THE DAIRY INDUSTRY OF TRINIDAD AND TOBAGO: AN ECONOMIC ANALYSIS

by

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(Under the Direction of Timothy Park and Jeffrey Mullen)

ABSTRACT

The dairy industry of Trinidad and Tobago is important to the social and economic development of the twin island state. The industry has experienced fluctuations in production over the past decades, has shown no change in production over the past few years, and is expected to decline without policy changes. Most of the efforts to encourage dairy development have focused on larger farms, with the smaller farms mostly neglected. The industry is constrained by high labor cost, lack of funds, competition with imported powdered milk, and lack of government support.

The objectives of this study are to investigate whether there is a difference in productivity between hired labor and family operated farms and between large and small farms. An F-test was used to test for difference in productivity between farms. The results show no significant difference in productivity between small and large farms and, also, no significant difference between hired labor and family operated farms. Therefore, large and small farms should be given similar considerations. Family labor could be substituted for hired labor where practical and economically feasible.

INDEX WORDS: Trinidad and Tobago, Productivity, Family labor, Hired labor, Large farms, Small farms, LABMLK

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CHAPTER 1

INTRODUCTION

Continued growth in human population creates considerable pressure on man to increase food production to support our nutritional needs. Since 1950, the world population has doubled and is expected to double again by the year 2020 (Cunningham 1985). Currently the world's population is about 6 billion. Milk and milk products, including cheese, yogurt, butter, and ice-cream have contributed to man's effort of supplying food to satisfy the nutritional needs of a growing human population. Dairy production provides one of the most cost-effective methods of converting crude, animal feed resources into high-quality, protein-rich food for human consumption (Castillo 1990).

Overview of World Dairy Production

Most of the milk consumed today is produced in the developed world; however, more dairy animals are found in the developing world. The developed world refers to countries that are highly industrialized and have a high standard of living, for example, the United States. On the other hand, the developing world refers to those countries where agriculture is more important than manufacturing, for example, Trinidad and Tobago. The developed world has one-third of the cattle, 23 percent of the people and produces over 80 percent of the milk, while the developing world, with three-quarters of the human population and two-thirds of all cattle stocks and produces less than 20 percent of all milk (Cunningham 1985). This represents a large disparity in milk production that can be attributed to differences in management practices, breeds, feed, climatic factors, government policies, and economic development and stability. This disparity is also seen in milk consumption, where less milk is consumed per person in developing countries. Low levels of per capita milk consumption, 42 kilograms per person, characterize the developing countries; this is about 20 percent of the average for developed countries (Griffin 1999). The major milk producers include the U.S.A., Canada, Brazil, Australia, Russia, Argentina, Japan, Ukraine, India, New, Zealand, and the European Community (E.C.) that includes United Kingdom, Germany, and France. Table 1.1 shows the major milk producers from 1994 to1996.   Current world milk production is over 530 million tons, and it is projected to exceed 600 million by 2005 (Griffin 1999).

Overview of the Dairy Industry in the CARICOM Region

The dairy industry in the CARICOM (comprised of the English speaking Caribbean islands as well as Belize in Central America, and Guyana in South America) region is dominated by small-scale producers scattered across the countries. Most of these producers operate on a subsistence level on the most marginal lands, where the dairy operation is usually a part of a mixed farming system. The major dairy producers are Guyana, Jamaica, Barbados, and Trinidad and Tobago. Table 1.2 shows the milk production in the CARICOM region for the period 1978 to 1990. Over the period 1988 to 1990, Jamaica and Guyana dominated milk production, producing 73,000 tons (63 percent) of the total milk produced in the region (Singh 1995).

Domestic milk consumption in the region is a small proportion of overall consumption. Milk from reconstituted powdered milk is the major form of milk consumed in the region. In 1990 29m. kilograms of powdered milk with a value of $60 million U.S. were imported into the region. Total milk imported was about 64 percent of total foreign exchange outflow in 1990 (Singh 1995). To encourage milk production and keep prices at affordable levels the dairy industry was largely subsidized by the various governments. Subsidies have varied across

Table 1.1. The World's Major Milk Producers 1994 - 1996 (million tons)

Country	Year		
	1994	1995	1996
European Communities	11297	121285	121581
United States of America	69763	70563	70066
Argentina	7777	8228	8900
Australia	8206	8716	9000
Brazil	16700	17535	19288
Canada	7741	7849	8060
Ukraine	18137	17274	15926
Japan	8389	8382	8656
New Zealand	9768	9780	10405
Poland	12100	11100	11200
Russia	42176	39241	35713
World	529000	528000	532000

Source: The World Market for Dairy Products 1997. World Trade Organization. Geneva. October 1997.

Table 1.2. Milk Production in CARICOM Region (000 tons)

Countries	1978 - 87	1988	1989	1990
Antigua & Barbuda	6	6	6	6
Barbados	7	12	12	12
Belize	4	4	4	4
Dominica	3	5	5	5
Grenada	1	1	1	1
Guyana	13	24	27	29
Jamaica	48	49	49	40
Montserrat	2	2	2	2
St. Lucia	1	1	1	1
St. Vincent	1	2	2	21
Trinidad & Tobago	6	10	10	12
Total	92	116	119	114

Source: Craig, K (1992). "The Impact of Pricing and Policies on Dairying in the Caribbean Community." Dairy Development in the Caribbean Region. CARDI / CTA. 1992.

powdered milk. The dairy industry provides a source of food, employment, and cash for farm families. This sub-sector has a role in the overall development of the region and effort should be made to ensure that the industry remains productive (Singh 1995).

Importance of the Dairy Industry

The importance of milk and milk products cannot be over emphasized. Milk is the first food a newborn receives, and it supplies necessary nutrients required for its development (van den Berg 1988). Milk consists of 80 to 90 percent water and supplies the diet with essential vitamins, minerals, fat, proteins, and sugars. According to Matthewman (1993), milk is valuable for growing children, convalescents, pregnant and lactating women, and the elderly.

In addition, the dairy industry is very important to economic and social development. Dairy production is geared towards milk production, but it also generates beef from culled animals and veal from young animals not used as replacement stock. It also provides manure, used as a fertilizer for crop and pasture development. The industry also provides employment and a source of cash for many rural farm families.

The export of milk and milk products generate foreign exchange that can be used to further economic development and to service foreign debts, a major problem in developing countries. In 1980 to 1981 the total value for all exports from New Zealand was $5.1 billion, of which the total value of dairy export was $800 million, about 16 percent of the total export (Holmes 1984). According to the Israeli Export Institute, in 1997 dairy and beef herds account for over 17 percent of Israel's total foreign agricultural production, 12.8 percent of its milk and dairy products, and 4.3 percent beef products. This sector supplies Israel's total dairy requirement. The dairy industry is therefore able to save foreign exchange that would have otherwise been spent on the importation of milk, meat, and other related products.

Dairy Industry in Trinidad and Tobago

The twin-island republic of Trinidad and Tobago is located at the southern most end of the West Indies, just off the Venezuelan coastline. Trinidad, the larger island, is 4,828 km^2,with a population of 1,281,825 inhabitants (1998), and Tobago is 300km^2 with 51,416 inhabitants (1997). The annual population growth is about 0.6 percent with an unemployment rate of about 15 percent. The major contributor to the economy is the petroleum industry, which contributes 26 percent to the Gross Domestic Product (GDP). Agriculture only contributes about 2 percent to the GDP. The major agricultural products are sugar, cocoa, rice, citrus, coffee, vegetables, poultry, pork, beef, and dairy. Agriculture employs an estimated 11 percent of the labor force (Collins, Internet).

The dairy industry of Trinidad and Tobago (T&T) is very important to the social and economic development of the country. Although not the largest agricultural sector, the dairy industry contributes nutritional value to diet, employment, and economic stability, especially in rural communities. The industry employs approximately 8,000 people and provides a source of cash for many farms. During the early 1950's, dairy farming was introduced and established by the largest oil companies, most sugar estates and a few small-scaled farms in the outlying districts. The farmers and residents of nearby communities consumed most of the milk produced by these farms fresh (Singh). By 1955, the industry had grown significantly due to the government’s involvement in research and breeding programs using selected local and imported bulls. In the 1960’s state lands were allocated for large-scale dairy development, and funds were set aside for the development of these lands by the International Bank for Reconstruction and Development (IBRD). Approximately 260 dairy farms were established on these lands in the Wallerfield, Carlsen Field, Turure, and Esmeralda areas. Nestle International Limited, one of the major milk processors, was established to provide a ready market for the milk produced by these farms. Most of the efforts in dairy production are centered on these farms and the rest of the farmers mostly neglected (Singh 1995). Figure 1.1 is a map of Trinidad and Tobago that shows the areas where these farms are located.

The dairy industry is dominated by a number of small producers scattered across the twin island state. There are approximately 4,000 dairy farmers in T&T. Most of the farmers occupy one parcel of land and many live on the farm. The majority of farmers milk their cows twice per day and the average milk yield is about 9.9 liters per cow per day. Farmers practice both hand and machine milking. Feeding system varies and usually includes a mixture of pasture or concentrate, and cut and carry systems (animals are kept in a confined area and fed cut grasses and other feeds). Farming practices range from pure dairy farming to a mixture of enterprises, dairy and other livestock, or dairy and crop cultivation.

The milk is usually consumed fresh and is also used in the production of dairy products such as yogurt and ghee. However, most of the milk produced is sold to processors, including Nestles Trinidad and Tobago Limited, Cannings, and Ramsaran Dairy. The dairy industry is highly subsidized to encourage production. The subsidies include a government price subsidy, and tax-and-duty free concessions on some agricultural items. Local milk production does not meet the local demand. This shortfall is imported from the United Kingdom, Canada, New Zealand, Denmark, the United States of America, as well as other countries. Imported powdered milk is less expensive than freshly produced cow's milk and is more lucrative for the processors. Powdered milk is cited as one of the major constraints to dairy production in the country, leading to a drastic decline in the dairy industry (Singh 1995).

Figure 1.1. Map of Trinidad and Tobago. Farms are located in St. Patrick, St. David, St. Andrew, St. George, and Caroni.

Constraints to Dairy Production in Trinidad and Tobago

The development of any dairy industry is very complex, drawing on various sectors of the economy. Dairy production is very sensitive, requiring good genetic material, excellent management, and capital investment. Milk, the major output, is highly perishable and requires good cold storage facilities, hygienic milking conditions, and proper transportation. The absence of such infrastructure can result in considerable losses.

There are a number of constraints to dairy production in Trinidad and Tobago. Singh (1995) concluded that imported powered milk is the major competitor and constraint to the dairy industry. High cost of production resulting in higher cost of locally produced milk makes it uneconomical for the processors causing them to rely more on the cheaper powdered milk. Lack of financial resources and delayed payment of government subsidy also constrains the dairy industry (Pemberton 1995). The inability of farmers to obtain financial assistance from financial institutions due to the insecure state of the industry prevents the farmers from procuring inputs in a timely manner. Similarly, delayed payment of government subsidy to farmers due to budget constraints limits the farmer's ability to purchase inputs when needed. Unavailable and inaccessible land prevents new farmers from entering the industry and limits existing farmers from expanding farm operations. The high cost of inputs for production also causes some farmers to leave the industry. The removal of government subsidies has made it uneconomical for some farms to continue operating forcing them to leave the industry. In addition, unavailable labor, low milk prices, praedial larceny, poor management and inadequate infrastructure are constraints facing the dairy industry (Pemberton 1995).

Problem Statement

The dairy industry of Trinidad and Tobago experienced an increase in production, which is the quantity of milk supplied to the processors, from 1981 to 1986, where production increased from about six thousand metric tons to 11.3 thousand metric tons. Over the period 1987 to 1988, production levels fell to just under 10 thousand metric tons and have since increased to 11 thousand metric tons in 1991. The industry has experienced fluctuation in production over the past decades and has shown no change in production over the past few years and is projected to decline without substantial government intervention (Singh 1995). New polices are needed to support and encourage dairy farms in the industry.

Objectives

The objectives of this study are to investigate whether there is any difference in productivity between large and small dairy farms in Trinidad and Tobago. Small dairy farms are neglected in favor of large dairy farms in government policy considerations (Singh 1995). Secondly, we investigate whether there is any difference in productivity between farms operated by hired labor and farms operated by family labor in Trinidad and Tobago. High cost and unavailability of labor are cited as a major limiting factor in dairy development.

Thesis Organization

The remainder of the thesis is organized as follows. The next chapter is the literature review, which looks at tropical dairy development, technical efficiency / productivity and frontier production techniques that are relevant to the study. It also includes definitions and concepts in production theory, production functions and characteristics, and application of production theory. Chapter three will address description of survey and data, variables used in model, estimation of production functions and model development. Chapter four presents and discusses the results. The summary, conclusions, implications and policy recommendations are presented in chapter five, followed by the references.

CHAPTER 2

LITERATURE REVIEW

This study is concerned primarily with development of a production function to explain productivity in the dairy industry of Trinidad and Tobago and to make recommendations that could enhance productivity of the dairy industry. The study will investigate whether large farms are more productive than small farms and determine if there is any difference in productivity between family and hired labor operated farms. This information is important for formulating appropriate policies to strengthen the dairy sector. With limited resources, farmers cannot afford to make inefficient use of resources as this would reduce profits and cause further decline in an already declining industry. Identification of the sources of inefficiencies would be the first step to put corrective measures in place to facilitate more efficient utilization of the limited resources available to dairy farmers.

This chapter will focus on two main areas of research. The first section will look at tropical dairy development and research issues; the second will look at production techniques employed to investigate and explain tropical dairy production.

Tropical Dairy Development

Dairy cattle in the tropics are faced with climatic stress, diseases and parasites prevalent in the tropics. Indigenous cattle have adapted to these conditions, but are less productive than their temperate counterparts. It has long been recognized that temperate dairy breeds are genetically higher producers than tropical breeds (Turton 1985). The major temperate dairy breeds include the Holstein, Jersey, Brown Swiss, Guernsey and the Ayrshire. There are many differences between these breeds. For the purpose of this study, the *Holstein friesian* will be the breed of reference, as this is the temperate breed that has shown much promise in the tropics (Hodges 1985). The Holstein dairy breed was developed in The Netherlands and is characterized by a large body, distinctive black and white markings, and outstanding milk production. Holsteins produce 8,000 kilograms (kg) of milk per 305 days lactation under temperate conditions, while tropical breeds produce 2,000 to 5,000 kg (McDowell 1985).

The transfer of the Holstein and other temperate breeds to the tropics have had mixed results. Under the best conditions in the tropics, the estimated yield per lactation is between 4,200 to 4,500 kg of milk per 305 days lactation. Dairy farmers in Mexico, Puerto Rico, Taiwan, and Columbia have been able to attain these levels. Table 2.1 shows average milk yield of Holstein (kg) in various tropical countries. Although data in table 2.1 is over eighteen years old it does show how Trinidad's milk yield compares with other tropical countries.

Dairy breeds transferred to the tropics do not perform as well as their temperate counter parts due to the effects of high temperature, humidity, parasites and diseases, and differences in nutrition and management (Archibald 1985). The higher temperatures and humidity have a direct effect on production. Higher temperature causes the animals to seek shade that reduces food intake and consequently milk yield. Indirectly, it affects feed quality and quantity leading to reduced milk yields. Pastures and feeds in the tropics tend to have a lower nutrient status and a more variable nutrient content than temperate pastures due to seasonal conditions. Tropical diseases and parasites have a negative impact on imported dairy breeds. Temperate breeds are more susceptible to tick infestations, tsetse flies, vampire bats, and dermatophilosis than local breeds where these diseases and parasites are endemic (Turton 1985).

Table 2.1. Average Milk Yield (kg) for Holstein in Various Tropical Countries.

Country	Milk yield (kg)
Mexico	5,650
Puerto Rico	4,410
Columbia	4,280
Venezuela	3,770
Jamaica	3,118
Cuba	4,100
Taiwan	4,350
India	2,990
Kenya	2,806
Zimbabwe	3,509
Nigeria	2,550
Uganda	3,200
Trinidad & Tobago	2,970
Peru	2,574

Source: McDowell 1985.

Recognizing the genetic superiority of temperate dairy breeds to producing higher quantities of milk, their susceptibility to harsh climatic conditions and parasites and diseases in the tropics have led to extensive breeding programs (Turton 1985). Attempts at dairy cattle breeding program in the tropics has been geared mostly towards improving the genetic characteristics and adaptability to the environmental conditions. Breeding for adaptability includes resistance or tolerance to diseases and parasites, low metabolic rate, low appetite, long calving interval, and good mechanism for cooling. The breeding programs in the tropics have taken-on many forms: selection of the highest milk producers of tropical breeds, crossing of temperate and tropical breeds and importing other tropical breeds to cross temperate and local stocks (Hodges 1985). These breeding programs have led to the development of more suitable breeds for the tropics, leading to considerable improvements in tropical milk production. The most notable of these includes the Jamaica Hope, Sahiwal, Red Sindhi, Australian Milking Zebu (AMZ), Australian Fresian Sahiwal (AFS), Damascus, and the Cuban Siboney.

The Jamaica Hope breeding program began in 1910 to develop a breed that was high yielding and adaptable to the climatic conditions on the island. It is the oldest established tropical breed. The Jamaica Hope is approximately 80 percent Jersey, 15 percent Sahiwal, and 5 percent Holstein. It comprises approximately 80 percent of dairy cattle in Jamaica and has been exported to neighboring Caribbean countries. The average lactation is 2,500kg per lactation (Turton 1980).

The Sahiwal originated in the Punjab region of India and Pakistan. It is one of the best dairy breeds in the region, and the heaviest milk producer of all Zebu breeds. It is rated for its tick resistance and heat tolerance. The average lactation is 2,270 kg of milk per lactation (Turton 1980).

The Australian Milking Zebu was developed in Australia in the 1950's to adapt to high temperatures and high tick infestation. It was developed from the Jersey, Sahiwal, and Red Sindhi breeds. The average lactation is 3,200kg of milk per lactation (Hodges 1985). The Australian Friesian Sahiwal was developed in Australia in the 1960's. The breed was developed for heat tolerance, tick resistance, and reliable milk yield. It has been tested in tropical and sub-tropical regions of Australia where it has out performed the Holstein. The average milk yield is 4,100 kg per lactation.

The Damascus breed originated in the Middle East, and is considered by some as the best tropical breed. They are well adapted to high temperatures and humidity and resistant to Malaria. The average milk yield is 2,000 to 4,500 kg, per 305 days lactation, and yields of 7,250 kg have been reported.

The Cuban Siboney was developed in Cuba in the 1960's. The breed is 63% Holstein and 37% Cuban Zebu. The average yield is 3,280 kg per lactation (Turton 1980). Table 2.2 shows the average milk yield (kg) of some tropical dairy breeds used in the dairy industry in the tropics.

Alongside genetic improvement, better nutrition has been a major concern in tropical dairy development. In the tropics, dairy nutrition is affected by climatic conditions, the availability of tropical forage, the production system, and socio-economic conditions. In order to achieve the highest milk yield, it is important to feed high quality feeds that will supply the necessary nutrients to promote high milk production. Dairy feeding in the tropics take several forms: cut-and-carry (especially where land is limited, for example, Trinidad and Tobago), zero grazing, pasture, and combinations of these systems. In the cut and carry system the animals are kept in confined areas and fed with cut grasses and legumes. Pasture is the dominant feed source in the tropics.

Table 2.2. The Average Milk Yields of Some Tropical Dairy Breeds

Breeds	Milk yield (kg)
Jamaica Hope	2,500
Sahiwal	2,270
Australian Milking Zebu	3,200
Australian Milking Sahiwal	4,100
Damascus	3,250
Cuban Siboney	3,280

Source: Mason 1996.

Tropical pastures are generally poorer than temperate pastures, having lower protein and mineral content and digestibility. Efforts have been made to improve tropical pasture by using improved grasses and legumes adapted to the tropics. These include Guinea grass (*Panicum maximum*), Elephant grass (Pannisetum purpureum), Para grass (*Barachiaria mutira*), Tanner grass (*Brachiaria radicans*), Pangola grass (*Digitaria decumbens*), Glycine (*Nesaotonia wightii*), Stylo (*Stylosanthes guianensis*), and Leucaena (*Leucaena leucocephala*) (Turton 1985). All of these grasses and legumes are grown in Trinidad and Tobago. These improved grasses and legumes allow for higher stocking rate and higher milk production.

In addition to improved pastures, various crop residues and industrial byproducts are used as feed in tropical dairy production as energy or protein supplements. These include sugarcane (molasses, bagasse), citrus (citrus pulp), coconut (copra meal), cotton (cottonseed meal), rice (rice bran, rice polishings), and banana. Concentrate rations of corn and soybean meal are also widely used in many dairy-feeding programs in the tropics. Significant efforts have been made to replace these two ingredients with crop residues and industrial byproducts (Archibald 1985). Sugarcane is normally grown for sugar, but it has been used as a source of feed for dairy cattle in the tropics. It is high in energy because of its high sugar content, but it is very low in protein. Sugarcane is fed fresh or as molasses or bagasse. Bagasse is used in feeding programs in Trinidad, Jamaica, Barbados, and Cuba, where sugarcane is grown on a large scale. Bagasse is very poorly digested. Efforts have been made to improve its digestibility by using steam or alkali treatment (Archibald 1985).

Citrus has long been used as a source of dairy feed in Trinidad and Jamaica. During the dry season, the cows are allowed to walk through the citrus orchard to feed on fallen fruits.

Citrus pulp, citrus seed meal, and citrus molasses are produced and fed as dairy ration. It is an important source of calcium, which is important for milk production. Samples of citrus pulp in Trinidad have contained 7% crude protein and 13% crude fiber. Improved pasture species have led to increased milk production. However, there is a need to continue pasture research and development to increase the nutritional value of pasture and year round availability. Efforts are being made to supplement pasture with concentrate and to use mineral supplements to reduce deficiencies; also, to incorporate more crop residues (banana, yam, sweet potato) into the feeding program (Archibald 1985).

Technical Efficiency / Productivity

Significant progress has been made towards the development of better dairy breeds and nutrition in the tropics. To be most profitable, farmers need to be technically efficient. However, few studies have been done to evaluate the technical efficiency of dairy farming in the tropics. Technical efficiency can be defined as getting the maximum quantity output attainable from a given level of inputs. In dairy farming, the outputs are typically milk, stock, and manure, while the inputs are land, labor, animals, feed, and capital. In addition to the above inputs, environmental and institutional variables, such as geographic location, education, extension programs, and off-farm income, can be included as input variables.

The geographic location of a farm is very important. It is plausible to think that farms that are located in the more fertile areas would have better grazing and less feed cost relative to farms on marginal lands. Similarly, farms located closer to input source and market would have lower cost of transportation that could make these farms more profitable.

The education level attained by the farmer and workers can affect farm productivity. Kumbhakar, Biswas and Bailey (1989) included education as an independent variable in their model to test the efficiency of Utah dairy farmers. The result showed education to have a positive and statistically significant effect on output. Higher Education was associated with increasing managerial ability, productivity of labor and capital. Yang (1997) also included education as an independent variable. He theorized that increased education could enhance labor quality, thereby producing more from a given number of hours or producing the same with fewer labor hours. Increased education allows for better farm decision-making and a better understanding of farm operations.

Extension programming is important to provide the farmer with relevant and current information that could increase farm productivity. Extension program is helpful in assisting the farmer to solve farm problems, developing marketing strategies and training of workers. The increased knowledge gained from the extension programming can lead to better farming decision and increased productivity.

Kumbhakar, Biswas and Bailey (1989) included off-farm income as an independent variable in their model to test the efficiency of Utah dairy farmers. Their study suggested that the larger the off-farm income, the less time the farmer would spend on the farm. This in turn would lead to poor decision making due to less than adequate farm information. The less time the farmer spends on the farm would diminish his information on farm activities and could lead to poor decision making.

Timely decision-making is a key to success in the dairy industry. Conlin (1990) indicated that dairy farming is one of the most intensive decision-making activities in the world of production agriculture. It requires detail and timing, science and judgment call, and factors the farmer has no control over. High quality management and supporting policies are necessary to fuel the continued development and sustainability of the dairy sector of Trinidad and Tobago.

Policy intervention can result in positive gains for dairy farmers. However, it is vitally important that policy makers are knowledgeable of the farmer's level of production efficiency before administering or implementing a policy change. The level of technical efficiency as well as identification of the sources of any inefficiencies are essential for policy making in the dairy sector in Trinidad and Tobago. Failure to recognize efficient practices could result in negative gain for farmers, and consequent policy failure. Many factors could affect the level of technical efficiency attained by dairy farmers in Trinidad and Tobago: age, educational level, farm size, labor use, and experience. This study will focus on farm size and how it affects productivity and cite earlier works that focused on farm size.

The issue of farm size has long been debated across many forums. It has been argued that larger farms are more efficient and that larger farms should be given more support. Small farms have often been overlooked for this reason and are seen by policy makers as time wasters and a hindrance to development. However, it is not necessarily the case that larger farms are more efficient than smaller farms. There have been mixed results in early studies looking at the effect of farm size on technical efficiency in dairy production.

Jaforullah and Delvin (1996) showed that there were no significant differences in the average technical efficiency levels between farm sizes for New Zealand dairy farms. Farms were categorized as small (< 50 hectares (ha), medium (50 to 100 ha), and large (> 100ha). These three groups comprise 22 percent, 50 percent, and 28 percent of the sample, respectively. The data were from a 1993 economic survey of dairy farmers conducted by the Livestock Improvement Corporation Limited on behalf of the New Zealand Dairy Board. The sample was randomly selected from the Board's record and initially comprised 452 dairy farmers. The final sample had 264 farms. Two types of stochastic frontier production functions, Translog and Cobb

- Douglas were used and three alternative possibilities regarding the distribution of the inefficiency term were used half-normal, truncated normal, and exponential. The inputs to production were taken to include labor, capital (including land and buildings), the dairy herd, animal health and herd testing, feed supplements and grazing, and fertilizer. These are the independent variables. The outputs included milk, milk products and stock, and were measured in terms of total farm revenue, the dependent variable. Farm size was also defined based on land size, 'small' farms were defined as less than 200 stock, 'medium' were between 200 and 299 head of stock and 'large' farms as 300 and more. These represented 35 percent, 38 percent, and 27 percent of the sample, respectively.

The results showed that there was no significant difference in the average technical efficiency levels between large, medium, and small farms. The results also suggested the farms are characterized by constant returns to scale. The technical efficiency ranges from 76 percent – 97 percent, indicating that the farmers operate close to their production frontier.

On the contrary, research by Kumbhakar, Biswas and Bailey (1989) showed that large farms are technically more efficient than small farms. The data from this study were obtained from a random sample of dairy farmers in Utah. The survey covered five counties in the major dairy producing area of Utah. A total of 116 farm families of a total of 510 were interviewed. Of the 116 farm families interviewed, 86 were used for the analysis. Again, farms were divided as small (fewer than 50 milk cows), medium (between 50 and 100 milk cows, and large (more than 100 milk cows). The survey covered a wide range of farm family data including age, acreage, educational level, herd size, off-farm income, and management style. Farm size was also categorized in terms of average values: small (under $100,000 sales), medium (between $100,000 and 250,000 sales), and large (over $250,000 sales). This research was concerned

primarily with investigating the productive efficiency of the farms. It also looked at the effect of off-farm income, education and labor on efficiency. A stochastic production frontier technique was used to do the analysis. In this model the dependent variable was average farm sales and the independent variables were the operator's age, education level, milk cows, off farm income, farm assets, and farm debts. The results indicated that large farms are technically more efficient than small farms. Output on the larger farms averaged 11.53 percent higher than small farms. Also, education increases the productivity of labor and capital making farms more productive.
The greatest estimated effect of education appeared to be on the medium farms. The effect of off-farm income was negative; this was most pronounced up strongest in the small farms that have a higher level of off-farm income.

Cornia (1985) in a study of farms in 15 developing countries, concluded that there is a strong negative correlation between farm size, and factor inputs and output. Of the fifteen countries studied all but three showed this negative correlation. Of the countries tested, seven showed decreasing returns to scale, five exhibited constant returns to scale and two increasing returns to scale. The decline in output of the larger farms could be attributed to decreasing returns to scale, while output in the smaller farms is as a result of higher factor inputs and more intensive use of land resource. Constant returns to scale was assumed when the sum of the input elasticities was between 0.95 to 1.05 at 80 percent level of significance, less than 0.95 was assumed decreasing and greater than 1.05 was assumed increasing returns to scale. However, these results cannot be generalized across farms. The results from this study may not confirm earlier studies due to differences in geographical, institutional and socio-economic factors. As with the earlier studies, a similar approach using stochastic frontier production technique will be used in this study.

Definitions and Concepts in Production Theory

Production is the process of combining and coordinating materials and forces (inputs, factors, resources, or productive services) in the creation of some goods and services (output or product) that are desired by humans (Beattie and Taylor 1985). This relationship between inputs and outputs is commonly referred to as the production function. The production function attempts to describe the maximum output(s) attainable from a given set of inputs for a given state of production technology and assigned assumptions. A general formula for the production function is:

$$Q = \int(K, L, M) \tag{1}$$

where Q is output, K is capital (man-made inputs), L is labor (time and services of individuals), and M is land (all natural resources).

For simplicity, a number of assumptions are assigned to a production function. The production process is mono-periodic, the process is for one period and the cycle is completed at the end of the period. All inputs and outputs are homogeneous, i.e. they are uniform or identical and can be used across farms. The production function and output and input prices are known with certainty. There are no budgetary constraints limiting farm decisions. Also, the objective of the producer is to maximize profits.

There are some very important concepts associated with production theory. These include marginal physical product (MPP), average physical product (APP), Elasticity (E), marginal rate of technical substitution (MRTS), returns to scale (RTS), and the law of diminishing returns.

MPP is defined as the quantity of extra output produced by each extra unit of input X_1 holding all other inputs fixed. It is the rate of change in output, Δ Y, as the change in a variable input goes to zero (infinitesimally small) holding all other inputs fixed. MPPi is mathematically represented:

$$MPP_i = \partial Y / \partial X_i \tag{2}$$

where Y is output and X_i is the variable input. MPP is the slope of the production function at a particular production level. APP is defined as total output divided by the quantity of an input. APP is mathematically represented :

$$APP_i = Y / X_i \ , \tag{3}$$

where Y is total output and X_i is total input.

Elasticity is another very important concept in production theory. Elasticity measures the proportional change in output resulting from a unit proportional change in all inputs. Elasticity of substitution is the proportional change in output resulting from a proportional change in the ith input holding all other inputs fixed. It measures the curvature of the isoquant and is a unit-less measure. When elasticity is equal to infinity (∞), it indicates perfect substitutability between inputs, and when it is equal to zero, inputs must be used in fixed proportions. Elasticity can be mathematically represented:

$$E = MPP / APP_{\text{i}} \tag{4}$$

If E > 1, an increase in the input level will result in a more than proportionate increase in output; for E < 1, this represents a proportionate increase in output less than proportionate increase in inputs; for E = 1, the proportionate increases are equal.

Marginal rate of technical substitution reflects the rate at which one input can be substituted for another while holding output constant. It measures the slope of the isoquant and can be shown as the negative of the ratio of MPP_1 to MPP_2 for two inputs. It can be mathematically presented as:

$$MRTS = -MPP_1/MPP_2 \tag{5}$$

Returns to scale is a long-run concept that reflects the degree to which a proportional increase in all inputs increases output. RTS is classified as constant when elasticity is one, increasing for elasticity greater than one and decreasing for elasticity less than one. Farms exhibit different RTS, depending on specialization and management practices.

The law of diminishing returns states that when one factor is held constant and another factor is increased, the marginal product (MP) of each additional unit of the variable factor must eventually decrease, due to congestion in the use of the fixed factor. Production can also be classified by stages: Stage1, Stage 2, and Stage 3. The elasticity factor can be used to separate the various stages of production. In stage 1 production $E > 1$, stage 2 production $0 < E < 1$, and stage 3 production $E < 0$. $E > 1$ implies that MPP > APP; for $E = 1$, MPP =APP (APP is at maximum); for $E < 1$, MPP < APP; for $E = 0$, MPP = 0 (total physical product (TPP) is at maximum); and for $E < 0$, MPP < 0.

The profit-maximizing farm operates in Stage II production, because Stages I and III can be shown to be inefficient. In Stage I production, the farm is inefficient since an extra unit of input increases AP of all the inputs used. The farm should not produce where AP is rising, as this implies that the farm could increase average productivity of that input by using more of that input. In Stage III production, an additional increase in input results in a decrease in output. The profit of the farm is defined as total revenue (TR) minus total costs (TC) for perfectly competitive firm. Thus, TR curve is a straight line (assumed for this study) with the slope equal to the output price (P) that passes through the origin. The long-run (LR) profit curve is equal to the TR curve minus the long-run total cost curve (LRTC). The largest gap between TR and

LRTC curves corresponds to the highest point on the LR profit curve. This point identifies the LR profit-maximizing level of output.

The optimal level of output to produce can also be determined using marginal curves. The profit-maximizing rule is to equate the marginal revenue curve (MR) to the long run marginal cost curve (LRMC); that is, MR = LRMC.

Production Functions and Characteristics

The production function is a mathematical description of a purely technical process (Coelli, Rao and Battese 1988). We use the production function concept to better understand economic behavior of firms or farms. Restrictions are imposed on the function in order to conform to production technologies with the realities of the economic environment in which the farm operates and to improve the ease of empirical estimation. The first step in any empirical application is to select an appropriate functional form. A number of functional forms have been used in applied economic analyses over the past decades.

Commonly used functional forms in estimating production functions are the Cobb-Douglas, Quadratic, Constant Elasticity of Substitution (CES) and Quadratic and translog functional forms. These functional forms have their strengths and weaknesses. The functional form chosen depends on the data available, the objectives of the analysis and the underlying assumptions. This study will focus on the Cobb-Douglas functional form.

The Cobb-Douglas functional form is probably the most widely used, because of its ease of estimation and interpretation and for its desirable economic properties. It is very easy to mathematically manipulate. However, it can be very restrictive. The elasticity of substitution is unitary, irrespective of the values of the parameters, and the returns to scale are fixed. The Cobb-Douglas functional form has smooth, convex isoquants. It is widely used in production economics to test for returns to scale and elasticity measures.

A simple Cobb-Douglas function can be represented:

$$Y = AX_1^{b1} X_2^{b2} \ , \qquad (6)$$

where Y is output, A represents the state of technology, and X_1 and X_2 the inputs.

Application of Production Theory

The knowledge and an appreciation for production theory can prove to be very beneficial to the farmer, leading to better understanding and management decisions. This knowledge gain can be used to measure the performance of the farm, can measure across time or against the industry, help to determine the levels of inputs to use, as well as the timing of application of these inputs. The farmer is faced with the dilemma of how much to produce and what combination of inputs would give the highest output. An understanding and application of production theory helps the farmer to make a more informed decision. In addition, the farmer is in a better position to determine the opportune time to procure inputs, to increase or decrease farm size, hire additional labor, or to eliminate or add other enterprises.

CHAPTER 3

RESEARCH METHODOLOGY AND DATA

Description of Survey and Data

The information for this study was obtained from a 1993 survey of the dairy industry of Trinidad and Tobago, commissioned by the Ministry of Agriculture and conducted by the Farm Management Information Systems Project, Faculty of Agriculture University of the West Indies. The purpose of this survey was to collect information to assess the state of the dairy industry and to make recommendations on findings. A team consisting of Dr. Carlisle Pemberton (project leader), Mrs. Charlene Henderson-Brewster and Aliza Dwarika (graduate assistants at the University of the West Indies), Patrick Joseph (technical assistant), Heather Augustine, Camille Kalyan, Reshma Maharaj and Camina Ramharack (interviewers) carried out the actual survey. The survey covered data over the period January to April 1993 and included data on 134 farms located in four areas: Wallerfield, Turure, Caroni, and St.Patrick.

Data were collected from each farmer on some or all of the following variables: quantity of milk sold, animal health cost, labor cost, herd size, cost of water and electricity, and feed cost. Information was also obtained from two of the major milk processors, Staff of Tobago House Assembly, Dr.Garcia, Department of Livestock Faculty of Agriculture U.W.I. The data collected were placed under the following headings: farmer profile, pasture establishment and production, milk production, sales and marketing, cost of production and revenue analysis, general issues, and report on the dairy industry in Tobago and the processors view of the industry.

From the survey, 46.3 percent of the farmers or respondents were located in Caroni, 27.6 percent in Wallerfield, 18.7 percent in St.Patrick and 7.4 percent in Turure. The majority of the farmers surveyed (69.4 percent) are males. At least 70 percent of the farmers attained primary level education and 2.2 percent attained tertiary level education. Farmers were listed as full-time or part-time. There were 87.3 percent full-time farmers. Farmers occupied one to three parcels of land; on average, one parcel was occupied. The land is owned, rented, leased, state owned, or other. The land was most often leased.

Farmers owned a number of different enterprises: dairy cattle, beef cattle, pigs, poultry, sheep and goats, and vegetables and tree crops. Dairy was the major enterprise operated by 78.9 percent of the farmers. For the dairy enterprise, a number of feeding systems were used: pasture, pasture / concentrate, concentrate and cut and carry. Pasture / concentrate dominated the type of feeding system with 32.8 percent. Almost 81 percent of the farmers have improved pastures. The grass types used include pangola, guatemala, tannagrass and paragrass. Fifty-six percent of farmers used fence. Fencing type includes post and barbwire post and mesh wire, post and chain link and brick wall. Post and barbwire was the most popular. The water sources included rain fed, ponds, standpipe, river, truck borne and spring; 46 percent of the farmers had private pipes. Road types of access included private, public and state, with public roads (68 percent) dominant. Pitch (50 percent), a black by-product of the petroleum industry, was the most common surface type of road used by the farmers.

Most of the farmers have a mixture of cows, heifers, calves and bulls. Bulls were the least kept animals. The outputs are milk, manure, and animals. Milk is the most valuable output. The average milk yield is 9.1 liters per day and animals are milked twice per day.

Eighty-six percent of the farmers practiced hand milking. Family labor was dominant on most farms. Costs of operating the enterprise include purchase of animals, milking machines, vehicles, manure, utilities, and taxes / rents. Information is obtained from a number of sources, including Extension officers, other farmers, farm stores and other sources. Extension officers and other sources are the major source of information. Of the farmers surveyed, 71 percent think they get adequate information, 52 percent keep records, 78 percent are not satisfied with the prices received for animals, and some think that dairy farming is unprofitable. Sixty-seven percent of the farmers received a subsidy for milk, 90 percent of the farmers had problems with subsidy payment and 93 percent are dissatisfied with milk prices.

Data were collected from 134 farms; however, only 89 farms were included in the study. This is because some of the farms did not completely answer the survey, or the information was not relevant to this study. The data included in the study cover milk produced, animal health, labor used, animal feed, herd-size, water, and electricity cost. Although not used directly in the hypotheses tested, the variables age, farming experience, family characteristics, and source of information are mentioned here, because they are important to the dairy industry of Trinidad and Tobago.

The mean age of the farmers surveyed was 48.4 years, with a minimum age of 19 years and a maximum age of 80 years. The group containing the highest percentage (25.7 percent) of respondents was older than 59 years and the smallest percentage (11.9 percent) was between 30 to 39 years. Overall, over 55 percent of the farmers were between the age of 30 and 59 years old (Table 3.1). This indicates the farmer's level of maturity, and could give an indication as to his ability to understand complex decisions that are necessary to manage the dairy operation. It

Table 3.1. Age Profile of Dairy Farmers in Trinidad and Tobago, 1993

Age (years)	Percentage	Number of farmers
<30	15.7	21
30 - 39	11.9	16
40 - 49	24.6	33
50 - 59	22.4	30
>59	25.4	34
Total	100	134

would also suggest that there is a need for young farmers to enter the industry to ensure its survival. Younger farmers tend to be more willing to take risk and new challenges while older farmers tend to be more resistant to change.

The mean time farming (farming experience) was 18.7 years, with a maximum of 70 years and a minimum of 0.5 years. Thirty-seven percent of the respondents were farming for a period of 20 to 29 years, and 7.5% have farmed for more than 40 years (Table 3.2). A high level of farming experience, especially where formal training is lacking, is critical to effectively manage the dairy operation. Farmers with little farming experience would tend to make poor decisions and are highly dependent on outside knowledge for making decisions.

The mean male and female family members living at home was 3 and 3 respectively. The mean number of male and female family member working on the farm was 2 and the maximum was 8 and 7, respectively. Thirty-two percent had 5 to 6 family members living at home and 6% had more than 8 (Figures 3.1). These numbers indicate the potential for family members to be involved in the dairy operation. It is important to have family members living at home, as they provide an avenue for farm labor and could help in decision making, especially where it is difficult to find affordable quality labor.

The survey showed the highest number of animals on the farm was milking cows, with a maximum of 50. Calves are lowest number of animals kept on the farm with a maximum of 16 head (Table 3.3). These numbers indicates the composition of the farm and the farm's milk potential. They also provide an indicator of the farm's ability to replace the herd.

The farmer spent the most time on the farm, at an average of 8.7 hours per day and 6.7 days per week (Table 3.4). This accounts for 63 percent of all family labor on the dairy farm. Spouses spends an average of 3.9 hours per day and 2.9 days per week on the dairy farm. This

Table 3.2. Farming Experience of Trinidad and Tobago Dairy Farmers, 1993.

Time (years)	Percentage	Number of farmers
<10	26.9	36
10 - 19	17.9	24
20 - 29	37.3	50
30 - 39	10.4	14
>39	7.5	10
Total	100	134

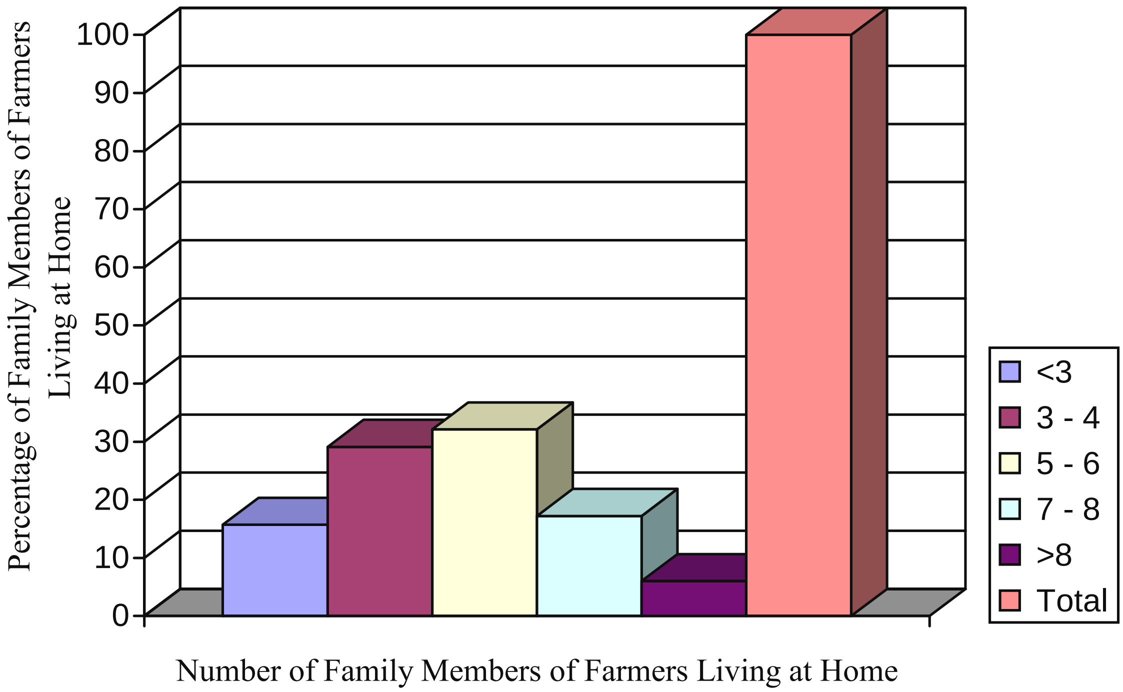

Figure 3.1 Family Characteristics of Trinidad and Tobago Dairy Farmers, 1993

Table 3.3. Characteristics of Dairy Herd in Trinidad and Tobago, January to April 1993

Type	Mean	Maximum	Minimum
Milking Cows	8	50	1
Dry Cows	4	24	1
Heifers	5	22	1
Pregnant Cows	4	20	1
Calves	4	16	1
Bulls	8	40	1

Table 3.4. Farm Family Labor Hours Spent on Trinidad and Tobago Dairy Farm, 1993

Family Member	Mean	Maximum	Minimum
Self Day/Week	6.7	7.0	0
Self Hour/Day	8.7	19.0	0
Spouse Day/Week	2.9	7.0	0
Spouse Hour/Day	3.9	9.0	0
Son Day/Week	2.0	7.0	0
Son Hour/Day	2.0	16.0	0
Daughter Day/Week	1.0	8.0	0
Daughter Hour/Day	0.9	16.0	0
Relative Day/Week	1.1	7.0	0
Relative Hour/Day	1.2	12.0	0

accounts for about 17 percent of all family labor on the dairy farm. Son spends an average of 2 hours per day and 2 days per week on the dairy farm. Son labor on the farm accounts for about 10 percent of total family labor. Daughter spends an average of 0.9 hours per day and 1 day per week on the farm, this accounts for about 3 percent of total family labor. Other relatives spend about 1.2 hours per day and 1.1 days per week on the farm, this accounts for 7 percent of total family labor on the dairy farm. These numbers indicate that the farmer is the major player on the farm. The more time the operator spends off-farm, the less would be is role in decision-making and this could affect farm productivity.

Of the farms used in this study, 42 percent employed spouses on the dairy farm. Thirty-three percent of the farmers employed their sons on the farm and 15 percent employed their daughters. Fifteen percent of the farmers also employed other relatives on their farms. The study showed that family labor was the popular labor on the dairy farms.

Variables Used in the Model

The dairy sector of Trinidad and Tobago produces milk, animals, and manure from a wide range of inputs. Based on the data available, milk is the major output on most farms. For the purpose of this study, total milk output, which is comprised of the quantity of milk sold plus the quantity of milk consumed on the farm, is the output (dependent) variable of choice. The quantity of milk sold is determined by the actual quantity of marketable milk sold by the farmers to the processor, over the period of January to April 1993, and it is measured in liters. Total milk is denoted in the model by TOTMLK.

The use of quantity of milk produced as the dependent variable is consistent with Kumbhakar, Biswas, and Bailey (1989) in their study of the economic efficiency of Utah dairy farmers. In their study, the quantity of milk was measured in pounds. In another study by

Jaforullah and Delvin (1991) on technical efficiency on the New Zealand dairy industry, total farm revenue was the dependent variable used. This approach was considered but not used, because farmers in Trinidad and Tobago received different prices from the processors that bought their milk and this information was not available.

Five primary input variables were used in this study: herdsize, feed, labor, animal health, and miscellaneous; these input variables are consistent with Jaforullah and Delvin (1996) study. In addition, two dummy variables were used and an additional variable, LABMLK, was introduced to measure labor productivity. Herdsize comprised the total number of milking cows, dry cows, pregnant cows, and calves. Although calves do not produce milk, they are included because they are used to stimulate milk let down. This approach is widely used throughout Trinidad and Tobago, where hand milking is commonly practiced. The bulls were not included, because most farmers do not keep bulls; they are sold at an early age. In the model, herdsize is denoted by LHERDSIZE.

The feed input reflects the cost in Trinidad dollars of dairy ration purchased by farmers (1US$ = 4.5TT$). Some farmers also used other feed products, such as molasses and brewers grain, but these were excluded since not enough farmers used these inputs. In the model, feed is denoted by LFEED. The labor input represents total labor used in the production of milk. It includes hired and family labor (spouse, sons, daughters, and other relatives). In the model, total labor is denoted by TLABOR, family labor by FLABOR, and hired labor by HTLABOR. In addition, for the purpose of analysis, a market variable (MKTLABOR) for labor was developed. This represents the ratio of hired labor (HLABOR) to total labor (TLABOR).

The animal health input variable reflects the cost of veterinary services in Trinidad dollars incurred by the farmer. In the model, it is represented by ANIMALH. The miscellaneous input variable represents the cost of water and electricity services in Trinidad dollars incurred by the farmers. In the model, it is denoted by MISCELL.

In this survey, there were cases of missing values and zero values for some of the observations. According to Battese (1997), regression analyses have been used to estimate production functions where at least one of the explanatory variables has zero values. This problem has been generally addressed using two approaches. One approach has been to eliminate those farmers with zero values from the model. This method of estimation could lead to bias and misleading information, as data on those farmers removed from the model could be useful in the estimation of parameters common to the farmers kept in the research. The other approach has been to include the zero observation cases in the model and replace the zero with 1 or an arbitrarily small number greater than zero; if the number of zero cases is significantly large this could lead to bias estimators of the parameters. For the purpose of this analysis, the Battese approach was used.

The input variables that showed the most cases of zero values were animal health and miscellaneous. Dummy variables for these two inputs were introduced to replace the above variables in the model to use the full data set so as to produce more efficient and non- bias estimators. The dummy variable for animal health in the model is denoted by ANIMALDM, and MISCELDM denotes the dummy variable for miscellaneous. The dependent variable in the model is TOTMLK and the independent variables are HERDSIZE, ANMALH, ANIMALDM, MISCELL, MISCELDM, FEED, TLABOR, HLABOR, FLABOR, MKTLABOR, and LABMLK.

The definitions of the variables used in the model are presented in table (3.5) and table (3.6) shows the descriptive statistics of the variables used in the model for the dairy industry of Trinidad and Tobago.

Estimation of Production Functions

Production functions can be estimated from sample data. This could be cross-sectional data (observations on a number of farms in a particular time period), time series data (aggregate industry level data observed over a number of periods, or panel data (observations on a number of farms in a number of time periods). The production function can be estimated either by a parametric function using econometric or statistical methods, or a non-parametric function using mathematical programming. The parametric approach is most often used in applied economic analyses, but the non-parametric approach is just as popular in efficiency analyses. LIMDEP, a computerized mathematical program was used to estimate production functions using Ordinary Least Squares (OLS) regression.

The Cobb-Douglas production function can be estimated using OLS, while the Translog production function can be estimated by generating the squares and cross products of the relevant variables by OLS. Ordinary Least Squares regression is widely used because of its favorable properties. It imposes no assumption on the production function. It is a parametric method of analyses that accounts for noise or disturbances, and it requires data on outputs and inputs.

Model Development

The data for this study was analyzed using LIMDEP computer package. Total milk produced (TOTMLK) was the output variable of choice, as it was the major output by most farmers. A large number of input variables were tested to determine what combination of input variables

Table 3.5. Definition of the Variables Used in the Model

Variable	Definition
TOTMLK	Total quantity sold to processors plus quantity consumed on farm
ANIMALH	Cost of veterinary services incurred
ANIMALDM	Dummy variable for zero cases of responses to cost of veterinary medicine
HERDSIZE	Total number of milking cows, dry cows, pregnant cows, heifers, and calves
FEED	Cost of dairy ration purchased by farmers
MISCELL	Cost of water and electricity incurred by farmers
MISCELDM	Dummy variable zero cases to miscellaneous costs
TLABOR	Total cost of family and hired labor employed on the farm
HLABOR	Cost of hired labor employed on farm
FLABOR	Cost of family labor employed on farm
MKTLABOR	Hired labor expressed as a ratio of total labor

Table 3.6. Descriptive Statistics of the Variables Used in the Model

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
TOTMLK	4193.5281	3953.9837	48.0000	23623.0000
ANIMALH	143.4607	203.0798	0.0001	999.0000
ANIMALDM	0.3438	0.4791	0.0000	1.0000
HERDSIZE	16.4382	11.5591	1.0000	61.0000
FEED	3526.2697	5334.6342	140.0000	43400.0000
MISCELL	813.7192	1483.9491	0.0001	9400.0000
MISCELDM	0.5393	0.5013	0.0000	1.0000
TLABOR	532.5057	793.8530	39.0000	4821.5044
HLABOR	320.6967	805.3106	0.0001	4704.0000
FLABOR	211.8091	101.7154	39.0000	468.0000
MKTLABOR	0.2122	0.3530	0.0000	0.9866

would give the best fit or best explain the dairy production of Trinidad and Tobago. The following input variables were selected: herdsize, labor, feed, animal health, miscellaneous, and a dummy variable each for the animal health and miscellaneous variable inputs. After the OLS estimators were obtained the log was then taken on observations of the variables, but not dummies and the model was run to yield the Cobb-Douglas production function. According to Greene (1993), " the Cobb-Douglas production function is essentially least squares regression of log output on a constant and the logs of the independent variables."

Following Battese (1997), the estimation of the Cobb-Douglas production function is adjusted for the case when a production input(s) has zero values. Zero-observation cases are included in our analysis by using the value of one the observations in question. The observations that are treated in this manner are ANIMALH (ANIMALDM) and MISCELL (MISCELDM). It was important to include these farmers in the analysis even though they had zero values for these inputs, because they had positive values for the other inputs common to the other farmers and excluding them could bias the estimation. Another approach considered was to exclude those farmers who showed zero values in the above-mentioned inputs. This method would result in a smaller sample size and make the analysis less useful.

Battese analysis was based on a production function involving one output Y and two inputs X_1 and X_2. The function is specified as:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + V_i, i = 1,2,...........n_1 \quad (7)$$

$$\ln Y_i = \alpha_0 + \beta_1 \ln X_{1i} + V_{i,} i = n_1 + 1,................n_1 + n_2 = n \quad (8)$$

Let n_1 represent the number of observations with positive values for the X_2 variable and n_2 is the number of observations where X_2 is zero and the random error terms V_is are independent and identically distributed. In this model the relationship between output and the inputs is such that the output elasticity with respect to X_1 is the same value, β_1, for the observations involving positive and zero values of X_2. By pooling equations 7 and 8 the model can now be specified as:

$$\ln Y_i = \beta_0 + (\alpha_0 - \beta_0)D_{2i} + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i}^* + V_i \ \ ,i = 1,2,....n \quad (9)$$

Equation 9 implies that when the X_2-variable is positive $X_{2i}^* = X_{2i}$, but if X_{2I} is zero then $X_{2I}^* = 1$. The unknown parameters $\beta_{0,}\ \beta_{1,}\ \beta_{2,}\ \alpha_0$, and $\sigma^2$of the production functions are efficiently estimated by using ordinary least squares regression associated with equation 9.

If the model, specified by equation 9, includes only one explanatory variable then a simple diagram can be used to illustrate the methodology. In figure 3.2, there are three observations associated with zero observations on the explanatory variable, X, and seven observations associated with the positive X-values. The latter observations lie around the solid line of slope, $\hat{\beta}_1$, which is the least squares line associated with the model defined by equation (9). However, the broken line of slope, $\tilde{\beta}_1$, is that which is estimated if the dummy variable, $D_{2,}$ is omitted from the model. This line is the wrong one for estimation of the effect of the X-variable on the changes in the output variable because it would give bias estimates.

Similarly, dummy variables are used in the production function of the Trinidad dairy farms. The econometric specification of the production function for Trinidad dairy farmers is:

$$\begin{aligned}&\text{lnMILKPROD}_i = \beta_0 + \beta_1\text{lnHERDSIZE}_i + \beta_2\text{lnFEED}_i + \beta_3\text{lnFARMLABOR}_i \\ &+ \beta_4 \ln \mathit{HIRLABOR} + \beta_5\text{lnANIMALH}^* + \beta_6\text{lnMISCELL} + u_i \quad (10)\end{aligned}$$

If ANIMALH equals 0, then we define a dummy variable ANIMALDM equals 1 while if ANIMALH is greater than 0, then ANIMALDM equals 0. Similarly, if MISCELL equals 0, then we define a dummy variable MISCELDM equals 1 while if MISCELL is greater than 0, then

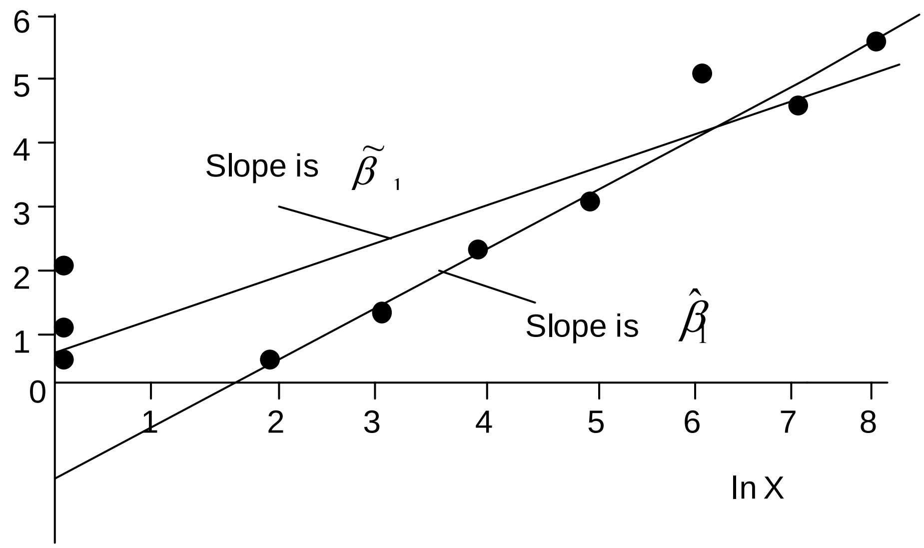

Figure 3.2 Comparison of Estimated Slope Coefficients When ‘Zero Observations’ Exist

MISCELDM equals 0. The resulting model specification following the Battese approach is:

$$\ln MILKPROD_i = \beta_0 + \beta_1 \ln HERDSIZE_i + \beta_2 \ln FEED_i + \beta_3 \ln FARMLABOR_i$$
$$+ \beta_4 \ln HIRLABOR_i + \gamma_1 ANIMALDM_i + \beta_5 \ln ANIMALH^* + \gamma_2 MISCELLDM \qquad (11)$$
$$+ \beta_6 \ln MISCEXP^* + u_i$$

where ANIMALH* equals the maximum (ANIMALH, ANIMALDM) and MISCEXP* equals the maximum (MISCELL, MISCELDM). The model, specified by equation 11, implies that when ANIMALH is greater than zero, then ANIMALH* equals $ANIMALH_{I,}$ but if $ANIMAL_i$ is equal to zero then ANIMALH* equals to one. Similarly, when MISCELL is greater than zero, then MISCEXP* equals $MISCELL_i$, but if $MISCELl_i$ equals zero then MISCEXP* equals one. The parameters of equation 11 are efficiently estimated using ordinary least squares.

Ordinary least squares regression is a technique for calculating the regression equation that minimizes the sum of the squared error terms. That is, the difference between the observed values for the dependent variable and the predicted values for the dependent variable. Ordinary least squares is used because of its favorable properties. An ordinary least squares estimator is unbiased, efficient, consistent, and asymptotically efficient. Ordinary least squares regression model consists of five basic assumptions about the way in which the observations are generated. The error terms are assumed to be independent, identically distributed, zero-meaned, normal random variables and the X matrix is nonstochastic and has full column rank. If these assumptions holds ordinary least squares regression model is said to be BLUE (Best Linear Unbias Estimator). An estimator is unbiased if $E(\hat{\beta}) = \beta$. That is, an estimator of a parameter, $\hat{\beta}$ is unbiased if the mean of its sampling distribution is β. This implies that the expected sampling error is zero. An estimator is efficient if it has the minimum variance possible for any unbiased estimator. An ordinary least squares estimator is consistent: as $n \to \infty, \hat{\beta} \to \beta$. This implies that the estimator $\hat{\beta}$ of a parameter β is a consistent estimator of β as the population gets very large. An estimator is asymptotically efficient if it has the smallest variance for any consistent estimator Greene 1993).

According to Yang (1997), in the estimation of production functions, two or more variables (herdsize feed and) are sometimes considered as endogenous variables which suggests that ordinary least square procedure will result in inconsistent estimators. Zellner, Kmenta, and Dreze (1966), argued that since farms were to maximize expected profits rather than ex post profit, one can use ordinary least squares to estimate the production function. The logic is that if one considers output, herdsize, and feed as endogenous variables in a simultaneous equation system, the optimal inputs are derived from the farm's first-order conditions. Solving for the reduced forms for the endogenous variables, it is reasonable to assume that the error terms for herdsize and feed are due to "human errors" of managerial judgment and that error terms for output are due to "acts of nature." Because of these assumptions, herdsize and feed are independent of the error tem for production. Hence ordinary least squares estimation gives consistent estimators for the parameters α and β.

Procedure

The objectives of this study are to investigate whether there is any different in productivity between family labor-operated and hired labor-operated farms and whether there is any difference in productivity between large and small dairy farms in Trinidad and Tobago**.** To satisfy the objectives, two null and corresponding alternative hypotheses were established. First a test was done to determine whether labor could be aggregated into a single input. The issue was to examine whether the impact of family labor on milk production has the same magnitude as hired labor. After specifying the labor input, the issue of returns to scale was examined. The final issue examined was the impact of labor on milk production if the farmer was to hire labor on the open market. This labor relationship is very important to the dairy industry of Trinidad and Tobago. Family labor accounts for most of the farm labor in Trinidad and Tobago. Unavailable labor is a major constraint to the dairy industry and farms need to tap into the unemployed labor force, which is about 15 percent.

First, test for the first null hypothesis is that there is no difference in productivity in family labor-operated farms and hired labor-operated farms in Trinidad and Tobago. The alterative hypothesis is that there is a difference in productivity between family labor-operated farms and hired labor-operated farms. Family labor-operated farms are defined as farms where family members and other relative provides greater than 50 percent of the labor on the farm; whereas, hired labor-operated farms are defined as farms that greater than 50 percent of the farm labor is provided by hired labor. The null hypothesis is presented as:

$$H_0 : \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + \beta_6 = 1 \quad (12)$$

The alternative hypothesis is represented as:

$$H_a : \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + \beta_6 \neq 1 \quad (13)$$

Where the βs in equations 12 and 13 are the coefficients of the input variables. In equation 12, β_1 represents the coefficient for the animal health variable, β_2 represents the coefficient for the herdsize variable, β_3 represents the coefficient for the feed variable, β_4 represents the coefficient for the miscellaneous variable, β_5 represents the coefficient for the family labor variable and

β_6 represents the coefficient for the hired labor variable. In equation 13 β_1 represents the coefficient for the animal health variable, β_2 represents the coefficient for the herdsize variable, β_3 represents the coefficient for the feed variable, β_4 represents the coefficient for the miscellaneous variable, and β_5 represents the coefficient for the total labor variable.

An F-Statistic is used to test this hypothesis (Greene 1993). In this test the F-observed value or calculated F-value is compared to the F-critical value in the F-distribution table. We reject the null hypothesis, if the F-observed value is larger than the F-critical value; otherwise, accept the null hypothesis. The F-test is represented as:

$$F[J, N-k] = \frac{(SSE_{restricted} - SSE_{unrestricted})/J}{SSE_{unrestricted}/(N-K)} \tag{14}$$

where J is the number of restrictions to be tested, the SSE's are the error sum of squares N is the number of observations in the unrestricted model and, K is the number of estimated parameters.

The F-test was done using a 90% confidence level. The test was done using an unrestricted and a restricted model. In the unrestricted model, the labor coefficient was separated into its components of hired labor and family labor. These two labor inputs were compared to determine if they have the same effect on the output by interpreting their respective marginal product. In the restricted model, hired labor and family labor were pooled to form the total labor coefficient.

In addition, the returns to scale measure were (the sum of the input elasticities) interpreted. The model used in this analysis was a Cobb-Douglas production model. The Cobb-Douglas production function imposes a constant returns to scale on the model. A new variable (LABMILK) was added to the production function to determine how the marginal product of total labor would react if farms were to hire a greater proportion of labor. The effect on total labor was determined by interpreting the marginal product of total labor. The issue of labor productivity is important, because the associated high cost of labor is cited as a major constraint to dairy production in Trinidad and Tobago. It is important that this issue be investigated to help farmers address their labor situation.

The second hypothesis tested was whether there was a difference in productivity between large and small farms. The null hypothesis is that there is no difference in productivity between large and small farms. The alternative hypothesis is that there is a significant difference in productivity between large and small farms. Farm size is based on the value of marketed production of milk. A large farm is defined as a farm which has marketed value of milk produced that is higher than the sample mean by one standard deviation. The null hypothesis is represented as:

$$H_0 : \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 = 1 \quad (15)$$

The alternative hypothesis is represented as:

$$H_a : \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 \neq 1 \quad (16)$$

Where the β's are the coefficients of the input variables. In equation 15 and 16, β_1 represents the coefficient for the animal health variable, β_2 represents the coefficient for the herdsize variable, β_3 represents the coefficient for the feed variable, β_4 represents the coefficient for the miscellaneous variable, and β_5 represents the coefficient for the labor variable.

An F-statistic (Chow Test) is used to test the above hypothesis (Greene 1993). In this test, the F-observed value or calculated F-value is compared to the F-critical value in the F-distribution table. The null hypothesis is rejected if the F-observed value is larger than the F-critical value in the table. The F-test (Chow Test) was done using a 90% confidence level to test the unrestricted and restricted models. The unrestricted or full model comprises all the farms, while the restricted model consisted only the small farms. Small farms were restricted to have the same production function as large farms. That is, small and large farms are assumed to use the same inputs.

CHAPTER 4

RESULTS AND DISCUSSION

The results used in the analysis for this study are presented in Tables 4.1 to 4.5. The objectives of the study were to determine if there is any difference in productivity between hired labor and family labor operated farms and to test if there is any difference in productivity between large and small dairy farms in Trinidad and Tobago. The study focused on two broad issues, the influence of labor on dairy production in and the influence of farm size on dairy production in Trinidad and Tobago. The labor issue will be discussed first to determine if there is any difference in productivity between family and hired labor farms and then the size issue to determine if there is any difference between large farms and small dairy farms in Trinidad and Tobago.

Test for Difference in Productivity between Family and Hired Labor Operated Farms

The purpose is to investigate whether there is any difference in productivity between family and hired labor operated farms. To achieve this objective, the role of family (LFLABOR) and hired labor (LHLABOR) was examined and a test was conducted to determine if these inputs were different. The f-test showed that family labor and hired labor were not different hence, they were combine to form a new variable, total labor (LTLABOR). A second variable, LABMLK, was developed to test the effect of market orientation on milk output. LABMLK is where more than 50 percent of labor input is provided by hired labor. The input elasticities (coefficients generated by model) were examined to determine the effect of each input variable had on milk output. Elasticity (measures the responsiveness in the dependent variable to changes in the independent variables. A large elasticity that is greater than one, suggests the output responds very strongly to increases in the use of the input. Large elasticity implies that MPP is very large relative to APP indicating that output from the last unit of incremental unit of input is very large relative to average output obtain from all units of that input. Elasticity between zero and one implies the output will increase as a result of the increase of the input, smaller is less responsive. A negative elasticity implies output will decrease as the level of the input increase. Elasticity is a unit-less ratio and can be presented :

$$E_p = (\Delta Y / Y)/(\Delta X / X) \tag{17}$$

where $\Delta Y = Y^1 - Y^{11}$ and $\Delta X = X^1 - X^{11}$

An F-.test was done to determine if there is any difference between family and hired labor farms. The returns to scale measure (sum of input elasticities) were calculated to measure the impact a proportional change in all inputs would have on output. RTS can be presented as $E_1 + E_2 + E_3 \ldots\ldots\ldots + E_n$ where the E's are elasticity measures. For the Cobb-Douglas production functional form the returns to scale can be computed:

$$Y = AX_1^{b_1} X_2^{b_2} \tag{18}$$

$$MPPx_1 / APPx_1 = E_1 \tag{19}$$

$$MPPx_2 / APPx_2 = E_2 \tag{20}$$

$$RTS = E_1 + E_2 \tag{21}$$

Equation 18 represents a modified two-input Cobb-Douglass production function. In this modified form Y represents output levels associated with production, A represents the level of technology, X_1 and X_2 are input variables of production and b_1 and b_2 are parameters estimated by the model. A modified Cobb-Douglas functional form was used for this model because it is easy to manipulate, interpret and is widely used in production economics.

Equation 19 is the elasticity associated with the X_1 input variable. It is a unit-less measure that shows the responsiveness of the output to changes in the X_1 input variable. It shows the percentage change in output marginal product ($MPPx_1$) divided by the percentage change in input average product ($APPx_1$) as the level of input X_1 changes. It measures the responsiveness in output to a one percent change in input X_1 holding input X_2 fixed. Elasticity measure is a tool with great importance in production agriculture. By analyzing elasticity values the farm can determine the relationship between output and input variables. Elasticity greater than one suggests that output is very responsive to changes in the input X_1.

Equation 20 is the elasticity associated with the X_2 input variable. It measures the responsiveness of output to a one percent change in the X_2 input variable. It shows how responsive output is to a one percent change in input variable X_2. It shows the percentage change in output or marginal product ($MPPx_2$) divided by the percentage change in input or average product ($APPx_2$) as the level of X_2 changes. Elasticities between 0 – 1 suggests that output would increase as X_2 increase and negative elasticities implies output decreasing as X_2 increases.

Equation 21 measures the returns to scale. Returns to scale (RTS) is the sum of the input elasticities associated with production. It measures the responsiveness of output to a proportional change in all inputs. Returns to scale can be term constant, decreasing or increasing. A return to scale of 1 indicates constant elasticity implying a one percent increase in all inputs would result in a one percent increase in output. Increasing returns to scale occurs when RTS is greater than 1 and implies a 1 percent increase in all inputs would result in a greater than one percent increase in output. Decreasing returns to scale occurs when RTS is less than 1 and implies that a one percent increase in all inputs would result in a less than one percent increase in output.

An examination of the coefficients for family and hired labor in the unrestricted model shows that there is an apparent difference in marginal productivity, however, the coefficients are not significantly different from one another and was used as total labor input. The marginal productivity of family labor is greater than the marginal productivity of hired labor as is reflected in their respective coefficient values of 0.398 and 0.005 (Table 4.1). A one percent increase in family labor would increase milk output by 0.398 percent and a one percent increase in hired labor would increase milk out put by 0.005 percent. The input variables, HERDSIZE and FEED were significant at the 10 percent level. This indicates that these variables are major contributors to milk output. A reasonable explanation for the difference in productivity between family labor and hired labor is that family labor has more dairy farming experience and have vested interest in the performance of the farm as it belongs to them. The family labor coefficient is significant at the 90% level; whereas, the hired labor coefficient was not statistically significant.

In the restricted model, (Table 4.2), the variables HERDSIZE and FEED were statistically significant at the 10 percent level, indicating that they are major contributors to milk output. A one percent increase in HERDSIZE would increase milk output by 0.363 percent and a one percent increase in FEED would increase milk output by 0.321 percent. A one percent increase in TLABOR would increase milk output by 0.195 percent; however, TLABOR was not significant at the 10 percent level.. This implies that it is not a major contributor to milk output.

Table 4.1. Milk Productivity with Family Labor versus Hired Labor Farms, Unrestricted Model, Trinidad and Tobago, 1993

Variable	Coefficient	Standard Error	t-ratio
Constant	1.061	2.020	0.525
LANIMLST	-0.032	0.140	-0.232
ANIMALDM	-0.292	0.722	-0.405
LHERDSIZ	0.359	0.200	1.795*
LFEED	0.336	0.134	2.728*
LMISCEST	0.168	0.221	0.760
MISCELDM	1.283	1.568	0.818
LFLABOR	0.398	0.221	1.802*
LHLABOR	0.005	0.017	0.317

*Denotes variables statistically significant at the 10 percent level of significance.

Table 4.2. Family Labor Versus Hired Labor Farms, Restricted Model Trinidad and Tobago, 1993

Variable	Coefficient	Standard Error	t-ratio
Constant	2.460	1.680	1.464
LANIMLST	-0.034	0.140	-0.245
ANIMALDM	-0.342	0.721	-0.475
LHERDSIZ	0.363	0.198	1.836*
LFEED	0.321	0.134	2.400*
LMISCEST	0.152	0.220	0.691
MISCELDM	1.168	1.558	0.750
LTLABOR	0.195	0.127	1.541
N	86		
R^2	0 .3626		
Adjusted R^2	0.3054		
Model test: F [7 , 78]	6.340		
F-cal	2.859		
F-table	3.960		

* Denotes variables statistically significant at the 10 percent level

Market oriented farms tend to be larger than non-market oriented farms, that is farms that rely more on family labor. The mean milk output on market oriented farms was 5,248 liters from January to April 1993 compared to 3,872 liters for non-market oriented farms. Milk output on market-oriented farms was 36 percent higher than non-market oriented farms. Feed cost for market-oriented farms was 141 percent higher with a mean cost of $6,235 T&T dollars compared to $2,592 for non-market oriented farms. Herd size is 50 percent larger on market-oriented farms with a mean herd size off of 21 animals compared to 14 animals on non-market oriented farms. Animal health costs were 41 percent higher on market-oriented farms with a mean cost of $184 T&T dollars compared to $131 on non-market oriented farms.

The model in Table 4.3 adapted on the model in Table 4.2.and included the variable LABMLK. LABMLK was included in this model to test the effects of market orientation on output. With the inclusion of the interaction term LABMLK , the calculated elasticity for TLABOR is 0.564 with a standard error of 0.22 and t-statistic of 2.599. TLABOR variable was significant at the 10 percent level. This indicates that TLABOR is a major contributor to milk output. A one percent increase in TLABOR would increase milk output by 0.564 percent. The increase in total milk output by TLABOR is due to the marketable labor component of TLABOR represented in LABMLK. The TLABOR elasticity was calculated to account for the for the interaction term in the model. The calculation of elasticity for TLABOR was as follows:

$$\frac{\partial \ln MILKOutput}{\partial \ln TLABOR} = \beta_8 + \beta_9 MARKETLABOR \qquad (22)$$

where MARKETLABOR is hired labor expressed as a percentage of TLABOR and TLABOR is the sum of FLABOR and HLABOR described earlier. The interaction term LABMLK is comprised of TLABOR times MARKETLABOR. The LABMLK term was introduce to test the

Table 4.3. Constant Returns To Scale With Interaction Term imposed on Restricted Model, Trinidad and Tobago Dairy, 1993

Variable	Coefficient	Standard Error	t-ratio
Constant	0.269	2.022	0.013
LANIMLST	-0.047	0.137	-0.344
ANIMALDM	-0.295	0.707	-0.418
LHERDSIZ	0.365	0.194	1.887*
LFEED	0.346	0.132	2.629*
LMISCEST	0.178	0.216	0.824
MISCELDM	1.389	1.530	0.908
LTLABOR	0.601	0.232	2.592*
LABMLK	-0.174	0.084	-2.072*

* Denotes variables statistically significant at the 10 percent level.

effect of labor on milk production when the farmer uses the farmer hires more than 50 percent of his labor outside family source or on the open market. HERDSIZE and FEED were statistically significant at the 10 percent level; indicating that they are major contributors to milk output. A one percent increase in HERDSIZE would increase milk output by 0.365 percent, and a one percent increase in FEED would increase milk output by 0.346 percent.

A comparison of elasticities across the two models showed that herdsize and feed elasticities were very close in magnitude in both models. However, the labor elasticities were strikingly different across models. The model (table 4.3), which included an interaction term for market orientation was 2.89 times higher with an elasticity of 0.564, compared to an elasticity of 0.195 in the model (table 4.2), which only considers the amount of total labor used.

The results showed that across every size category of farm, the majority of farmers hire less than 50 percent of labor from outside the immediate family. Size category is defined by total milk production. Eight-four percent of farmers with milk output below 1,000 kilograms of milk for the period surveyed relied primarily on family labor. Seventy-six percent of farmers with production levels between 1,000 to 5,000 kilograms of milk relied primarily on family labor and 73 percent of farmers with more than 5,000 kilograms of milk rely strictly on family labor.

Thirty-four percent of the farms surveyed reported zero values for the animal input variable. Of the farmers who reported positive expense values for animal health, 70 percent of these farmers did not hire any labor outside of the family. This is slightly lower than the farmers who did not report any positive expenses for animal health. If the model eliminated any farmers who did not incur animal health expenditures, this would also eliminate a greater proportion of farmers who relied completely on family labor. Fifty-four percent of the dairy farms surveyed reported zero payments for the miscellaneous input variables water and electricity. Similarly, if the model eliminated any farmers who did not incur miscellaneous expenses , this would also eliminate a greater proportion of farmers who relied on completely on family labor as 70 percent of these farmers do not hire labor on the open market. The inclusion of these farmers in the model allowed for a larger model size and yields more efficient estimates than if these farms were excluded, supporting the decision to used the Battese approach discussed earlier. These findings are helpful in formulating strategies to help boost production of the dairy industry in Trinidad and Tobago. The results suggest that milk output can be increase by farmers hiring more than 50 percent of their labor force from outside the immediate family.

To test for productivity between family and hired labor operated farms, an F-statistic was used. The results of the F-Test are presented in Table 4.2. The F-Statistic is computed using:

$$F[J, N-K] = \frac{(SSE_{restricted} - SSE_{unrestricted})/J}{SSE_{unrestricted}/(N-K)} \tag{24}$$

where J is the number of restrictions to be tested, the SSE's are the error sum of squares, N is the number of observations in the unrestricted model, and K is the number of parameters. The test showed no significant difference in productivity. The calculated F-value of 2.86 (table 4.2) is less than the F-Value of 3.96 in the table at alpha equals 0.05. Since the value of 2.86 does not exceed 3.96, the hypothesis that family operated farms are equally productive as hired labor operated farms cannot be rejected at the 5% level of significance. Thus, the results support the hypothesis that family operated farms are just as productive as hired labor operated farms given similar conditions.

Following Cornia (1985), constant returns to scale are assumed to occur when the sum input elasticities at 10 percent level of significance falls between 0.95 – 1.05, below 0.95 or 1.05, one has decreasing or increasing returns to scale. The return to scale measure (Table 4.2), which is the sum of the input elasticities, is 0.997. This implies constant returns to scale indicating that proportionally increasing all inputs would increase output by the same factor. If all inputs were increased by 1percent milk output would also increase by one percent. The finding of constant returns to scale is in line with other studies on agricultural production in developing countries reported by Lopez and Valdes (2000).

Test for Difference in Production Between Large and Small Farms

Abundant evidence suggests that there is an inverse relationship between farm size and productivity. Rosenzweig and Binswanger (1993) show that profit rates of poorer Indian farm are systematically higher than those for richer farms and Berry and Cline (1979) demonstrate that the productivity of small farms is greater than the largest farms in a wide range of countries including Brazil, Pakistan, and Malaysia as specific examples. The usual explanation is based on diminishing returns and fiction in the land, credit, labor or insurance markets prevent the efficient allocation of land. The analysis of farm size in the production structure of Trinidad and Tobago dairy farms address this important issue relating farm size and productivity. The purpose is to determine whether there is any difference in productivity between large and small farms. To make this determination, two models were used, a restricted and an unrestricted model. In the restricted model (Table 4.4) both small and large farms are restricted to having the same production function and are pooled together. In the unrestricted model, the small farms were separated and estimated (Table 4.5). An F-Test (Chow Test) is used to determine if there is any significant difference in productivity between large and small farms. The results of the F-Test are presented in Table 4.5.

A large farm is defined as a farm that has marketed value of milk produced higher than the sample mean by 1 standard deviation. Based on the criteria used to define small and large

Table 4.4. Large Farms Versus Small Farms, Unrestricted Model, Trinidad and Tobago Dairy, 1993

Variable	Coefficient	Standard Error	t-ratio
Constant	1.61573	2.1934	0.737
LANIMLST	0.04259	0.17074	0.249
ANIMALDM	-0.08863	0.86688	-0.102
LHERDSIZ	0.20155	0.21655	0.931
LFEED	0.38236	0.14564	2.636*
LMISCEST	-0.08363	0.25535	-0.328
MISCELDM	-0.38291	1.7654	-0.217
LTLABOR	0.57718	0.24784	2.329*
LABMLK	-0.19384	0.9478E-01	-2.045*
N	74		
R^2	0.319		
Adjusted R^2	0.235		
	3.81		
Model Test F[8, 65]			

* Denotes variables statistically significant at the 10 percent level.

Table 4.5. Large Farms Versus Small Farms, Restricted Model, Trinidad and Tobago Dairy, 1993

Variable	Coefficient	Standard Error	t-ratio
Constant	0.590	1.929	0.306
LANIMLST	0. 050	0.135	-0.371
ANIMALDM	-0.352	0.696	-0.506
LHERDSIZ	0.370	0.191	1.935*
LFEED	0.364	0.129	2.829*
LMISCEST	0.131	0.209	0.629
MISCELDM	1.053	1.479	0.712
LTLABOR	0.536	0.221	2.425*
LABMLK	-0.155	0.0810	-1.918*
N	89		
R^2	0.393		
Adjusted R^2	0.333		
Model Test F[8, 80]	6.49		
F-cal	0.209		
F-table	1.456		

* Denotes variables statistically significant at the 10 percent level.

farms, there were 15 large and 74 small farms. The mean value of milk produced by the 89 farms in the sample was 3,739 liters with a standard deviation of 3,172 liters. Therefore, a farm is considered large if total volume of milk produced exceeds 6,911 liters.

Average total milk output on large farms was 9,582.4 liters compared to 3,111.6 liters on small farms for the period of January to April 1993. Therefore, large farms produced 3 times more milk than small farms. The minimum milk output on large farms was 7,250 liters and the maximum output was 14,208 liters compared to 48 liters minimum and a maximum of 23,623 liters for small farm. The average herdsize on large farms is 29 animals with a minimum of 13 animals and a maximum of 61 animals. The average herd size for small farms is 14 animals with a minimum of 10 animals and a maximum of 59 animals. The disparity between herd size and milk output across farm size could be attributed to the composition of the dairy herd.

The average feed cost for large farms was $8,341 T&T dollars with a minimum cost of $1,320 and a maximum cost of $43,400 dollars for January to April 1983. On the small farms, average feed cost was $2,557 T&T dollars with a minimum of $140 and a maximum of $17,000 dollars for January to April 1993.

Average animal health cost on large farms was $139 T&T dollars with a minimum of zero dollars and a maximum of $999 dollars. The average animal health cost on small farms was $146 T&T dollars with a minimum cost of zero dollars and a maximum cost of $999 dollars. Animal health cost did not differ much across farm size. Miscellaneous costs did not differ across farm size.

The farmer provided 65 percent of the labor on larger farms compared to 63 percent on small farms. Spouse provided 11 percent of the labor on large farms and 18 percent on small farms.

Forty percent of large farms used their sons on their farms, compared to 32 percent of the small farms. Thirty three percent of large farms used spouse on their farms compared to 44 percent of the small farms.

The F-value calculated at the 10 percent significance level is 0.209 and is less than the critical value of 1.456 (Table 4.5). Since the F-value of 0.209 is less than F-value of 1.456 in the table, the hypothesis that large and small farms are just as productive cannot be rejected. This was the expected result and is consistent with the findings of Jafforullah and Delvin (1996) that there is no difference in productivity between large and small farms. This finding refutes the widely perceived notion in the Caribbean that larger farms are more productive than smaller farms. One possible explanation is the use of resources. Smaller farms tend to be more intensive, having all their lands under full production while larger farms would set aside lands to follow or idle. It is possible that smaller farms are more efficient at managing their resources than larger farms. The farms exhibited constant returns to scale. This implies that farm size does not confer any advantage or disadvantage to output. This further supports the null hypothesis that there is no difference in productivity between large and small farms.

In both the unrestricted and restricted models the variables FEED and TLABOR were significant at the 10 percent level of significance. This indicates both variables are major contributors to milk output. The herdsize variable is only significant in the restricted model., indicating that it is a major contributor in the production of milk. A one percent increase in HERDSIZE would result in 0.370 percent increase in milk output. In the unrestricted model, a 1 percent increase in FEED would result in 0.382 percent increase in milk output but only 0.364

percent in the restricted model. In the unrestricted model, a 1 percent increase in TLABOR would result in 0.577 percent increase in milk output and only 0.536 percent in the restricted model.

CHAPTER 5

SUMMARY, CONCLUSION, AND IMPLICATIONS AND RECOMMENDATIONS

Summary

This study has been primarily concerned with investigating whether large dairy farms are more productive than small dairy farms and whether there is any difference in productivity between family and hired labor operated farms in Trinidad and Tobago. Two models were used in the analysis, and in both models Ordinary Least Squares Regression was used. A modified Cobb-Douglas production function was used in both models. No frontier analysis was done. An F-Value statistic was used to test for difference in productivity in both models. An initial test examined the role of family and hired labor on milk output by interpreting the elasticities for hired labor and family labor inputs. A t-test was conducted to determine if the hired labor and family labor inputs could be combined into one input. The test showed that family labor and hired labor are not significantly different from each other; thus, they were combined to form a single input, total labor. The results showed that family labor had a larger elasticity than hired labor indicating that hired labor had limited use in the production of milk.

There was no difference in productivity between family and hired labor-operated farms. In addition, farms becoming more market oriented showed increase in milk output. Seventy-three percent of the farms hire less than 50 percent of their labor from non-family source. Hiring more than 50 percent of additional labor from non-family sources showed an increased in overall labor productivity. The addition of hired labor could afford the farmer more time to manage and also allows for labor specialization. This should be encouraged once the enterprise continues to be profitable and can effectively compete in the industry, since 15 percent of the labor force is unemployed. The results obtained support the null hypothesis that there is no difference in productivity between hired-labor and family labor oriented farms in Trinidad and Tobago.

The herdsize and feed variables were statistically significant at the 10 percent level of significance, suggesting that these inputs are major contributors to milk output. Both variables had positive elasticities indicating that an increase in these inputs would result in an increase in milk output. The farmer can thereby increase his milk output by increasing feed and herdsize.

The results show that there is no difference in productivity between large and small farms. There was no difference in the elasticity measures for the input variables used in large versus small farms. Based on this research, small farms are just as productive as large farms given the resources available to them. HERDSIZE and TLABOR were significant in both large and small farms indicating that they are the major contributors to milk output. An increase in the HERDSIZE and TLABOR inputs would result in an increase in milk output. The farms exhibited constant returns to scale implying that a proportional increase in all inputs would increase output by the same factor. The data used in this study had cases of zero observations for the animal health and miscellaneous input variables in the models. Earlier approaches used to address this situation involved the elimination of variables with zero cases or arbitrarily assigning a very small number (0.00001) to these variables to include in the analysis. If the variables were eliminated it could result in a small sample size and give bias estimates. Battese (1997) using a special technique showed that variables with zero cases could be kept in the analysis and given efficient estimates. In the Battese approach dummy variables were included in the model to represent those variables with zero cases. Zero cases were assigned a value of one and kept in the model for analysis.

A dummy variable was incorporated into the model and assigned a value of one if the variable in question had a zero value. If the variable in question is positive the dummy variable was assigned a value of zero. The variable in question would then be equal to the larger of the positive variable or the dummy variable. For example, if ANIMALH equals 0, then we define dummy variable ANIMALDM equals 1. If ANIMALH is greater than 0, then ANIMALDM equals 0. Using the Battese approach ANIMALH* would equal the maximum of ANIMALH and ANIMALDM. This technique allowed for a larger sample size and more efficient estimates using ordinary least squares regression. Zero cases could not be used in the model as there is no value for the log of zero. Using the Battese approach was important to ensure a large enough sample size to perform the analysis. Keeping those farms with zero cases in the model allowed for the use of information that was common to the other farms and relevant to the study.

Data were collected on 134 farms; however only 89 farms were included in the study. Some of the farmers did not adequate completed the survey or the information provided was not relevant to this study. The data included in the study covered milk output, labor used on the farms, cost of water and electricity, animal health and cots of dairy ration used on the farms. Although not used in the models tested, data on age, farming experience, family characteristics, source of information and herd characteristics were analyzed in the study because they are important to the dairy industry of Trinidad and Tobago.

The study showed that most of the farms were located in the Caroni area. Caroni is a county located in western Trinidad, on the gulf of Paria. It is one of the major sugar cane growing areas in Trinidad and Tobago. Most of the farmers were full time farmers. Sixty-nine percent of the farmers were males. At least 70 percent of the farmers attained primary level of education. The land was owned, rented, leased, state owned, or other and most farmers occupied one parcel of land. Farmers were engaged in a number of farm enterprises utilizing various combination of crop cultivated and livestock. Dairy production was the major enterprise for 78.9 percent of the farms surveyed.

Most of the farmers used a number of feeding systems including pasture, pasture/concentrate, concentrate and cut and carry. Almost 81 percent of the farmers had improved pastures of pangola, guatemala, tannagrass and pargrass. Fifty-six percent of the farmers used fence, fencing material included post and barbwire, brick wall, post and mesh wire and post and chain link. The major water source included rain-fed, ponds, rivers, springs, standpipe and truck-borne. Forty-six percent of the farmers had private pipes.

Dairy farms comprised a mixture of cows, heifers, calves, and bulls and the average milk yield was 9.1 liters per cow per day and cows were milked an average twice daily. The outputs were milk, manure and animals used for beef, veal or replacement stock. Family labor was the dominant type of labor used on the farms with the farmer providing most of the labor, spending an average of 8.7 hours per day and 6.7 days per week. The major source of dairy information was the extension service, farm stores, and other farmers. Seventy-one percent of the farmers think they get adequate dairying information. Fifty- two percent of the farmers kept records. Sixty-seven percent of the farmers received a price subsidy for milk and 90 percent of these farmers had problems with subsidy payments. Ninety-three percent of the farmers are dissatisfied with milk prices and some think that dairy farming is unprofitable.

The mean age of the farmers was 48.4 years, with a minimum of 19 years and a maximum age of 80 years. Fifty-five percent of the farmers were between the age of 30 and 59 years. Thirty-seven percent of the farmers were farming for a period of 20 to 29 years. Thirty-two percent of the farmers had 5 – 6 family members living at home and provided an avenue for farm labor. This is very important as the study showed family labor to have higher marginal labor productivity. The farmer spends the most time on the farm, at an average of 8.7 hours per day and 6.7 days per week.

Conclusion

This study sheds light on the role of family and hired labor on milk production in Trinidad and Tobago. There was no difference in productivity between hired labor and family labor operated farms. However, the study revealed that farmers could increase milk output by hiring 50 percent of their labor force from non-family members. Therefore, farmers should be encouraged to hire more employees that are non-family members as a way to increase milk output.

Similarly, there was no difference in productivity between large and small farms. The small farms were as productive as the large farms. Consequently, small farms should be given similar attention with respect to policy development and technology transfer. The policy of supporting large farms while neglecting small farms should be abandoned in light of the findings of this research. Based on this finding, the smaller farms should be encouraged to increase farm size; thereby, increasing overall milk output. Also, the larger farms needs to be more productive by increasing efficiency of resource use. Other criteria beside farm size should be looked at and thoroughly investigated for policy development with respect to the dairy industry. Some of the farms were of mixed enterprises, and this feature could affect how much quality time is actually spent on the dairy portion of the enterprise. Also, some farmers worked off farm; the larger the off-farm income, the less time the farmer is likely to spend managing farm operations. Production decisions based on insufficient information due to less time spent on the farm and the dairy enterprise could lead to reduced productivity. The data set did not allow for exploration of the effects of human characteristics and economic factors, such as age, education, sex, farming experience, land tenure and location. It is reasonable to think that these factors do affect the level of farm productivity. The relationship between these factors and productivity should be investigated to facilitate policy development.

Implications and Recommendations

This study showed that large dairy farms are not more productive small dairy farms. The results suggest the smaller farms with current level of production could increase production given more resources. Therefore, more lands should be made available to the smaller farmers to boost dairy production. Thus, there is a need for land reform to support this venture. From the study, most of the farmers advocated that labor shortage is a major shortcoming of the industry. The findings showed that family operated and hired labor operated farms are just as productive. Hence, where family labor is available efforts should be made to encourage this excess labor to participate in farm activities.

Small farms were shown to be as productive as larger farms and therefore should be given the same support and considerations as large farms with respect to policy development. Farms exhibited constant returns to scale so farm size per see offers no advantages. Based on the findings of this study, farm size is not a good criterion for farm support. Farm support should be meted out an individual farm basis. The policy of supporting the larger farms should be discontinued, as there is no difference in productivity across farms of different size. Since, the smaller farms were shown to be equally productive, there is no justification to continue giving support to the large e farms on the basis of farm size.

Across farms, family labor–operated farms were shown to be as productive as productive as hired labor-operated farms. Marginal productivity of family labor was higher than hired labor thus family labor should be encouraged to participate in farm operations were possible. However, it was shown that farms hiring more than 50 percent of labor from non-family source or on the open market increased the total labor efficiency. Therefore, farmers with the resources to hire more labors should be encouraged to do so as this would lead to and increase in milk output and reduce the unemployment rate.

The farms in this study were treated as pure dairy farms, however the study showed that dairy enterprise was the major enterprise for 78.9 percent of the farmers surveyed. The farmer was engaged in other farm enterprise including poultry, vegetables, beef, pork, and coffee. The efforts and time of the farmer and farm employees working in these farm enterprises were not accounted for in this study. The impact of having other farm enterprise in conjunction with the dairy enterprise should be investigated to determine the effect on the dairy enterprise and the necessary corrective actions taken if needs be.

Farms in this study exhibited constant returns to scale. A proportional increase in all input factors would increase milk output by the same factor. Farms should be encouraged to utilize al idle resources to maximize milk output. There is need for land reform to encourage farms to expand and to encourage new dairy farmers to enter the industry. The data used in this study did not allowed for the study of the effects of human characteristics, such as age, education level, gender, and farming experience on milk productivity. Other studies have shown these factors to affect farm level performance. Therefore, the effect of these factors on milk production in Trinidad and Tobago should be investigated. Also, the effects of geographic location, source and quality of information and off-farm income should be investigated to determine their effect on milk output on dairy farms in Trinidad and Tobago. The farms in the survey was drawn from different geographic locations and some farmers were dissatisfied with the quality of information they received. Studies have showed off-farm income to have a negative impact on farm productivity, the larger the off-farm income the less time the farmer is likely to spend on the farm.

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APPENDIX

SURVEY OF DAIRY FARMERS IN TRINIDAD AND TOBAGO, 1993

Dairy Codebook #1

Number	Ques. #	Text	Column	Length	Character
1		Questionnaire	1	3	N
2	1.4	Location	4	1	N
	1=	Wallerfield			
	2=	Turure			
	3=	Caroni			
	4=	St. Patrick			
3	1.6	Sex of Farmer	5	1	A
	m=	Male			
	f=	Female			
	=	NR			
4	1.7	Age on last birthday	6	2	N
	01=	<30			
	02=	30-39			
	03=	40-49			
	04=	50-59			
	05=	>59			
5	1.8	Length of time farming	8	2	N
	01=	<30			
	02=	30-39			
	03=	40-49			
	04=	50-59			
	05=	>59			
6	1.9	Members of family living at home	10	2	N
	01=	<3			
	02=	3-4			
	03=	5-6			
	04=	7-8			
	05=	8>			
7	1.10	# of members are males	12	2	N
8	1.10	# of members are females	14	2	N
9	1.11	# of members work on farm (MALES)	16	1	N
10	1.11	# of members work on farm (FEMALES)	17	1	N

11	1.12	Are you a part-time or full time...	18	1	A
	P=	Part-time			
	f=	Full-time			
	=	NR			
12	1.13	If P-time, what is your occupation	19	2	N
	01=	Labourer			
	02=	Tradesman			
	03=	Domestic			
	04=	Artisan			
	05=	Proprietor			
	06=	Pensioner			
	07=	Civil Servant			
	08=	Teacher			
	09=	Driver			
	10=	Professional			
	11=	Other			
	=	=NR			
13	1.14	If P-time, % if inc. from farming	21	1	N
	1=	<25			
	2=	25-49			
	3=	50-74			
	4=	>75			
	5=	All			
14	1.5	Highest level of education achieved	22	1	N
	1=	Primary			
	2=	Secondary			
	3=	University			
	4=	Other			
	=	NR			
15	1.16	# of parcels of land you farm	23	1	N
16	1.17	Acreage (Parcel 1)	24	2	N
	01=	<6			
	02=	6-10			
	03=	11-15			
	04=	15-19			
	05=	>19			
17	1.17	Distance (Parcel 1)	26	2	N
	01=	<3			
	02=	3-5			
	03=	6-8			
	04=	>8			
	05=	99			

18	1.17	Tenure (Parcel 1)	28	1	N
	1=	Owner			
	2=	Rented			
	3=	Leased			
	4=	Other			
	5=	State			
19	1.17	Acreage (Parcel 2)	29	2	N
20	1.17	Distance (Parcel 2)	31	2	N
21	1.17	Tenure (Parcel 2)	33	1	N
	1=	Owned			
	2=	Rented			
	3=	Leased			
	4=	Other			
22	1.17	Acreage (Parcel 3)	34	2	N
23	1.17	Distance (Parcel 3)	36	2	N
24	1.17	Tenure (Parcel 3)			
	1=	Owned			
	2=	Rented			
	3=	Leased			
	4=	Other			
25	1.18	Do you have improved pasture	39	1	A
	y=	Yes			
	n=	NO			
	=	NR			
26	1.18	Do you have unimproved pasture	40	1	A
	y=	Yes			
	n=	NO			
	=	NR			
27	1.18	Do you have scrub (waste)land	41	1	A
	y=	Yes			
	n=	NO			
	=	NR			
28	1.19	Type of crop #1	42	1	N
	1=	Paddy (Rice)			
	2=	Cocoa			
	3=	Coffee			
	4=	Citrus			
	5=	Coconut			
	6=	Short Crops/Veg.			
	7=	Root Crops			
	8=	Fruit			
	9=	Banana/Plantain			
	0=	Other			
29	1.19	Acreage of crop #1	43	2	N

30	1.19	Type of crop #2	45	1	N
	1=	Paddy (Rice)			
	2=	Cocoa			
	3=	Coffee			
	4=	Citrus			
	5=	Coconut			
	6=	Short Crops/Veg.			
	7=	Root Crops			
	8=	Fruit			
	9=	Banana/Plantain			
	0=	Other			
31	1.19	Acreage of crop #2	46	2	N
32	1.19	Type of crop #3	48	1	N
	1=	Paddy (Rice)			
	2=	Cocoa			
	3=	Coffee			
	4=	Citrus			
	5=	Coconut			
	6=	Short Crops/Veg.			
	7=	Root Crops			
	8=	Fruit			
	9=	Banana/Plantain			
	0=	Other			
33	1.19	Acreage of crop #3	49	2	N
34	1.19	Type of crop #4	51	1	N
	1=	Paddy (Rice)			
	2=	Cocoa			
	3=	Coffee			
	4=	Citrus			
	5=	Coconut			
	6=	Short Crops/Veg.			
	7=	Root Crops			
	8=	Fruit			
	9=	Banana/Plantain			
	0=	Other			
35	1.19	Acreage of crop #4	52	2	N
36	1.20	Currently involved in dairy prod'n	54	1	N
	y=	Yes			
	n=	No			
	=	NR			

37	1.21	Type of livestock #1	55	1	N
	1=	Dairy Cattle			
	2=	Beef Cattle			
	3=	Sheep/Goat			
	4=	Poultry			
	5=	Pigs			
	6=	Other			
38	1.21	No. of heads (livestock #1)	56	3	N
39	1.21	Type of livestock #2	59	1	N
	1=	Dairy Cattle			
	2=	Beef Cattle			
	3=	Sheep/Goat			
	4=	Poultry			
	5=	Pigs			
	6=	Other			
40	1.21	No. of heads (livestock #2)	60	3	N
41	1.21	Type of livestock #3	63	1	N
	1=	Dairy Cattle			
	2=	Beef Cattle			
	3=	Sheep/Goat			
	4=	Poultry			
	5=	Pigs			
	6=	Other			
42	1.21	No. of heads (livestock #3)	64	3	N
43	1.21	Type of livestock #4	67	1	N
	1=	Dairy Cattle			
	2=	Beef Cattle			
	3=	Sheep/Goat			
	4=	Poultry			
	5=	Pigs			
	6=	Other			
44	1.21	No. of heads (livestock #4)	68	3	N
45	1.22	Most important enterprise	71	1	N
	1=	Dairy Cattle			
	2=	Beef Cattle			
	3=	Sheep/Goat			
	4=	Poultry			
	5=	Pigs			
	6=	Cocoa/Coffee			
	7=	Citrus			
	8=	Coconut			
	9=	Short Crops/Veg.			
	0=	Other			

46	1.22	2nd most important enterprise	72	1	N
	1=	Dairy Cattle			
	2=	Beef Cattle			
	3=	Sheep/Goat			
	4=	Poultry			
	5=	Pigs			
	6=	Cocoa/Coffee			
	7=	Citrus			
	8=	Coconut			
	9=	Short Crops/Veg.			
	0=	Other			
47	1.22	3rd most important enterprise	73	1	N
	1=	Dairy Cattle			
	2=	Beef Cattle			
	3=	Sheep/Goat			
	4=	Poultry			
	5=	Pigs			
	6=	Cocoa/Coffee			
	7=	Citrus			
	8=	Coconut			
	9=	Short Crops/Veg.			
	0=	Other			
48	1.23	Why consider the first most imp...	74	2	N
	01=				
	02=				
	03=				
	04=				
	05=				
	06=				
	07=				
	08=				
	09=				
	10=				
49	1.24	Type of road	76	1	N
	1=	Private			
	2=	Public			
	3=	State trace			
	4=	Other			
	=	NR			
50	1.24	Type of surface	77	1	N
	1=	Gravel			
	2=	Pitch			
	3=	Non-paved			
	4=	Other			
	=	NR			

51	1.24	Road condition	78	1	N
	1=	Good			
	2=	Fair			
	3=	Poor			
	=	NR			
52	1.25	Source of water supply	79	2	N
	01=	Rain			
	02=	Spring catchment			
	03=	Private pipe			
	04=	Pond			
	05=	Public standpipe			
	06=	River			
	07=	Truck borne			
	08=	Other			
	09=				
	10=				
	11=				
	12=				
	13=				
	14=				
	15=				
53	2.1	What system of dairy feeding you use	81	1	N
	1=	Pasture only			
	2=	Pasture/Concent.			
	3=	Concent. Only			
	4=	Cut & Carry			
	=	NR			
54	2.2	Acres currently under pasture	82	2	N
55	2.3	Pangola (acreage)	84	4	N
56	2.3	Guatemala (acreage)	88	4	N
57	2.3	Paragrass (acreage)	92	4	N
58	2.3	Tanna (acreage)	96	4	N
59	2.3	Other (acreage)	100	4	N
60	2.4	Pangola (acreage)	104	4	N
61	2.4	Guatemala (acreage)	108	4	N
62	2.4	Paragrass (acreage)	112	4	N
63	2.4	Elephant (acreage)	116	4	N
64	2.4	Tanna (acreage)	120	4	N
65	2.4	Other (acreage)	124	4	N

66	2.5	Is your pasture fenced	128	1	A
	y=	Yes			
	n=	No			
	=	NR			
67	2.5	Type of fencing material used	129	1	N
	1=	Post & barb wire			
	2=	Post & square mesh			
	3=	Post & chain-link			
	4=	Brick wall			
	5=	Other			
	6=				
	7=				
	8=				
	9=				
68	2.7	Experience problems in obtaining material	130	1	A
	y=	Yes			
	n=	No			
	=	NR			
69	2.8	Give details of problems experienced	131	1	N
	1=				
	2=				
	3=				
	4=				
	5=				
	6=				
	7=				
	8=				
	9=				
	0=				
	=	NR			
70	2.9	Major constraints to inc. pasture pr	132	1	N
	1=				
	2=				
	3=				
	4=				
	5=				
	6=				
	7=				
	8=				
	9=				
	0=				
	=	NR			

71	2.10	Incentive to increase your pasture	133	1	N
	1=				
	2=				
	3=				
	4=				
	5=				
	6=				
	7=				
	8=				
	9=				
	0=				
	=	NR			
72	2.11	Fencing material (total cost)	134	4	N
73	2.11	Fertilizer (total cost)	138	4	N
74	2.11	Ploughing (total cost)	142	4	N
75	2.11	Seeding (total cost)	150	4	N
76	2.11	Weed control (total cost)	154	4	N
77	2.11	Other (total cost)	158	4	N
78	2.12	Fencing (total labour cost)	162	4	N
79	2.12	Fertilizer (total labour cost)	166	4	N
80	2.12	Ploughing (total labour cost)	170	4	N
81	2.12	Seeding (total labour cost)	174	4	N
82	2.12	Weed control (total labour cost)	178	4	N
83	2.12	Other (total labour cost)	182	4	N
84	3.1	# of milk cows	186	2	N
85	3.1	# of dry cows	188	2	N
86	3.1	# of pregnant cows	190	2	N
87	3.1	# of heifers	192	2	N
88	3.1	# of calves	198	1	N
89	3.1	# of bulls	196	2	N
90	3.2	Used veterinary services in this yr.	198	1	A
	y=	Yes			
	n=	No			
	=	NR			
91	3.3	Cost of service	199	3	N
92	3.3	Cost of medicines	202	4	N
93	3.4	Dairy ration (total cost)	206	5	N

94	3.4	Other concentrate feed (total cost)	211	5	N
95	3.4	Molasses (total cost)	216	3	N
96	3.4	Urea (total cost)	219	3	N
97	3.4	Salt block (total cost)	222	3	N
98	3.4	Vitamins & minerals (total cost)	225	4	N
99	3.4	Chains/rope (total cost)	229	3	N
100	3.4	Brewers' grain (total cost)	232	4	N
101	3.4	Other (total cost)	236	4	N
102	4.0	Chains/rope (total cost)			

Dairy Codebook #2

Number	Ques. #	Text	Column	Length	Character
1		Questionnaire #	1	3	N
2	3.5	Bulls purchased	4	1	N
3	3.5	Milking cows purchased	5	3	N
4	3.5	Heifers purchased	7	2	N
5	3.5	Calves purchased	9	2	N
6	3.5	Bulls (total cost)	11	4	N
7	3.5	Milking cows (total cost)	15	4	N
8	3.5	Heifers (total cost)	19	4	N
9	3.5	Calves (total cost)	23	4	N
10	3.6	Vehicles (total cost)	27	6	N
11	3.6	Milking machine (total cost)	33	5	N
12	3.6	Freezer (total cost)	38	5	N
13	3.6	Water pump (total cost)	43	5	N
14	3.6	Other (total cost)	48	6	N
15	3.7	Tractor (total cost)	54	5	N
16	3.7	Vehicle (total cost)	59	5	N
17	3.7	Other (total cost)	64	5	N
18	3.8	Land & building taxes	69	4	N
19	3.8	Land rent	73	4	N
20	3.8	Water rates	77	4	N
21	3.8	Electricity rates	81	4	N
22	3.8	Telephone rates	85	4	N
23	3.8	Fuel/lubricants	89	5	N
24	3.8	Vehicle licenses	94	4	N
25	3.8	Repairs to buildings	98	6	N
26	3.8	Repairs to vehicles	104	4	N
27	3.8	Repairs/maintenance of quipment	108	4	N
28	3.8	Insurance of building	112	4	N
29	3.8	Insurance of livestock	116	4	N
30	3.8	Insurance of vehicles	120	4	N

31	3.8	Tools	124	4	N
32	3.8	Other	128	4	N
33	3.9	Self (# days/week)	132	1	N
34	3.9	Self (# hours/week)	133	2	N
35	3.9	Spouse (# days/week)	135	1	N
36	3.9	Spouse (# hours/week)	136	2	N
37	3.9	Sons (number)	138	2	N
38	3.9	Son (# days/week)	140	1	N
39	3.9	Son (# hours/week)	141	2	N
40	3.9	Daughters (number)	143	2	N
41	3.9	Daughter (# days/week)	145	1	N
42	3.9	Daughter (# hours/week)	146	2	N
43	3.9	Other relatives (number)	148	2	N
44	3.9	Other relatives (# days/week)	150	1	N
45	3.9	Other relatives (# hours/week)	151	2	N
46	3.10	Hired labour (January) Males	153	4	N
47	3.10	Hired labour (January) Females	157	4	N
48	3.10	Hired labour (January) Youth	161	4	N
49	3.11	Hired labour (February) Males	165	4	N
50	3.11	Hired labour (February) Females	169	4	N
51	3.11	Hired labour (February) Youth	173	4	N
52	3.12	Hired labour (March) Males	177	4	N
53	3.12	Hired labour (March) Females	181	4	N
54	3.12	Hired labour (March) Youth	185	4	N
55	3.13	Hired labour (April) Males	189	4	N
56	3.13	Hired labour (April) Females	193	4	N
57	3.13	Hired labour (April) Youth	197	4	N
58	3.14 h= m= b= =	What type of milking system.... Hand Machine Both NR	201	1	A
59	3.15	How often do you milk your cows/day	202	1	N

60	3.16	Average yield cow/day (litres)	203	2	N

Dairy Codebook #3

Number	Ques #	Text	Column	Length	Character
1		Questionnaire #	1	3	N
2	4.1	Milk - amount sold (January)	4	5	N
3	4.1 1= 2= 3= 4=	Milk - to whom sold (January) Nestle	9	1	A
4	4.1	Milk - value (January)	10	5	N
5	4.1	Milk - amt. consumed (January)	15	3	N
6	4.1	Calves - amount sold (January)	18	2	N
7	4.1 1= 2= 3= 4=	Calves - to whom sold (January)	20	1	A
8	4.1	Calves - value (January)	21	4	N
9	4.1	Calves - amt. consumed (January)	25	3	N
10	4.1	Heifers - amount sold (January)	28	2	N
11	4.1 1= 2= 3= 4=	Heifers - to whom sold (January)	30	1	A
12	4.1	Heifers - value (January)	31	4	N
13	4.1	Heifers - amt. consumed (January)	35	3	N
14	4.1	Culled cows - amount sold (January)	38	2	N
15	4.1 1= 2= 3= 4=	Culled cows - to whom sold (January)	40	1	A
16	4.1	Culled cows - value (January)	41	4	N
17	4.1	Culled cows - amt. consumed (January)	45	3	N
18	4.1	Bulls - amount sold (January)	48	2	N

19	4.1 1= 2= 3= 4=	Bulls - to whom sold (January)	50	1	A
20	4.1	Bulls - value (January)	51	4	N
21	4.1	Bulls - amt. consumed (January)	55	3	N
22	4.1	Manure - amount sold (January)	58	5	N
23	4.1 1= 2= 3= 4=	Manure - to whom sold (January)	63	1	N
24	4.1	Manure - value (January)	64	4	N
25	4.1	Manure - amt. consumed (January)	68	3	N
26	4.2	Milk - amount sold (February)	71	5	N
27	4.2 1= 2= 3= 4=	Milk - to whom sold (February) Nestle	76	1	A
28	4.2	Milk - value (February)	77	4	N
29	4.2	Milk - amt. consumed (February)	81	3	N
30	4.2	Calves - amount sold (February)	84	2	N
31	4.2 1= 2= 3= 4=	Calves - to whom sold (February)	86	1	A
32	4.2	Calves - value (February)	87	4	N
33	4.2	Calves - amt. consumed (February)	91	3	N
34	4.2	Heifers - amount sold (February)	94	5	N
35	4.2 1= 2= 3= 4=	Heifers - to whom sold (February)	99	1	A
36	4.2	Heifers - value (February)	100	4	N
37	4.2	Heifers - amt. consumed (February)	104	3	N

38	4.2	Culled cows - amount sold (February)	107	2	N
39	4.2 1= 2= 3= 4=	Culled cows - to whom sold (February)	109	1	A
40	4.2	Culled cows - value (February)	110	4	N
41	4.2	Culled cows - amt. consumed (February)	114	3	N
42	4.2	Bulls - amount sold (February)	117	2	N
43	4.2 1= 2= 3= 4=	Bulls - to whom sold (February)	119	1	A
44	4.2	Bulls - value (February)	120	4	N
45	4.2	Bulls - amt. consumed (February)	124	3	N
46	4.2	Manure - amount sold (February)	127	5	N
47	4.2 1= 2= 3= 4=	Manure - to whom sold (February)	132	1	A
48	4.2	Manure - value (February)	133	4	N
49	4.2	Manure - amt. consumed (February)	137	3	N
50	4.3	Milk - amount sold (March)	140	5	N
51	4.3 1= 2= 3= 4=	Milk - to whom sold (March) Nestle	145	1	A
52	4.3	Milk - value (March)	146	4	N
53	4.3	Milk - amt. consumed (March)	150	3	N
54	4.3	Calves - amount sold (March)	153	2	N
55	4.3 1= 2= 3= 4=	Calves - to whom sold (March)	155	1	A

56	4.3	Calves - value (March)	156	4	N
57	4.3	Calves - amt. consumed (March)	160	3	N
58	4.3	Heifers - amount sold (March)	163	2	N
59	4.3 1= 2= 3= 4=	Heifers - to whom sold (March)	165	1	A
60	4.3	Heifers - value (March)	166	4	N
61	4.3	Heifers - amt. consumed (March)	170	3	N
62	4.3	Culled cows - amount sold (March)	173	2	N
63	4.3 1= 2= 3= 4=	Culled cows - to whom sold (March)	175	1	A
64	4.3	Culled cows - value (March)	176	4	N
65	4.3	Culled cows - amt. consumed (March)	180	3	N
66	4.3	Bulls - amount sold (March)	183	2	N
67	4.3 1= 2= 3= 4=	Bulls - to whom sold (March)	185	1	A
68	4.3	Bulls - value (March)	186	4	N
69	4.3	Bulls - amt. consumed (March)	190	3	N
70	4.3	Manure - amount sold (March)	193	5	N
71	4.3 1= 2= 3= 4=	Manure - to whom sold (March)	198	1	A
72	4.3	Manure - value (March)	199	4	N
73	4.3	Manure - amt. consumed (March)	203	3	N

Dairy Codebook #4

Number	Ques #	Text	Column	Length	Character
1		Questionnaire #	1	3	N
2	4.4	Milk - amount sold (April)	4	5	N
3	4.4 1= 2= 3= 4=	Milk - to whom sold (April) Nestle	9	1	N
4	4.4	Milk - value (April)	10	4	N
5	4.4	Milk - amt. consumed (April)	14	3	N
6	4.4	Calves - amount sold (April)	17	2	N
7	4.4 1= 2= 3= 4=	Calves - to whom sold (April)	19	1	A
8	4.4	Calves - value (April)	20	4	N
9	4.4	Calves - amt. consumed (April)	24	3	N
10	4.4	Heifers - amount sold (April)	27	2	N
11	4.4 1= 2= 3= 4=	Heifers - to whom sold (April)	29	1	N
12	4.4	Heifers - value (April)	30	4	N
13	4.4	Heifers - amt. consumed (April)	34	3	N
14	4.4	Culled cows - amount sold (April)	37	2	N
15	4.4 1= 2= 3= 4=	Culled cows - to whom sold (April)	39	1	A
16	4.4	Culled cows - value (April)	40	4	N
17	4.4	Culled cows - amt. consumed (April)	44	3	N
18	4.4	Bulls - amount sold (April)	47	2	N

19	4.4 1= 2= 3= 4=	Bulls - to whom sold (April)	49	1	A
20	4.4	Bulls - value (April)	50	4	N
21	4.4	Bulls - amt. consumed (April)	54	3	N
22	4.4	Manure - amount sold (April)	57	5	N
23	4.4 1= 2= 3= 4=	Manure - to whom sold (April)	62	1	A
24	4.4	Manure - value (April)	63	4	N
25	4.4	Manure - amt. consumed (April)	67	3	N
26	4.5 y= n= =	Are you satisfied with MILK price? Yes No NR	70	1	A
27	4.5 y= n= =	Are you satisfied with ANIMALS price? Yes No NR	71	1	A
28	4.6 01= 02= 03= 04=	Please explain reason for dissat.... Unprofitable Inputs too expensive Prices not satisfactory 2&3	72	2	N
29	4.7 y= n= =	Receive subsidy payments for milk? Yes No NR	74	1	A
30	4.8	What is the value of this payment?	75	4	N
31	4.9 y= n= =	Are there problems associated with..	79	1	A

32	4.10 01= 02= 03= 04=	Please indicate the nature of problem.	80	2	N
33	4.11 01= 02= 03= 04= 05= 06= 07= 08= 09= 10= 11=	Best way to solve these problems.	82	2	N
34	4.13 01= 02= 03= 04=	If so, what are these problems.	85	2	N
35	5.1 1= 2= 3= 4= =	Where do you obtain info on dairying? Ext. Officer Farming stores Other farmers Other NR	87	1	N
36	5.2 y= n= =	Is the info you received adequate? Yes No NR	88	1	A
37	5.3 01= 02= 03= 04= 05= 06= 07= 08=	If not, what do you require.	89	2	N

38	5.4	How do you obtain funds.......	91	2	N
	01=				
	02=				
	03=				
	04=				
	05=				
	06=				
	07=				
	08=				
	09=				
	10=				
39	5.5	Do you have difficulty obtaining....	93	1	A
	y=	Yes			
	n=	No			
	=	NR			
40	5.6	Do you keep farm records?	94	1	A
	y=	Yes			
	n=	No			
	=	NR			
41	5.7	(If no) Why is this so.	95	2	N
	01=				
	02=				
	03=				
	04=				
	05=				
	06=				
	07=				
	08=				
	09=				
	10=				
42	5.8	Main problems you face....	97	2	N
	01=				
	02=				
	03=				
	04=				
	05=				
	06=				
	07=				
	08=				
	09=				
	10=				

43	5.9	Best feature of dairy industry...	99	2	N
	01=				
	02=				
	03=				
	04=				
	05=				
	06=				
	07=				
	08=				
	09=				
	10=				
44	5.10	Do you intend to continue	101	1	A
	y=	producing?			
	n=	Yes			
	=	No			
		NR			
45	5.11	Why?	102	2	N
	01=				
	02=				
	03=				
	04=				
	05=				
	06=				
	07=				
	08=				
	09=				
	10=				
46	5.12	Cause increase in herd/milk	104	2	N
	01=	production.			
	02=				
	03=				
	04=				
	05=				
	06=				
	07=				
	08=				
	09=				
	10=				

47	5.13	Reduce from 1.00 to .50, effect.	106	2	N
	01=				
	02=				
	03=				
	04=				
	05=				
	06=				
	07=				
	08=				
	09=				
	10=				
48	5.14	If the subsidy on milk is	108	2	N
	01=	removed....			
	02=				
	03=				
	04=				
	05=				
	06=				
	07=				
	08=				
	09=				
	10=				
49	5.15	Other places to sell milk......	110	1	A
	y=	Yes			
	n=	No			
	=	NR			
50	5.16	If yes, what are these other	111	2	N
	01=	markets.			
	02=				
	03=				
	04=				
	05=				
	06=				
	07=				
	08=				
	09=				
	10=				
51		State land farmer or private	113	1	A
	s=	farmer?			
	p=	State			
		Private			