve for 37 dairy farms from KwaZulu-Natal Midlands, 1999-2007

Following the approach adopted by Short (2004) in the US, estimated cost of production were ranked from lowest to highest in order to form a cumulative distribution of farms and this is illustrated in Figure 7. 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 real 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 percent of the dairy farmers in the sample were able to compensate for costs of production. Of the 84 percent, 39 observations (representing 25percent of the sample) can be classified as low-cost producers but they were, however, inconsistent in their ability 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 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.

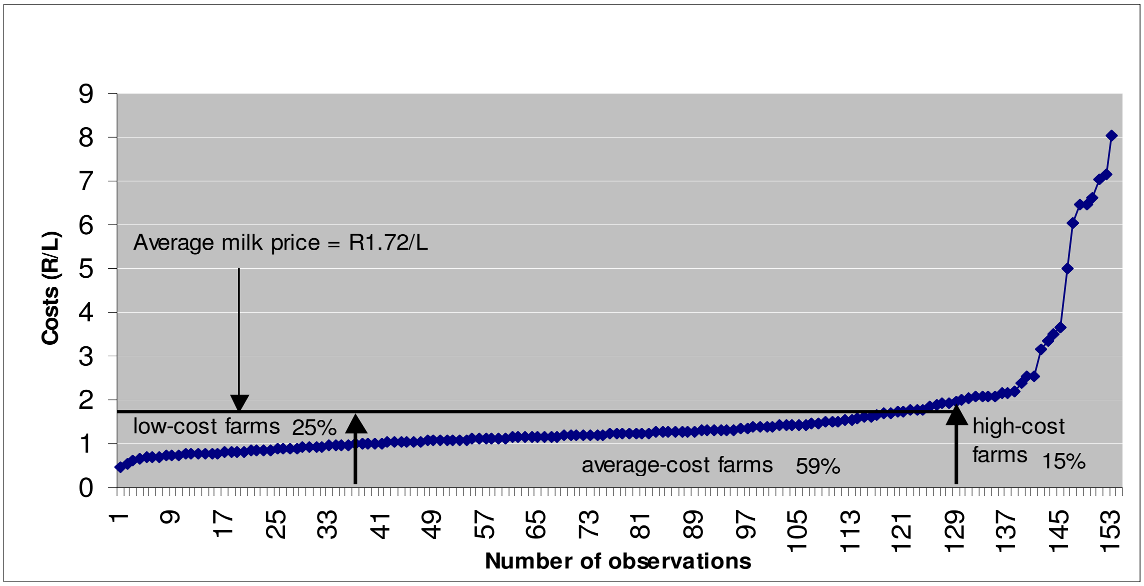

Figure 7 : Cumulative distribution of unit costs of producing milk in 37 dairy farms from KwaZulu-Natal Midlands (1999-2007)

5.3 Further results and 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 curve LAC was estimated by using a reciprocal function (for example Hubbard, 1993). This reciprocal function allows for continuously falling average cost, which is consistent with an L-shaped curve.

In the first estimation step a Cobb-Douglas production function was estimated and this is shown in Table 6. Notwithstanding the restrictiveness of the Cobb-Douglas production function, results obtained were quite insightful. No further general functions are reported as these did not give any significantly different estimates of planned output, so it is reasonable to 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. 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 numbers 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) seems 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 large increased milk production but will invariably increase the unit cost of producing milk.

Table 6: Production function estimates for dairy farms from KwaZulu-Natal Midlands (1999-2007)

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. The R^2 of 0.49 implies that 49percent of the variation in planned average cost is explained by variation in planned output and management. The findings of the current study are similar to those of Burton *et al*. (1993) 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 7: Cost function estimates for dairy farms from KwaZulu-Natal Midlands (1999-2007)

Variable	**Coefficient**
Constant	17.33 (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

Values in parenthesis are t-statistics

Table 7 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 89percent of the costs incurred in producing milk in the sample. It was suspected that colliniarity existed between some of the variables and this was circumvented by taking the natural logs of all the variables rather than their absolute values. Initially, total feed costs were used but purchased feed proved to me a better variable in terms of colliniarity. Purchased feed, as expected, accounted for the bulk of the costs followed by labour cost. Table 8 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 were also high correlations between land and milk; land and purchased feed and this also is consistent with *a priori* expectations.

Table 8: Correlation between the total cost variables for 37 dairy farms from KwaZulu-Natal Midlands (1999-2007)

	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

Results indicate that economies of size in milk production exist and these persist even in relatively high levels of output. Diseconomies of size, on the other hand, 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 attendant to 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 findings of the study.

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.

Caution would have to be exercised in using these findings in a generalized 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. Notwithstanding the foregoing cautionary, 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. In view of the limitations highlighted from the foregoing analysis and discussion, it became imperative to interrogate the subject further from a different angle.

CHAPTER 6 : CONCLUSIONS

6.1 Research implications

Notwithstanding the comparative importance of the South African dairy sector to the country's agriculture, very little analysis has been done and published on the structure of dairy production and the unit cost of production as affected by scale of operation and the response of dairy farmers to increasing cost and other policy changes. This is partly due to the industry's apparent lack of good data suitable for performing the required analyses. However, the paucity of good quality data appears to improving with more institutions within the industry being more willing to share data with reputable research institutions and this is a positive movement for the both the industry and research.

Cost response studies take many forms and the complexity of agricultural input cost response as opposed to studies on consumer demand only contributes to the diversity in methods of analysis. A predominant method of cost response analysis that is employed in many empirical studies pertaining to milk production, is econometric estimation of the parameters of the production process through the use of duality theory, whereby cost or profit functions (rather than production functions) are fitted to data from farm or regional cost surveys (time-series, cross-sectional or panel data). This approach has many computational and estimation advantages over normative or programming methods and over direct econometric estimation of production functions. For this study, the cost function approach was chosen.

Due to the small sample size and some missing price observations in the data, as well as the substantial demand on degrees of freedom required by the functional specifications, aggregation of inputs and outputs were necessary. Each farm was treated as a multi-input production unit. The output was income from the sale of milk (product income). Variable inputs comprised of feed (combination of purchased feed and self-produced feed) and veterinary costs. The quasi-fixed variables that were used are milk machinery and other machinery (capital), labour cost, and herd size (number of cows).

Consequently, 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 estimation of the LAC curve was done by using a reciprocal function (e.g. Hubbard, 1993). 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 straight-forward cost function was estimated and this yielded good econometric results.

In the first estimation step a Cobb-Douglas production function was estimated, which is shown in Table 5. Notwithstanding the restrictiveness of the Cobb-Douglas production function, results obtained were quite insightful. No further general functions are reported as these did not give any significantly different estimates of planned output, so the decision was to 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. The relationship between the number of cows in milk and milk output is closely related and the two are highly correlated (0.98) thus including both in any analysis is bound to create autocorrelation problems. The input elasticities for milk (which could read as cows due the high correlation between milk production and the number f 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 numbers 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) seems 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.

Given the illustrative nature of this study, it is the author's believe that the model has displayed some potential and has given pertinent answers within the chosen framework. Of course, further work remains to be done. First, the panel was not entirely representative. Hence, the behavioural insights and policy implications outlined above are not straightforwardly applicable to the whole of South African dairy industry. Second, generally farms are multi-output firms, with varying degrees of specialisation. So, using aggregate output as measure of economic performance hinders the possibility of appreciating the effects of production quota on decision processes on dairy farms.

Lastly but not least, the small dairy farms in South Africa are observed to have higher costs than larger farms, and whether those higher costs are due to technology or inefficiency has implications for policy to address the small farm. This research focused to find the curve that best represents the relationship between average cost and level of output. That was done by relating average cost to actual output, but was more appropriate to relate average cost to planned output, on the basis that costs are more likely to reflect what the farmer expected as output. As a result, a pragmatic two-step procedure was adopted. To identify the determinants of production cost thus the drivers of higher costs on small farms, the cost of milk production by farm size was decomposed into frontier and efficiency components with a stochastic cost curve and long run cost curve using data from Kwazulu-Natal (South Africa) dairy farms. Financial data of 37 farms for the period 1999 to 2007 were used in econometrics estimation of long run average cost curve (LAC) function for different levels of production (as a proxy of planned output – size of enterprise). Results show that average cost curves showing the variation of unit cost with output and 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 long-run average cost curve (LAC) for the sample of dairy farms is L-shaped rather than U-shaped.

6.2 Recommendations

It must be recognised, upfront, that at farm level near perfect competition exists in the dairy industry in South Africa. They are many dairy farmers dispersed over a large area and they are largely price takers selling a homogenous product, example liquid milk, butter, fat and cheese. As a consequence of this market scenario, farmers in the dairy industry are susceptible to a perpetual cost price squeeze. Cost-price squeeze here refers to a situation where costs of production (input prices) rise faster than the price of the product being produced (price of milk in R/L). Farmers are also find themselves caught between the rock and a hard place because both the input suppliers and buyers of milk (distributors and processors) are largely companies operating under oligopolistic market environment. This means that farmers are, for all intend and purposes, bound to the prices that they have to pay (for inputs) and receive (for milk) and they can only bargain for better prices to a very limited extent with either input suppliers or milk buyers. The most plausible recourse that farmers have is to intensify their production processes and to improve productivity. There appears to be large dividends that could be received from increased efficiency which should also translate to reduced production cost per unit of output. The formation of more functional cooperatives to increase farmers' bargaining power is another alternative available to them.

The quality of results is partly ascribed to the quality of the data that it is based on. In the dairy sector, substantially more detail is required for useful analyses and where this detailed data exists, it is important that analysts gain access to it - for the benefit of the dairy industry sector. In the absence of data, the industry and researchers should collaborate on developing surveys, managing the information and dissemination of results to the industry.

While there is an abundance of methods available for the analysis of production cost, the problem of access to good quality data remains the most inhibiting factor in such an endeavour. As much as this study tried to show the potential use of existing data, it is also a call for increased cooperation between the industry and researchers in serving the needs of the dairy industry. The results from this study suggest that dairy producers in the KwaZulu-Natal Midlands in South Africa are pasture-based and are relatively efficient in the use of available resources. This has insinuation for the animal feed sector in conditions of verify dairy farmers first choice for systematically invented feed mechanism as well as it put forward the augmented force on the global antagonism.

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List of appendices

Appendix 1: The first stage of deregulation of agricultural marketing

Scheme/product	First intervention	Main features	Reform process
Dairy	1956 1961 Dairy Industry Act	Dairy Scheme run as a surplus removal scheme with wide Powers of intervention.	Consumer price control on fresh milk abolished (1983); price control over butter and cheese abolished (1986 & 1988 respectively); power to determine transport tariffs, prohibit fresh milk sales, and to manage pools for fresh milk, butter and cheese not used after 1987; Price stabilisation ended after Court ruling ended levy income (1992); Milk Scheme implemented in 1994; Scheme terminated in 1998

Appendix 2: Current Arrangements for Marketing Regulations

Commodity	Organisational structure	Source of income	Remaining assets	Imports and exports	Information	Research
Milk	SAMFED (SA Milk federation) consisting of: Milk Producers' Organisation (MPO) SA Milk Organisation (SAMO) National Milk Distributors Association (NMDA)	SAMFED Voluntary contributions	Approximately R199 000 to be transferred to the MPO for funding of research etc	Phytosanitary requirements and quality standards should be adhered to and PPECB certificate Import tariffs	SAMFED from Voluntary levies. SAMO for the Secondary sector. MPO for primary sector	SAMFED from Voluntary levies. SAMO for the Secondary sector. MPO for primary sector