EMPIRICAL ANALYSIS OF MARKETED MILK PRODUCTION IN KENYA: A CASE STUDY OF THE OFFICIAL MILK MARKET

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DECLARATION

This thesis is my original work and has not been presented for a degree award in any other University.

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DEDICATION

To my late brother, Simon Bitange Omiti. Your untimately demise denied me your reliable proof-reading talent.

ABSTRACT

This study is concerned with marketed milk going through the official channel in Kenya during the period between 1957 and 1985. The objectives of the study were to:

1. Study the supply pattern of commercial milk production; and

2. Determine the duration between one period of both milk surplus and deficit and another.

3. Determine the significant factors influencing the magnitude of marketed milk production.

Graphical and regression methods are used in analysing the time series data on marketed milk production.

Results of graphical analysis indicate that during the period when the quota and contract pricing system was operating, i.e. 1957 to 1971, there was a stable and predictable pattern of marketed milk production. However, there are marked fluctuations in the level and pattern of marketed milk production during the current uniform pricing system.

The results indicate that there is a 4.59 to 4.95 year cycle between any two different periods, each of which is composed of milk surplus and deficit. It is determined at 4.77 ± 0.18 years.

The results of regression analysis indicate that previous levels of marketed milk production, technology, method of producer pricing and weather are, at 95 percent confidence interval, significant as the factors influencing the magnitude of commercial milk production in Kenya. Previous surplus appears to have a negative influence on subsequent levels of marketed milk production. Technology has an overall upward influence on marketed milk production. The quota and contract pricing system appears to have had a negative influence on commercial milk production. The weather has a directly corresponding influence on marketed milk production.

The implications of the results relate to stabilizing the level and pattern of commercial milk production through price adjustments. It is suggested that future producer prices be regulated through adoption of quantity premiums. This may encourage more efficient milk collection systems. Furthermore, strategic use of various livestock feeds is suggested especially in the dry season to help stabilize the observed seasonal and cyclic fluctuations in the magnitude of commercial milk production.

CHAPTER ONE

INTRODUCTION AND PROBLEM FORMULATION

1.1 ECONOMIC IMPORTANCE OF MILK

Milk is important in Kenya's economy both as a source of animal protein and in terms of its gross marketed value. Land devoted to milk production alone is estimated to account for about 46 percent of the 5.2 million hectares of land that is used for farming in Kenya (Sessional Paper No. 1, 1986). Milk produced at farm level is used for rearing calves and household consumption, and the surplus milk is sold either in the rural markets or to the Kenya Co-operative Creameries (K.C.C) Ltd.

The dairy sector is a source of employment for both the dairy farmers and their employees, and the employees of the processing and distribution sectors. The dairy sector is thus a source of income for both the commercial dairy farmers, their employees and the employees of the processing and distribution service sectors. The income accruing from the dairy sector can play an important role as a driving force for more investments in either the dairy sector or the other competitive enterprises.

Commercial milk production plays an important role as a source of animal protein for the urban consumers. Urban consumers depend mainly on the K.C.C. channel for their milk requirements. An estimated 15 percent of the total urban milk sales in Kenya is supplied through parallel markets (ILCA, 1986). Regardless of the channel of domestic distribution or the municipal byelaws governing milk sales, milk production has implications on foreign exchange reserves. Milk production plays a role as a source of foreign exchange savings through import substitution of dairy products. Moreover, domestic milk production plays a role as a source of foreign exchange earnings through exports of dairy products (K.C.C, 1958 - 1977). Overall, the dairy sector in Kenya contributes to general economic growth and development of the country.

1.2 PROBLEM FORMULATION

The demand for fluid milk is expected to increase with growth in population and per capita real incomes in Kenya. This expectation arises out of the fact that milk has no close substitute. The amount of milk supplied to urban areas and the primary schools under the school milk feeding programme has to increase to meet the increasing demand for fluid milk.

It is in view of the increasing demand that various livestock development plans have spelled out the need to improve the milk production and marketing systems in Kenya. The need to improve relative profitability of dairying with respect to other agricultural activities is central to any efforts to make dairy farming attractive. The specific strategies spelled out in various livestock development plans include increasing the dairy herd, the milk yield per cow per lactation and a more attractive dairy production and marketing package.

In the period between 1957 and 1985, marketed milk production has increased substantially. The pricing policy on milk in Kenya has undergone a considerable amount of discussion and reviews over the last three decades. Inspite of these and other strategies aimed at increased milk production, milk production entering the commercial channel has experienced year to year fluctuations.

A review of available literature as discussed in chapter two indicates that most of the discussions on the dairy sector concentrate on how to regulate the seasonal and yearly fluctuations in marketed milk production. However, these studies have not examined the pattern of milk production and what factors influence the observed pattern in marketed milk production in detail. This study examines the factors that have been responsible for the observed pattern in milk production, and thereby attempts to predict the future performance of the dairy sector.

1.3 OBJECTIVES OF THE STUDY

A general objective of this study was to synthesize and present together various data relating to the marketed milk production in Kenya for the period from 1957 through 1985. Currently these data are scattered through various annual and other reports by companies and government departments. Thus these data are not readily available to those interested in policy analysis.

The specific objectives of this study were to:

(1) study the pattern of marketed milk production in Kenya, using K.C.C. milk intake as a proxy for the total marketed milk production, during the last three decades.

(2) determine the duration (years) between one period of both milk suplus and deficit and another.

(3) determine the significant factors that influence the marketed milk production in Kenya.

1.4 HYPOTHESES TO BE TESTED

1. That weather has a significant influence on marketed milk production.

2. That the method of pricing of fluid milk bears a significant influence on the magnitude of marketed milk production, especially milk supply to the Kenya Co-operative Creameries.

3. That technological advances have played a significant role in influencing the volume of marketed milk production during the last three decades.

4. That previous levels of commercial milk production have significant influence on the levels of commercial milk production.

1.5 ASSUMPTIONS BEHIND THE HYPOTHESES

It is assumed that:

1. there is freedom of entry or exit with regard to participation in the milk market. This is to facilitate interpretation of supply behaviour

under different circumstances of production, climatic, price and other relationships that may influence choice of which type of agricultural commodity to produce and offer for sale at farm-level.

2. Technological changes have shifted the supply function gradually and more or less at a constant growth rate during the whole period under analysis. A trend variable is assumed to capture the various technological changes in the dairy industry in general and the marketed milk production in particular. The trend variable thus captures the changes that have occured over time.

3. the weather variable captures variations in the potential of agricultural land which is considered as a particular source of the various volumes of marketed milk production. Forage availability is assumed to correspond to the prevailing weather regimes during the period under study.

CHAPTER TWO

LITERATURE REVIEW

Studies on marketed production of agricultural commodities such as milk require data covering a long period of time or a large area of production. Such data are lacking in many developing countries. However, a substantial amount of work has been done in developed countries such as the United States of America (U.S.). This section reviews literature on supply analysis in general and emphasizes studies on the dairy industry in Kenya.

2.1 LITERATURE ON DAIRY STUDIES

Kriesel (1965) discusses the dairy problem in the U.S. agriculture and notes that the problem is one of supply outstripping market demand of dairy products. He argues that the dairy surplus problem is due to high price support programmes. He thus proposes the establishment and encouragement of programmes to absorb the surplus milk, for example, through channels such as school lunch programmes and other welfare programmes in non-competitive markets. Such programmes should be directed to the sections of the population that are considered to be consuming less than the amounts of milk regarded as adequate in relation to the stated welfare policy objectives. He also notes that there are relatively low returns for the human effort engaged in dairying and he argues that this is another important aspect of the dairy problem. He concludes that one of the reasons why the dairy problem exists in the U.S. is that there are many commercial dairy farmers willing to work long hours at substantially lower returns than the ones earned by their urban cousins or their farm cousins on other farm enterprises. This is primarily associated with memories of joblessness in the cities. He suggests that enough people be assisted to move out of dairying so as to reduce milk production until equilibrium is re-established at the prevailing price levels.

Koller (1965) also discusses the dairy problem in the U.S. agriculture. He argues that the dairy problem exists because of inefficient production, organization and methods of distribution. He argues for the need to help fit dairy farming into the framework of a more efficient agriculture. He thus concludes that improved pricing, particularly for fluid milk, can be helpful as a long-term basic solution for the dairy problem. For instance, lower consumer prices especially in markets that are now having relatively large volumes yet experiencing high prices could encourage use of more milk and also attract current non-users.

Wheeler (1965) discusses the impact of technological changes on milk production in the U.S agriculture. He discusses various aspects of technology and argues that the developments affecting the production and utilization of forage crops may tend to increase the advantage of keeping dairy animals on the farms that grow the feed. The expenses of transporting any kind of silage or green forage over long distances would be prohibitive. With such developments, dairy farming may come to depend, to a greater extent, on home-grown forage and less on purchased feed. He argues that because of adoption of artificial insemination, resources formerly used on maintaining bulls are now becoming more and more available for keeping more cows and replacement animals from superior sires. Furthermore, as more expensive and specialized equipment, e.g. automated milking machines, come into use there is a noticeable trend towards specialization in dairying and Wheeler (1965) expects this trend to continue. He cites the possibility of increasing milk production if bulk tanks are put on diversified farms with small dairy herds. Moreover, more cows can be kept on the same acreage of land through an intensification of crop production methods and through other changes in farm organisation including greater specialization in dairying. However, more capital is needed to keep more cows per farmer and to provide building and additional herd or land improvements to house and keep the larger herds. On the whole, Wheeler (1965) concludes that in city markets, the intensity of competition between nearby and distant milk producers will increase with peri-urban areas accounting for more than a proportionate share of any change in total milk production.

McClintock (1984) analyses the factors that affect output levels from African livestock sectors. He observes that increases in the level of milk supply are closely linked to climatic zones. He finds that public expenditure in agriculture, number of research scientists in agriculture, increase in the number of research scientists in agriculture, absolute and relative research expenditures in agriculture and veterinary all do not appear to play any significant role with regard to output levels from the livestock sectors. With specific regard to milk production, McClintock (1984) concludes that more cows can be kept on the same acreage of land through an intensification of crop production methods and through other changes in farm organisation including greater specialization in dairying. However, more capital is needed to keep more cows per farmer and to provide building and additional herd or land improvements to house and keep the larger herds. On the whole, Wheeler (1965) concludes that in city markets, the intensity of competition between nearby and distant milk producers will increase with peri-urban areas accounting for more than a proportionate share of any change in total milk production.

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Gitu and Wyckoff (1986), in their assessment of Kenya's livestock industry, characterize droughts as being endemic in Kenya. Local droughts occur virtually every year in some parts of Kenya. Farmers respond differently to droughts depending on, among other things, the economic environment. To cope with the droughts, livestock farmers either can sell all but their breeding stock or they could purchase animal feeds or move to less affected areas. Sale of livestock because of anticipated or actual drought suggests that the dairy animals mostly end up in the hands of butchers. Thus dairy animals are lost such that, after the drought, the decline in milk production and sales is felt. In the case of nomadic or partial migration to less impacted areas, milk production may not reach the commercial channels. This usually arises because of poor infrastructure in the remote areas. Thus drought is a possible cause of fluctuations in the milk production entering commercial channels.

Kidane (1978), in his study of the seasonal supply pattern and pricing efficiency for milk in Kenya with particular reference to Kiambu District, finds that the K.C.C. milk market experiences shortages and surpluses of milk in the dry and wet seasons respectively. He argues that the cost of milk production in the dry season is high compared to that during the wet season. Farmers use cheaper forms of feed, e.g. natural pastures, during the wet season and milk production therefore reaches a peak. However, the dry season acts as a hindrance to increased milk output, at least in Kiambu District.

Hopcraft and Ruigu (1976) discuss the question of milk shortages in Kenya in relation to drought and pricing and marketing policies. They state that the K.C.C. is expected to purchase all the milk supplied to its factories regardless of whether or not this is financially attractive. The K.C.C. therefore makes lower financial returns in the wet season because a large proportion of milk purchased must be processed into other milk products such as milk powder and sold at relatively lower whole milk equivalent prices. There are also costs associated with processing and storage of milk products. Conversely, the K.C.C. makes higher financial gains during the dry season because virtually all milk is sold as whole milk, which fetches more attractive prices. However, during the dry seasons, the very considerable processing facilities necessary to handle the peak of the wet season milk supplies lie idle. Since milk supplies could be maintained during the dry season but only at a substantially higher level of the cost of production, Hopcraft and Ruigu (1976) conclude that higher dry season prices would be necessary as an incentive for the commercial dairy farmers.

Hopcraft and Ruigu (1976) further discuss the effects of the quota and contract pricing system for milk in Kenya prior to 1971. They argue that the pricing system was a fairly effective method of maintaining dry season milk supplies, but they note that the only major problem with the system was that most of the quota and contract milk suppliers were the well established farmers (mostly European settlers). After Kenya's independence in 1963, the new and less experienced African dairy farmers, who managed to secure quotas to supply the K.C.C. with milk, had difficulty in maintaining or fulfilling them during the dry season. They thus lost their quota allocations. Furthermore, the quota pricing system tended to discourage efficient milk production above the quota requirements. However, following a change in government policy, the quota and contract pricing system was abolished in 1971 in accordance with the recommendations of the Tentoni Report (1969) and the Kibaki Commission (1965) . A uniform milk producer pricing system was then introduced. Hopcraft and Ruigu (1976) associate increased seasonal fluctuations of milk supplies to the K.C.C. with uniform producer pricing system. They feel that the uniform producer price for milk relative to the cost of milk production is too high in the wet season but too low during the dry season.

Ruigu (1976) discusses opportunities and problems in smallholder milk production and marketing in Kenya. While noting that the price the dairy farmers are paid is an important incentive for sustained and/or increased milk output, he states that the dairy co-operatives and unions usually deduct some commission for services rendered in the process of handling the farmers' milk. This commission is not fixed, as in the case of maize. The residual is the producer price of milk <u>in stricto</u> (i.e. including any other mandatory deductions such as those of any local government cess that the dairy farmers have to meet). Hence this residual is the key price that affects milk output. In most cases, this residual price is relatively low, and it thus does not act as an incentive for increased milk output.

Stotz (1975) argues that the uniform producer price for milk has even encouraged beef ranches to shift towards a combined beef and milk production. These beef ranches produce milk only in the wet seasons when natural grazing is plenty and this aggravates the seasonality of milk production and supplies to the commercial channels.

Konandreas et al (1983) discuss economic trade-offs between milk and meat production in Botswana. They observe that milk production is on the decline due to more favourable beef prices. The rationale behind more favourable beef prices hinges on the importance attached to the viability of the beef industry in Botswana as the main source of foreign exchange earnings. It is feared that high producer prices for milk relative to beef prices would tend to shift farmers from beef to dairy production. They conclude that promotion and implementation of any dairy development policy should be considered on its own merits and that dairy production should only be encouraged in areas near consumption zones to minimize transfer costs.

Mbogoh (1987) in his review and analysis of organizational and socio-economic effects of dairy development schemes in Ethiopia and Kenya, argues that the milk sector in Kenya did not suffer much from the effects of the drought in 1984. This argument is based on the observation that milk production level in Kenya was about 1.6 million litres in 1985, which is a remarkable performance soon after the drought. However, droughts seem to be an important factor influencing the magnitude of total marketed milk production, irrespective of the agro-ecological zone of the affected areas. He notes that prior to 1963, when Kenya became independent, dairy production from grade cows was largely confined to large-scale farms which were mostly owned by European settlers. Few smallholder African farmers were keeping dairy grade cattle before then. The gradual transformation of the structure of the dairy herds has been a result of government policies and activities which have enhanced the sub-division of large-scale farms as a strategy for the settlement of landless people in Kenya. As a result, milk production from the large-scale dairy farms has continuously been on the decline since the 1960's. Nonetheless, the decline has more than been compensated by steadily rising milk production from the smallholder farms. This reflects a fast rate of adoption of grade dairy cows for milk production in the smallholder farms. Finally, Mbogoh (1987) observes that the success of smallholder dairy farms has largely been due to government support. First, artificial insemination services have resulted in widespread upgrading of the local breeds of cattle. Secondly, the continued development of a network of rural access roads, which link up with the main all-weather roads, has contributed a great deal to the development of a reliable distribution system for milk and milk products in addition to facilitating the timeliness of artificial insemination services. It is also worthwhile to note that the transportation systems facilitate the delivery of inputs for dairy production including the veterinary services. Further, with the Government support in the guaranteeing of the credit, K.C.C. has been able to procure funds from donor agencies, such as the Danish International Development Agency, to establish dairy processing facilities in various parts of Kenya. These facilities have made it easier for the rural dairy producers to market their milk output. Provision of veterinary services, especially in the area of prevention and control of animal diseases, has also made dairying a less risky enterprise.

ILCA (1979), in its report on economic trends of dairy products in Sub-Saharan Africa, epitomises dairy products imports as an illustration of the inadequacy of domestic milk supplies in tropical Africa. *The report notes that transportation of milk from remote areas to urban areas presents specific market problems.* These problems arise because of the perishability of milk, the hygienic requirements and also the state of infrastructural facilities in the remote areas. As such, milk supplies from remote areas can not be guaranteed by the areas of production. In the case of mixed farming areas, milk production is more for farm-level consumption and milk surplus is sold locally in the relatively populous rural regions. Therefore, ILCA (1979) argues that urban milk supplies should depend more on smallholder dairy farmers in peri-urban areas who raise a limited number of dairy cows with a view to sell milk at relatively high prices.

In this literature review, various factors have been identified and will be used in interpreting the observed trends in milk production that gets through the K.C.C. channel. These are technology (in the forms of artificial insemination, vaccines, breeds of dairy animals), weather, structural policies relating to sub-division of land, and pricing policies, among others.

2.2 LITERATURE ON SUPPLY ANALYSIS

An individual variable observed with the passage of time, such as marketed milk production, is called a time series variable and is viewed as being composed of trend, seasonal, cyclic and random (erratic) components. Most empirical analysis of the time series data involves the decomposition of such time series data into the four components. However, it is difficult to separate a time series variable into the four distinct components (Wonnacott and Wonnacott, 1977). For any time series variable, the erratic or random disturbances are associated with natural or biological phenomena, such as riots, strikes, fires, war scares, variations in rainfall amounts or rainfall distribution over wide geographical areas or disease epidemics. Such unpredicatable changes can lead, for example, to such events as occassional milk supplies to the K.C.C. from beef ranches. Once such effects are corrected for, a more normal behaviour of the pattern of supply can be revealed (Kotler, 1985). The seasonal component of the time series variable includes all seasonal changes, such as weather changes and cultural activities. Oury (1960) suggests that collapsing of the different weather variables into a single variable covering the entire period, under consideration, can be a solution to the complex problem of deciding which weather variable to use for the purpose of explaining the observations for a particular period. He firmly proposes the use of Lang's weather index as a single representative of the various weather variables. The index (WI) is derived as:

$$WI = \frac{P}{T}$$

Where: WI = Weather index

P = Precipitation (mm)

T = Temperature (°C)

The weather index takes into account the twin effect of rain and temperature on forage production and distribution. It thus varies directly with precipitation and inversely with temperature. Grilliches (1960) states that the use of a single weather variable is useful in supply analysis since the weather accounts for a substantial fraction of the explained variance. Stallings (1960) argues that variations in output due to non-weather factors are independent of weather variables and are randomly and normally distributed with an expected value of zero. However, in aggregate supply analysis, the coefficient for a weather variable may be low or insignificant due to inclusion of extreme drought years. The cyclic components of any time series data reveal the wave-like movements of the variables under consideration. Such cyclic components tend to be harmonic and can be estimated by analysing the residuals of the original data of the depedent variable after removing the random, seasonal and trend components. The cyclic component is useful in intermediate-range forecasting (Kotler, 1985). The trend component of time series data captures the long-term patterns of the variables, such as capital formation, technology or such items as trust fund (Wonnacott and Wonaccot, 1977 and Kotler, 1985).

Grilliches (1960) argues that the state of technology besets a critical problem in supply analysis. While it may not violate reality too badly to assume that demand functions for agricultural commodities have remained relatively stable with the passage of time, no such an assumption is possible for supply functions. The underlying technological conditions of supply tend to change too much with time. The predictive power of supply equations will thus be limited because the most critical factor in long-run supply is technology, and this is precisely the variable that is most difficult to incorporate into supply models. Grilliches (1960) suggests the use of a trend variable to measure the impact of technological change on supply. Efforts to find a proxy for technology other than a trend variable have been less successful. The trend variable represents changes in those factors which cannot be conveniently incorporated into supply analysis. The use of a trend variable assumes a constant rate of upward, overall technological change. The trend variable further takes into account all secular changes caused by changes in the state of arts, population, tastes, that occur over a time frame.

Most studies on aggregate supply functions of individual commodities are based on time-series data using single-equation models and ordinary least squares estimation techniques. Nerlove and Addison (1958) suggest the use of lagged variables of the depedent variable to reduce or eliminate the problem of serial correlation evident in the calculated residuals of the regression(s). Since farmers may respond slowly to changes in prices and other factors, a distributed lag model is used and leads to the introduction of lagged output as an additional independent variable. Distributed lag models tend to generate higher ratios of explained variation to total variation (R^2) and also reduce or eliminate serial correlation amongst residuals of regressions. However, the presence of serial correlation in the error terms of economic relationships does not lead to biased and inconsistent estimates of parameters of the relationships. Rather, it leads to biased estimates of the multiple correlation and the standard errors of the estimated parameters (Kmenta, 1971).

X Kenya's dairy industry faces several challenges, the most important one being to meet the market demand for milk in the urban areas. The increasing demand for milk and milk products is affected by the growth of population, rate of urbanization, rural - urban migration of people including agricultural labour, growth rates of per capita disposable incomes, and increasing pressure on productive resources, particularly land.

The preceding review of previous studies on Kenya's dairy industry clearly indicates that the studies have dealt with milk production and marketing either at farm-level or region-specific areas. Some of these studies are descriptive and have limited quantitative analysis with projections that are not long-run in nature. Such studies which address only specific agro-ecological zones or regions, e.g. Stotz (1975), Hopcraft and Ruigu (1976), Kidane (1978) though they may contribute as a building block into a larger analytical framework, by themselves are of limited help at the national planning level. No specific attention has been given to the analysis of the marketed milk production in Kenya. This therefore implies that the various factors influencing the marketed milk production in Kenya have not been quantified. The present study analyses the long-run pattern of the marketed milk production and also quantifies the major factors which influence that pattern. The work of Grilliches (1960) and Hopcraft and Ruigu (1976) will provide the main theoretical guidelines while the rest of the reviewed literature materials will provide some substance to the framework of the analysis and interpretation of the pattern of marketed milk production in Kenya.

CHAPTER THREE

METHODOLOGY

3.1 RATIONALE FOR THE SELECTION OF THE K.C.C. AS THE UNIT FOR THE CASE STUDY

Marketed milk production is the residual after some of the total milk production has been used to rear calves and meet subsistence requirements. The amount of milk sold in the official milk market by dairy farmers and co-operatives is the total marketed milk production less the milk surplus that is sold in rural markets and parallel markets in the urban areas, municipal byelaws notwithstanding. This study deals with the marketed milk production going through the K.C.C. channel. This is because the K.C.C. handles the largest proportion of the total milk entering the commercial milk market in Kenya. It is estimated that the K.C.C. handles between 85 and 90 percent of total marketed milk production in Kenya (kidane (1978), ILCA (1986)). Though conservative estimates reveal that the contribution of parallel markets is likely to increase by the year 2000, records on their market share, however inaccurate, are not available. Generally there is lack of accurate data on total milk production and the amounts consumed and sold at farm-level on a nationwide scale. Therefore the K.C.C. records provide the only reliable source of data on the marketed milk production in Kenya. Hence the study of the K.C.C. annual milk intake is indicative of the long-run pattern of the total marketed milk production in Kenya.

3.2 VARIABLES IN THE ANALYSIS

3.2.1 The Dependent Variable

The dependent variable is the K.C.C. annual milk intake, which is used as a proxy for annual total marketed milk production in Kenya. In the regression model, it is presented as gross marketed volume (litres) and not in monetary value.

3.2.2 The Independent Variables

The process of milk production and marketing, as is the case with most other agricultural activities, is usually influenced by many factors. These factors range from controllable to uncontrollable ones, such as livestock stocking rates and producer prices. However, in this analysis the variables which were used to specify the regression model for marketed milk production included: (i) Lang's weather index. (2) Dummy variable for method of pricing of fluid milk. (3) trend, and (4) lagged marketed milk production. The trend variable was introduced to substitute for basic variable which were not directly observed or whose data could not be obtained, but are known to affect the dependent variable. For example, technology is one such variable that has definite impact on milk production but cannot be observed directly. Thus technology is some function of time observed chronologically. Madnani (1986) notes that there are cases or situations whereby an independent variable affecting a dependent variable is so closely related with time that is is advisable to introduce the trend variable rather than the particular independent variable. Examples of technology in the dairy industry include:

1. Adoption of high-yielding exotic breeds of dairy animals, e.g. Friesian, Guernsey, or their crosses with local breeds.

2. Improved feeding techniques, e.g. zero grazing or near-zero grazing practices.

3. Improved production methods, such as fodder production and storage, mechanization, artificial insemination, cold-storage of milk, etc.

4. New methods of tick and pest control, such as dipping and drenching.

5. General improvements in sanitation techniques which have contributed a great deal to better hygienic conditions especially for end-products, such as milk.

Rainfall and temperature data were used to generate the weather index. This weather index is the Lang's weather index (see literature review). The weather index is to take into account the twin effects of rainfall and temperature on pasture and fodder crops. It is assumed that weather regimes do influence the amount and distribution of forage availability and the voume of milk entering the commercial market.

3.3 DATA SOURCES AND TREATMENT

Data sources for this analysis included the records of the K.C.C., the Kenya Dairy Board (KDB), Ministry of Agriculture, Ministry of Livestock Development, and the Meteorological Department at Dagoretti (Nairobi).

The data have been cross-checked using data available in various Economic Surveys, Statistical Abstracts and other publications especially at the Central Bureau of Statistics, Nairobi. The data on marketed milk production do not include milk sales in urban areas by dairy farmers who operate under KDB licences. It also does not include data on milk sales in regions which operate independent of the K.C.C. These regions have included Bungoma and Meru Districts since 1985.

The volume of milk delivered to the K.C.C. for the period from 1958 through 1970 was recorded in the imperial system but has been converted into the metric system[1].

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[1] The following conversion factors were used:

1 gallon = 4.54545 litres

1 Kg = 2.2046 lbs.

The data were analysed using trend and regression programs on micro-computer facilities.

3.4 METHODS OF DATA ANALYSIS

3.4.1 Graphical Analysis

The data on marketed milk production was analysed graphically to determine the duration between any two different periods, each composed of milk surplus and deficit. The data on marketed milk production can be viewed as being composed of trend, cylic, seasonal and random (erratic) components. Random and seasonal fluctuations in original data were corrected for by using moving averages of the original data. Technological influences in the original data of marketed milk production were corrected for by using a trend line, once random and seasonal influences had been corrected for. The residuals after correcting for random, seasonal and trend influences constitute the cyclic component. The cyclic component displays a wave-like distribution that is one of the subjects of interest in this analysis. The purpose of the graphical analysis was to identify the influence of the various independent variables on the pattern of supply of marketed milk production in Kenya for the period from 1958 through 1985. The variables involved were the method of producer pricing of milk, trend and weather.

After the original data of the dependent variable had been corrected for random, seasonal and cyclic components, a linear trend model (equation 1) as adopted from Madnani (1986) was fitted in order to estimate the level of volume of marketed milk production after any time interval. The linear trend model for the dairy industry was specified as follows: $Q_i = B_0 + BT_i + U_i$ (1)

Where:

Q_i = Volume of commercial milk production in the i^{th} year,(litres)

B_0 = Initial volume of commercial milk production,(litres)

B = Constant absolute annual increment in marketed milk production,(litres)

T_i = Time interval (i years)

U_i = error term

In this approach, the volume of marketed milk production is estimated quite precisely. It is important to note that the difference between estimated milk production and actual milk production arises largely from the influence of random, seasonal and secular changes of forces operating in the commercial dairy sector. The error term does take care of these random, seasonal and secular changes.

3.4.2 Regression Analysis

Regression analysis was done on the data in order to quantify the significance of economic relationship involving marketed milk production in Kenya. Both simple and multivariate regression analyses were performed using the semi-logarithmic regression model. The regression model was derived from the following general function:

$$Y = f(X_1, X_2, X_3, X_4) \qquad (2)$$

Where:

Y = marketed milk production (litres)

X_1 = previous levels of milk production (litres)

X_2 = trend (in years), 1 = 1958, 2 = 1959... 28 = 1985.

X_3 = dummy variable for quota and uniform pricing systems:

1 = 1958 - 1970 (quota and contract pricing system

0 = 1971 - 1985 (uniform producer pricing system)

X_4 = Lang's Weather Index

The specific regression model used for the purpose of the analysis of the marketed milk production data was the semi-logarithmic model of the form:

$$LnY = b_o + b_i X_i + U_i \quad (3)$$

Where:

LnY = natural logarithmn of marketed milk production (litres)

b_o = intercept on the ordinate axis

b_i = coefficient of the i^{th} regression variable (i = 1, 2 ...4)

U_i = error term

In simple regression analysis the contribution of one independent variable on the level of supply of marketed milk production was analysed and presented. In multivariate regression analysis, all the independent variables were included in the analysis in order that their multiple effect on the marketed milk production in Kenya was estimated during the period under investigation.

The choice criteria of the appropriate model was intuitively based on the value of R-squared, the significance of individual regression coefficients and the ability to provide results that were both statistically and economically meaningful. Preliminary results using the linear, quadratic, semi-log and double-log models led to the selection of the semi-log model as the appropriate model. The other models appeared to be less satisfactory with the data on marketed milk production. Inclusion of producer prices of milk also indicated that price was not a significant explantory variable. Moreover, the semi-log model allows for the non-linear relationship among the individual regressors as factors influencing milk production at farm-level as predicted by the various theories of production economics. It is worthwhile to note that R-squared is the coefficient for determining the "goodness of fit". It is a ratio of explained variance to total variance. i.e.

$$R^2 = \frac{\text{Explained variance}}{\text{Total variance}}$$

CHAPTER FOUR

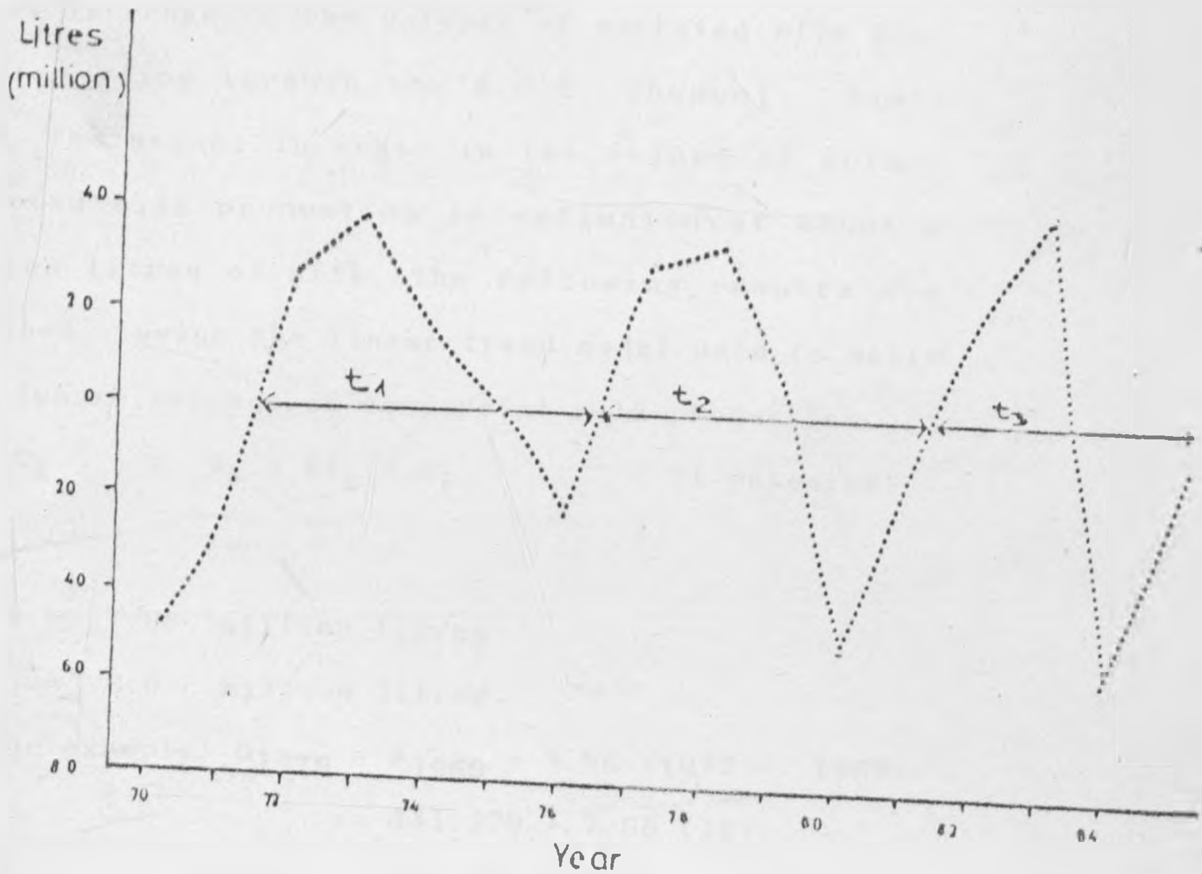
EMPIRICAL RESULTS

4.1 RESULTS OF THE ANALYSIS OF SUPPLY PATTERNS

Subsequent discussions are based on the results of graphical analyses of the supply behaviour of marketed milk production in Kenya for the period from 1958 through 1985.

Having corrected for the erratic, seasonal and technological influences on the actual volumes of marketed milk production, Graph 4.1 shows the residuals of marketed milk production from 1970 to 1985. The graph reveals that the period, each composed of both milk surplus and deficit, occurs after 4.77 $\pm$ 0.18 years. This result indicates that fluctuations in the volumes of marketed milk production occur, on average, after 4.59 to 4.95 years in the official milk markets in Kenya. During the period from 1958 through 1985, the results also reveal that the years recording the lowest amount of marketed milk production were 1976, 1980 and 1984. If extrapolated, it is predicted that milk production will be at the lowest ebb in the years 1989, 1993, 1997 and the year 2000 A.D ceteris paribus.

Graph 4.1: Residuals of Marketed Milk Production (1970/85)



t_1 = 4.8, t_2 = 5.0, t_3 = 4.5

Source: K.C.C. Unpublished records

Graph 4.2 shows the actual milk intake by the K.C.C. and the trend and residuals along the trend line for the period 1958 through 1985. The trend component of graph 4.2 is useful in estimating the annual increase in the volumes of marketed milk production going through the K.C.C. channel. Since 1958, the annual increase in the volume of actual marketed milk production is estimated at about 8 million litres of milk. The following results are obtained, using the linear trend model used to estimate future volumes of commercial milk production.

$$Q_i = B_o + BT_i + U_i \qquad \text{(1 repeated)}$$

Where:

B = 7.96 million litres

= 8.0 million litres

For example, $Q_{1979} = B_{1969} + 7.96\ (1979 - 1969)$

$= 141.278 + 7.96\ (10)$

$= 220.88$ million litres

Actual production,

$Q_{1979} = 232$ million litres

Error term, $U_{1979} = 11.12$ million litres

also $Q_{1982} = Q_{1969} + 7.96\ (12)$

$= 141.278 + 7.96\ (12)$

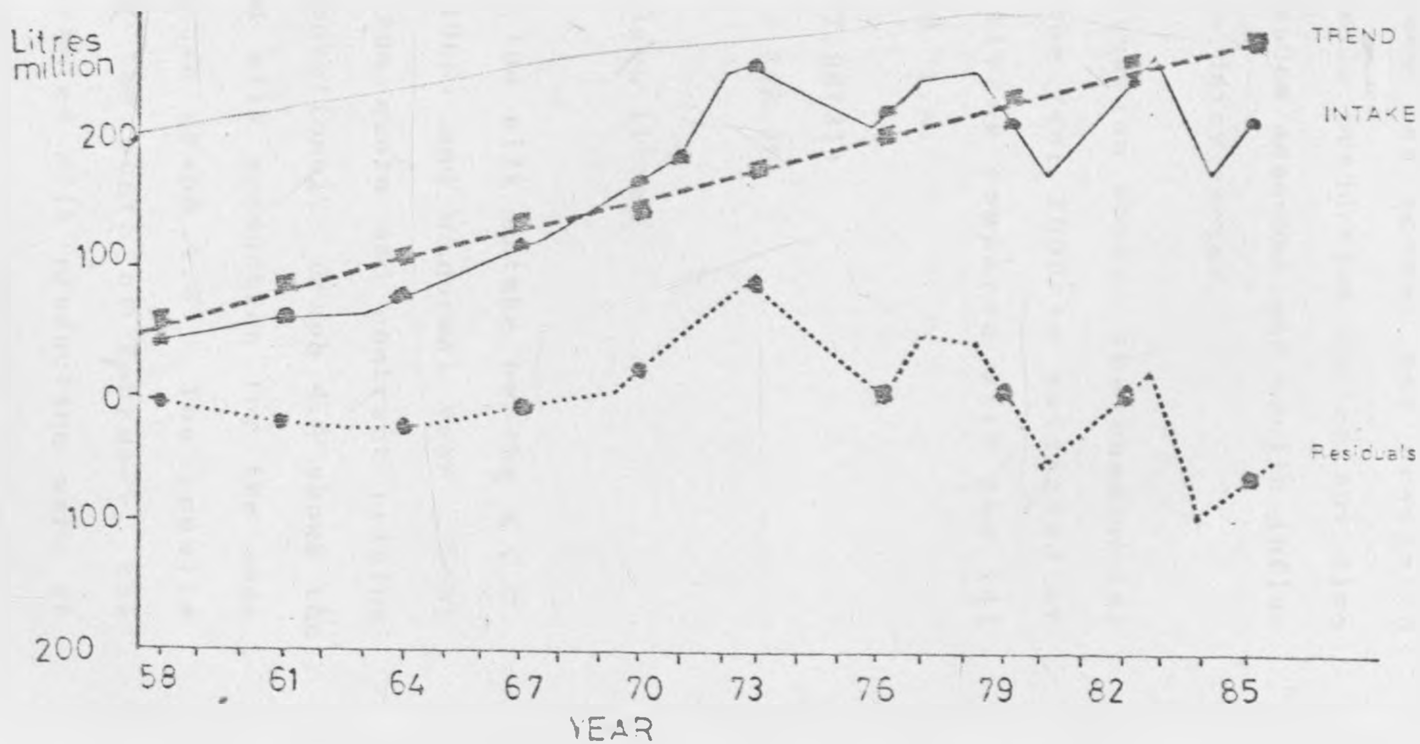
$= 236.8$ million litres

Actual production,

$Q_{1982} = 246.947$ miilion litres

Error term, $U_{1982} = 10.15$ million litres

Graph 4.2: K.C.C. Intake, Trend and Residuals of Marketed Milk Production, 1958-85



Source: K.C.C. Unpublished records

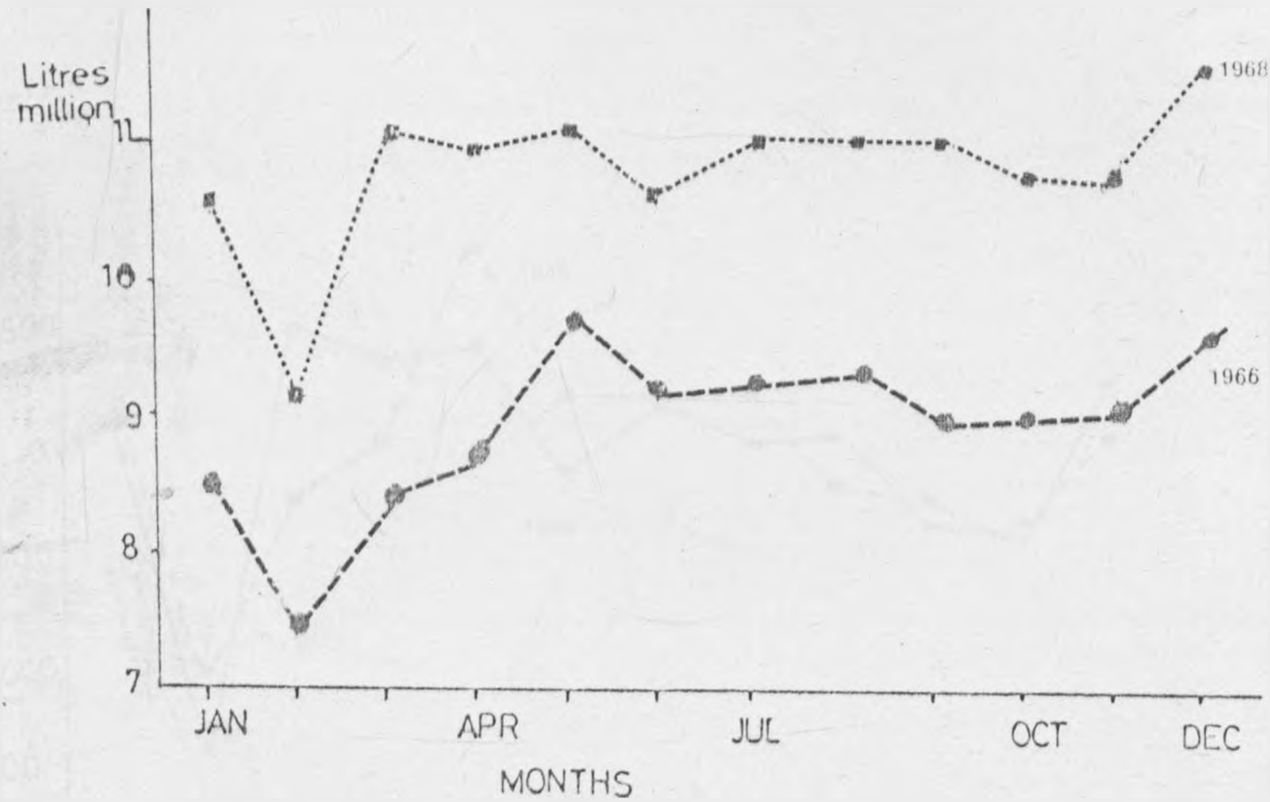
The difference between the actual and predicted volumes of marketed milk production during any time interval is due to random seasonal and cyclic influences operating in the dairy sector.

From the same equation above, the commercial milk production in the year 2000 is estimated at about 388 million litres compared with the 141 million litres in 1969, i.e.

$$Q_{2000} = B_{1969} + 7.96(31)$$
$$= 141.278 + 246.76$$
$$= 388.038$$
$$= 388 \text{ million litres}$$

Graph 4.3 shows the milk intake by the K.C.C. during a dry year (1966) and a normal year (1968) during which period the quota and contract pricing system of milk was operational. Graph 4.4 shows the residuals in marketed milk production for the same years as illustrated in graph 4.3. The results indicate that during the month of February, the volumes of actual marketed milk production were at the lowest level irrespective of the then prevailing weather regimes during the quota and contract pricing system. Furthermore, graphical analyses of both the milk intake and the corresponding residuals reveal that there are no marked differences, either on

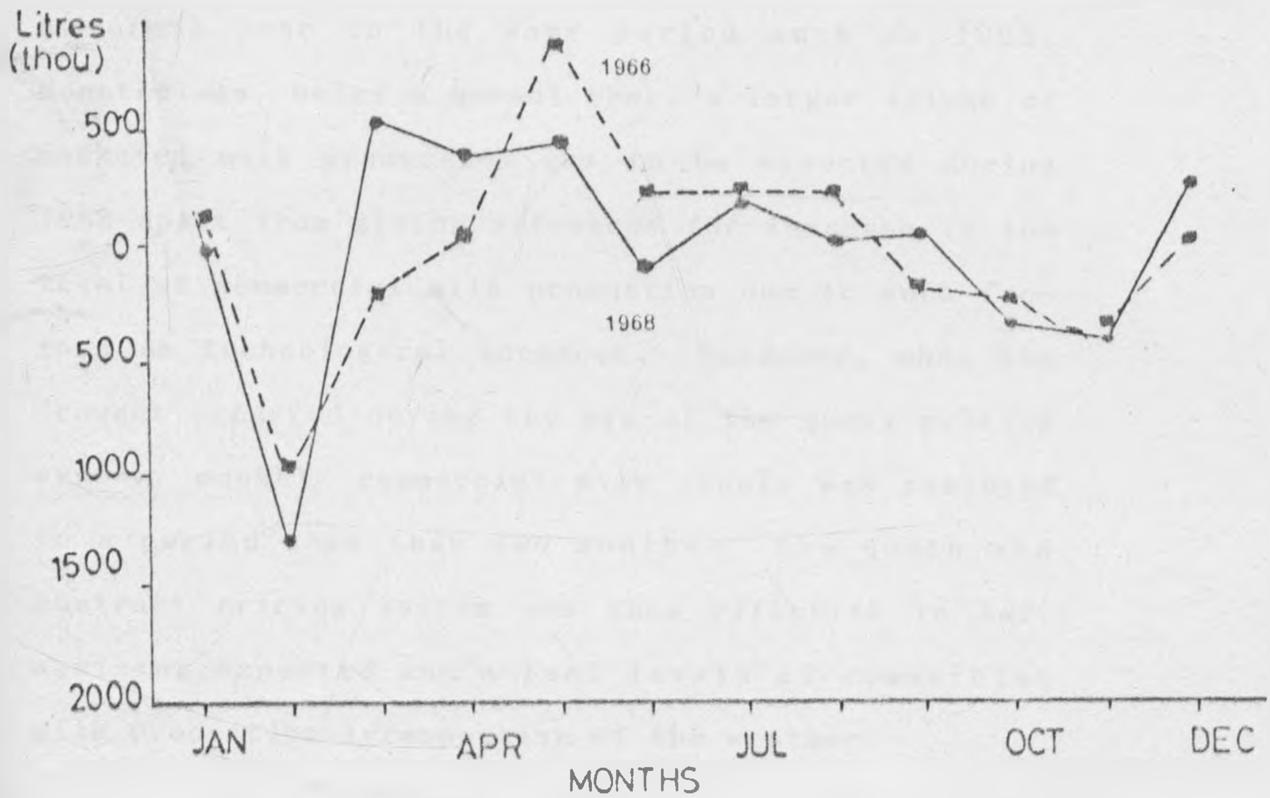
Graph 4.3: K.C.C. Monthly Milk intake during a dry year (1966) and a normal year (1968) during Quota and Contract Pricing System



1966 - Dry Year
1968 - Normal Year

Source: K.C.C. Unpublished records

Graph 4.4: Residuals of Marketed Milk Production during different weather regimes under Quota and Contract Pricing System



.... 1966, Dry Year

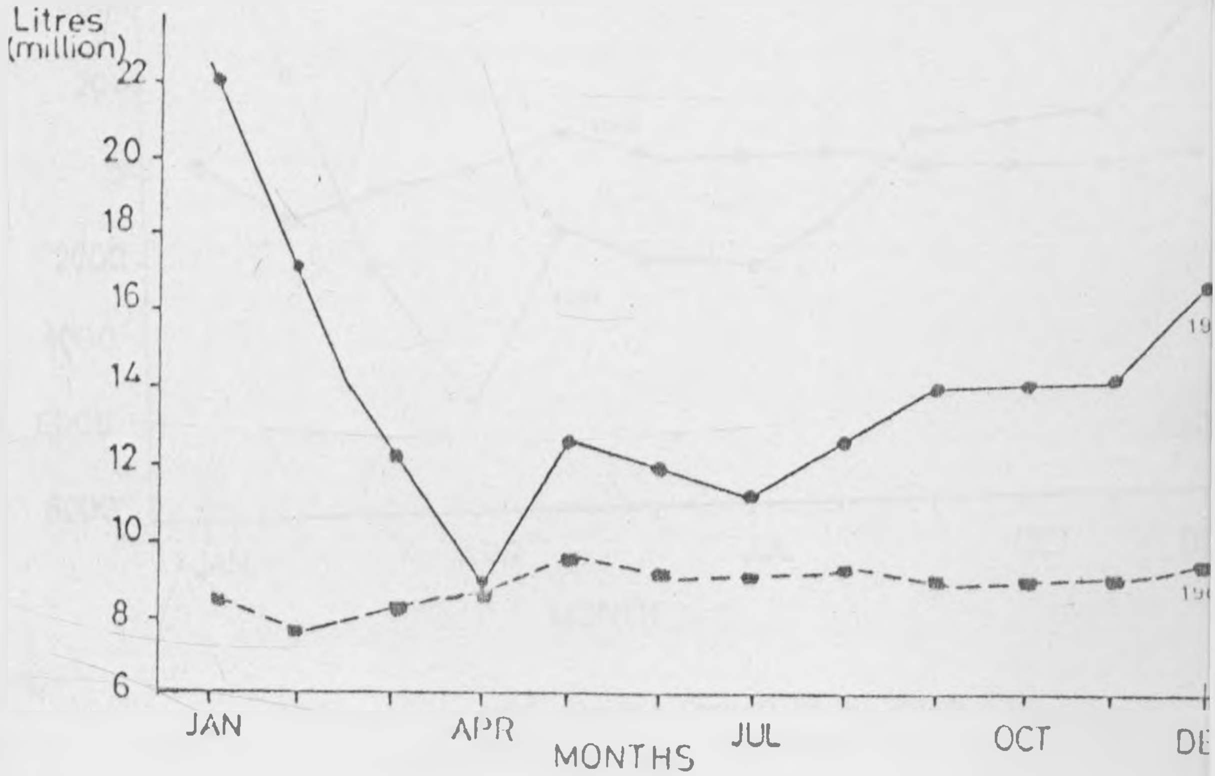
____________ 1968, Normal Year

Source: K.C.C. Unpublished records

monthly or annual basis, in the supply behaviour of marketed milk production. For example, taking the climatic drought prevalent in most parts of Kenya in 1966 into consideration, there is no marked decline in milk supplies to the K.C.C., almost as any other period during the quota and contract pricing system for fluid milk. These two graphs show the supply behaviour is essentially the same when compared with a normal year in the same period such as 1968. Nonetheless, being a normal year, a larger volume of marketed milk production was to be expected during 1968 apart from giving allowance for increase in the level of commercial milk production due to such factors as technological advances. Moreover, when the drought occurred during the era of the quota pricing system, monthly commercial milk supply was restored in a period less than two months. The quota and contract pricing system was thus effective in harmonizing expected and actual levels of commercial milk production irrespective of the weather.

Graphs 4.5 and 4.6 compare the actual marketed milk production and the residuals thereof during two respective dry years 1966 and 1984. The year 1966 is chosen to represent one period during which the quota and contract pricing system was in force while the year 1984 represents the current uniform producer

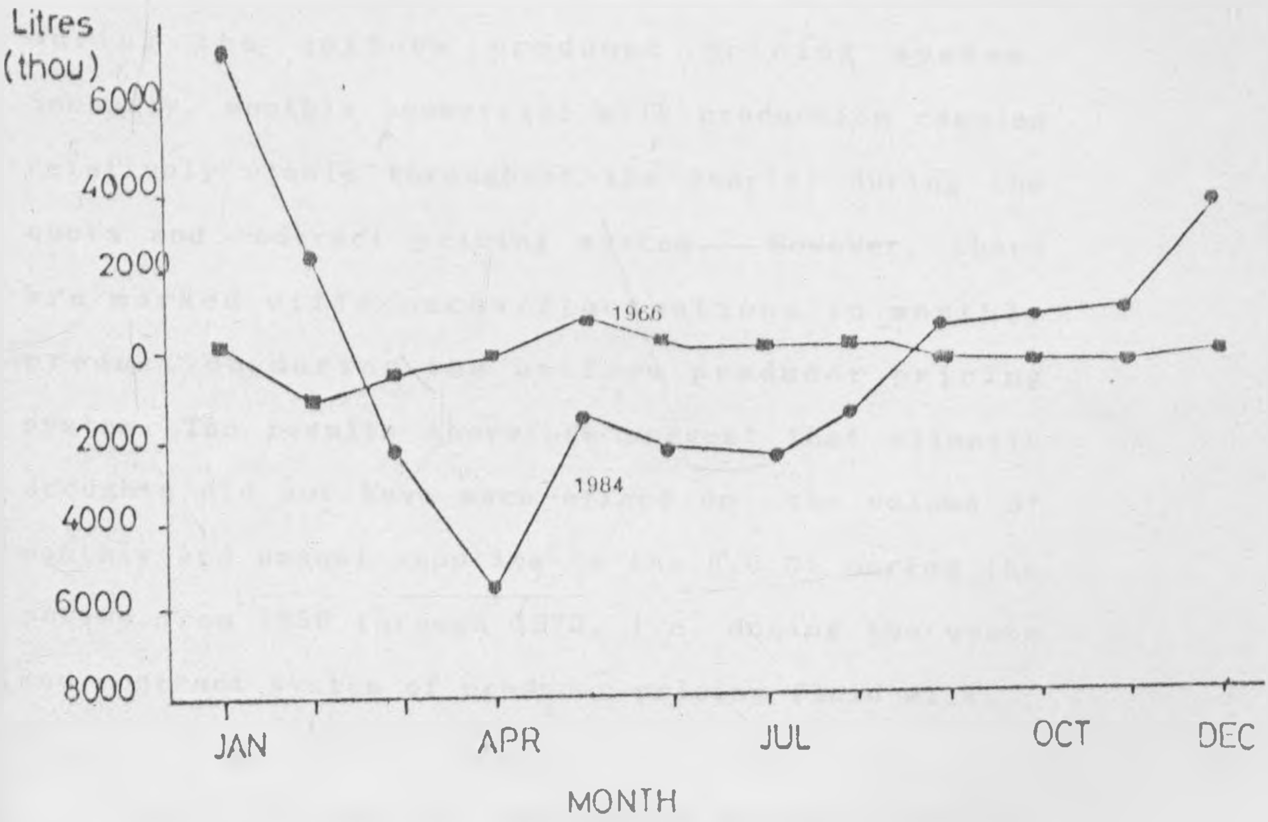
Graph 4.5: K.C.C. Monthly Milk Intake in Dry Years du
different producer Pricing Systems



1966 - Quota & Contract Pricing Systems
1984 - Uniform Pricing System

Source: K.C.C. Unpublished records

Graph 4.6: Residuals of Marketed Milk Production during Dry Years under different Pricing Systems



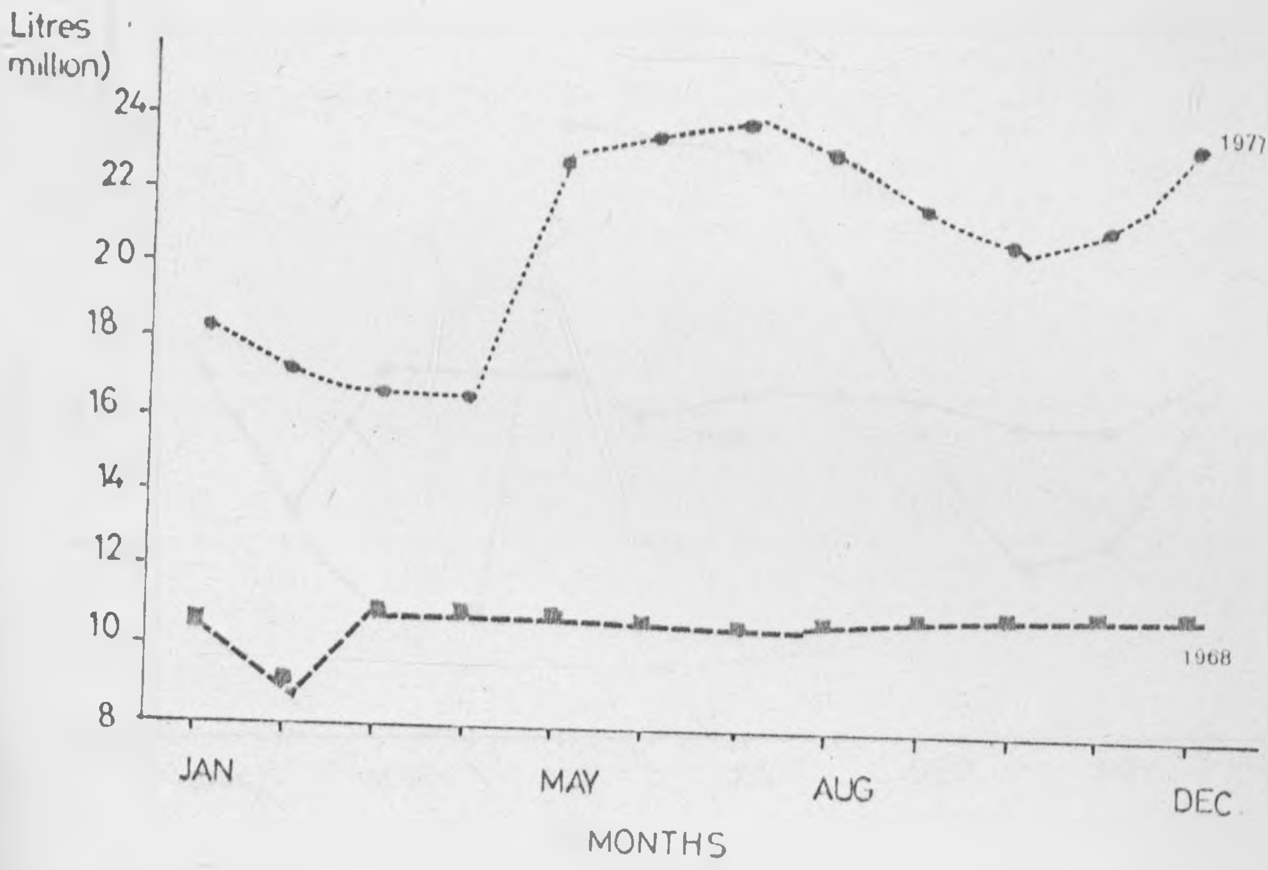
1966 - Quota & Contract Pricing System
1984 - Uniform Pricing System

Source: K.C.C. Unpublished records

pricing system for fluid milk. The graphs reveal significant differences in the supply behaviour as reflected in the amounts of actual marketed milk production between the two years. First, the month recording the least volumes of milk production during the quota system is February whereas March-April records the least amounts of marketed milk production during the uniform producer pricing system. Secondly, monthly commercial milk production remains relatively stable throughout the year(s) during the quota and contract pricing system. However, there are marked differences/fluctuations in monthly production during the uniform producer pricing system. The results therefore suggest that climatic droughts did not have much effect on the volume of monthly and annual supplies to the K.C.C. during the period from 1958 through 1970, i.e. during the quota and contract system of producer pricing fluid milk.

Graphs 4.7 and 4.8 compare the actual volumes of commercial production and the corresponding residuals during two normal years, 1968 and 1977. The two years respectively represent the period during which the quota and contract and uniform systems were operational. The purpose is to draw any parallels between the influences of weather and the method of pricing on the supply behaviour of marketed milk production in Kenya. The results of the analyses as shown on graphs 4.7 and 4.8 do not contradict the earlier findings that the months of February and March-April record the least amounts of marketed milk production during the quota and contract and the uniform pricing system respectively. Graph 4.7 shows that monthly marketed milk production fluctuated between 9.2 and 11.5 million litres in 1968 whereas there is as wide a fluctuation as between 16.7 and 23.4 million litres in 1977. The residuals reveal that during the quota and contract pricing system fluctuations in marketed milk production during a normal year are not as large as those observed during a normal year during the uniform pricing system. As graph 4.8 shows, fluctuations in 1968 and 1977 are 2.3 and 7.6 million litres respectively. The results of this analysis lead to the conclusion that the quota pricing system of fluid milk was a very powerful tool in maintaining the levels of monthly and annual commercial milk production in Kenya prior to its abolition in 1971. Under the uniform pricing system, there are higher levels of marketed milk production recorded, despite the marked fluctuations, in comparison with the quota and contract pricing system across and within years. The results discussed on graphs 4.7 and 4.8 appear consistent with the remarks made by Hopcraft and Ruigu (1976)

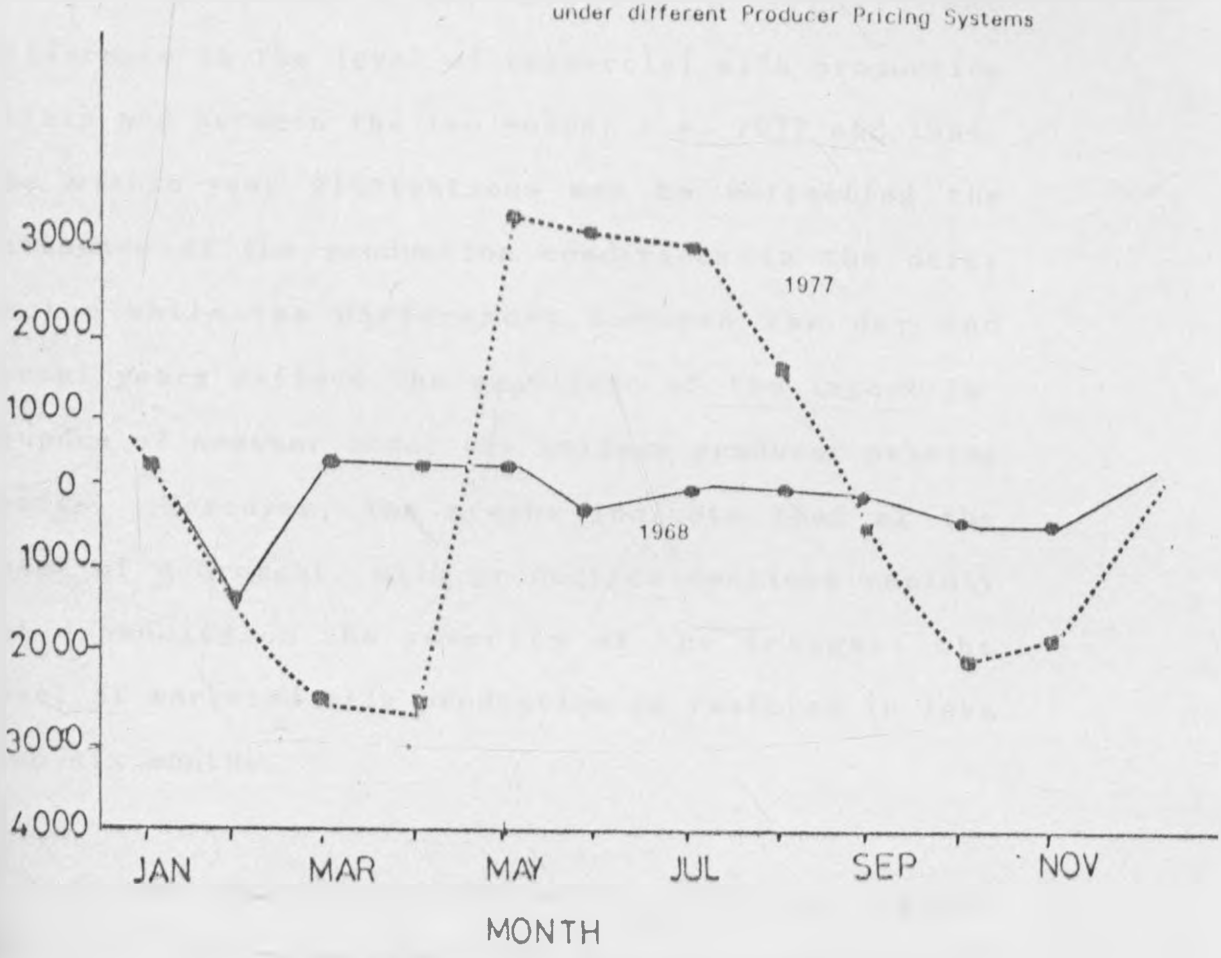
Graph 4.7: K.C.C. Monthly Milk intake during Normal Years under the different Producer Pricing Systems



1968 - Quota Pricing System
1977 - Uniform Pricing System

Source: K.C.C. Unpublished records

Graph 4.8: Residuals of K.C.C. Milk Intake during Normal Years under different Producer Pricing Systems



1968 - Quota & Contract Prices

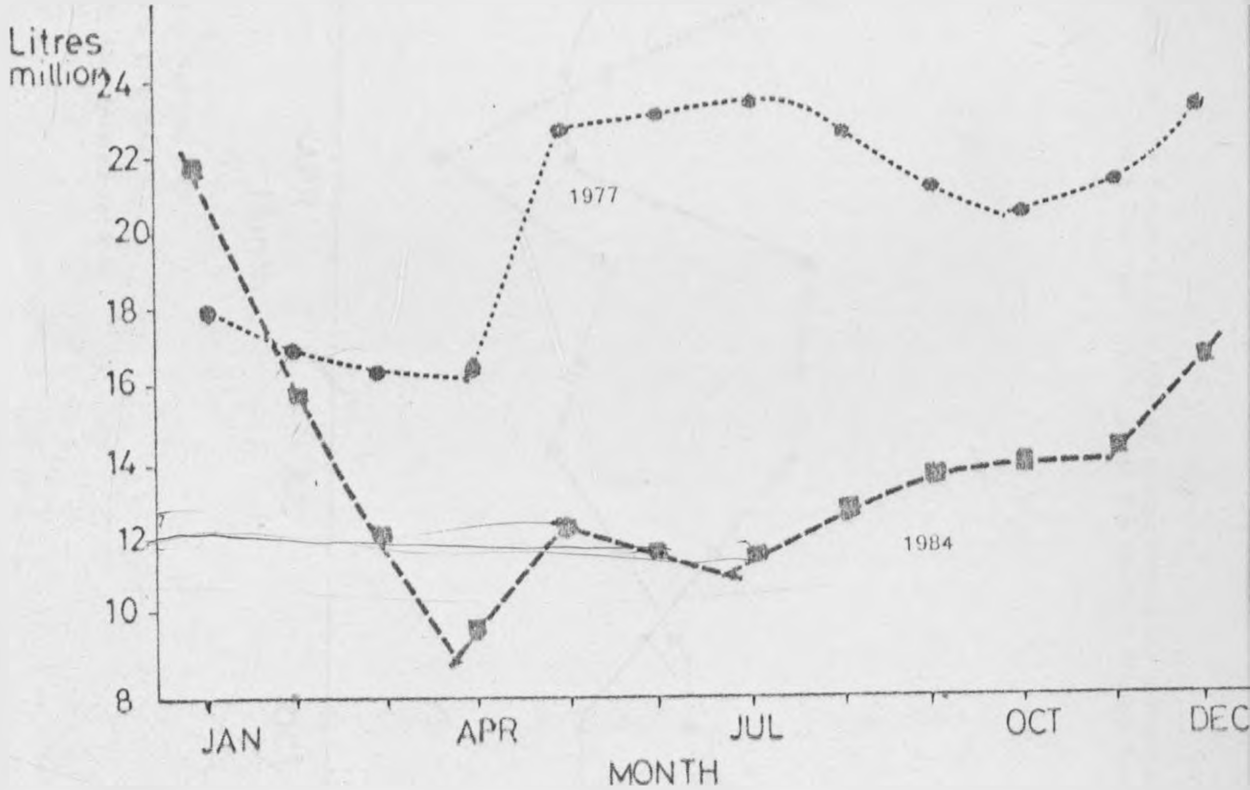
1977 - Uniform Prices

Source: K.C.C. Unpublished records

Graphs 4.9 and 4.10 illustrate the supply behaviour of marketed milk production during both the drought and normal periods when the uniform producer pricing system has been operating in Kenya. The graphs (4.9 and 4.10) display a significant difference in the level of commercial milk production within and between the two years, i.e. 1977 and 1984. The within-year fluctuations may be reflecting the influence of the production conditions in the dairy sector while the differences between the dry and normal years reflect the magnitude of the impact/influence of weather under the uniform producer pricing system. Moreover, the graphs indicate that at the onset of a drought, milk production declines rapidly but depending on the severity of the drought, the level of marketed milk production is restored in less than six months.

Across years, marketed milk production levels show declines in the months of January through April. This is due to the effects of the dry spells which are often felt earlier in the months of December and January in the various milk-producing areas. However, milk supplies to the K.C.C. tend to be restored as the long rains set in around the months of April and May.

Graph 4. 9: K.C.C. monthly Milk Intake during different weather regimes under Uniform Pricing System

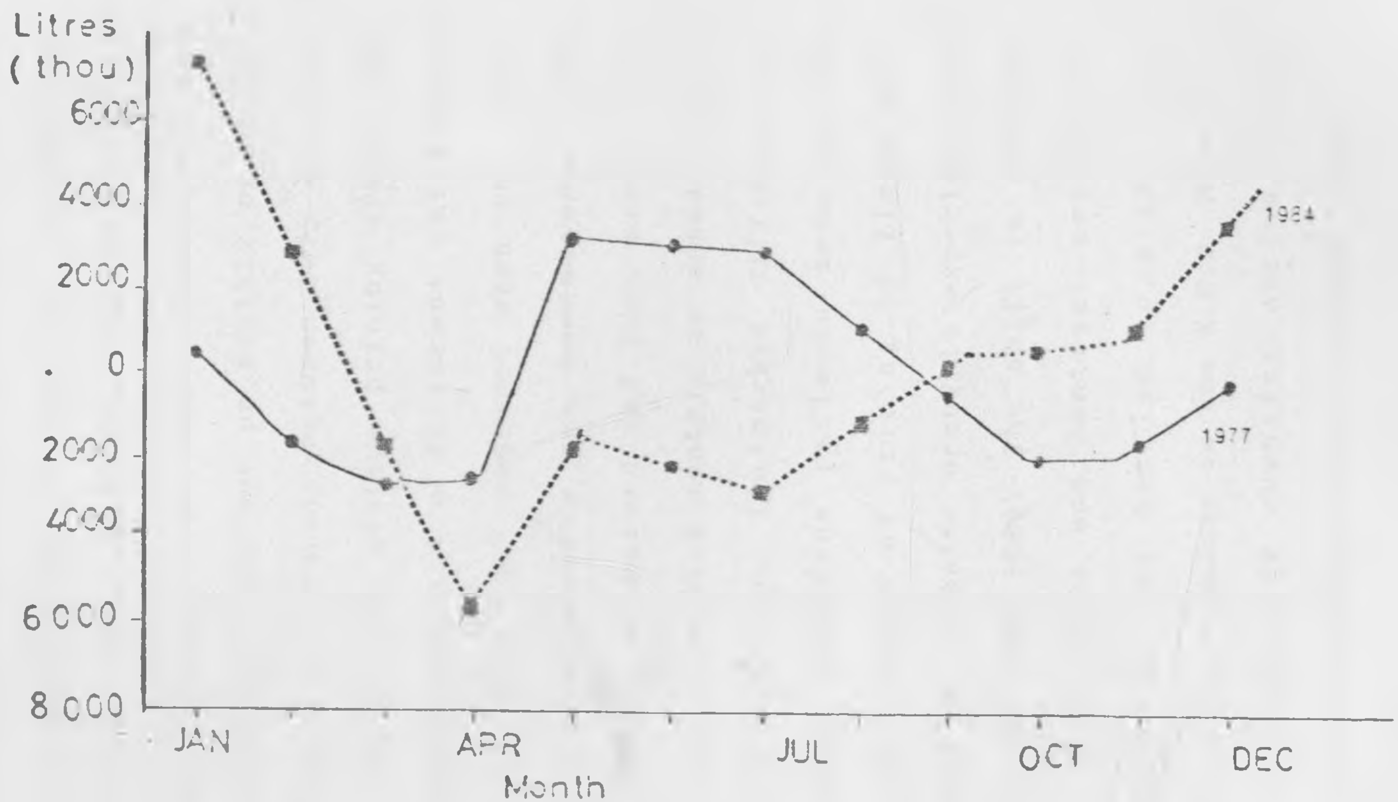


1977 - Normal Year

1984 - Dry Year

Source: K.C.C. Unpublished records

Graph 4.10 The Residuals of marketed production during a Normal Year (1977) and a Dry Year (1984) under the Uniform Pricing System



1977 - Normal Year

1984 - Dry Year

Source: K.C.C. Unpublished records

Results of all these graphical analyses presented have illustrated the supply behaviour of marketed milk production under different pricing systems and weather regimes. During the period from 1958 through 1970, when quota and contract pricing system was operational, the supply behaviour was stable and predictable whether on monthly or annual basis. Analysis of the supply between 1971 and 1985 during which period the uniform pricing system has been operational, reveals a different pattern of supply behaviour from that observed when the quota and contract pricing system was operational. The supply behaviour is haphazard and less precise in aiding prediction of either monthly or annual levels of commercial production. The marked difference in commercial supply patterns reflects more on the influence of the method of pricing of fluid milk rather than that of climatic droughts experienced in Kenya between 1958 and 1985. The shift in official price policy from quota and contract pricing to uniform producer pricing has led to significant fluctuations in milk supplies to the K.C.C. Moreover, it has led to more milk supplies during normal weather and less milk during dry or drought years.

4.2 RESULTS OF THE REGRESSION ANALYSIS

This section presents and discusses the results of both stepwise and multivariate regression analyses using the semi-log regression model:

$$LnY = b_o + b_iX_i + U_i \qquad \text{(3 repeated)}$$

The results of the estimates of the semi-log regression model using ordinary least squares (OLSQ) are given in Table 4.2. The objective of the stepwise regression was to estimate the significance of the different independent variables on the level of the marketed milk production. Unless otherwise stated, subsequent discussions are based on the results as shown in Table 4.2.

Table 4.2: Results of Stepwise Regression Analysis

Model: $LnY = b_o + b_iX_i + U_i$ (3 repeated)

Independent Variable	Const b_o	Coeff. b_i	S.E.	F-ratio	t-stat	R^2
X_4	16.75	0.032	0.022	2.11	1.45	0.04
X_3	19.23	-0.99	0.12	72.30	8.50	0.725
X_2	17.87	0.062	$6.81\times10^{[illegible]}$	82.87	9.10	0.752
X_1	17.72	6.68×10^{-9}	5.68×10^{-10}	137.84	11.74	0.835

Source: Appendix Tables (4 - 7)

The weather index X_4, explains 4 percent of the total variance. It has a positive coefficient (0.032) with a standard error of 0.022. The t-statistic for the weather index is statistically significant at 10 percent level of significance. The positive coefficient for the weather index indicates that the level of marketed milk production will increase as more rainfall is received in the milk producing areas of Kenya. This interpretation is derived from the formulation of the weather index. When there is rainfall, temperatures are low. Thus the weather index, X_4 is large. Hence there is more milk produced and marketed through the commercial channels. The reverse holds true. This is reasonable with due regard to the weather effects on the forage production in various milk producing areas. The influence of weather on the level of marketed milk production is reinforced by the results of graphical analyses discussed in section 4.1. Thus a positive coefficient with low standard error appears realistic in the light of levels of commercial milk production recorded in Kenya during the period from 1958 through 1985.

The dummy variable, X_3, used to reflect on the influence of the method employed in the pricing of fluid milk emerges as a significant explanatory

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The dummy variable, X_3, used to reflect on the influence of the method employed in the pricing of fluid milk emerges as a significant explanatory variable. The dummy variable, X_3, explains 73 percent of the total variance in the magnitude of marketed milk production in Kenya. Both the F-ratio and the t-statistic are significant at both 5 percent and 1 percent levels of statistical significance. It has a negative coefficient (-0.988) with a small standard error of 0.12.

The negative coefficient for the dummy variable shows that the quota and contract pricing system tended to hinder marketed milk production. Dairy farmers were required and expected to fulfill their quota allocations only. Thus the existence of an even and predictable pattern of commercial milk production during the quota and contract pricing systems seems realistic. The abolition of quota and contract pricing system has had a different consequence. The dairy farmers have tended to produce and sell milk in response to prevailing weather and price conditions. This is evident from the large milk supply during normal (i.e. wet) weather and low levels of milk supply during dry or drought periods. This result implies that increases as well as fluctuations in the level of commercial milk production would be expected from the moment quota and contract prices were abolished. Indeed it has happened as shown by the results of the graphical analyses. However, this result should not be overemphasized as the influence of the dry weather premium which is operational during the dry season (January - April) has not been incorporated in the analysis.

The trend variable, X_2, explain 75 percent of the total annual variations in the levels of marketed milk production in Kenya. It has significant t-statistic and F-ratio at both 5 percent and 1 percent levels of statistical significance. It has a positive coefficient of 0.062 with a small standard error of 6.81×10^{-3}. The small but positive coefficient for the trend variable indicates that any technological advances bearing relevance to the dairy sector as a whole will slowly influence the amount and rate of improvement in the level of marketed milk production in Kenya. The reasons for this kind of result hinge on the slow rate of technological change and, generally, the slow rate of adoption of better technologies by dairy farmers on a wide scale. Such technologies include better yielding breeds of dairy animals, irrigation, cold storage of milk output and production techniques of fodder. Thus technology will continue to influence the rate and magnitude of commercial milk production in Kenya.

The lagged variable of the dependent variable X_1, explains 83 percent of the total variance in the level of marketed milk production in Kenya. Both the F-ratio and t-statistic are significant at both 5 percent and 1 percent levels. The positive coefficient of lagged commercial milk production has a small standard error (5.68×10^{-10}). The positive coefficient of lagged marketed milk production indicates that there will be lower milk surplus in the year(s) following those recording excessive surplus. This is not unrealistic. This is true when a farmer supplying over the quota requirements would be penalised. Usually the farmers would end up earning less unit producer price than if the amount of milk supplied was within quota allocations. In extreme cases, the quota allocation would be withdrawn. Furthermore, hardships through which dairy farmers go during peak milk production periods, e.g. delayed cash payments, or their milk supplies being understated, downgraded or rejected, at some K.C.C. factories, also help to explain the low supplies in subsequent years.

In order to check on the accuracy of ordinary least squares (OLS) technique, both two-stage least squares (TSLS) technique and ordinary least squares with correction for autocorrelation (TSCORC) techniques were used. Subsequent discussions are discussions are based on results of multivariate regression analyses illustrated in appendix tables 8,9 and 10.

The results of milk regression analyses comparing the results of the OLS, TSLS and TSCORC estimation techniques indicated no significant differences among the techniques. For all the three techniques, the Durbin-Watson statistic indicated inconclusive test for autocorrelation at 1 percent level of statistical significance. The results thus suggest that there is no basis for the superiority of the TSLS and TSCORC techniques over OLS technique when using the semi-log regression model in the analysis of the data on marketed milk production. Thus the OLS technique is adopted for multivariate regression analysis of milk production data.

The results of the multivariate regression analysis using the ordinary least squares estimation approach on the semi-log model can be summarised as:

$$LnY = 11.513+0.000634X_1+0.017X_2-0.057X_3+0.011X_4 \quad (4)$$

S.E (0.729) (0.000185) (0.012) (0.233) (0.011)

t-stat 15.79 3.42 1.35 0.25 1.03

$R^2 = 0.847$

Durbin-Watson = 1.18, inconclusive test for autocorrelation

$n = 28$

$d.f = 23$

Where:

Y = marketed milk production (litres)

X_1 = lagged marketed milk production (litres)

X_2 = trend (1 for 1958, 2 for 1959, ..., 28 for 1985)

X_3 = dummy variable for method of pricing of fluid milk:

1 = quota and contract system (1958/70)

0 = uniform pricing system (1971/85)

X_4 = weather index

The coefficients of the variables for one-year lag on marketed milk production, trend, dummy variable and the weather index are 0.000634, 0.017, -0.057 and 0.011 respectively. The coefficient of the variable for lagged milk production is positive with a small standard error (0.000185). This indicates that the volume of milk supplies to the K.C.C. is significantly influenced by the volume of the previous year's supplies to the K.C.C.

Milk supplies to the K.C.C. will increase at an estimated absolute annual increment of about 8 million litres of fluid milk, as projected using graphical analysis in section 4.1. Moreover, the shift in official pricing system to the uniform pricing system has had a positive influence on marketed milk production in Kenya. This is indicated by the negative coefficient of the dummy variable for the quota and contract pricing system of fluid milk in Kenya.

The positive coefficient for the weather index indicates the direct influence of weather on the levels of marketed milk production. The result indicates that the amounts of rainfall and temperature in the various milk producing areas have a corresponding influence on the levels of the volume of commercial milk production in Kenya. When there is plenty of rainfall, usually temperatures are low. Thus the calculated value of the weather index is large. There is more milk produced and supplied to the commercial channel. The reverse holds true. Hence less milk is supplied to the commercial channels.

The intercept term is positive and greater than unit. All variables taken together, the resultant sum of the coefficients is greater than unit (11.48634). The commercial milk market would expect to get some fluid milk however unfavourable the production conditions in the various milk-producing areas. The change in milk supply will depend on the overall rate, magnitude and direction of change of all the responsible factors.

4.3 HYPOTHESES TESTING

The first hypothesis put forward required testing of whether weather is statistically significant as a factor influencing marketed milk production in Kenya. From the results of ordinary least squares (OLS) estimates of the semi-log regression model, it is established that weather is statistically significant, in influencing commercial milk production. The hypothesis is thus not rejected .

The next hypothesis sought to determine whether the method of pricing of fluid milk bears any significant influence on the magnitude of commercial production, especially with respect to milk supply to the K.C.C. From the regression results using the semi-log regression model, it is established that the method of pricing of fluid milk is a significant explanatory variable influencing commercial milk production in Kenya, particularly with respect to milk supply to the Kenya Co-operative Creameries. The hypothesis is not rejected

The third hypothesis put forward required testing whether technological advances have played a significant role in the magnitude of marketed milk production during the last three decades. The results of the regression analysis suggest that any advances in dairy technology as a whole will bear significant influence on the direction and rate of change in the commercial dairy sector in Kenya. In other words, the trend variable, which reflects the influence of technological advances, is found to be a significant variable in determining the level of marketed milk production in Kenya. Hence, the hypothesis is not rejected.

The last hypothesis sought to find whether previous levels of commercial milk production have any significant influence on the current level of commercial milk production. From the ordinary least squares (OLS) estimates using the semi-logarithmic regression model, it is established that the lagged variable of commercial milk production is statistically significant in determining the magnitude of commercial milk production in Kenya during the last three decades. The hypothesis is thus not rejected.

These results indicate that weather, the method of pricing of fluid milk, technology and the previous levels of commercial milk production are all significant variables in explaining the observed variations in the levels of commercial milk production in Kenya.

However, preliminary regression results using the semi-log regression model established that producer price of milk *per se* is not a significant explanatory variable for the observed variations in marketed milk production in Kenya at both 5 percent and 1 percent levels of statistical significance. It was thus dropped from the semi-log regression model.

CHAPTER FIVE

CONCLUSIONS AND IMPLICATIONS OF THE STUDY

5.1 CONCLUSIONS AND IMPLICATIONS OF THE EMPIRICAL RESULTS

This study has analysed the supply pattern of marketed production of an agricultural commodity with no close substitute at the consumer or demand level. Subsequent discussions on the policy implications of the study on marketed milk production are based on the results hitherto presented.

The supply behaviour of marketed milk production was relatively uniform and predictable until the abolition of the quota and contract producer prices operational until 1970. There was little variation between planned and actual commercial milk production. However, with the introduction of the uniform producer prices, the supply behaviour has become less predictable and wide fluctuations in the levels of commercial milk production are evident within and between years. In effect, the stability of milk supplies to the K.C.C. lay in the strength of the quota and contract pricing system of fluid milk and the structure of farming systems prevalent in the period 1958 through 1970.

The impact of the dry weather is evident on the level of commercial milk production inspite of the dry weather premium milk supplies to the K.C.C. from January through April. It thus appears that the commercial milk market has lost much of its resiliency in responding to the influence of droughts or dry periods on the levels of marketed milk production in view of the shift in pricing policy. The study indicates that the monthly and annual milk supplies to the K.C.C. have shown more fluctuations within the uniform pricing system. This suggests that the dry season price premium has not had any marked effect on levelling the magnitude of fluctuations in commercial milk production in Kenya. This is evident from the supply behaviour patterns since the dry weather premium was instituted about one decade ago. This study proposes a review of the various pricing mechanisms so far instituted in the dairy sector with a view of guiding the performance of the sector. An analogue of the quota and contract pricing system is suggested in the form of quantity premiums. That the more fluid milk that a supplier delivers to K.C.C., the higher the unit price rather than a uniform dry weather premium. This may tend to encourage large-scale dairying and formation of efficient milk-collection systems. The dairy co-operatives may have more incentive to collect more fluid milk from the member dairy farmers. This may lead to installation of cold storage facilities in remote aress that would collect milk output from small farms. In essence, this would help considering that traditional subdivision of land will continue. It is suggested that this may perhaps iron out any supply problems that the dairy farmers may be experiencing in some parts of the country, especially during the wet season or at peak production. It also may eliminate uneconomical hawking of milk surplus at farm-level, thereby helping serve urban demand.

The results based on graphical analyses of the supply patterns of commercial milk production indicate that periodic fluctuations in milk supplies to the Kenya Co-operative Creameries occur every 4.40 years to 5.14 years. These results suggest that the fluctuations in the supply pattern occur almost at the same frequency as climatic droughts do. In view of the substantial amount of capital investments in facilities involved in processing, storage and distribution of dairy products, the execution of these activities by any organisation involved ought to be carried out with some modicum of efficiency in the interest of the economy as a whole. It is also suggested that any international trade be scheduled with due regard to the domestic level and pattern of commercial milk production as a food security measure. And since there is a four year cycle between the highest and the lowest levels of milk production, any international trade should take a pattern that harmonizes the observed supply patterns. This may in the long-run help to stabilize the level of domestic milk supply.

The quota and contract method of pricing of fluid milk appears to have had a negative influence on the magnitude of marketed milk delivered to the K.C.C., unlike the current uniform pricing system. Producer prices are set by the government and are a crucial factor if the official milk marketing system is to guarantee regular and sustainable supplies. The method of pricing may stifle the performance of the dairy sector even if there are minimal fluctuations between planned and actual marketed milk production as observed during the period when quota and contract pricing system was operational. Therefore, the method of pricing has profound influence on the direction and rate of resource use in the various dairy production activities. This study suggests a regular review and adjustment, not necessarily a shift, in the method of producer pricing in order to appraise the effectiveness of various price tools implemented in the dairy sector. That is why this study has proposed a producer price regime based on the quantity of milk delivered to the K.C.C. or any similar institution. This is to assist in the competitiveness of both official and parallel markets, such as the K.C.C. and other competing organisations like the Kitinda Farmers Co-operative Society in Bungoma District and Meru Central Farmers Co-operative Union in Meru District.

The behaviour and characteristics of commercial milk production indicate that the stability of the predictable supply patterns depended largely on the quota and contract pricing system. Despite guaranteeing dairy farmers of a fair price for planned milk supplies, the quota and contract pricing system discouraged surplus production over and above the quota allocations especially during the wet season. Moreover the preceding quota allocations were not transferable to subsequent periods. Among other things, these restrictions tended to discourage storage and led to inappropriate processing policies, and uneconomic hawking of surplus milk in areas prohibited by municipal bylaws. Therefore the quota and contract pricing system generally inhibited efficiency in dairy marketing.

The uniform pricing system with the dry season price bonus has witnessed both increased milk production and seasonal fluctuations despite the dry season bonus. Perhaps the dry season bonus does not offset the extra cost of milk production during the dry season. Given the above limitations of both the quota and contract pricing system and the uniform pricing system with the dry season price bonus, there is need to consider alternative pricing policies for milk in Kenya.

In essence, this study proposes the gradual de-controlling of milk prices whereby the market forces of supply and demand will determine the producer and retail prices of milk. Effectively the market forces will determine the dry season and wet season competitive prices that will eventually stabilize commercial milk production. However, there will be need to have a powerful monitoring agency to advise, among other things, on the various policy guidelines aimed at sustaining milk production levels. There is the need to protect consumers since milk has no close substitute. For example, the monitoring agency will advise on imports/exports that may duly affect competitive prices in the domestic milk market.

Finally, the use of high-yielding and quick-growing fodder crops along with appropriate postharvest storage techniques, such as ensiling, may relieve dairy farmers of the problem of feed shortages in the dry seasons. Simple and affordable irrigation systems if adopted on a broad scale by the majority of dairy farmers may ease the problem of feed shortages especially during droughts or dry periods and thus sustain the level of commercial milk production. Technological advances emerged quite significant in explaining the observed variations in marketed milk production in Kenya. Any farm-level or institutional innovations that tend to stimulate milk production should be encouraged. Any factors that tend to hinder efficient production and marketing of fluid milk need close and systematic identification. Policies that are conducive to sustainable improvements within the dairy sector should be encouraged. Since the trend variable only incorporates the influence of technological changes through the use of time, the components of the trend factor need to be viewed in isolation and be taken much more carefully. A study on the impact of specific technological advances on the performance of the commercial dairy sector is therefore suggested.

5.2 NEED FOR FURTHER RESEARCH

To be able to get a more complete understanding of the dairy sector in Kenya and the overall response of total dairy production to weather and prices, this study suggests research to be carried in the following areas:

(i) The level of milk production going towards calf-bearing and home consumption in the various regions of Kenya at different seasons. This may provide data to enable a comprehensive analysis of farmers' response to milk prices.

(ii) The variance of costs of milk production across seasons and geographical areas. If the analysis of variance indicates that there are significant differences in the cost of milk production across seasons and geographic areas, then possibly the level of marketed milk production can be maintained and even stimulated through suitable pricing policies for fluid milk depending on geographical location and/or severity of the weather change in the milk producing areas.

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Appendix 1: Rainfall Data

The data are collected through the assistance of the staff of the Rainfall section at the Meteorological Department, Dagoretti (Nairobi). Appendix 1 represents rainfall data in various milk producing areas of Kenya. The areas included are: Mariakani, Nyeri, Meru, Kabete, Kiambu, Naivasha, Nyahuru, Nakuru, Kericho, Eldoret, Kitale and Kisii.

These areas are selected to reflect various rainfall regimes in corresponding years in the areas in or near the neighbourhood of the various K.C.C. factories. These K.C.C. factories are located in Mariakani, Kiganjo, Dandora, Naivasha, Nyahururu, Nakuru, Sotik, Eldoret and Kitale.

Appendix 1 also shows the annual average rainfall for the milk producing areas of Kenya since 1958. A conversion figure of 1 inch to 25.4 mm is used to convert rainfall data for the period from 1958 through 1961 into the metric system. In some cases data from adjacent stations were used to substitute for non-existent data for similar geographical areas. For example, Sotik data are derived from a blend of Kericho and Kisii data. It is not too bad a substitution because Kericho and Kisii areas receive almost similar rainfal amounts in similar patterns as Sotik area. To some extent, Kilifi data are used to reflect on Mariakani area. Even more significant Kilifi is the main milk producing area on Kenya's coastal strip.

Rainfall data of Kabete or other peri-urban areas are presented to reflect the actual or potential contribution of peri-urban areas of marketed milk production. Blank spaces mean that the particular Meteorological stations were not operational or were closed down for one reason or another.

Appendix 1: Rainfall Data for Milk Producing Areas in Kenya

Rainfall Data (mm) in Milk Producing Areas of Kenya

YEAR	MARIAKANI	NYERI	MERU	KABETE	KIAMBU	NAIVASHA	NYAHURURU	NAKURU	KERICHO	ELDORET	KITALE	KISII	AVERAG
1958	-	921	2423	-	1027	567	943	866	1600	1009	-		117[illegible]
1959	-	922	2998		1026	566	939	863	1600	997	-	1863	1380
1960	940	918	-	-	1024	563	936	860	1598	993	-	1885	1080
1961	958	932	3044	997	1037	574	964	889	1610	999	1177	1899	1257
1962	952	930	3045	1002	1037	581	964	865	1616	989	1172	1922	1256
1963	957	934	-	1016	1052	596	974	868	1624	1002	1169	1923	1103
1964	950	936	-	1019	1048	600	976	869	1629	1002	1197	1924	1105
1965	944	932	-	1018	1043	596	966	863	1627	992	1173	1927	1098
1966	941	932	2973	1020	1042	594	965	861	1631	994	1175	1939	1256
1967	953	956		1025	1047	598	966	861	1636	1001	1183	1929	1105
1968	966	941		1030	1050	603	982	860	1643	1001	-	1931	1101
1969	962	938		1023	1043	600	976	856	1638	994		1943	1097
1970	957 .	939	-	1029	1042	602	977	860	1647	1006	1185	1955	1109
1971	952	936	2640	1024	1044	603	978	860	1643	1007	1187	1952	1236
1972	954.	936	2544	1023	1042	603	968	859	1640	1016	1180	1954	1226
1973	955	934	2344	1018	1035	600	961	857	1641	1015	1171	1953	1207
1974	945	935	2265	1017	1033	602	951	857	1639	1009	1163	1953	1198
1975	944	932	2163	1014	1025	599		860	1640	1021	1157	1957	1210
1976	943	930		1030	1031	594	954	859	1638	1015	1140	1963	1099
1977	946	929	2250	1093	1028	600	965	864	1640	1031	1135	1984	1205
1978	956	931		1134	1038	664	964	869	1653	1031	1126	1996	1124
1979	963	935	2243	1018	1036	606	962	874	1654	1028	1190	2001	1209
1980	963	932	2291	1021	1035	605	-	869	1651	1021	1182	1990	1233
1981	963	933	2289	1023	1034	602	964	870	1655	1019	1195	1989	978

1982	974	935	2299	1054	1034	606	966	873	1657	-	1204	1991	123[illegible]
1983	977	939	2233	1026	1035	604	968	872	1654	-	1216	1997	1229
1984	982	932	2167	-	1030	599	956	868	1650	1062	1207	1989	1222
1985	-	932	-	1021	1025	592	951	865	1648	-	1211	1992	1024

Source: Meteorological Department, Dagoretti

) Author's compilation

Appendix 2: Temperature Data

Data on temperature in milk producing areas of Kenya from 1958 through 1985 are presented in Appendix 2. The data was collected from and through the assistance of the staff of the climatological section at the Meteorological Department at Dagoretti, Nairobi.

The data are collected for the same areas as in Appendix 1. There are no temperature data for Naivasha and Nyahururu areas. Thus Naivasha and Nyahururu areas are not shown in Appendix 2.

The temperature data are the cumulative annual aggregated divided by the number of months that the data are aggregated. Black spaces indicate that the data were not recorded for that year either because the station(s) was/were not yet operational or closed down for one reason or another.

The rainfall and temperature data were used to determine the weather index. The weather index is given as the independent, X_4, in the semi-log regression model.

Appendix 2: Temperature Data

Temperature Data (C) in Milk Producing Areas of Kenya

YEAR	MARIAKANI	NYERI	MERU	KABETE	KIAMBU	NAKURU	KERICHO	ELDORET	KITALE	KISII	AVERAGE
1958	26.5	-	-	19.3	17.6	17.0	-	16.9	18.7		19.3
1959	26.5	-	-	19.4	17.6	16.9	-	17.0	18.9	-	19.4
1960	26.3	-	-	19.2	17.5	16.9	-	17.3	18.7		19.3
1961	26.7	-		19.7	18.1	17.1		16.8	18.7	-	19.4
1962	26.6	-	-	19.1	17.5	16.4		16.5	18.3		19.1
1963	26.1	-	-	18.7	17.3	16.6		16.2	18.3		18.9
1964	26.1	-		18.7	17.2	16.8	-	16.2	18.1	-	18.9
1965	26.0	-	-	18.9	17.5	17.3		16.6	18.3		19.1
1966	26.2	-	-	19.2	17.7	17.3		17.0	18.4	-	19.3
1967	26.1	-	-	19.0	17.6	17.3		16.6	18.1		19.1
1968	25.6	-	-	18.1	17.1	17.2	15.4	16.6	17.9	-	18.3
1969	26.4			18.4	18.2	17.6	16.1	-	-	-	19.1
1970	26.4	-	-	18.6	.18.1	16.3	15.9	-	18.3	-	18.9
1971	26.1	-	-	18.2	17.4	16.9	15.7		18.0		18.7
1972	26.4	-	-	18.7	18.1	17.6	16.0	-	18.4		19.2
1973	26.3	-	-	19.1	18.2	18.0	16.3	16.9	18.6	-	16.6
1974	26.5	-	-	18.7	17.6	17.2	16.0	15.7	18.1		18.5
1975	26.2	-	17.5	18.7	17.8	17.2	15.8	16.5	18.0	-	18.5
1976	26.4		18.8	19.2	18.3	17.3	16.7	16.8	18.2	-	18.9
1977	26.6	17.2	17.8	18.9	18.1	17.7	15.9	16.8	18.1	-	18.6
1978	26.3	17.8	17.8	18.7	18.0	17.4	16.0	16.6	18.3		18.5
1979	26.4	17.4	18.0	19.0	18.0	17.7	14.9	17.0	18.6		18.6
1980	26.4	18.0	16.9	18.9	18.3	18.2	16.5	17.2	19.1		18.3

1981	-	19.1	20.0	-	-	-	17.3	18.5	18.8	-	18.6
1982	-	15.8	20.4	-	-	-	16.2	15.9	18.6	18.6	17.6
1983	-	17.0	17.5	-	-	-	15.2	17.3	17.3	20.6	17.5
1984	-	16.3	18.5	-	-	-	16.0	18.8	18.5	22.2	18.4
1985	-	16.9	18.2	-	-	17.9	16.2	17.0	18.5	19.7	17.8
1986	-	-	-	-	-	-	-	-	-	-	-

Source: Meteorological department, Dagoretti

Author's work

Appendix 3: Variables in the Semi-log Regression Model

OBS	Y	LY	X_1	X_2	X_3	X_4
1959	49.997204	17.72747	4.022E+7	1.000000	1.000000	60.62176
1959	52.654433	17.77926	5.000E+7	2.000000	1.000000	67.42268
1960	56.552048	17.85067	5.265E+7	3.000000	1.000000	55.95854
1961	57.738316	17.87143	5.655E+7	4.000000	1.000000	64.79381
1962	62.688661	17.95369	5.774E+7	5.000000	1.000000	65.75916
1963	64.169972	17.97704	6.269E+7	6.000000	1.000000	58.35970
1964	77.112015	18.16076	6.147E+7	7.000000	1.000000	58.46560
1965	89.169279	18.30604	7.711E+7	8.000000	1.000000	57.48691
1966	106.965346	18.48801	8.917E+7	9.000000	1.000000	65.07772
1967	121.746852	18.61745	1.070E+8	10.00000	1.000000	57.85340
1968	129.737383	18.68102	1.217E+8	11.00000	1.000000	60.16393
1969	141.278018	18.76624	1.297E+8	12.00000	1.000000	57.43455
1970	172.456070	18.96565	1.413E+8	13.00000	1.000000	58.67724
1971	194.487629	19.08587	1.725E+8	14.00000	0.000000	66.09625
1972	25.217482	19.33784	1.945E+8	15.00000	0.000000	63.85416
1973	265.996857	19.39899	2.502E+8	16.00000	0.000000	72.71084
1974	240.070677	19.29644	2.660E+8	17.00000	0.000000	64.75675
1975	224.134756	19.22775	2.401E+8	18.00000	0.000000	65.40540
1976	202.278374	19.12515	2.241E+8	19.00000	0.000000	58.14814
1977	252.901311	19.14850	2.025E+8	20.00000	0.000000	64.78494
1978	260.767743	19.37914	2.529E+8	21.00000	0.000000	60.75675
1979	232.778564	19.26559	2.608E+8	22.00000	0.000000	65.00000
1980	172.205658	18.96420	2.328E+8	23.00000	0.000000	67.37704
1981	212.990044	19.17675	1.722E+8	24.00000	0.000000	52.58064

1982	246.947536	19.32468	2.130E+8	25.00000	0.000000	70.22727
1983	265.878985	19.39855	2.469E+8	26.00000	0.000000	70.22857
1984	168.130308	18.94024	2.659E+8	27.00000	0.000000	66.41304
1985	210.019241	19.16270	1.681E+8	28.00000	0.000000	57.52808

Source: K.C.C. Statistics

Author's compilation

Appendix 4

SMPL 1958 - 1985

OLSQ // DEPENDENT VARIABLE IS LnY

	COEF	S.E	T-STAT
C	17.71817	0.100229	176.7762
X_1	6.679E-9	5.68E-10	11.74053

R-Squared = 0.84130

Adjusted R-Squared = 0.83520

Observations = 28

Sum of Squared Residuals = 1.463559

S.E. of Regression = 0.237256

Durbin-Watson Statistic = 1.39319

F-Statistic = 137.84

Source: Computed from K.C.C. unpublished records

Appendix 5

SMPL 1958 - 1985

OLSQ // DEPENDENT VARIABLE IS LnY

	COEF	S.E	T-STAT
C	17.87179	0.113021	158.1270
X_2	0.061987	6.809E-3	9.103411

R-Squared = 0.76118

Adjusted R-Squared = 0.75200

Observations = 28

Sum of Squared Residuals = 2.202491

S.E. of Regression = 0.291051

Durbin-Watson Statistic = 0.31381

F-Statistic = 82.8721

Source: Computed from K.C.C. Unpublished records

Appendix 6:

SMPL 1958 - 1985

OLSQ // DEPENDENT VARIABLE IS LnY

	COEF	S.E	T-STAT
C	19.22883	0.09086	243.1367
X_3	-0.986925	0.116067	-8.503050

R-Squared = 0.73550

Adjusted R-Squared = 0.72533

Observations = 28

Sum of Squared Residuals = 2.439322

S.E. of Regression = 0.306300

Durbin-Watson Statistic = 0.61577

F-Statistic = 72.3018

Source: Computed from K.C.C. Unpublished records

Appendix 7:

SMPL 1958 - 1985

OLSQ // DEPENDENT VARIABLE IS LnY

	COEF	S.E	T-STAT
C	16.75167	1.394511	12.01257
X_4	0.032230	0.022194	1.452157

R.Squared = 0.07502

Adjusted R-Squared = 0.03944

Observation = 28

Sum of Squared Residuals = 8.530789

S.E of Regression = 0.572806

Durbin-Watson Statistic = 0.24580

F-Statistic = 2.10876

Source: Computed from K.C.C. Unpublished records

Appendix 8:

SMPL 1958 - 1985

OLSQ // DEPENDENT VARIABLE IS LnY

	COEF	S.E	T-STAT
C	18.41992	0.729166	25.26161
X_1	5.137E-9	1.502E-9	3.420997
X_2	0.016735	0.012435	1.345837
X_3	-0.056763	0.222955	-0.254594
X_4	-0.010777	0.010387	-1.037524

R-Squared = 0.86979

Adjusted R-Squared = 0.84715

Observations = 28

Sum of Squared Residuals = 1.200816

S.E of Regression = 0.228493

Durbin-Watson Statistic = 1.18083

F-Statistic = 38.4120

Source: Computed from K.C.C. Unpublished records

Appendix 9:

SMPL 1958 - 1985

TSLS // DEPENDENT VARIABLE IS LnY

INSTRUMENT LIST: C X_2 X_3 X_4

	COEF	S.E	T-STAT
C	17.68086	0.106560	165.9238
X_1	6.915E-9	6.13E-10	11.28121

R-Squared = 0.84025

Adjusted R-Squared = 0.83410

Observations = 28

Sum of Squared Residuals = 1.473312

S.E. of Regression = 0.238045

Durbin-Watson Statistic = 1.44486

F.Statistic = 136.755

Source: Computed from K.C.C. Unpublished records

Appendix 10:

SMPL 1958 - 1985

TSCORC // DEPENDENT VARIABLE IS LnY

RHO = 00

INSTRUMENT LIST: C X_2 X_3 X_4

	COEF	S.E	T-STAT
C	17.60086	0.106560	165.9238
X_1	6.915E-9	6.13E-10	11.28121

R-Squared = 0.84025

Adjusted R-Squared = 0.83410

Observations = 28

Sum of Squared Residuals = 1.473312

S.E. of Regression = 0.238045

Durbin-Watson Statistic = 1.44486

F-Statistic = 136.755

Source: Computed from K.C.C. Unpublished records