The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

RURAL ECONOMY

An Economic Analysis of Productive Efficiency in Alberta Dairy Production

Scott R. Jeffrey and Heather-Anne R. Grant

Project Report #01-02
AARI Project #97M090

PROJECT REPORT

Department of Rural Economy
Faculty of Agriculture, Forestry
and Home Economics
University of Alberta
Edmonton, Canada

An Economic Analysis of Productive Efficiency in Alberta Dairy Production

Scott R. Jeffrey and Heather-Anne R. Grant

Project Report #01-02
AARI Project #97M090

The authors are, respectively, Associate Professor and Graduate Student, Department of Rural Economy, University of Alberta, Edmonton, Alberta.

Copyright 2001 by S. Jeffrey and H. Grant. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

TABLE OF CONTENTS

LIST OF TABLES

ACKNOWLEDGMENTS

This project report is based on the M.Sc. thesis research of Heather-Anne Grant. The authors gratefully acknowledge the financial support of Alberta Agricultural Research Institute and Alberta Milk Producers. Thanks also go to Carlyle Ross, Terry Appleby and Dale Kaliel from Alberta Agriculture for their assistance with data. Useful information and insights were provided by Michele Veeman, John Feddes, Brian Cameron and Jim Unterschultz.

ABSTRACT

The World Trade Organization is currently formulating an agenda for a new round of global trade negotiations. Therefore, the likelihood of increased competition within Canada's supply managed dairy industry is probable. Consequently, there is agreater need for producers to be concerned with efficiency and with their competitiveness in the international marketplace. This study assessed the cost efficiency and competitiveness of Alberta dairy producers by estimating the economic costs associated with milk production, and deriving the physical and economic efficiency of producers. Results support the presence of economies of size and economies of yield within Alberta milk production. A link between increased herd size, labour productivity, and lower total labour costs was identified in the analysis.

1. INTRODUCTION

1.1 Problem Setting

Marketing and pricing of milk for Canada's dairy industry is governed by a system of supply management. This method of orderly marketing dates from the 1940's, but was formally introduced at the national level in the early 1970's as an attempt by the federal government to combat mounting stocks of dairy products and potential falls in prices. Since its inception, an intense dispute over the effectiveness of supply management as a policy approach has occurred in Canada. However, while a debate of market failure versus rent seeking has occurred domestically, future pressures on Canada's dairy industry can be expected to arise from the globalization of agricultural markets.

One fundamental component of Canada's existing supply management system has been its reliance on import controls for foreign dairy products. Complying with the General Agreement on Tariffs and Trade (GATT) rulings on agriculture, formulated in the Uruguay Round, Canada's dairy sector was obligated to convert previous import quotas to tariff equivalents in the mid-1990's. Canada committed to making specified reductions in these tariffs during the implementation. A pressing challenge for the industry lies in the fact that the current system of supply management, which is based on domestic and import control, would be untenable in an open market.

Jeffrey (1992) summarizes the concerns of many producers rooted in the idea of a Canadian dairy sector with a substantial reduction or a complete elimination of import controls:

> It is reasoned that either or both of these changes will result in less stable and lower farm-level milk prices, as well as increased competition from US producers. The US dairy sector is much larger than the Canadian sector and it is perceived that US producers enjoy a comparative advantage in milk production. Once domestic policies are removed, Canadian producers might not be able to effectively compete and many of these producers will therefore be forced out of business (p.1).

Over the past three decades, the structure of the Alberta dairy sector has changed substantially. Specifically, the total number of dairy farms in the province has decreased, while at the same time, herd sizes and average production levels per cow have increased. According to Statistics Canada (1996), between 1981 and 1996 the total number of dairy operations in Alberta fell 68 percent from 8,827 to 2,822. Ross et al (1998) state that provincial milk production per farm increased twelvefold from 16,952 litres in 1961 to 210,698 litres in 1996. Kotowich et al (1998) report that the average Alberta dairy farm milked 83 cows in 1998. Alterations to Canada's supply management system, in the form of reduced tariffs on dairy imports, may reinforce these trends.

1.2 Problem Statement

With the World Trade Organization (WTO) currently formulating an agenda for a new round of global trade negotiations, the likelihood of increased competition in the Canadian dairy industry is probable. Changes in Canada's supply management system would undoubtedly have implications at the farm level. Consequently, there may be a greater need for producers to be concerned with their *competitiveness*. However, there is a lack of information in this area. How competitive are Alberta dairy producers? What management factors contribute to increased competitiveness, however that is defined?

There is a general belief that economies of size exist in dairy production, although the extent to which these are realized is likely affected by domestic dairy policy. If size is defined as total milk production, economies of size can be viewed as having two parts; herd size economies and milk yield economies. Increased "size" may be one means by which Alberta dairy producers may maintain or improve their competitiveness. However, to what degree do these economies exist in Alberta dairy production, and how important are they in relative terms? These questions provide the focus for the analysis to be conducted in this study.

1.3 Study Objective

The objective of this research is to assess the cost competitiveness of Alberta dairy producers. Specifically, this study investigates the nature of dairy costs of production in Alberta. It is hypothesized that economies of herd size and economies of milk yield exist in Alberta milk production. Management factors contributing to these economies are examined. Finally, the level of physical and economic efficiency of Alberta dairy producers is evaluated.

1.4 Study Outline

The remainder of this study is organized into five sections. Chapter 2 presents a critical analysis of the concept of farm competitiveness. Chapter 3 contains a review of pertinent literature relating to the competitiveness of dairy producers in an open marketplace. Chapter 4 describes the data and methodology utilized in the study. The results of the analysis are presented and discussed in Chapter 5. Chapter 6 outlines the conclusions and gives suggestions for further research.

2. DEFINING COMPETITIVENESS

Defining competitiveness at the firm level creates a benchmark for comparing the success of Alberta's dairy producers in an open market economy while examining the impact of various farm characteristics and management techniques. According to West (1993), a problem with applying the concept of competitiveness is that no specific economic criteria to measure the competitiveness of business have been established. As stated by Coffin et al (1993), "the term competitiveness has come to mean many things to many people" (p.460). This chapter discusses various interpretations of a globally competitive position in order to derive a working definition of competitiveness for this study.

2.1 Absolute Advantage

Early economists explained patterns of trade through the principle of absolute advantage. In application of this theory, exports came from the country whose production costs for a particular good were lower than other countries, at prevailing prices and exchange rates (Houck, 1992). However, as stated by Houck (1992), the logic of absolute advantage fails when it is applied to industries and to nations. Realistically, due to the recognition of available resources and consumer demands, a country could never be an "absolute" exporter, importing zero products.

2.2 Comparative Advantage

As opposed to looking at the absolute costs of individual products, David Ricardo in 1817 considered the costs of producing additional units of a particular product in terms of the reduction necessary in the output of other goods (Houck, 1992). In short, the opportunity cost of a domestic commodity is compared to its given international price. A nation will specialize in the industries having the lowest opportunity cost associated with production or whose domestic cost of production is less than comparable international prices.

Houck (1992) identifies domestic specialization as the main catalyst for absolute free trade: "specialization according to comparative advantage permits a nation to produce more export goods than it wants, then trade them for less costly imported goods from all over the world," (p.16). From this, a greater variety of products at cheaper prices are available to consumers and peoples' purchasing power increases. Domestic industries producing commodities with high opportunity costs disappear as markets are lost to imports, and national resources and investment move out of high cost production and into expanding sectors (Houck, 1992). It may be demonstrated that trade through comparative advantage ensures the most efficient allocation of an economy's resources.

The term *competitive* advantage is often used as being somewhat synonymous to comparative advantage. However, according to Barichello et al (1996), "competitive advantage is a more political than economic concept; an industry can have a trading advantage because of subsidies, tax breaks, trade protection or other forms of intervention," (p.98). Barichello et al (1996) contend that in order to determine which nation will produce and export under free trade, a measure of comparative advantage as opposed to competitive advantage is required. Thus, an alternative approach must be used to arrive at a definition of competitiveness that is appropriate for Alberta dairy farms.

2.3 A Strategic Management Definition of Competitiveness

West (1987), Hazeldine and Freeley (1991) and Coffin et al (1993) define farm-level competitiveness as the ability to earn profits and maintain market shares. Profitability and market share prove to be the most commonly employed measures of competitiveness at the firm level. However, West (1993) warns that both indicators are influenced by government domestic and trade policies and thus distort a firm's actual competitive ranking. West (1993) provides an example: ". . . a market share maintained by import controls does not reflect fundamental competitiveness nor do small export shares due to a lack of access to foreign markets indicate a lack of competitiveness" (p.7).

One approach to compensate for this distortion is found in a competitiveness framework developed by Martin et al (1991). This framework categorizes factors of competitiveness by the degree to which firms and governments control them. According to West (1993), a firm can control, to at least some degree, its strategy, products, technology, training, research and development, cost and linkages. The government controls the business' operating environment by influencing taxes, interest rates and exchange rates. To assess the "fundamental" competitiveness of a firm affected by government subsidies, West (1993) contends that the examination of trends in the determinants of competitiveness is imperative.

2.3.1 Determinants of Competitiveness

Porter (1990) recognizes six determinants of competitiveness. These determinants, as a system or individually, " . . . shape the environment in which local firms compete that promote or impede the creation of competitive advantage," (p.71). Each is outlined below:

(1) Factor Conditions

According to West (1993), the continual upgrading of a firm's factors of production is a necessity for sustained competitiveness. Porter (1990) identifies natural resources, climate, location, unskilled labour and debt capital as "basic factors" and in contrast, deems communications infrastructure, highly trained personnel and research activities as "advanced factors." Porter (1990) argues that, outside of extractive and agriculturally based industries, basic factors of production are becoming less crucial in influencing competitiveness due to the fact that they are increasingly more accessible in global markets at cheaper prices. Advanced factors are critical for obtaining a competitive edge as they are more scarce than basic factors and more difficult to trade between nations.

(2) Demand Conditions

The composition, size and growth rate of domestic demand has an impact on a firm's competitive position. Porter (1990) states that the composition of domestic demand and pressures from domestic buyers force local firms to be innovative and responsive to consumer needs. The faster and more accurately a firm can adjust in response to changes in the domestic market, the greater its projected advantage on a global level. With respect to the size of domestic demand, Porter (1990) contends that a large and rapidly growing home market facilitates a competitive advantage by encouraging aggressive investment in technology development and productivity improvements. According to West (1993), a small home market or slow growth rate pressures domestic firms to seek export opportunities.

(3) Related and Supporting Industries
As described by Porter (1990), the coordination of related and supporting industries establishes a "value system" for a firm. This value system provides the affiliated firm with efficient, fast and preferential access to cost-effective inputs and innovative production techniques. West (1993) reports that both domestic and international suppliers may comprise a given value system and contribute to activities such as technology development, manufacturing, distribution, marketing and service. Domestic suppliers promote the close working relationships required for process innovation and upgrading. Inputs having little impact on innovation or on product performance are obtained from international sources (West, 1993).

(4) Sector Strategy, Structure and Rivalry
The structure and goals of a national industry govern the operations of the individual firms comprising it. More specifically, West (1993) states that economies of size, the nature of competition among firms, vertical and horizontal linkages, and a firm's exposure to world markets are all dictated by a sector's organization. According to Porter (1990), the rivalry among domestic firms that grows within a particular business environment forces firms to improve and innovate, ". . . to lower costs, improve quality and service, and create new products and processes" (p.118).

(5) The Role of Chance
Chance events are happenings beyond the control of a firm and are often unrelated to a nation's situation. Porter (1990) identifies the role of chance as a key determinant of competitiveness because unexpected occurrences " . . . create discontinuities that allow shifts in competitive position" (p.124). Examples provided by West (1993) of chance events specific to agricultural firms include: political decisions, wars, major changes in consumer preference, the development of new transportation and handling systems, outbreaks of disease, and the weather.

(6) The Role of Government
According to Porter (1990) the actions of a national government should not be recognized as a determinant of individual competitiveness, but observed in terms

of its impact on the previous five determinants. Subsidies, policies and regulations implemented by a government can have both positive and negative effects on the competitiveness of a firm (West, 1993). Porter (1990) argues that government "help" will fail if it removes the pressures on firms to improve and upgrade or if it is the only source of a firm's competitive advantage.

Coffin et al (1993) include costs of production as a seventh determinant of competitiveness. West (1993) states that production costs are a key determinant of competitiveness for homogeneous products with many suppliers. The competitive ranking of a firm can be identified by comparing prices paid for major inputs and observing how they change over time. Incorporating the dimension of time is important when examining a firm's competitiveness: ". . . meaningful measurement of competitiveness must reflect an ability to contend over time with changes in the operating environment which drive rivalry. . . . ," (Coffin et al, 1993; p.462).

For an individual firm the challenge is to choose the optimal approach to competing, given its specific business environment. This environment is to a large extent determined by the described determinants of competitiveness. According to Porter (1985), a firm's competitive ranking is born out of the " . . . value a firm is able to create for its buyers that exceeds the firm's cost of creating it," (p.3). Porter (1990) describes this value as a firm's chosen position within its industry or its competitive strategy.

2.3.2 Competitive Strategy

By choosing a position the firm is indicating its 'approach to competing.' Porter (1990) reveals two competitive strategies a firm may choose from: (1) lower cost; and (2) product differentiation.

> Lower cost is the ability of a firm to design, produce and market a comparable product more efficiently than its competitors. At the prices at or near competitors, lower cost translates into superior returns . . . . Differentiation is the ability to provide unique and superior value to the buyer in terms of product quality, special features or after-sale service. . . . Differentiation allows a firm to command a premium price, which leads to superior profitability provided costs are comparable to those of competitors (p. 37).

Porter (1990) states that it is difficult, but possible for a firm to gain a competitive advantage through both a low cost and differentiated product strategy. The difficulty arises from the fact that a differentiated product, in a majority of cases, has higher production costs as it possesses increased quality and performance. It is suggested that, in the long run, increasing firm technology can simultaneously reduce costs and improve the product.

A third competitive strategy introduced by Porter (1990) is competitive scope, or as identified by Coffin et al (1993), focusing on a niche market. Porter (1990) stresses that no one strategy is necessarily better than the other. A firm's chosen position reflects its individual structure, resource base and goals. The success of one's implemented competitive strategy is dependent upon the way the firm organizes and coordinates its discrete activities through distinguishing management techniques (Porter, 1990).

2.4 A Working Definition of Competitiveness

The strategic management approach described in the previous section can be used to develop a working definition of competitiveness for Alberta dairy farms. With the high degree of government involvement in Canada's dairy industry, determining the fundamental competitiveness of dairy farmers requires the analysis of trends in the determinants of competitiveness. Because of a) the uniform marketing of milk by dairy producers, resultant of Canada's supply management system, b) the homogeneity of milk production at the farm level, and c) the inelastic nature of domestic milk demand, the most appropriate determinant to evaluate is cost of production. Thus, the working definition of competitiveness employed by this study is based on the cost competitiveness of Alberta dairy producers. Specifically, the dairy farm or group of dairy farms achieving the lowest per unit cost of production is identified as being the most competitive.

3. LITERATURE REVIEW

A significant amount of research has been conducted that examines the cost competitiveness of Canada's milk producers. These have been largely cost of production (COP) studies. A critical analysis of various methods utilized and the results of these studies is presented in this chapter.

3.1 Constructing a Cost of Production Analysis

Barichello and Stennes (1994) state that for most empirical examinations of business cost competitiveness, costs of production in competitive sectors can in the long run be expected to equal the average market price received. However, this is not true for Alberta's supply managed dairy industry, due to the use of marketing quotas. According to Barichello and Stennes (1994), the average market price of milk in the long run can be expected to equal the sum of annual farm production costs plus the annual cost of holding quota. The authors thus conclude that the appropriate method of obtaining dairy cost of production data for analysis at the farm level is to estimate and aggregate each cost component directly.

3.1.1 Empirical Issues in Using Cost of Production Data

Much controversy exists over the use of cost of production data in analysis, especially when the objective is to conduct interregional comparisons. Stanton (1986) presents the following outline of issues provoking argument among researchers (p.5):

(1) the representativeness of the data and the situations for which costs were presented and the sampling procedures used in collecting data;

(2) the comparability of the enterprises or systems being studied, including climate, quality differences in the final products, size of enterprise, etc.;

(3) the choice of appropriate currency exchange rates to use in making national comparisons;

(4) a procedure to handle different rates of inflation within individual countries and the choice of appropriate deflators;

(5) agreement on the list of items which are treated as direct and variable costs;

(6) the time period over which production costs are calculated;

(7) the treatment of fixed costs and their relative importance in making comparisons;

(8) mechanisms to recognize government subsidies or special programs which influence prices and costs; and

(9) the economic environment in which production occurred.

Barichello and Stennes (1994) agree that within economic research there is an undeniable frustration with COP studies: “Cost of production estimates from sampled farm data will incorporate both inaccuracies and biases which under some circumstances will be significant. Indeed, some would argue that the exercise of calculating farm costs of production is significantly full of pitfalls that it should not be attempted” (p.3).

To minimize the difficulties inherent in cost analysis, Barichello and Stennes (1994) suggest that researchers should carefully define the nature of the costs. For example, the researcher must indicate whether feed is valued at average annual market prices or at the on-farm cost of production.[1] To alleviate some of the concerns associated with COP analysis, Barichello and Stennes (1994), and Stanton (1986) recommend the pricing of inputs at their supply price or opportunity cost. If on-farm intermediate inputs are used, Barichello and Stennes (1994) state that, depending upon which is lower, a cost reflecting alternative sources of supplying the input or the cost of keeping the required home-produced inputs on the farm should be utilized.

In order to validate the credibility of COP comparisons across nations, components must be expressed in units of a single domestic currency. The chosen currency is typically that of the country whose economic trade performance is of concern. Houck (1992) adds that one may use the major currency in which international assets are held, or alternatively, the currency in which world prices of the commodity in question are normally quoted.

Stanton (1986) emphasizes that when conducting a COP study over a period of several years, changes in the rate of inflation must be taken into consideration. Stanton (1986) notes a debate over which is the correct set of index numbers to use in cost analysis. Some argue that price deflators of GDP or GNP are the most appropriate as they are the most basic indicators of price movements. Others contend that using a series based on prices paid by farmers is accurate. Stanton (1986) discourages the latter, claiming that a majority of agricultural economists view this procedure as inappropriate due to the fact that a number of the items included in the index are also components of the cost of production series being studied.

Finally, in order to further improve the status of COP studies, Barichello and Stennes (1994) suggest that economic rents should be excluded from any analysis as

---

[1] For further details on calculating individual cost components see Barichello and Stennes (1994).

these are not costs. In an example, the authors define the return to management as an economic rent that is available to better managers, and is therefore not a component to be calculated in a COP analysis. A second example would be the economic rent associated with production quota and the capitalization of the quota into the farm's fixed assets.

3.1.2 Impediments in Using Farm-Level Dairy Cost Data

Barichello and Stennes (1994) point out that following the guiding principle of opportunity cost and adopting the stated suggestions in dealing with cost data will not necessarily produce a flawless depiction of dairy cost competitiveness. This is because the use of farm level data typically leads to overstated cost estimates. Barichello and Stennes (1994) report six reasons for this result, each of which is summarized below.

First, most farm-level data are collected for the purpose of determining milk prices. Specifically, this provides an incentive for producers to provide cost estimates that are biased upwards.

Second, costs are often recorded for tax purposes as opposed to reasons related to management decisions. This is particularly true for smaller dairy operations. The net result is an error in cost calculations, as there are differences in both the amounts and types of costs reported for taxes versus "true" enterprise costs.[2]

Third, segments of primary farm production often have a significant percentage of total variable inputs as value-added activities; that is, non-purchased raw materials. As a result, quantification and valuation of farmer-owned inputs is required. This involves a procedure that is subject to considerable error, when compared to the valuation of purchased inputs.

Fourth, prices for farmer-owned inputs, predominately the supply of operator labour, will vary across farm enterprises. Barichello and Stennes (1994) credit regional differences, alternative skills of farm operators or varying degrees of a farmer's preference for working in agriculture as contributors to this variation. The authors expand on this point, recognizing that the problem is at its greatest among small farms:

> Labour costs are dominant on those farms, and they remain competitive by virtue of their low (i.e., family) labour costs . . . the only means for such farms to avoid making losses at current prices is for family labour to be valued at low wage rates. . . . Therefore, it is not surprising that the cost

---

2 An example of this is the use of Capital Cost Allowance (CCA) as a proxy for depreciation.

> data above, valuing all labour at the hired wage (family labour at 66% of hired labour), places small farms at unit costs levels which are not only the highest of all farm categories, but significantly above unit prices they receive, an impossibility in anything but the shortest of time periods (p.5).

Fifth, valuing farm machinery, equipment and buildings at new prices when calculating depreciation will result in exaggerated depreciation values. Barichello and Stennes (1994) explain that an inventory of all new capital is not typical of the average farm.

The final difficulty in dealing with farm data is that average farm costs are used instead of long run marginal costs of the operation. Barichello and Stennes (1994) state:

> Under any policy change the relevant costs for industry change are those of the farms which are staying in the industry, those responding by changing production levels or those entering the industry- farms active at the margin of production. However, in addition to such farms, there are a number which, for reason of operator age, small size, outdated management or technical skills, or other cause of high costs and lower production, are most likely to exit . . . . (p.5).

Because relatively uncompetitive dairy farms may be included in average cost data, the overall data is given an upward bias. It is suggested that grouping of operations according to size or net farm income would aid in correcting this problem.

Despite these six difficulties, which are unavoidable when using farm cost data, Barichello and Stennes (1994) maintain the usefulness of cost analysis in bench-marking the competitiveness of milk production. They defend this method, acknowledging costs to be more commonly exaggerated among small farms and small regions and that the stated problems will be "experienced in all areas or times periods" (p.4).

3.1.3 Related Studies

In their 1994 study of the cost competitiveness for the Canadian dairy industry, Barichello and Stennes derived costs of production for producers in Quebec, Ontario, Alberta, Wisconsin, New York and California. The researchers found variable costs to comprise the greatest portion of total costs (62 percent) incurred by Alberta dairy farms. Variable cost per hectolitre in Alberta was significantly higher than those calculated for Quebec and Ontario. However, fixed costs and unpaid labour costs for Alberta operations were substantially lower in comparison. A similar result was found for the American regions examined in the study. California had the greatest unit variable cost, but lower fixed costs and unpaid labour expenses relative to Wisconsin and New York. Barichello and Stennnes (1994) concluded this to be the result of scale differences, as similar herd sizes in all regions had similar costs per hectolitre: "Despite the extra variable costs that appear to arise with large sized operations, the potential savings in fixed costs and unpaid labour is large enough to give cost advantages to larger farms" (p.19).

Overall, the results of Barichello and Stennes (1994) show total costs of production to be highest in Ontario ($43.36/hl) and Quebec ($44.21/hl) and lowest in California ($28.24/hl). Alberta exhibited the lowest Canadian total average cost, at $35.88 per hectolitre. This is approximately 10 percent higher than in New York and Wisconsin.

Ross et al (1998) compared recorded costs of production for Quebec, Ontario, Manitoba and Alberta dairy farms for the years 1992 to 1995. With the exception of 1993, Ontario displayed a slight cost advantage over Alberta. Manitoba had the lowest total cost per hectolitre in each of the four years examined. The researchers credit this finding to the fact that in each observed year, Alberta had significantly higher costs for purchased feed and capital than in the other provinces. Ross et al (1998) report Alberta as having the lowest labour expense from 1992 to 1995.

The results reported by Ross et al (1998) conflict with Barichello and Stennes (1994) who concluded that Alberta was the most cost competitive dairy region in Canada. The answer to this inconsistency lies in the data utilized by Ross et al (1998). According to Ross et al (1998), their cost estimates for Quebec, Ontario and Manitoba came from the CDC's annual national cost of production studies. The data representing Alberta were obtained by an alternative source, the province's Production Economics and Statistics Branch. As pointed out by Ross et al (1998), ". . . the CDC survey is aimed more at the larger efficient low cost dairy farms. Farms must ship at least 60 percent of the average annual farm production to qualify for inclusion in the sample," (p.41). The Alberta cost data, on the other hand, mirror the provincial industry average. With respect to labour, the CDC includes the costs incurred by operations in their crop and forage production. Operator and family labour reported in the Alberta cost data are valued at industry wage rates and represent only the hired labour expense for the dairy enterprise. Following the logic of economies of size, it makes sense that Alberta would display an overall cost disadvantage and at the same time sustain a low labour cost. The discrepancy observed between the 1994 study of Barichello and Stennes and the work of Ross et al (1998) demonstrates the sensitivity of COP analysis. It reinforces the importance of use of compatible data in comparisons of costs of production.

In their 1998 study, Ross et al also make a comparison between 1994 costs of production computed for Alberta dairy farmers and those incurred in the same year by producers in six different regions of the United States. Ross et al (1998) report average total production costs to range from $53.17 and $54.70 per hectolitre in the north east, south east, upper midwest and corn belt regions. The southern plains and pacific regions had the lowest costs of production at $46.92 per hectolitre and $40.74 per hectolitre, respectively. The researchers determined Alberta dairy producers to operate at a COP value of $45.71 per hectolitre, thereby realizing the second lowest total production costs. According to Ross et al (1998), this standing is a result of Alberta having a cost advantage of $6.00 to $7.00 per hectolitre in feed costs. Ross et al (1998) do not reveal how the feeds costs for American farms were calculated; however, this finding makes sense when one considers the fact that Alberta is a major feed grain producer and that the majority of feed utilized on large United States south western dairy operations is purchased from out of state.

A recent study of Alberta milk production reports costs of production for the province's dairy producers rose $0.69 per hectolitre to $52.99 per hectolitre in 1998, an increase of 1.33 percent over the previous year (Kotowich et al, 1998). Kotowich et al (1998) conclude that this is a result of fixed costs increasing from $11.63 per hectolitre $13.04 per hectolitre during the 1998 dairy year. The authors found total feed costs to have declined from $20.79 per hectolitre to $19.63 per hectolitre from 1997 to 1998. It is of interest that each component of total feed expense: grain, complete feed, supplement, minerals and vitamins, roughage and processing costs, decreased. This is not consistent with the dry and slow growing season in 1998 reported by Kotowich et al (1998). Perhaps large on-farm stocks of feed remaining from a record harvest of forage and hay in 1997 sustained the decreased quality and quantity of the 1998 crop. Producers increasing rotational grazing into their management practices may be a second explanation for this finding.

3.2 Profitability

When the revenue of individual farms is considered in cost analysis, the profitability of dairy producers can be assessed. Ruch et al (1992) define profitability as "the ratio of total revenue to total cost; indicates the percent of revenue that covers the costs of resources and the percent that goes to profit," (p.291). In accounting terms, net farm income is the measure of profit determined by subtracting total annual expenses from total annual revenue.

In practice, profitability is the result of a farm's management decisions. It is directly related to an operation's success or failure in achieving low cost production. According to Lazarus et al (1989), large farms will be more profitable than small farms as economies of size spread overhead costs over more producing units. Lazarus et al (1989) identify age of the farm operator, debt load, form of business organization, and the educational level of the operator as the major determinants of profitability. However, one must take caution in utilizing profitability as a means to predict Canada's cost competitiveness in an open market economy.

Jeffrey (1992) calculated net returns per litre of milk produced on Canadian and American farms. The results indicated that, in the late 1980's, Canadian province, with the exception of Manitoba and Saskatchewan, generated a net return of between $0.12 and $0.15 per litre. This was substantially higher than for American producers who received a net return of $0.034 to $0.096 per litre. From this, Jeffrey (1992) concludes Canadian farmers are compensated for higher costs of production by higher milk prices.

Ross et al (1998) reported Alberta as having a return to equity of $10.30 per hectolitre while returns to equity computed for the United States varied from a low of -$8.43 per hectolitre in the Upper Midwest to a high of -$0.09 per hectolitre in the Pacific region[3]. According to Ross et al (1998), Alberta's 1994 blend price for milk was $51.03 per hectolitre, $14.21 per hectolitre higher than the average price received by producers in the United States pacific region.

Due to producer price guarantees under the nation's supply management system, it is not recommended that net income be adopted as an indicator of the economic well-being of Canadian dairy producers when direct comparisons of current costs of production are made with the United States. However, in the event that a simulation of various international milk prices is carried out, which assumes supply management no longer defines the policy environment of the Canadian dairy sector, profitability would provide an appropriate estimate of a farm's financial position.

Grant (1998) tabulated changes in the net farm income of Nova Scotia dairy farms using 1995 milk prices representative of New Zealand, three American regions and the United States 1995 average price of milk. The results suggested that Nova Scotia dairy producers, at current costs of production, are noncompetitive at each international price as a negative average net farm income was found for all herd sizes. The sample group representing the province's largest dairy operations, 75 head and over, sustained the smallest average net loss at each stated price.

3.3 Incorporating Efficiency

Richards and Jeffrey (1996), unwilling to dismiss the difficulties inherent in using farm cost data, conclude that producer efficiency and its relationship with production costs is a more appropriate measure of competitiveness than simply comparing average total costs of production. The researchers claim that producer efficiency provides an explanation for

---

[3] Net income and return to equity calculations are reported in Canadian dollars per hectolitre.

differences in farm costs and therefore facilitates the development of a strategic plan for the business to follow.

Ruch et al (1992) credit increased efficiency for decreasing the effort, quantity of materials, and time required in the production of a given level of output, and as a result, generating greater benefits for all involved. Bravo-Ureta and Rieger (1991) state that "efficient farms are more likely to generate higher incomes and thus stand a better chance of surviving and prospering," (p.421). Phillips et al (1989) contend that "the most efficient production process would have the lowest cost per unit. Those producers with lowest cost possess an absolute advantage over competitors," (p.3). Hence, incorporating efficiency measures into cost analysis is vital in determining the cost competitiveness of Canadian dairy producers in a changing dairy policy environment.

3.3.1 Technical and Economic Efficiency

According to Jeffrey (1992), there exists within economics various interpretations and applications of efficiency. In examining the performance of the dairy sector, technical and economic efficiency are the most commonly applied concepts (e.g., Bravo-Ureta, 1986; Bravo-Ureta and Rieger, 1991; Jeffrey, 1992; Richards and Jeffrey, 1996). The foundation for measuring efficiency was laid by Farrell in his 1957 paper, 'The Measurement of Production Efficiency.' He proposed an index measure whereby economic or total efficiency is the product of technical and allocative efficiency. Black (1997) defines technical or physical efficiency as "efficiency concerned with getting the largest possible outputs for given inputs, or the smallest possible inputs for given outputs. This is efficiency in production," (p.463). Allocative efficiency is defined by Richards and Jeffrey (1996) as "the producer's ability to respond to economic signals and choose optimal input combinations (i.e., proportions) given relative input prices. . . ." (p.4). Thus, economic efficiency, as defined by Jeffrey (1992) is "the ability to choose the technically efficient output/input combination that optimizes a decision-maker's goal(s), given relative output and input prices" (p.3). Jeffrey (1992) states that in studies of the economic efficiency of dairy producers, the goal is usually assumed to be minimization of total production costs.

3.3.2 Empirical Examination

The empirical method adopted for assessing firm efficiency, according to Jeffrey (1992), is dependent on the type of efficiency being considered and the availability and consistency of data. Below is an outline of various methodologies utilized by researchers to determine the efficiency of dairy producers and the results obtained.

Matulich (1978) employs an economic-engineering approach to assess efficiencies in large-scale California dairy farms. Specifically, Matulich (1978) separates farm operations into three technical stages: milking, housing and feeding. Using market prices, input-output relationships in each stage, for each farm observed, were pooled into representative groups of various herd sizes. Short-run and long-run cost functions were then derived for each group. Bravo-Ureta (1986) dismisses the findings of studies using the economic-engineering approach, claiming the method is only a reflection of the actual farm situation to the extent that the specific assumptions are met.

A 1990 study by Weersink et al looks at the technical efficiency for a cross sectional sample of Ontario dairy farms. More specifically, overall technical efficiency, pure technical efficiency, relative output loss due to input congestion and scale efficiency are calculated.[4] Following the approach of Fare et al (1985), Weersink et al (1990) employ a deterministic, non-parametric approach to measure efficiency levels. A set of linear programming models for each of the observed farms is solved, deriving efficiency by evaluating the given operation's input and output relation relative to all other farms in the sample. The authors argue that using this method, as opposed to a stochastic, parametric approach, allows for the relaxation of the assumption of constant returns to scale:

> Without these restrictions, the approach can identify the magnitude of technical efficiency and decompose the resulting measure into purely technical, congestion and scale efficiency terms. . . . Without requiring a parametric specification of the functional form for the frontier, unwarranted structure is not imposed on the technology, thereby preventing a distortion in the efficiency measures (p.440).

Weersink et al (1990) conclude that a high level of technical efficiency exists on Ontario dairy farms. The authors observed an average overall technical efficiency value of 91.8 percent, with 43 percent of sampled farms operating at full efficiency. Weersink et al (1990) claim overutilization of inputs to be a minor cause of inefficiency as input congestion was found in only 3 of the 60 inefficient dairy farms.[5] They conclude that pure technical allocation and an improper scale of the dairy enterprise are the major sources of inefficiency. Weersink et al (1990) state that as herd size increases, the level of total efficiency per farm increases, while the variability of calculated efficiency decreases. In accordance with the research of Grisley and Mascarenhas (1985), Weersink

---

4 Weersink et al (1990) describe pure technical efficiency as a measure of technical efficiency where constant returns to scale is not imposed on the level of technology of a given farm. Scale efficiency is defined by Weersink et al (1990) as overall technical efficiency divided by pure technical efficiency.

5 According to Weersink et al (1990), "input congestion occurs when the marginal product of an input is negative," (p.444).

et al (1990) credit uniform management practices and technology found on larger farms for this finding.

Average levels of pure technical efficiency computed by Weersink et al (1990) were found to be lower than the average level of scale efficiency for individual farms. However, the total number of farms demonstrating technical efficiency was larger than the total number of scale-efficient farms. These results cause Weersink et al (1990) to conclude that ". . . small farms are combining resources properly but farm size needs to be increased," (p.449).

The findings of Weersink et al (1990) are somewhat misleading because calculated levels of efficiency are determined within a closed system of linear equations. According to Phillips et al (1989), a cost competitive analysis should involve the determination of regional efficiency by means of a cross-country production function or an input-output analysis.

Phillips et al (1989) adopt an input-output approach, arguing that with an input-output accounting framework, all factors of production are recognized. Phillips et al (1989) states that the major limitation of this approach is a bias which may develop over time due to changing relative factor prices and relative weights of factor inputs. However, the authors contend that this concern can be alleviated if examination occurs in the short run. Phillips et al (1989) add that a problem of large year-to-year fluctuations in output volume may also surface. With respect to Canada, they do not see this as an issue due to a consistency in supply promoted by the nation's supply management system.

Jeffrey (1992) also utilizes an input-output approach of farm accounting data to determine the technical and economic efficiency of dairy farms in selected regions of Canada and the United States. Jeffrey (1992) argues that employing this farm management approach in analysis has an advantage over econometric and mathematical programming approaches because it is less data intensive and is less complicated to implement and interpret.

Jeffrey (1992) concludes that American dairy farms, having greater milk production per cow and greater labour productivity, are more technically efficient in comparison to Canadian dairy operations: "Washington has the greatest milk production per cow (8626 litres) while Manitoba has the lowest (5984 litres). All four American farms have greater production per cow than British Columbia, which has the greatest production per cow of the Canadian farms" (p.11).[6] A similar conclusion was reported by Phillips et al (1989) in a study comparing milk production in New Brunswick, Ontario, Quebec, the Netherlands and the United States. The authors found that producers in the

---

6 Jeffrey (1992) is referring to four American states which are examined: New York, Minnesota, Washington, and California.

upper midwest realized greater milk production per cow than their Canadian counterparts.

With respect to labour productivity, Jeffrey (1992) found that each of the American states examined in the study generated a higher level of the ratio of the number of cows per worker equivalent than for any of the Canadian provinces under consideration.[7] Values ranged from a high of 75 cows per worker equivalent in Washington to 43 cows per worker equivalent in Minnesota. Manitoba had the highest labour productivity in Canada, at 38 cows per worker equivalent. Quebec, realizing only 30 cows per worker equivalent had the lowest overall labour productivity.

In comparing economic efficiency levels, Jeffrey (1992) also concludes that American farms are performing better than Canadian farms. In terms of variable costs, Jeffrey (1992) determined that all four American states to have a cost advantage over their Canadian counterparts. Of all the regions evaluated in this 1992 analysis, farms in New York had the lowest variable costs per litre of milk produced ($0.27/litre), while those in Ontario realized the greatest ($0.330/litre).

When economic efficiency is measured as total costs per litre of milk produced, Jeffrey (1992) concludes California to be the most efficient, with total costs at $0.293 per litre. Saskatchewan was found by Jeffrey (1992) to have the least efficient production with total costs equaling $0.486 per litre. Again, Canada was found by Jeffrey (1992) to have a less efficient dairy sector in comparison to the United States. Alberta, with total costs of production at $0.374 per litre, had the lowest costs of any Canadian province observed.

When evaluating economic efficiency as feed costs per litre of milk produced, Jeffrey (1992) concludes dairy operations in Ontario and New York to be the least efficient with feeds costs of $0.217 per litre and $0.212 per litre respectively. Jeffrey (1992) found British Columbia ($0.129/litre) and Alberta ($0.159/litre) to be the most economically efficient overall with the lowest feed costs per litre of milk produced. The feed costs used by Jeffrey (1992) were valued using on-farm costs of production. Phillips et al (1989) on the other hand, calculated feed efficiency using purchased feed prices. Phillips et al (1989) argue that this method provides a measure of a farm's dependence on off-farm resources. The results of Phillips et al (1989) show that New Brunswick producers pay $13.71 per hectolitre for purchased feeds. The Netherlands and Quebec face a purchase price of $11.96 per hectolitre and $7.68 per hectolitre, respectively. The United States Upper Midwest and Ontario farmers are much less dependent upon purchased feeds, paying $5.86 per hectolitre and $4.57 per hectolitre respectively. The cost of purchased feeds measured in New Zealand was $0.61 per hectolitre. This comparatively low figure can be explained by the fact that in New Zealand, milk is

---

[7] Jeffrey (1992) defines a worker equivalent as 3000 hours of labour.

largely produced using grazing of pasture with associated on-farm produced hay for supplementary feeding.

A correlation between costs of production and economic efficiency measured in terms of labour costs per litre of milk produced was detected by Jeffrey (1992). The researcher reports California and Washington to be the most labour efficient with low labour costs and high labour productivity, while Canadian dairy farms are less efficient. Due to the fact that herd size of each representative region examined by Jeffrey (1992) increases moving from eastern to western Canada and moving from Canada to the United States (the exception is Minnesota which has a herd size comparable to British Columbia), Jeffrey (1992) concludes that "relative labour productivity and cost seem to be directly related to herd size," (p.14). Jeffrey (1992) claims these "herd size efficiencies" to be a result of different technologies utilized for milking and feeding.

3.4 Economies of Size and Economies of Yield

Several of the competitiveness studies reviewed above report economies of size to exist in the dairy industry. According to Binger and Hoffman (1998), economies of size result when the minimum unit cost associated with using a particular production process can only be achieved when a substantial number of units of the good are produced. In other words, the larger a herd size, the more cost competitive its position in the dairy industry. Barichello et al (1996) note that the existence of economies of size in the dairy industry is generally agreed upon among agricultural economists. These authors indicate that several studies conclude economies of milk yield also exist in the dairy industry; that is, there are studies indicating that average costs of production will decrease as milk production per cow is increased. Barichello et al (1996) contend that average yield per cow increases when herd size increases: "This suggests that lower COP results not merely from an increase in farm size, but also from an increase in yield per cow or a combination of these two factors" (p.108). Barichello et al (1996) argue that this hypothesis has not been properly addressed as cost competitive studies have not taken into account the fact that the distribution of milk yields may vary with farm size when establishing a relationship between COP and farm size. A limitation of many cost competitive studies, according to Barichello et al (1996), is the omission of technical and allocative efficiency measures and how they relate to economies of size and economies of yield.

3.4.1 Farm Costs of Production as Related to Economies of Size and Yield

In a 1996 study of the Quebec and Ontario dairy industries, Barichello et al analyze the impact of farm size and milk production per cow on farm production costs. Surveyed farms were subdivided into groups according to herd size and milk yield per cow. First, Barichello et al (1996) compared cash costs, COP, labour productivity, interest and depreciation, on a per hectolitre basis, between each herd size category. It was found that for those farms milking less than 50 head, in both Quebec and Ontario, average production per cow does not increase significantly with increased herd size.

In Quebec, average cash costs were found to be higher for herd sizes of less than 30 cows compared to all other herd size subgroups. Differences in average cash costs for Ontario farms were only statistically significant between small farms (i.e., less than 35 cows) and large farms (i.e., more than 50 cows). With respect to average total costs of production, the same trend was found as only small dairy operations showed significantly higher costs in comparison to all other herd sizes. Barichello et al (1996) concluded interest payments to be consistent between all farm operations in Ontario, while larger farms in Quebec had higher interest payments than small operations. The authors state that depreciation costs per hectolitre decreased with farm size up to 40 cows, than increased for farms milking 41 to 50 cows and decreased again for larger dairy farms. Barichello et al (1996) report increased labour productivity with increased farm size.

Second, Barichello et al (1996) compared the cost stated above and labour productivity between each yield grouping. When examining farms in Quebec, Barichello et al (1996) found that cash costs and total COP decreased as yield per cow increased only on those farms milking less than 50 cows. In Ontario, there was no evidence of economies of yield. As with increasing farm size, labour productivity was found by Barichello et al (1996) to increase with volume of milk production per cow.

3.4.2 Efficiency as Related to Economies of Size and Yield

In order to investigate the relationship of a farm's technical and allocative efficiency with economies of size and economies of yield, Barichello et al (1996) constructed a production function representing primary milk production in Quebec and Ontario. Yield per cow was used as the dependent variable and forage per cow, grains and protein supplements per cow, number of labour hours per cow, and the value of dairy equipment per cow were used as the explanatory variables. Barichello et al (1996) explain that following the initial estimation of this production function, farms meeting a desired level of milk yield per cow are used in a second estimation of the production function. According to the researchers, the process is repeated until the production function is a representative of only the most efficient dairy operations in each province. A "potential yield per cow" is then estimated for each farm. A technical efficiency index is calculated for every farm in the sample by the ratio of actual yield per cow to potential yield per cow. Each efficiency index is compared to labour productivity and COP. Barichello et al (1996) simply conclude that ". . . cash costs and COP are not affected by the size of the farm when the level of efficiency is taken into account" (p.111).

With respect to levels of efficiency and milk yields, Barichello et al (1996) state that when moving from high cost to low cost producers, in Quebec and Ontario, technical efficiency increases, but potential production decreases. Also, average yield per cow was low for small herd sizes, but no difference in yield existed between average and large sized herds. Because of this two findings, Barichello et al (1996) report ". . . farms with higher costs could lower their cash costs and also increase yield per cow by using inputs more efficiently. However, farms have lower COP more as a result of their efficient use of production factors than high yield per cow" (p.111).

3.5 Employing a Cost Competitiveness Study

The literature reviewed in this chapter provides the framework on which to build a methodology to assess the cost competitiveness of Alberta dairy farms. The essential elements of a cost competitiveness study which are to be adopted by this study are summarized below. When the cost competitiveness of primary dairy producers is assessed by way of a COP study, the researcher must be aware of the difficulties inherent in using farm cost data. Defining the nature of cost components and the pricing of inputs at either their supply price or opportunity cost is vital. It is suggested that to ensure consistent data collection of farmer-owned inputs, predominately the supply of labour, uniform labour time sheets and cost questionnaires be distributed to producers. Because farm data is presented in terms of average costs and not long run marginal costs, it is recommended that sampled farms be divided into groups according to size or net return. The fact that farm data are essentially upwardly biased is accepted by virtue of this bias occurring over all areas and time periods.

In choosing a methodology to compare the cost competitiveness of Alberta dairy farmers with other countries, a profitability framework is discouraged as Canada's guaranteed milk prices compensate for the country's higher production costs. Incorporating measures of efficiency into a COP study can possibly provide an explanation for differences in production costs. Due to its ease of implementation and interpretation, an empirical model employing a farm management approach is recommended to compute the technical and economic efficiency values of dairy farms. The major limitation of employing this methodology is a bias which may develop over time due to changes in factor prices. However, this concern can be alleviated if examination occurs in the short-run.

The majority of the studies reviewed in this chapter conclude economies of size to be the central determinant of cost competitiveness within the dairy industry. A less accurate inference on the presence of economies of yield in the industry was made. In light of this, no assessment of dairy competitiveness at the farm-level can be considered complete without incorporating an examination of the role of herd size and milk yield in milk production.

4. ISSUES OF METHODOLOGY AND DATA

4.1 Method of Analysis

The methodology employed here to assess the competitive position of Alberta's primary dairy producers is based upon a farm management approach in analyzing cost and revenue data. In order to incorporate the dimension of time into the analysis of this research study, and to observe changing trends in the operating environment of Alberta's dairy producers, COP data for three consecutive years are examined: 1994, 1995 and 1996. Two analyses are performed on each set of annual data to facilitate a more concise assessment of competitiveness for producing milk in Alberta at the farm level. Each method adopted is explained in detail below.

4.1.1 Grouping Farm Data for Analysis

As indicated by Barichello and Stennes (1994), one of the problems associated with using farm cost data is the focus on average costs rather than long run marginal costs. Inclusion of high cost producers results in an upward bias for average cost calculations (Barichello and Stennes, 1994). To alleviate this problem, and also to determine if economies of herd size and/or economies of yield exist among the province's dairy farms, each annual data set is divided into groups based on milking herd size. A second data division groups operations according to farms' average production per cow.

To determine the appropriate point of division for each subgroup of herd size, the distribution of the total number of milking cows per farm for 1994, 1995 and 1996 was mapped onto a histogram. The resulting histogram displayed an asymmetrical distribution of data. More specifically, milking herd sizes contained in the three annual data sets were positive or right-skewed. As revealed by Berenson and Levine (1996), data found to be right-skewed represent a mean which is greater than the median: ". . . the mean is increased by some unusually high values," (p.127).

Due to the fact that a symmetrical distribution of milking herd sizes was not observed, an adhoc or random grouping of the farm data is inappropriate. Thus, the clustering of farm herd sizes was examined in order to determine how to form subgroups. Three distinct groupings of farm herd sizes were found to exist. The first cluster was found at a herd size of 40 to 50 milking cows. A second concentration of farm herd size data was observed at 50 to 70 head of milking cattle. The third and final accumulation of farm herd size data was found at 90 head and above. These three explicit clusters of farm herd size data were employed to represent three study groups of Alberta dairy farms. Thus, farms milking between 40 and 50 cows are taken to be representative of the province's small dairy farms (Group H1). Average size dairy operations in Alberta are represented by farms within each annual data set milking between 50 and 70 head (Group H2). The farms reporting over 90 head reflect the province's large dairy enterprises (Group H3). The largest herd sizes included in Group H3's annual data set for the 1996, 1995, and 1994 dairy years were 167 milking cows, 180 milking cows, and 176 milking cows respectively.

It is interesting to note that these groupings of herd size represent differences in the level of technology employed within the Alberta dairy industry. Farms comprising the small herd size group are likely to have a tie stall milking system with grazing and round bale silage as the fundamental components of their feeding program. These farms milking between 40 and 50 head would have no more than 2 or 3 tractors. Farms in the average herd size grouping represent a transition stage of farm technology. More specifically, farms milking 50 to 70 head could have a tie stall set-up or a small milking parlour (i.e. a double 4). These herds would operate with approximately 4 tractors and 1 to 2 tower silos. Farms in the large herd size group would have a large milking parlour (i.e. a double 10 to a double 18) with a free stall system for housing cows. On these farms where over 90 head are milked, 4 to 6 tractors would be found. Large farms are more likely to use bunker silos due to the higher level of maintenance required by tower silos.

The procedure described above was also carried out to determine the most appropriate point of division for subgroups of milk yield. Specifically, the distributions of hectolitres of milk produced per cow per farm for 1994, 1995 and 1996 were determined by means of histograms. Unlike the size of milking herds, recorded production per cow appeared to be symmetrically distributed. According to Berenson and Levine (1996), such symmetrical distribution of data indicates that ". . . there are no really extreme values in a particular direction so that low and high values balance each other out," (p.127).

Since farm milk yield exhibited a symmetrical distribution, an adhoc grouping of farm data according to production per cow was acceptable. To correspond with the three study groups of herd size, three divisions of milk yield were defined. The first study group was comprised of all farms realizing average production per cow of less than 80 hectolitres of milk (Group M1). The smallest production level recorded for this group of low yielding farms was 57.95 hectolitres per cow in 1996, 57.18 hectolitres per cow in 1995, and 59.50 hectolitres per cow in 1994. The second study group contained all dairy operations reporting an average milk yield between of 80 and 90 hectolitres per cow (Group M2). The third study group consisted of all farms achieving an average production level reported to be greater than 90 hectolitres of milk per cow (Group M3). The high producing group, M3, saw milk yields range as high as 107.66 hectolitres per cow in 1996, 103.09 hectolitres per cow in 1995, and 110.12 hectolitres per cow in 1994.

Applying these groupings, each of the following analyses is performed twice on each annual set of data. First, empirical examination of annual data is made with farms divided according to farm herd size: small versus average versus large. This allows for an investigation of the role of scale in Alberta's dairy industry. Second, in order to examine the potential relationship between milk yield and farm economic performance, an assessment is made of data organized according to farm production per cow: low versus average versus high.

4.1.2 Dairy Costs of Production

The economic costs of producing milk at the farm level in Alberta are estimated for each category of herd size and milk yield within each set of annual data. When economic costs of production are derived, an estimation of both owner's equity and family labour is made. Here net income is referred to as economic profit and is equal to the gross revenue of the dairy enterprise minus accounting costs as well as imputed family labour expenses and owner's equity.

It must be emphasized that this study does not estimate an industry cost function. Instead, these estimations compare particular points on the industry cost curve. Differences in the economic costs of production imputed across study groups and across years are tested for significance by performing a single factor analysis of variance (ANOVA) using the computer software package *Microsoft Excel*. If a statistically significant difference is detected by an analysis of variance comparing all three categories of herd size, or all three categories of milk yield, three additional ANOVAs are performed in order to reveal the basis of the significant difference. For example, if the 1996 hired labour cost for small, average, and large herd sizes is found to differ significantly, an ANOVA will be conducted to compare the hired labour expense incurred by the small and average herd sizes (Group H1 and Group H2). A second ANOVA is then run to determine if the hired labour cost of the small and large herd sizes differ significantly (Group H1 and Group H3). Finally, a third ANOVA is performed to examine if a statistical difference in hired labour costs exists between average sized herds and the province's largest dairy operations (Group H2 and Group H3).[8]

The null hypothesis of ANOVA is that there exists no difference in population means. The alternative hypothesis is of course the opposite case where it is assumed that not all population means are equal. Equations 4.1 and 4.2 display the null and alternative hypothesis in their empirical form:

$$H_0 : F_1 = F_2 = F_3 \ldots = F_c \qquad \textbf{(4.1)}$$

$$H_1 : \text{Not all } F_j \text{ are equal (where } j = 1, 2, 3, \ldots, c). \qquad \textbf{(4.2)}$$

where c is the number of subgroups of interest.

An F statistic is calculated from the ANOVA to test the null hypothesis. As discussed by Berenson and Levine (1996), this F statistic is distributed with c - 1 and n - c degrees of freedom, where n is the total number of observations and c is defined as above. At a specific level of significance, the null hypothesis stated in Equation 4.1 is rejected and the calculated costs of production between study groups are determined to be significantly different, if the calculated F statistic of Equation 4.1 is greater than the

---

[8] Instead of performing a secondary set of ANOVA tests, the Tukey-Kramer Procedure is recommended as a more efficient approach to determine the source of the identified variation.

critical F value. Parallel to this, the null hypothesis is not rejected and the operating expenditures of study groups are not considered significantly different from each other if the computed F statistic is less than the critical F value. Berenson and Levine (1996, Chapter 14) provide a more in-depth discussion on the empirical development of an ANOVA analysis.

To justify the use of an ANOVA analysis, three major assumptions must be made. First, it is assumed that the population data are randomly chosen for the analysis and as a result independence of errors exists. Second, it is assumed that normality prevails among the values of subgroups. More specifically, it is assumed that calculated costs of production are normally distributed within each subgroup of herd size and milk yield. The third and final assumption made when performing an ANOVA is the homogeneity of variance. According to Berenson and Levine (1996), ". . . homogeneity of variance states that the variance within each population should be equal for all populations . . . this assumption is needed in order to combine or pool the variances within the groups into a single with-in group source of variation," (p.539). It is therefore assumed that the variance of each category of herd size and milk yield do not differ from one another.

4.1.3 Technical and Economic Efficiency

Following Jeffrey (1992) and Phillips et al (1989), technical and economic efficiency measures for the various study groups are computed using a farm management approach. A farm's physical efficiency can be described by its milk productivity and labour productivity. In this study, milk productivity is measured by the average hectolitres of milk produced per cow on each farm. Labour productivity is expressed in terms of cows per worker equivalent. Jeffrey (1992) defines a worker equivalent as ". . . the annual number of labour hours available from a full-time worker (operator or employee)," (p.6). This study denotes one worker equivalent as 2,500 hours of labour in the annual period.

Complying with the format of Jeffrey (1992), economic efficiency is measured in terms of cost efficiency and this is estimated by means of cost control ratios. According to Jeffrey (1992), cost control ratios demonstrate a farm's ". . . ability to convert input costs into dairy sales," (p.7). Ratios for feed, labour, and the total user cost of capital are derived as these represent three major categories of production expenses for dairy farms. A cost control ratio for the total cost of production is also computed. As revealed by Jeffrey (1992), ratios are expressed in terms of costs per dollar of dairy enterprise revenue; thus, the lower the cost control ratio, the more efficient the farm. Differences in the cost control ratios for each study group are tested for significance by performing a single factor analysis of variance (ANOVA) using the computer software package *Microsoft Excel*. As was explained above, if a statistically significant difference is detected by an analysis of variance comparing all three categories of herd size, or all three categories of milk yield, three additional ANOVAs are performed in order to assess the basis of the significant difference.

4.2 The Data

4.2.1 Source

Cost of production data for selected Alberta dairy producers were utilized in this study. The observed data, obtained from the Production Economics Branch, Economic Services Division of Alberta Agriculture, Food and Rural Development, were primarily compiled to construct the province's annual dairy cost study.[9] Figures are tabulated from monthly questionnaires completed by all participating dairy producers. According to Appleby (1995), the monthly survey data are collected to represent a cross section of Alberta's dairy farms according to the size of their fluid milk quota. Appleby (1995) explains that producers are divided regionally, northern versus southern Alberta, and are then ranked from largest to smallest, corresponding to their quota holding.[10] Systematic random sampling is carried out to select the participating farms for the study.[11] Appleby (1995) contends that because the quality and the cost of producing industrial milk are not significantly different than for fluid milk, and since approximately one-half of fluid milk produced in the province is used for industrial milk manufacturing, basing data collection entirely on a farm's fluid quota should not compromise the analysis. It is stressed that the COP data employed encompasses only those costs incurred by the participating farms' dairy enterprise. Appleby (1995) defines the dairy enterprise as ". . . all activities associated with the milking cows, dry cows and young dairy stock," (p.3).

4.2.2 Defining Revenue and Cost Data

As previously stated, the validity of any COP study is dependent upon the careful definition of each source of revenue and each cost component. The following sections outline the interpretation of revenue and production cost sources which were contained in the data set employed by this study to assess the cost competitiveness of Alberta dairy farms.

4.2.2.1 Milk Sales

As only the dairy enterprise of each farm is examined, milk sales are the primary source of revenue. The producer price for fluid milk is set by the Alberta Energy and Utilities

---

9 Alberta's annual dairy cost study was introduced during World War II and continues to be used today as a component in setting fluid milk prices.

10 According to Appleby (1994), the Production Economics Branch identifies the region north of the 39th township as 'northern Alberta' and the region lying south of the 39th township is recognized as 'southern Alberta'.

11 According to Appleby (1995), the sample size is determined statistically according to the following equation:

$$n = \frac{4 \times s^2}{L^2}$$

where: n is sample size
s is the standard deviation of the population
L is the expected accuracy of the sample average cost

Board (AEUB) and administered by the Alberta Dairy Control Board (ADCB). Like the federally determined target price for industrial milk, the AEUB uses a formula reflecting particular items that influence the cost of milk production. The AEUB alters the fluid milk price only when a trend persists two to three months is observed in the price suggested by the formula. Table 4.1 outlines changes in the province's producer price for fluid milk that occurred during the time period of study, from 1994 to 1996.

4.2.2.2 Producer Subsidy

The federal dairy subsidy directly paid to dairy farmers was $1.508 per kilogram of butterfat or $5.43 per hectolitre of milk produced per farm in 1994. At the beginning of the 1995 dairy year, the direct producer subsidy payment was decreased to $1.28 per kilogram of butterfat or $4.62 per hectolitre of milk. The subsidy was further reduced in 1996 by $0.82 per hectolitre, over the previous year to a level of $3.80 per hectolitre of milk produced (Canadian Dairy Commission, 2000).

4.2.2.3 Milk Levies

According to Appleby (1995), an "all milk levy", administered by the CDC, was charged to producers during 1994 and 1995. This levy funded the removal of surplus skim milk powder from the Canadian market. All milk produced between January 1st and July 31st, 1994 was charged a levy of $0.25 per kilogram of butterfat. This levy increased to $0.49 per kilogram of butterfat August 1st, 1994 and was reduced to $0.25 per kilogram of butterfat on August 1st, 1995.

An over-quota levy on each kilogram of butterfat produced in excess of 100 percent of producer MSQ was also required in 1994 and 1995. This "producer tax" was used to fund exports of dairy products which exceeded domestic consumer demand (Appleby, 1995). The over-quota levy was set at $8.90 per kilogram of butterfat between January 1st and July 31st, 1994. On August 1st, 1994 this increased to $9.08 per kilogram of butterfat. From January 1st, 1995 to July 31st, 1995 producers were charged $9.06 per kilogram of butterfat on excess milk production. On August 1st of the same year, the over-quota levy was reduced to $7.77 per kilogram of butterfat (Appleby, 1995). With the implementation of the milk category termed the 'Special Milk Classes', and with the introduction of the Western Milk Pool, all levies charged to producers were eliminated.

4.2.2.4 Net Cattle Sales and Net Inventory Change

As noted by Appleby (1995), due to the fact that the cost of raising young dairy stock is an expense incurred in the production of milk, net cattle sales and net inventory change should be included in enterprises' total income. Net cattle sales are equal to the balance of the dollar value of cattle purchased, subtracted from the dollar value of cattle sold. Each farm was required to report the sale and purchase prices of their cows, bred heifers, open heifers, heifer calves, bull calves and bulls.

Table 4.1 Alberta Fluid Milk Price Changes: 1993 - 1996

EFFECTIVE DATE	PRODUCER PRICE ($/hL)	CHANGE ($/hL)
October 1, 1993	56.95	+ 0.98
May 1, 1994	55.97	- 0.98
March 1, 1995	56.95	+ 0.98
July 15, 1995	58.91	+ 1.96
January 1, 1996	60.87	+ 1.96
April 1, 1996	62.83	+ 1.96
July 15, 1996	64.79	+ 1.96

Source: Appleby (1994, 1995, 1996).

Changes in a farm's herd composition or an operation's "herd growth" is determined by calculating the net inventory adjustment (Appleby, 1995). In this study, the year-end inventory for each of the cows, bred heifers, open heifers, heifer calves, bull calves, and bulls was subtracted from the corresponding inventory at the beginning of the year for each category. The net inventory change for each year was calculated by summing the dollar value of each annual inventory change.

4.2.2.5 Miscellaneous Receipts

Any revenue generated outside the sale of milk and cattle or apart from pool adjustments is represented by miscellaneous receipts. As this analysis only examines the dairy enterprise of each sampled dairy operation, miscellaneous receipts consist only of the sale of assets specific to the production of milk. Examples include the sale of pasture land, dairy buildings and equipment.

4.2.2.6 Farm Produced Feeds

Farm produced feeds utilized by the dairy enterprise can be valued using one of two methods: (1) the whole farm approach or (2) the enterprise approach. According to Ross et al (1998), the CDC annual national milk cost of production study uses a whole farm approach in determining dairy feed costs. Farm produced feeds are valued at their cost of production less operator and family labour costs. Ross et al (1998) clarify that labour costs of cropping are included in the CDC calculations of total labour costs. Jeffrey (1992) identifies costs of seed, fertilizer, pesticides, real estate rental, machinery expenses and depreciation and any hired labour that is exclusive to the farm's cropping enterprise, as the costs of production incurred by those farms producing their own feed. Barichello and Stennes (1994) also employ a whole farm approach; they note that if farm-produced feed is sold and cannot be netted from total feed costs, revenues from the sale of the feed must be subtracted from total dairy costs.

This study follows the enterprise approach, as used by Ross et al (1998) in valuing home-grown grains and forages. Here, farm produced feeds are valued at average annual market prices and are treated as purchases by the farm's dairy enterprise from its cropping enterprise. Specifically, hay produced on the farm is valued at regional prices of stacked hay on the farm. The cost of feed grain are taken as the regional elevator prices provided by the Alberta Grain Commission. Thus, the final cost incurred by a farm for farm-produced feeds is equal to annual regional commodity prices multiplied by the quantity consumed by the dairy enterprise.

4.2.2.7 Hired Labour

A cost competitiveness study of Canadian dairy producers by Barichello and Stennes (1994) did not utilize the values of hired labour expenditures which were indicated on farm data surveys. They conclude that there is an inconsistency in labour expenditure data from different surveys. They also recognize the difficulty in quantifying non-cash income received by farm workers. Thus, Barichello and Stennes (1994) recommend valuing any labour, other than unpaid operator and family labour, at a standard hired labour wage rate for the given region.

The concerns expressed above are valid. However, the hired labour data used in this analysis were taken directly from farm surveys collected by the Production Economics Branch. The inconsistencies in labour expenditure data noted by Barichello and Stennes (1994) are avoided as the same survey format is distributed to participating farms in each of the three observed years; 1994, 1995, and 1996. Along with the wage rate paid per worker on each farm, producers are required to record the value of any room and board provided to their employees.

4.2.2.8 Operator and Family Labour

The majority of dairy farms in Alberta are operated as family enterprises where family members contribute to the business through unpaid family labour. Because the dairy operation benefits from this investment, unpaid family labour can be calculated and recognized as a cost of production. As noted in Section 4.1.2 of this study, the approach used to handle unpaid family labour within a cost analysis defines the approach employed to evaluate the economic well-being of a farm enterprise. Because the economic costs and economic profit of the surveyed dairy operations are estimated, a dollar value for unpaid family and operator labour must be imputed.

The data utilized to impute the dollar value of family and operator labour were obtained from monthly labour statements recorded by individual farms. Total labour of the farm operator is valued at the annual Alberta farm management wage rates as reported by Statistics Canada.[12] Annual general farm labour wage rates for Alberta, also

---

[12] Annual farm management wage rates for Alberta, as reported by Statistics Canada CANSIM Matrix 160, are as follows: 1994 - $11.58 per hour; 1995 - $13.49 per

reported by Statistics Canada, are assigned to hours worked by spouses and children of the farm operators.[13]

4.2.2.9 User Cost of Capital

As previously stated, the economic profit of producing milk at the farm level in Alberta is derived in this study. Therefore, a user cost of farm capital is imputed for each farm in the sample. This approach differs from the traditional method of determining accounting costs where the depreciation of farm capital is calculated and a farm's interest payment on its capital loan is computed. Estimating the user cost of capital provides an estimate of the *opportunity cost* of investing in the dairy industry rather than simply examining the farms' debt-load; thus, a more accurate picture of a farm's total costs can be portrayed.

This study calculated the user cost of four capital assets comprising the dairy enterprise: (1) farm buildings, (2) farm machinery and equipment, (3) land, and (4) the dairy cattle. Consistent with Moschini (1988), the following equation was employed to derive each estimate of the user cost of capital for all farms in each set of annual data:

$$r_j = R_j \, (i + \delta_j) \tag{4.3}$$

where r_j is the user cost of capital input j,
R_j is the capital (replacement) price for capital input j,
i is the interest rate or the opportunity cost of holding capital, and
δ_j is the physical depreciation rate for capital input j.

The capital or replacement price R, expressed in Equation 4.3, is represented by the current value of each capital asset. Specifically, as stated by Appleby (1996), the current market value of the farms' capital assets is determined by updating their original value with corresponding inflation factors and then depreciating according to the number of years in use.

As defined by Brigham and Gapenski (1991), the interest rate, i, denotes the farm's opportunity cost of investing in the dairy industry or the rate of return the farm could earn on alternative investments of equal risk. When choosing the appropriate interest rate to represent a farm's opportunity cost, this must directly reflect levels of risk

hour; 1996 - $14.20 per hour.

13 Annual general farm labour wage rates for Alberta, as reported by Statistics Canada CANSIM Matrix 160, are as follows: 1994- $9.53 per hour; 1995 - $9.06 per hour; 1996 - $9.34 per hour.

characteristic to the specific agricultural commodity. Bauer (1988) expands on this: "(the) degree of risk is frequently expressed in terms of how predictable a particular outcome is. Outcomes which deviate only a small amount from the expected or average value are said to be less risky than those which exhibit greater variability," (p.7). Statistically, risk is expressed as the standard deviation of a farm's percent return on its assets over time. Bauer (1988) reports that indices of returns on investments in stock markets are readily available, but are lacking in agriculture since formal trading of shares in farm businesses does not occur. However, an estimate of the business risk measure for a Quebec dairy farm, or the standard deviation of its percent return, is 0.18. This compares to a risk rating of 0.54 for a small Saskatchewan grain and oilseed farm and a risk measure of 1.37 for a Manitoba hog farrow to finish operation. Expanding on this, the risk premium of a hog farm is assessed as 10 to 20 percent, reflecting an opportunity cost interest rate of 15 to 25 percent. Since dairy farming exhibits a lower business risk than hog farming, an interest rate of 8 to 10 percent seems likely to reflect sufficiently the opportunity cost of an Alberta dairy enterprise.[14]

Interest rates for Government of Canada long term benchmark bonds were employed to represent the opportunity cost of farmers investing in the Alberta dairy industry. Interest rates for 1996, 1995 and 1994 were obtained by taking the average of the long term benchmark bond recorded for each month as reported by the Bank of Canada (2000). Interest rates of 7.75 percent, 8.41 percent, and 8.69 percent were utilized for 1996, 1995, and 1994 respectively.

The physical depreciation rates of capital employed in this study follow Moschini (1988). Farm machinery and equipment were depreciated at a rate of 0.15 while depreciation of farm buildings was calculated using a rate of 0.05. Land was not depreciated as this is a nondepreciable asset. For the dairy herd, like land, a depreciation rate of zero is assumed. Although individual dairy cows depreciate in value, because of the costing of herd replacement, the total value of the total dairy herd is maintained in the short run.

4.2.2.10 Variable Costs versus Fixed Costs

All operating expenses incurred by a farm are classified to be either variable costs or fixed costs. Variable costs are those expenses that are responsive to changes in production levels while fixed costs remain constant as output varies in the short run. Stanton (1986) views variable costs as the most critical of all costs when conducting any cost comparison:

---

[14] The discussion related to the unit cost of capital, and references to specific risk measures and opportunity costs for agricultural enterprises, is based on personal communication with Dr. Jim Unterschultz. 2000. Edmonton, Alberta.

> In the longer run it is the differences in variable costs per unit of output which are most important in making comparisons. This is true because the fixed resources generally take on the value of expected future earnings from a profitable enterprise. The pricing of variable inputs are determined by current economic conditions and only need adjustments when they are directly affected by government action or subsidy (p.22).

Barichello and Stennes (1994) state that with the exception of hired labour, variable costs can be derived directly from survey data.

Fixed costs are comprised of cash and noncash items. Barichello and Stennes (1994) report that the cash portion of fixed costs are assessable directly from survey data and include costs of utilities, taxes, insurance and general overhead costs. The authors define noncash fixed costs as the rental cost for owned land, unpaid operator and family labour and theuser cost of farm capital stock (with the exception of production quota). According to Stanton (1986), the trend in the specialization of farm production allows more ease to access fixed cost accounting data.

The variable costs estimated in this study for sampled dairy farms include the following: feed; processing costs; bedding and supplies; breeding; veterinary and medicine costs; milk hauling; producer fees; utilities; fuel, oil, and lube; rent; labour expenses; and miscellaneous costs. The cash portion of imputed fixed costs are represented by taxes and insurance expenses, and building and machinery repairs. The noncash fixed cost estimated by this study is the user cost of capital. Table 4.2 defines how each variable and fixed expense was calculated for this study.

Levies incurred are factored into the gross revenue of each dairy enterprise, along with milk sales, subsidies, net cattle sales, and miscellaneous receipts. Producer marketing quota is not an estimated expense. It is argued that dairy quota is not a cost a production, rather it provides producers with the right to produce milk within Canada's supply managed dairy industry.

Table 4.2 Definition of Estimated Variable and Fixed Expenses

PRODUCTION EXPENSE	DEFINITION OF EXPENSE
VARIABLE EXPENSES	

Feed	*Purchased* dairy ration, calf feed, milk replacer, supplement, alfalfa pellets, molasses, minerals and vitamins, salt, brewers grain, beet pulp, oats, barley, wheat, mixed grain, alfalfa hay, straw fed, greenfeed and silage. *Farm Produced* oats, barley, wheat, mixed grain, alfalfa hay, straw feed, greenfeed and silage.
Processing Costs	Grinding and processing costs of home grown dairy feed.
Bedding and Supplies	Bedding and dairy supplies for cows, heifers and calves.
Breeding	Cow, heifer and other breeding costs.
Veterinary and Medicine	Veterinary care and medicine for cows, heifers and calves.
Milk Hauling	Milk transportation costs.
Producer's Fees	License and provincial milk producer association fees.
Utilities	Electrical and hydro costs.
Fuel, Oil and Lube	Fuel, oil, lube for operation of dairy buildings, machinery and equipment.
Rent	Charge on all rented resources.
Hired Labour	Hired farm labour.
Operator Labour	Dollar value of farm operator's labour contribution to dairy enterprise.
Family Labour	Dollar value of unpaid family labour.
Miscellaneous	Any other variable expense incurred by dairy enterprise.
FIXED EXPENSES	
Taxes and Insurance	Government taxes and farm insurance.
Building and Machine Repairs	Repair costs of dairy buildings and machinery.
User Cost of Capital	Opportunity cost of investing in dairy industry. User cost calculated for farm buildings, farm machinery and equipment, land and the dairy herd.

5. RESULTS and DISCUSSION

5.1 Characteristics of Study Groups

As previously explained in Section 4.1.1 of this study, three distinct groupings of farm herd sizes were defined for the distribution of the total number of milking cows per farm for 1994, 1995, and 1996. The first cluster is from at 40 to 50 milking cows and is representative of Alberta's smaller dairy operations (Group H1). A second concentration of farm herd size data is from 50 to 70 head of milking cattle. This subgroup is identified as Group H2 and is a proxy for the average sized dairy farms in the province. The third accumulation of farm herd size data was found at 90 milking head and above. This final grouping is a representation of Alberta's larger dairy enterprises and is referred to as Group H3.

The distribution of milk production per cow (average hectolitres of milk produced per cow per farm) for 1994, 1995, and 1996 was determined to be symmetrical. This meant that an adhoc grouping of farm data according to milk yield per cow was acceptable. To correspond with the three study groups of herd size, three divisions of milk yield were established. The first study group of milk yield, Group M1, is comprised of all farms realizing an average production per cow less than 80 hectolitres of milk. Group M1 is thus representative of Alberta's low yielding farms. The province's average dairy operation is depicted by Group M2, those surveyed farms with an average milk yield between 80 and 90 hectolitres per cow. High producing herds are all those farms achieving an average milk yield greater than 90 hectolitres per cow, Group M3.

The examination of characteristics and general operational features of study groups facilitates a greater understanding of farm level competitiveness. Identification of significant differences in the operating environment of each subgroup of herd size and milk yield provides a possible explanation for statistically different costs of production, efficiency, and profitability.

5.1.1 General Characteristics of Herd Size Groups: 1996 - 1994

The management and operational characteristics of the subgroups of dairy enterprises for which data are available are provided below according to farm herd size. The computed F statistic from the ANOVA for each group characteristic is also presented, indicating whether the data characteristics that are examined and assessed differ significantly between each study group. If a significant difference was found, three additional analyses of variance were conducted among the categories of herd size in order to identify the source of the variance. Tables 5.1, 5.2 and 5.3 summarize results for 1996, 1995 and 1994, respectively.

Since herd size is the defining factor of each study group, it is expected that there is a significant difference in the average number of milking cows in each defined group for each of the three consecutive years under examination. For small dairy herds (Group H1) the average herd size was 44.23 cows, 46.03 cows, and 45.64 cows in 1996, 1995, and 1994, respectively. The mean herd size for Alberta's average sized dairy operations (Group H2) was 59.20 cows in 1996, 60.57 cows in 1995 and 58.34 cows in 1994. The province's largest dairy farms, (Group H3) exhibited an average herd size of 130.39 cows in 1996, 136.84 cows in 1995 and 135.02 cows in 1994. An ANOVA analysis of annual milk production and farm quota holding, expressed in hectolitres and dollars, also denoted a difference in variance between the subgroups of herd sizes for each observed year. Further explanation is provided below.

Average annual milk production per farm was found to differ significantly between each individual study group for each of the three dairy years. As larger herd sizes imply greater volumes of milk produced, it is no surprise that a direct relationship between average annual milk production and herd size was observed. The small dairy farms examined, those milking between 40 and 50 cows, realized an average annual milk production of 3,755.35 hectolitres in 1996, 3,793.12 hectolitres in 1995 and 3,514.50 hectoltres in 1994. Average sized operations, farms comprised of 50 to 70 dairy cows, produced on average 5,242.16 hectolitres, 5,075.76 hectolitres and 4,935.39 hectolitres in 1996, 1995 and 1994, respectively. Average annual milk production for farms milking over 90 head was found to be 10,787.14 hectolitres in 1996, 11,166.69 hectolitres in 1995 and 11,080.03 hectolitres in 1994. Due to the fact that the average milk yield per cow did not differ significantly between groups, the inverse relationship observed with respect to average annual milk production and study group is solely the result of farm size; that is, the total number of milking cows per farm.

Parallel with annual milk production, average quota holding, expressed in terms of hectolitres per farm, increased with herd size. During 1996 and 1994, the large dairy herd group reported a significantly larger quota holding. In the 1995 dairy year, average hectolitres of quota per farm differed significantly for each study group.

As was previously noted, data revealing dairy income as a percent of total farm income were available only for 1996. An ANOVA analysis revealed that a significant difference in dairy income (expressed as a percentage of total farm income) existed between farms comprised of 50 to 70 milking cows (Group H2), and farms milking over 90 head (Group H3). Specifically, for Group H2 the dairy enterprise accounted for 94.64 percent of total farm income while milk production comprised only 78.21 percent of net returns for farms in Group H3. The fact that the largest dairy operations in the sample reported the smallest portion of their net farm income to arise from the production of milk was surprising.

It is generally believed that larger sized herds are more difficult to manage than small herds due to the need for increased time and skills. This, in turn, might be expected to encourage more intensive and specialized larger operations. However, because the dairy enterprise becomes a less important source of income for Alberta dairy farms milking over 90 head, it can be suggested that the managers of larger dairy farms in Alberta are more diversified in their business ventures. Recognizing that Alberta's large-scale dairy farms are diversified operations spurs consideration of factors influencing the management decisions of producers.

As noted in the review of literature (Section 2.2), Houck (1992) contends that specialization is a main catalyst for absolute free trade: “specialization according to comparative advantage permits a nation to produce more export goods than it wants, then trade them for less costly imported goods from all over the world,” (p.16). The fact that the province’s largest dairy herds are broadening their business ventures might suggest that the *perceived* comparative advantage of farm managers does not lie in milk production. Perhaps dairy producers lack confidence in the current direction of Canada’s supply management system, or maybe the high cost of marketing quota has created a barrier to further growth of some dairy farmers, preventing the further expansion of their dairy herds; thus inhibiting the province of Alberta from realizing a comparative advantage in milk production. Another possible explanation is that Alberta’s largest dairy producers may be pursuing particular vertical or horizontal integration linkages or activities. Unfortunately, because the examined data set presents cost figures incurred by the dairy enterprise only, it is impossible to conclude whether any of these speculations is applicable. The questions raised suggest that further research examine the nature of apparent diversification for Alberta’s large-scale dairy operations.

From the literature review (Section 3.4), Barichello et al (1996) report that many studies on the competitiveness of Canada’s dairy industry conclude average yield per cow to increase with herd size: “this suggests that lower COP result not merely from an increase in farm size but also from an increase in yield per cow or a combination of these two factors,” (p.108). It may be noted that the data compiled for this study do not support this inference about the relationship between herd size and milk yield. In each of the three years of observed data, average milk production per cow did not differ significantly between the subgroups of herd size. This statement made by Barichello et al (1996) will be re-examined in further analyses within this study.

Table 5.1 1996 Farm Characteristics of Three Study Groups Based on Herd Size[a]

FARM CHARACTERISTIC	GROUP H1 40-50 Dairy Cows	GROUP H2 50-70 Dairy Cows	GROUP H3 Over 90 Dairy Cows	F STATISTIC
Percentage of Study Farms	23.40	46.81	29.79	N/A
Average Milking Herd Size	44.23 cows	59.20 cows	130.39 cows	124.66*
Average Number of Years Farming	13.36	14.73	20.86	2.05
Average Dairy Income as percent of Total Farm Income per Farm	90.45	94.64	78.21	4.35*
Average Annual Milk Production (hl)	3,755.35	5,242.16	10,787.14	89.86*
Average Volume of Milk per Cow (hl)	84.85	88.30	82.04	1.56
Average Quota Holding per Farm (hl)	2,659.16	3,266.44	7,562.84	39.74*
Average Percent Over-Quota Milk Production	28.77	37.06	30.30	1.24
Average Quota Holding per Farm ($)	155,665.89	189,420.93	436,850.53	38.37*

a * denotes statistical significance at a 95 percent confidence interval.

Table 5.2 1995 Farm Characteristics of Three Study Groups Based on Herd Size[a]

FARM CHARACTERISTIC	GROUP H1 40-50 Dairy Cows	GROUP H2 50-70 Dairy Cows	GROUP H3 Over 90 Dairy Cows	F STATISTIC
Percentage of Study Farms	29.17	41.67	29.17	N/A
Average Milking Herd Size	46.03 cows	60.57 cows	136.84 cows	152.02*
Average Number of Years Farming	13.21	15.15	18.29	0.79
Average Dairy Income as percent of Total Farm Income per Farm	N/A	N/A	N/A	N/A
Average Annual Milk Production (hl)	3,793.12	5,75.03	11,166.69	120.38*
Average Volume of Milk per Cow (hl)	82.04	83.89	82.46	0.12
Average Quota Holding per Farm (hl)	2,408.75	3,247.16	7,546.58	35.67*
Average Percent Over-Quota Milk Production	34.74	35.69	33.03	0.08
Average Quota Holding per Farm ($)	132,609.47	178,205.66	409,505.29	35.08*

a * denotes statistical significance at a 95 percent confidence interval

Table 5.3 1994 Farm Characteristics of Three Study Groups Based on Herd Size[a]

FARM CHARACTERISTIC	GROUP H1 40-50 Dairy Cows	GROUP H2 50-70 Dairy Cows	GROUP H3 Over 90 Dairy Cows	F STATISTIC
Percentage of Study Farms	29.41	45.10	25.49	N/A
Average Milking Herd Size	45.64 cows	58.34 cows	135.02 cows	192.31*
Average Number of Years Farming	16.07	15.22	17.00	0.12
Average Dairy Income as percent of Total Farm Income per Farm	N/A	N/A	N/A	N/A
Average Annual Milk Production (hl)	3,514.50	4,935.39	11,080.03	160.85*
Average Volume of Milk per Cow (hl)	82.46	84.48	82.87	2.16
Average Quota Holding per Farm (hl)	2,498.70	3,020.32	7,582.87	41.08*
Average Percent Over-Quota Milk Production	27.69	37.90	31.90	1.31
Average Quota Holding per Farm ($)	136,105.97	162,425.20	405,373.24	39.46*

a * denotes statistical significance at a 95 percent confidence interval

5.1.2 General Characteristics of Milk Yield Groups: 1996 - 1994

Characteristics revealing the management and operational features of the subgroups of farm milk yield are provided below. The computed F statistic from the ANOVA for each group characteristic is also presented, indicating whether the data characteristics that are examined and assessed differ significantly between each category of milk yield. If a significant difference was found, three additional analyses of variance were conducted among the study groups in order to identify the source of the variance. Results for 1996, 1995 and 1994 are found in Tables 5.4, 5.5 and 5.6 respectively.

Tables 5.4, 5.5, and 5.6 show that the percentage of surveyed farms categorized according to milk yield are fairly evenly distributed between study groups. This uniform allocation of farms reflects the normal distribution of milk production per cow identified by the histogram of milk yield per cow. As milk production per cow is the defining characteristic of each of these subgroups of farms, a significant difference in milk yield between study groups was found in all three years examined. Low producing herds (Group M1) realized an average production per cow figure of 73.52 hectolitres, 70.69 hectolitres and 71.82 hectolitres in 1996, 1995 and 1994, respectively. Group M2 achieved an average milk yield of 85.15 hectolitres per cow in 1996, 85.90 hectolitres per cow in 1995, and 85.77 hectolitres per cow in 1994. High yielding farms (Group M3) were found to have an average production level of 95.57 hectolitres per cow in 1996, 96.33 hectolitres per cow in 1995, and 96.38 hectolitres in 1994.

During the 1996 and the 1994 dairy years, the percentage of over-quota milk production was found to be significantly different between farm subgroups. In 1996, at 43.40 percent, farms with an average milk yield greater than 90 hectolitres per cow (Group M3) reported a significantly higher quantity of over-quota milk production compared to farms averaging less than 90 hectolitres of milk per cow. In 1994 a significant difference in over-quota milk production was detected between study groups M1 and M3: 28.87 percent versus 30.02 percent.

The average number of years that dairy operators have been farming was not significantly different between the groups except in 1994. Specifically, at an average of 10.55 years, farms with an average milk yield between 80 and 90 hectolitres per cow were managed by operators who had been involved in the industry for a significantly shorter time period. Herds comprising Groups M1 and M3 were operated by individuals who had been farming for an average of 19.10 years and 17.62 years respectively. Because no significant difference in the number of years farming applied between groups for the 1996 and 1995 data, it is concluded that 1995 surveyed farms which averaged between 80 and 90 hectolitres of milk per cow (Group M2) involved a younger sample of farmers than those operating farms with an average milk yield less than 80 (Group M1) or herds with an average production level greater than 90 hectolitres per cow (Group M3).

No evidence of a statistically significant trend in herd size with respect to milk production was found over the three years examined. This finding does not support the inference made by Barichello et al (1996) that average yield per cow increases with herd size. Again, the relationship between herd size and milk yield will be addressed in later analyses within this study.

Statistically significant differences in the management characteristics and general operational features of study groups identified above facilitates a greater understanding of farm level competitiveness. The issues arising from the above discussion will be incorporated into the preceding analyses of this study. Reasoning for significant differences in the operating environment of each subgroup of herd size and milk yield could possibly provide an explanation for contrasting costs of production estimated in Section 5.2, as well as for different levels of efficiency derived in Section 5.3.

Table 5.4 1996 Farm Characteristics of Three Study Groups Based on Milk Yield[a]

FARM CHARACTERISTIC	GROUP M1 Under 80 hl/cow	GROUP M2 80-90 hl/cow	GROUP M3 Over 90 hl/cow	F STATISTIC
Percentage of Study Farms	31.15	36.07	32.79	N/A
Average Milk Yield (hl/cow)	73.52	85.15	95.57	98.57*
Average Number of Years Farming	17.05	15.05	16.15	0.19
Average Dairy Income as percent of Total Farm Income per Farm	87.58	84.64	92.60	0.99
Average Annual Milk Production (hl)	5,283.38	6,200.02	6,654.33	0.99
Average Herd Size	71.80 cows	72.69 cows	69.96 cows	0.03
Average Quota Holding per Farm (hl)	3,705.28	4,603.02	3,826.91	0.80
Average Percent Over-Quota Milk Production	27.38	28.39	43.40	7.37*
Average Quota Holding per Farm ($)	217,887.08	265,767.25	220,741.49	0.73

a * denotes statistical significance at a 95 percent confidence interval

Table 5.5 1995 Farm Characteristics of Three Study Groups Based on Milk Yield[a]

FARM CHARACTERISTIC	GROUP M1 Under 80 hl/cow	GROUP M2 80-90 hl/cow	GROUP M3 Over 90 hl/cow	F STATISTIC
Percentage of Study Farms	35.82	41.79	22.39	N/A
Average Milk Yield (hl/cow)	70.69	85.90	96.33	165.13*
Average Number of Years Farming	16.25	14.89	18.33	0.53
Average Dairy Income as percent of Total Farm Income per Farm	N/A	N/A	N/A	N/A
Average Annual Milk Production (hl)	5,170.74	6,374.71	6,086.74	0.99
Average Herd Size	73.87 cows	73.88 cows	62.94 cows	0.47
Average Quota Holding per Farm (hl)	3,411.57	4,404.89	3,776.82	1.05
Average Percent Over-Quota Milk Production	29.59	32.41	40.07	1.74
Average Quota Holding per Farm ($)	188,839.69	239,196.27	205,505.30	0.93

a * denotes statistical significance at a 95 percent confidence interval

Table 5.6 1994 Farm Characteristics of Three Study Groups Based on Milk Yield[a]

FARM CHARACTERISTIC	GROUP M1 Under 80 hl/cow	GROUP M2 80-90 hl/cow	GROUP M3 Over 90 hl/cow	F STATISTIC
Percentage of Study Farms	44.60	27.03	28.38	N/A
Average Milk Yield (hl/cow)	71.82	85.77	96.38	158.62*
Average Number of Years Farming	19.09	10.55	17.62	4.96*
Average Dairy Income as percent of Total Farm Income per Farm	N/A	N/A	N/A	N/A
Average Annual Milk Production (hl)	4,938.20	5,620.80	6,552.40	1.90
Average Herd Size	68.48 cows	65.13 cows	67.78 cows	0.05
Average Quota Holding per Farm (hl)	3,349.18	4,007.91	3,916.53	0.61
Average Percent Over-Quota Milk Production	28.87	30.02	41.41	3.47*
Average Quota Holding per Farm ($)	182,247.24	213,859.43	206,973.57	0.46

a * denotes statistical significance at a 95 percent confidence interval

5.2 Costs of Production

The estimated economic costs of production for Alberta dairy farms are presented in Tables 5.7 to 5.12 for each of the three years examined: 1996, 1995, and 1994. The preceding discussion in Section 5.2.1 is related to the possibility that economies of size may apply in the province's dairy industry and was based on COP estimates for the observed data as farms are grouped by herd size. The following section (5.2.2) is directed at the possibility of whether economies of yield exist among Alberta dairy producers based on estimated production costs for the three study groups of farms grouped by differences in milk yield. All estimated costs are averages for the respective study groups and are reported in terms of dollars per hectolitres of milk produced ($/hectolitre).

5.2.1 Investigating Economies of size: Herd Size Distribution of Data

5.2.1.1 Estimated economic costs of production for the 1996 dairy year

Cost of production estimates for 1996 for the three herd size groups are reported in Table 5.7. An F statistic from the single factor / one-way ANOVA preformed for individual production expenses is also presented to indicate whether or not each estimated group average cost of production differs significantly between the three study groups. If a given cost was identified as being significantly different among the study groups, three additional analyses of variance were run to determine the source of the variation.

Total production costs derived from the 1996 data set were found to decrease as herd size is increased; however, total cost differences between the three study groups were not statistically significant. Thus, the existence of economies of size among Alberta dairy producers cannot be inferred for the 1996 total production cost data constructed as outlined in Chapter 4. However, although none of the specified groupings of herd size demonstrated a significant total cost advantage over other groupings, significant differences among study groups were observed for some operating expenses, as detailed below.

Fuel, oil and lube costs were found to differ significantly for small and average sized herds. For farms milking 40 to 50 head (Group H1) the reported average operating expense was $1.06 per hectolitre, while herds comprised of 50 to 70 milking cows (Group H2) reported an average production cost of $0.69 per hectolitre, a per unit cost advantage of $0.37 over the small herd size group. Recognizing that the user cost of farm capital did not differ significantly between study groups, it is concluded that farms milking over 50 head are more cost efficient users of fuel, oil and lube in their operation of dairy buildings, machinery and equipment.

Miscellaneous expenses were found to differ significantly between Group H2 and Group H3. More specifically, a $1.21 per unit decrease was calculated as miscellaneous costs fell from $2.23 per hectolitre to $1.02 per hectolitre, when moving from the group of farms milking 50 to 70 head to the large herd size grouping of farms milking over 90 head.

Hired labour expenses differed significantly between each study group, revealing a direct relationship between COP estimates and categories of herd size. For Group H1, farms milking 40 to 50 cows, an average hired labour cost of $0.44 per hectolitre of milk was calculated. Group H2, comprised of farms with 50 to 70 milking head, reported a hired labour expense averaging $1.95 per hectolitre of milk produced. Farms milking over 90 cows, Group H3, reported the greatest average hired labour expense for 1996 at $4.73 per hectolitre.

In contrast to hired labour expenses, imputed operator labour costs were found to decrease as herd size increased. The small herd size grouping incurred an average imputed operator labour cost of $8.71 per hectolitre. Average sized dairy operations reported an average operator labour expense of $6.78 per hectolitre, while the operator labour cost estimated for large herd size groups was $2.39 per hectolitre. It is concluded that as herd size is increased, hired labour is substituted for operator labour. This trend in farm labour composition is found to be cost effective, because the lower imputed operator labour for farms milking over 90 head outweighed the cost of hired labour for farms milking under 70 head. Specifically, at $8.45 per hectolitre, the large herd size group reported a significantly lower average total labour cost compared to the small and average herd size groups whose estimated average total labour expenses were $12.20 per hectolitre and $11.30 per hectolitre respectively.

5.2.1.2 Estimated economic costs of production for the 1995 dairy year

Table 5.8 outlines estimated 1995 producer costs of production for three groups based on differences in farm herd size. The F statistic from the single factor / one-way ANOVA performed for each production expense is reported. If a given cost was identified as being significantly different among the study groups, three additional analyses of variance were run to assess the source of the variation.

In 1995, as in 1996, an inverse relationship between average total costs of production and herd size was observed. However, in contrast to the 1996 cost estimates, total cost differences for the 1995 dairy year were found to be significantly different for the three groups. More specifically, total annual expenditures of the large herd size group differed significantly from those of the small and average sized herd groups. Thus, it is concluded that during 1995, cost benefits of larger size were achieved by Alberta dairy farms milking over 90 cows. Operations comprised of 40 to 50 milking cows (Group H1) reported the highest average total cost of milk production at $55.81 per hectolitre. For herds of 50 to 70 head (Group H2) an average total milk production expense of $55.38 per hectolitre was estimated. Farms milking over 90 head (Group H3) achieved the lowest average total milk COP value for 1995 at $45.59 per hectolitre; $10.22 a unit less than the average total milk production cost of Group H1, and $9.79 per hectolitre below the average total operating expense incurred by Group H2. Significantly lower use of both family labour and operator labour production costs, and a lower user cost of land outweighed a significantly higher utilities expenditure, allowing Group H3 to achieve this total cost advantage. This finding is discussed further below.

The 1995 average family labour expense calculated for the large herd size group was $2.11 per hectolitre. This figure differed significantly from the small and average sized herd. Decreasing with herd size, average family labour costs for Groups H1 and H2 were $6.03 per hectolitre and $4.83 per hectolitre respectively.

Operator labour expenditures mimicked family labour costs as herds over 90 head (Group H3) reported a significantly lower average cost for this labour category at $2.56 per hectolitre. The smaller farms (Group H1) reported an average operator labour production cost of $8.83 per hectolitre while for average sized herds (Group H2), an expense of $6.90 per hectolitre applied.

The cost advantage in family labour and operator labour reported by the large herd size group allowed the farms milking over 90 head to achieve a significantly lower average total labour cost at $6.05 per hectolitre. The estimated average total labour cost for the small and average sized herd groups were $25.82 per hectolitre and $26.57 per hectolitre.

The user cost of land was significantly lower for farms milking over 90 head compared to farms comprised of less than 90 milking cows. The computed 1995 average user cost of land was $0.26 per hectolitre for Group H3 while Groups H1 and H2 reported an average user cost of $0.73 and $0.61 per hectolitre, respectively. An ANOVA analysis performed to examine differences in the market value of land among farms in each study group (the value of R in Equation 4.3) found no significant difference in land values between the three groups. A second ANOVA analysis was conducted using market value of farm land measured on a per hectolitre basis. Results showed the value of land for the large herd size group to be significantly lower than that of the small and average sized herd groups. From these two findings it is inferred that the lower user cost of land achieved by farms milking over 90 cows is the result of economies of size rather than a reflection of factors influencing land prices, such as farm location and development potential.

In contrast to family and operator labour expenses and the user cost of land, the utilities expense incurred by Group H3 was significantly higher than the utilities component of production costs for Groups H1 and H2. Specifically, farms milking over 90 head reported an average utilities expense of $1.20 per hectolitre. Herds of 50 to 70 cows realized the lowest average utilities cost at $0.95 per hectolitre. Operations comprised of 40 to 50 head followed with an average utilities cost of production of $0.97 per hectolitre.

5.2.1.3 Estimated economic costs of production for the 1994 dairy year

Estimated farm-level costs of production for 1994, the final dairy year to be examined in this study, are presented below in Table 5.9 for the three groups of herd size. The F statistic from the single factor / one-way ANOVA performed for each production expense is indicated. If a given cost was identified as being significantly different among the study groups, three additional analyses of variance were run to assess the source of the variation.

For each of the three years considered, average total costs of milk production were found to decrease as herd size increased. Specifically, average total annual expenditures for the large herd size group differed significantly from those of the small and average sized herd groups. This mirrors the evidence found in the 1995 data set that economies of size materialize only among farms milking over 90 cows. During 1994, herds in Group H3 reported an average total operating expense of $44.81 per hectolitre. This represents a savings in the per unit cost of milk production of $13.64 per hectolitre over Group H1, which sustained the highest average total production cost at $58.45 per hectolitre. Group H2 realized an average total COP value of $54.65 per hectolire, $9.84 per hectolitre greater than that of Group H3. Parallel to 1995, significantly smaller family labour, and operator labour production costs aided Group H3 in achieving a total cost advantage over Groups H1 and H2. As well, during 1994, significantly smaller expenses for producer fees and user cost of farm machinery and equipment also contributed to the lower total operating expenditure for Group H3 than for other groups. Further explanation is provided below.

In 1994, imputed family labour expenditures for the large herd size group (Group H3) differed significantly from family labour of the small and average sized herds groups. Farms milking over 90 head reported an average family labour production expense of $2.31 per hectolitre, less than half of the cost incurred by farms with less than 90 head. Average family labour costs realized by Groups H1 and H2 for the 1994 dairy year were $6.40 per hectolitre and $5.46 per hectolitre, respectively.

Coinciding with family labour costs, the average imputed operator labour expense of the large herd size group differed significantly from operator labour costs reported by small and average sized farms. Decreasing with herd size, operator labour costs estimated for 1994 were $7.64 per hectolitre, $6.37 per hectolitre, and $2.27 per hectolitre for Groups H1, H2, and H3, respectively. An inverse relationship between category of herd size and 1994 total labour costs was identified. Decreasing as average herd size is increased, average total cost of labour estimates were $16.52 per hctolitre for Group H1, $13.96 per hectolitre for Group H2, and $6.11 per hectolitre for Group H3.

Like total labour costs, average producer fees differed significantly between each study group, decreasing as herd size increased. Herds milking 40 to 50 head (Group H1) reported producer fees equal to $1.22 per hectolitre. Farms with 50 to 70 cows milking (Group H2) paid an average of $1.13 per hectolitre in producer fees during 1994 while herds over 90 head (Group H3) realized the lowest average COP value at $1.06 per hectolitre. This significant inverse relationship between producer fees and herd size appears to represent a fixed cost spread over an increasing number of production units.

The average user cost of machinery and equipment for farms in Group H1 was significantly higher than the user costs of machinery and equipment incurred by Group H2 and Group H3 herds. Specifically, farms milking 40 to 50 cows realized an average user cost of $4.69 per hectolitre in 1994. Herds of 50 to 70 head reported a user cost of $3.40 per hectolitre while the average user cost machinery and equipment for farms milking more than 90 head was $3.08 per hectolitre.

5.2.1.4 Summary of economic production costs derived according to herd size

Table 5.10 summarizes the average annual total costs of production calculated for each study group and cites the percentage change in average total operating expenditures between 1994 and 1996. The F statistic from the single factor / one-way ANOVA performed for each year is also presented.

When comparing total costs of production across years, the large herd size group (Group H3) is the only study group for which a significant change in total operating expenses is seen in 1996, compared to 1995. The 11.03 percent increase in total expenditures reported by the group between 1995 and 1996 was the result of significantly higher costs for feed, producer fees and hired labour, and a higher user cost of cattle. These expenses, plus a higher level of imputed costs of family labour, contributed to a significant increase in estimated total costs for farms milking over 90 head between 1994 and 1996. The rise in imputed family labour costs between 1994 and 1996 resulted from of a significantly higher number of total labour hours worked by the farm family during 1996 as the wage rate assigned to family labour decreased from $9.53 per hour in 1994 to $9.34 per hour in 1996.

It is interesting to note that although the total cost of milk production estimated for the small herd size group (Group H1) did not differ significantly between 1994 and 1996, these farms milking 40 to 50 head reported unpaid family labour expenses to fall by $3.34 per hectolitre during this time period. It can therefore be suggested that over time Alberta's smaller herds have become increasingly more labour efficient. The validity of this observation will be examined in detail in Section 5.3 when the physical and economic efficiency of herd size groups is estimated.

The hypothesis that large dairy operations have a cost competitive advantage over smaller herds, due to economies of size, was validated for the 1995 and 1994 dairy years. Specifically, operating expenses were found to decrease significantly for farms milking over 90 cows. The 11.03 percent increase in total operating expenses between 1995 and 1996 prevented the large herd size group from exhibiting its total cost advantage in 1996. This may suggest that the province's largest herds may be losing their cost competitive position. Perhaps controlling rising feed, and hired and family labour costs and a higher user costs of cattle would allow Group H3 to regain its total cost advantage. The examination of production cost data of more recent years is suggested in order to address this concern.

The evidence that economies of size exist in the Alberta dairy industry follows the observation made by Lazarus et al (1989) that large farms are more prosperous than smaller herds due to the fact that overhead costs are spread over more producing units. Recall from Section 3.1.3 of this study, that Barichello and Stennes (1994) took their explanation of economies of size a step further than Lazarus et al (1989), stating: "despite the extra variable costs that appear to arise with large sized operations, the potential savings in fixed costs and unpaid labour is large enough to give cost advantages to larger farms," (p.19). The estimated costs of production derived in this study did not entirely confirm this inference made by Barichello and Stennes (1994).

Consistent with the findings of Barichello and Stennes (1994), the large dairy herds examined in this study achieved a cost advantage through lower use of unpaid labour by the farm family and farm manager. Also following the findings of Barichello and Stennes (1994), the largest dairy operations examined exhibited lower average fixed costs than the small and average sized farms. In contrast to the conclusion of Barichello and Stennes (1994), the operating costs of Alberta dairy farms computed for this study, reveal that the variable expenses of farms milking more than 90 head do not differ significantly from those of smaller herds.

Table 5.7 1996 Average Dairy Costs of Production by Cost Category According to Herd Size ($/hl)[a]

COST ITEM	GROUP H1 40 - 50 Dairy Cows	GROUP H2 50 - 70 Dairy Cows	GROUP H3 Over 90 Dairy Cows	F STATISTIC
Feed	20.35	18.84	19.96	0.84
Processing	0.23	0.18	0.03	2.07
Bedding & Supplies	1.74	2.04	1.54	3.15
Breeding	0.74	0.81	0.66	0.56
Vet & Medicine	1.37	1.52	1.23	0.56
Milk Hauling	1.84	1.78	1.77	0.69
Producer Fees	1.03	1.00	1.01	2.75
Utilities	1.19	1.09	1.23	0.56
Fuel, Oil & Lube	1.06	0.69	0.53	6.14*
Rent	1.23	0.51	0.32	2.13
Miscellaneous Expenses	1.33	2.23	1.02	3.49*
Hired Labour	0.44	1.95	4.73	21.70*
Unpaid Family Labour	3.06	2.58	1.33	3.12
Operator Labour	8.71	6.78	2.39	33.59*
Insurance & Tax	0.59	0.73	0.67	0.49
Build/Machine Repairs	1.68	2.06	2.14	1.01
User Cost of Buildings	4.18	4.50	4.88	0.22
User Cost of Machinery & Equipment	3.18	3.17	3.05	0.04
User Cost of Land	0.50	0.53	0.25	2.95
User Cost of Dairy Herd	1.76	1.85	1.89	1.47
Total Variable Cost[b]	**32.12**	**30.66**	**29.29**	**1.61**
Total Labour Cost	**12.20**	**11.30**	**8.45**	**9.76***
TOTAL COP	**56.22**	**54.80**	**50.62**	**2.75**

a * denotes statistical significance at a 95 percent confidence interval
b Average Total Variable Cost excludes labour expenses

Table 5.8 1995 Average Dairy Costs of Production by Cost Category According to Herd Size ($/hl)[a]

COST ITEM	GROUP H1 40 - 50 Dairy Cows	GROUP H2 50 - 70 Dairy Cows	GROUP H3 Over 90 Dairy Cows	F STATISTIC

Feed	16.19	16.38	16.66	0.14
Processing	0.07	0.14	0.10	0.27
Bedding & Supplies	1.60	1.69	1.54	0.29
Breeding	0.62	0.81	0.46	1.94
Vet & Medicine	1.02	1.26	1.06	1.08
Milk Hauling	1.85	1.78	1.77	2.17
Producer Fees	0.97	0.96	0.98	1.162
Utilities	0.97	0.95	1.20	3.28*
Fuel, Oil & Lube	0.72	0.60	0.49	1.57
Rent	0.45	0.19	0.27	0.77
Miscellaneous Expenses	1.36	1.80	1.78	0.44
Hired Labour	1.46	2.52	1.39	2.23
Unpaid Family Labour	6.03	4.83	2.11	24.75*
Operator Labour	8.83	6.90	2.56	24.61*
Insurance & Tax	0.91	0.80	0.57	2.65
Build/Machine Repairs	1.85	1.87	1.70	0.19
User Cost of Buildings	4.93	5.26	5.23	0.10
User Cost of Machinery &Equipment	3.09	3.92	3.36	1.51
User Cost of Land	0.73	0.61	0.26	6.05*
User Cost of Dairy Herd	2.14	2.12	2.10	0.26
Total Variable Cost[b]	**25.82**	**26.57**	**26.32**	**0.21**
Total Labour Cost	**16.32**	**14.24**	**6.05**	**23.97***
TOTAL COP	**55.81**	**55.38**	**45.59**	**9.47***

a * denotes statistical significance at a 95 percent confidence interval
b Average Total Variable Cost excludes labour expenses

Table 5.9 1994 Average Dairy Costs of Production by Cost Category According to Herd Size ($/hl)[a]

COST ITEM	GROUP H1 40 - 50 Dairy Cows	GROUP H2 50 - 70 Dairy Cows	GROUP H3 Over 90 Dairy Cows	F STATISTIC
Feed	15.01	16.16	15.48	0.45
Processing	0.16	0.93	0.01	1.76
Bedding & Supplies	1.64	1.80	1.30	1.29
Breeding	0.75	0.87	0.49	1.35
Vet & Medicine	1.20	1.26	0.92	1.04
Milk Hauling	1.65	1.66	1.69	0.24
Producer Fees	1.22	1.13	1.06	9.81*
Utilities	1.26	0.98	1.26	2.43
Fuel, Oil & Lube	0.66	0.57	0.49	0.97
Rent	0.35	0.27	0.07	1.00
Miscellaneous Expenses	1.24	1.59	1.77	0.78
Hired Labour	2.48	2.14	1.54	0.81
Unpaid Family Labour	6.40	5.46	2.31	34.77*
Operator Labour	7.64	6.37	2.27	35.74*
Insurance & Tax	0.67	0.62	0.58	0.28
Build/Machine Repairs	2.14	2.10	2.10	0.01
User Cost of Buildings	6.12	5.17	5.86	0.79
User Cost of Machinery & Equipment	4.69	3.40	3.08	4.90*
User Cost of Land	0.92	0.82	0.35	2.75
User Cost of Dairy Herd	2.29	2.20	2.17	1.12
Total Variable Cost[b]	**25.10**	**26.38**	**24.55**	**0.84**
Total Labour Cost	**16.52**	**13.96**	**6.11**	**32.12***
TOTAL COP	**58.45**	**54.65**	**44.81**	**13.17***

a * denotes statistical significance at a 95 percent confidence interval
b Average Total Variable Cost excludes labour expenses

Table 5.10 Changes in Average Total Costs of Production According to Herd Size: 1994-1996 ($/hl)[a]

STUDY GROUP	1994	1995	% Change	F STAT 1994-95	1996	% Change	F STAT 1995-96	F STAT 1994-96
40 - 50 Cows	58.45	55.81	- 4.52	0.61	56.22	+ 0.73	0.02	0.44
50 - 70 Cows	54.65	55.38	+ 1.34	0.14	54.80	- 1.05	0.08	0.01
Over 90 Cows	44.81	45.59	+ 1.43	0.07	50.62	+ 11.03	5.04*	5.84*

a * denotes statistical significance at a 95 percent confidence interval

5.2.2 Investigating Economies of Yield: Milk Yield Distribution of Data

5.2.2.1 Estimated economic costs of production for the 1996 dairy year

Estimated 1996 producer costs of production, grouped on the basis of differences in average milk yield per farm, are noted below in Table 5.11. The F statistics from the single factor / one-way ANOVA preformed for individual production expenses are presented to indicate whether or not each computed cost of production differs significantly between the three groups. If a given cost was identified as being significantly different among the study groups, three additional analyses of variance were conducted to assess the source of the variation.

Average total operating expenses derived for the 1996 dairy year were found to decrease as milk yield per cow increased, with a significant difference in total costs detected between the low yielding group (Group M1) and the high yielding group (Group M3). Therefore, the existence of economies of milk yield in Alberta's dairy industry can be inferred when moving from an average production level below 80 hectolitres of milk per cow to an average milk yield of over 90 hectolitres per cow. Estimated average total costs of production calculated for each group are as follows: $57.08 per hectolitre for Group M1, $53.41 per hectolitre for Group M2, and $51.43 per hectolitre for Group M3. To provide further insight into the composition of costs for the 1996 dairy year, significant differences among study groups for the identified operating expenses are discussed below.

Parallel with average total production costs, a significant difference in producer fees was observed between the low yielding group (Groups M1) and the high yielding group (Group M3). Farms realizing an average production level below 80 hectolitres per cow reported producer fees totaling $1.03 per hectolitre. Herds averaging over 90 hectolitres of milk per cow reported an average producer fee expense of $1.00 per hectolitre.

The user cost of farm machinery and equipment was found to differ significantly between Group M1 and Group M2. Specifically, herds with an average milk yield below 80 hectolitres of milk per cow sustained an average user cost of $4.23 per hectolitre. Farms with an average production per cow between 80 and 90 hectolitres reported an average user cost of $2.90 per hectolitre. Although Group M2 achieved a $1.33 per hectolitre cost advantage over Group M1, no significant difference in the market value of farm machinery and equipment was found between the two study groups. Further analysis revealed that computed user costs of machinery and equipment also did not differ significantly among groups when figures were expressed as absolute numbers (as opposed to being examined on a per hectolitre basis). It is thus concluded that the significantly higher user cost of machinery and equipment reported by low yielding farms was the result of economies of milk yield.

An inverse relationship between milk yield per cow and the average user cost of cattle was identified. Decreasing with increased production levels per cow, estimated user costs of cattle are as follows: $1.96 per hectolitre, $1.86 per hectolitre, and $1.72 per hectolitre for Groups M1, M2, and M3 respectively. An investigation of the individual components comprising the user cost of cattle showed no significant differences in the market values of cattle between the three study groups. The inverse relationship between the user cost of cattle and milk yield is, therefore, solely the result of economies of yield.

Although differences in 1996 average hired labour costs, average family labour costs and average operator labour costs did not differ significantly between the three categories of milk yield, the average total labour expense of Group M1 herds was significantly higher compared to the average total labour cost of Group M2 and Group M3. Specifically, farms with an average milk yield below 80 hectolitres of milk per cow reported an average total labour expense of $12.72 per hectolitre. The estimated average total labour expense for milking herds averaging between 80 and 90 hectolitres per cow was $10.34 per hectolitre. Farms with an average milk yield greater than 90 hectolitres of milk per cow reported a total labour cost of $9.65 per hectolitre.

5.2.2.2 Estimated economic costs of production for the 1995 dairy year

Estimated farm level costs of production, expressed according to the average milk yield per cow of each farm in the 1995 data set, are presented in Table 5.12. The F statistic from the single factor / one-way ANOVA performed for each production expense is also reported. If a given cost was identified as being significantly different among the study groups, three additional analyses of variance were run to determine the source of the variation.

Total dairy costs of production estimated for the 1995 dairy year averaged $57.09 per hectolitre for the low yielding group (Group M1), $51.03 per hectolitre for the average yielding group (Group M2), and $51.85 per hectolitre for the high yielding group (Group M3). A significant difference in average total costs was observed only between Groups M1 and M2. Thus, for 1995 as for 1996, it is concluded that economies of milk yield do exist in Alberta's dairy industry when moving from an average production level below 80 hectolitres of milk per cow to an average milk yield over 90 hectolitres per cow. Significant differences detected for individual cost items are discussed below.

Veterinary and medicine expenses were found to be significantly higher for the average milk yield group during 1995. Specifically, farms which average 80 to 90 hectolitres of milk per cow, reported an average veterinary and medicine cost of $1.34 per hectolitre. Veterinary and medicine production costs estimated for the low yielding group and the high yielding group were $1.00 per hectolitre and $0.99 per hectolitre respectively.

At $2.94 per hectolitre, the user cost of farm machinery and equipment incurred by the average yielding group of farms was found to be significantly lower than the user cost incurred by the low and high yielding study groups. Group M1 reported an average user cost of $4.48 per hectolitre, $1.54 per unit greater than that of Group M2. Group M3 realized an average user cost of machinery and equipment of $4.27 per hectolitre, $1.33 per unit higher than that of Group M2.

Parallel to the cost analysis for 1996, the user cost of cattle was found to decrease as milk yield increased. However, in contrast to 1996 estimations, a significant difference in the user cost of cattle was detected only when expenses were expressed on a per hectolitre basis. The significantly higher user cost of cattle reported by low yielding farms is therefore the result of economies of milk yield.

5.2.2.3 Estimated economic costs of production for the 1994 dairy year

Dairy production costs estimated for the 1994 dairy year are presented in Table 5.13. according to the average milk production per cow of each study group. To reveal the significance of cost differences, the F statistic of the single factor / one-way ANOVA performed for each operating expense is also stated. If a given cost was identified as being significantly different among the study groups, three additional analyses of variance were run to determine the source of the variation.

Estimated average total costs of production did not differ significantly between the three categories of milk yield. Thus, the existence of economies of milk yield among Alberta dairy producers cannot be inferred for 1994 total production cost data constructed as outlined in Chapter 4. When examining individual cost items, the user cost of cattle was the only operating expense which displayed a significant difference among study groups during the 1994 dairy year.

The average user cost of cattle for farms averaging a milk yield below 80 hectolitres per cow was found to be significantly lower than the average user cost of cattle incurred by herds with an average production level greater than 90 hectolitres of milk per cow. Specifically, Group M1 reported a user cost of cattle of $2.30 per hectolitre while Group M3 realized a user cost of $2.06 per hectolitre. No significant difference in the market value of cattle was detected between the three study groups; thus as was found for 1996 and 1995, the significantly lower user cost reported by Group M1 is attributed to economies of milk yield.

5.2.2.4 Summary of economic production costs derived according to milk yield
A summary of changes in average annual total operating expenditures for each category of milk production per cow is given in Table 5.14. To identify the significance of these average total cost changes, the E statistic from the single factor / one-way ANOVA is presented.

Between 1994 and 1996, average total costs of production remained consistent for each study group. No significant change in annual total expenses was detected for any of the milk yield categories.

The hypothesis that economies of milk yield exist within Alberta's dairy industry was confirmed by the cost estimations of this study for both the 1996 and 1995 dairy years. Specifically, economies of milk yield were observed when moving from an average production level below 80 hectolitres of milk per cow to an average milk yield over 90 hectolitres per cow. This total cost disadvantage sustained by the low yielding farm group is credited to a significantly higher user cost of machinery and equipment and a higher user cost of cattle reported by these farms during 1996 and 1995. No cost saving incentives associated with increased production levels per cow were identified for the 1994 dairy year.

As discussed in the literature review (Section 3.1), there exists much controversy over the use of farm-level dairy cost data in analysis. Richards and Jeffrey (1996), unwilling to dismiss the difficulties inherent in using farm cost data, suggest that producer efficiency and its relationship with production costs is a more appropriate measure of competitiveness than simply comparing average total costs of production. They claim that producer efficiency provides an explanation for differences in farm costs and therefore facilitates the development of a strategic plan for the business to follow.

Following Richards and Jeffrey (1996), this study incorporates efficiency measures into its portfolio of Alberta dairy farm competitiveness. Following Jeffrey (1992) and Phillips et al (1989), Section 5.3 measures the technical and economic efficiency for the various study groups using a farm management approach.

Table 5.11 1996 Average Dairy Costs of Production by Cost Category According to Milk Yield ($/hl)[a]

COST ITEM	GROUP M1 Under 80 hl/cow	GROUP M2 80 - 90 hl/cow	GROUP M3 Over 90 hl/cow	F STATISTIC
Feed	20.05	19.11	18.94	0.55
Processing	0.20	0.03	0.15	2.71
Bedding & Supplies	1.67	1.98	1.82	1.07
Breeding	0.66	0.72	0.70	0.13
Vet & Medicine	1.22	1.33	1.30	0.13
Milk Hauling	1.84	1.78	1.81	0.77
Producer Fees	1.03	1.01	1.00	3.37*
Utilities	1.24	1.12	1.06	0.95
Fuel, Oil & Lube	0.91	0.71	0.622	2.36
Rent	0.75	0.37	0.69	0.65
Miscellaneous Expenses	1.18	1.82	1.73	1.18
Hired Labour	2.44	2.76	1.84	0.83
Unpaid Family Labour	2.63	2.12	2.16	0.46
Operator Labour	7.66	5.47	5.66	2.89
Insurance & Tax	0.72	0.70	0.68	0.05
Build/Machine Repairs	1.91	1.93	2.22	0.71
User Cost of Buildings	4.23	5.14	3.91	1.36
User Cost of Machinery &Equipment	4.23	2.90	3.04	5.33*
User Cost of Land	0.58	0.56	0.38	1.13
User Cost of Dairy Herd	1.96	1.86	1.72	13.63*
Total Variable Cost[b]	**30.73**	**29.98**	**29.82**	**0.28**
Total Labour Cost	**12.72**	**10.34**	**9.65**	**8.64***
TOTAL COP	**57.08**	**53.41**	**51.43**	**4.06***

a * denotes statistical significance at a 95 percent confidence interval
b Average Total Variable Cost excludes labour expenses

Table 5.12 1995 Average Dairy Costs of Production by Cost Category According to Milk Yield ($/hl)[a]

COST ITEM	GROUP M1 Under 80 hl/cow	GROUP M2 80 - 90 hl/cow	GROUP M3 Over 90 hl/cow	F STATISTIC
Feed	16.97	15.79	16.07	1.49
Processing	0.08	0.15	0.09	0.64
Bedding & Supplies	1.41	1.78	1.69	2.28
Breeding	0.59	0.72	0.69	0.44
Vet & Medicine	1.00	1.34	0.99	4.21*
Milk Hauling	1.85	1.79	1.82	2.23
Producer Fees	0.97	0.97	0.96	0.18
Utilities	1.19	1.19	1.01	0.72
Fuel, Oil & Lube	0.73	0.62	0.63	0.50
Rent	0.31	0.30	0.11	0.77
Miscellaneous Expenses	1.42	1.49	1.69	0.23
Hired Labour	2.27	1.94	2.10	0.19
Unpaid Family Labour	5.13	4.09	3.97	2.22
Operator Labour	7.31	5.72	5.60	1.94
Insurance & Tax	0.80	0.84	0.63	1.31
Build/Machine Repairs	1.98	1.97	1.96	0.00
User Cost of Buildings	5.76	4.65	5.11	1.49
User Cost of Machinery &Equipment	4.48	2.94	4.27	7.13*
User Cost of Land	0.62	0.67	0.48	0.55
User Cost of Dairy Herd	2.19	2.08	1.99	7.84*
Total Variable Cost[b]	**26.54**	**26.13**	**25.73**	**0.25**
Total Labour Cost	**14.71**	**11.48**	**11.67**	**2.27**
TOTAL COP	**57.09**	**51.03**	**51.85**	**4.05***

a * denotes statistical significance at a 95 percent confidence interval
b Average Total Variable Cost excludes labour expenses

Table 5.13 1994 Average Dairy Costs of Production by Cost Category According to Milk Yield ($/hl)[a]

COST ITEM	GROUP M1 Under 80 hl/cow	GROUP M2 80 - 90 hl/cow	GROUP M3 Over 90 hl/cow	F STATISTIC
Feed	15.36	14.85	16.07	0.77
Processing	0.10	0.16	0.01	2.88
Bedding & Supplies	1.66	1.57	1.62	0.08
Breeding	0.73	0.65	0.75	0.18
Vet & Medicine	1.14	1.01	1.26	0.79
Milk Hauling	1.65	1.62	1.69	1.29
Producer Fees	1.18	1.16	1.11	1.86
Utilities	1.22	1.04	1.23	1.09
Fuel, Oil & Lube	0.65	0.69	0.54	0.91
Rent	0.30	0.15	0.14	1.04
Miscellaneous Expenses	1.26	1.53	1.53	0.66
Hired Labour	2.83	1.39	2.30	2.95
Unpaid Family Labour	5.16	5.32	4.31	1.60
Operator Labour	5.87	6.33	4.87	1.65
Insurance & Tax	0.64	0.72	0.63	0.38
Build/Machine Repairs	2.26	2.25	1.98	0.37
User Cost of Buildings	5.32	5.18	6.05	0.78
User Cost of Machinery &Equipment	4.49	3.32	3.63	2.99
User Cost of Land	1.00	0.65	0.58	2.96
User Cost of Dairy Herd	2.30	2.12	2.06	10.49*
Total Variable Cost[b]	**25.23**	**24.42**	**25.95**	**0.75**
Total Labour Cost	**13.86**	**13.05**	**11.48**	**1.44**
TOTAL COP	**55.11**	**51.71**	**52.36**	**1.35**

a * denotes statistical significance at a 95 percent confidence interval
b Average Total Variable Cost excludes labour expenses

Table 5.14 Changes in Average Total Costs of Production According to Milk Yield: 1994-1996 ($/hl)[a]

STUDY GROUP	1994	1995	% Change	F STAT 1994-95	1996	% Change	F STAT 1995-96	F STAT 1994-96
Under 80hl/cow	55.11	57.09	+ 3.59	0.66	57.08	- 0.02	5.98E-06	0.65
80 - 90 hl/cow	51.71	51.03	- 1.32	0.13	53.41	+ 4.66	1.56	0.96
Over 90hl/cow	52.36	51.85	- 0.97	0.04	51.43	- 0.81	0.03	0.17

a * denotes significance at a 95 percent confidence interval

5.3 Efficiency

Jeffrey (1992) explains that there exists within economics various interpretations and applications of efficiency. In examining the performance of the dairy sector, technical and economic efficiency are the most commonly applied concepts (e.g., Bravo-Ureta, 1986; Bravo-Ureta and Rieger, 1991; Jeffrey, 1992; Richards and Jeffrey, 1996)

5.3.1 Physical Efficiency

Technical or physical efficiency is defined by Black (1997)as: “efficiency concerned with getting the largest possible outputs for given inputs, or the smallest possible inputs for given outputs. This is efficiency in production,” (p.463). This study estimates a farm’s efficiency in production by computing its milk productivity and labour productivity. As previously revealed, milk productivity is identified by the average hectolitres of milk produced per cow on each farm while labour productivity is expressed in terms of cows per worker equivalent. Section 5.3.1.1 investigates any possible benefits of scale by measuring physical efficiency when data are organized according to farm herd size. In order to determine possible advantages of yield, Section 5.3.1.2 reviews milk and labour productivity when surveyed farms are arranged with respect to average milk yield.

5.3.1.1 Calculated physical efficiency: herd size distribution of data

Table 5.15 outlines annual measures of physical efficiency for each category of herd size in terms of labour productivity. The significance of differences in the estimated physical efficiency for each study group is examined by the F statistic. When a given labour productivity estimate was identified as being significantly different among the categories of herd size, three additional analyses of variance were conducted to assess the basis of the detected variation.

Reporting a significantly higher number of cows per worker equivalent in each of the three years examined, farms milking over 90 head (Group H3) were found to be the most labour-efficient category of herd size. This significantly higher level of labour productivity reported by the large herd size group reveals a link between increased herd size, labour productivity, and the lower total labour cost estimated for Group H3 in Section 5.2.1. Specifically, it is suggested that more efficient use of unpaid family labour and operator labour by herds milking over 90 cows facilitates a lower average per unit cost of farm labour. Perhaps the capital inventory employed by the large herd size group promotes a significantly greater level of labour productivity, and therefore significantly lowers total labour costs on farms milking over 90 cows. Further research on the role of labour-saving technology in Alberta's dairy industry is suggested.

Recall from Section 5.2.1.4 that the family labour expenses of the small herd size group (Group H1) were found to decrease by $3.34 per hectolitre from 1994 to 1996. An ANOVA test comparing the group's labour productivity between 1994 and 1996 was conducted to see if Alberta's smaller herds have become increasingly more labour efficient. Results showed the cows per worker equivalent reported by Group H1 to significantly increase between 1994 and 1996; however, this encouraging trend is outweighed by the fact that the imputed labour productivity of the average sized and large sized herds also rose during this time period.

A measure of physical efficiency, expressed as milk productivity per cow, is presented in Table 5.16 for each subgroup of herd size. The F statistic of the single factor/one-way ANOVA performed to reveal the significance of differences in average farm production per cow is indicated.

Milk productivity per cow estimated for the three categories of herd size did not differ significantly. It is concluded that no relationship is evident between scale and herd productivity. This inference follows the findings of Section 5.1.1 of this study which previously noted that there exists no correlation between average milking herd size and average milk yield per cow. Again, the suggestion made by Barichello et al (1996) that there is a direct relationship between farm herd size and cow productivity is not supported.

5.3.1.2 Calculated physical efficiency: milk yield distribution of data

Table 5.17 presents a measure of physical efficiency, expressed in terms of labour productivity, for each category of milk yield. The significance of differences in labour productivity between study groups is revealed by the F statistic of the single factor / one-way ANOVA.

Labour productivity estimates did not differ significantly among the three categories of milk yield. This finding provides an explanation as to why average per unit hired labour, family labour, and operator labour costs imputed in Section 5.2.2 were not statistically different between the study groups. The labour productivity of Alberta dairy producers is apparently not influenced by farm milk yield, but as was observed in Section 5.3.1.1, efficient use of labour is induced by economies of size. Table 5.18 outlines the average productivity per cow within each study group.

The significance of differences in this efficiency measure is indicated by the F statistic of the single factor / one-way ANOVA. If productivity per cow estimates were found to be significantly different among the subgroups of milk yield, three additional analyses of variance were performed to determine from which group or groups the detected variation was originating.

With milk production per cow acting as the distinguishing factor between Groups M1, M2, and M3, it is expected that the estimated productivity per cow of each group differ significantly for the three years examined. This observation follows the findings of Section 5.1.2 of this study where milk yield per cow was addressed with respect to the data characteristics of each study group.

It is important to note that because surveyed farms were grouped according to average milk production per cow per year, the examination of economies of milk yield in Section 5.2.2 addressed the impact of physical efficiency on costs of production. Recall that when average milk productivity per cow per farm moved from a level below 80 hectolitres to a level greater than 90 hectolitres, average total costs of production decreased for the 1996 and 1995 dairy years. Also as previously indicated, no cost saving incentives associated with increased milk productivity were identified for the 1994 dairy year.

Table 5.15 Labour Productivity According to Farm Herd Size: 1994 - 1996 (cows/worker equivalent)[a]

LABOUR PRODUCTIVITY (cows/worker equivalent)	GROUP H1 40 - 50 Dairy Cows	GROUP H2 50 - 70 Dairy Cows	GROUP H3 Over 90 Dairy Cows	F STATISTIC
1996	31.04	30.81	46.58	22.32*
1995	22.13	26.16	36.44	13.31*
1994	24.02	23.48	37.08	8.00*

a* denotes statistical significance at a 95 percent confidence interval

Table 5.16 Milk Productivity per Cow According to Farm Herd Size: 1994 - 1996 (hl milk/cow)[a]

MILK PRODUCTIVITY (hl milk/cow)	GROUP H1 40 - 50 Dairy Cows	GROUP H2 50 - 70 Dairy Cows	GROUP H3 Over 90 Dairy Cows	F STATISTIC
1996	84.85	88.30	82.98	0.58
1995	82.04	83.89	82.46	0.12
1994	76.78	84.48	82.87	2.16

a * denotes statistical significance at a 95 percent confidence interval

Table 5.17 Labour Productivity According to Farm Milk Yield: 1994 - 1996 (cows/worker equivalent)[a]

LABOUR PRODUCTIVITY (cows/worker equivalent)	GROUP M1 Under 80 hl/cow	GROUP M2 80 - 90 hl/cow	GROUP M3 Over 90 hl/cow	F STATISTIC
1996	35.47	35.37	35.49	0.00
1995	29.50	27.46	26.53	0.51
1994	29.60	24.41	26.23	1.32

a * denotes statistical significance at a 95 percent confidence interval

Table 5.18 Milk Productivity per Cow According Farm Milk Yield: 1994 - 1996 (hl milk/cow)[a]

MILK PRODUCTIVITY (hl milk/cow)	GROUP M1 Under 80 hl/cow	GROUP M2 80 - 90 hl/cow	GROUP M3 Over 90hl/cow	F STATISTIC
1996	73.52	85.15	95.57	98.57*
1995	70.69	85.90	96.33	165.13*
1994	71.82	85.77	96.76	158.62*

a* denotes statistical significance at a 95 percent confidence interval

5.3.2 Economic Efficiency

The definition of economic efficiency utilized in this study is adopted from Jeffrey (1992): "the ability to choose the technically efficient output/input combination that optimizes a decision-maker's goal(s), given relative output and input prices," (p.3). Also employed from Jeffrey (1992), the interpretation of 'optimizing a decision-maker's goal' in terms of economic efficiency is to minimize total costs of production. Thus, economic efficiency is measured in terms of cost efficiency by means of cost control ratios. Once again, any possible benefits to scale and yield are examined. Section 5.3.2.1 determines possible advantages of size by computing cost ratios when data are organized according to farm herd size. Section 5.3.2.2 inquires into possible benefits of yield by comparing cost ratios across categories of milk production per cow. Cost control ratios reveal a farm's ability to convert input costs into dairy sales. Each ratio is expressed in terms of costs per dollar of dairy enterprise revenue; therefore, the smaller the ratio, the more cost efficient the given dairy operation.

It is important to note that the costs of production, expressed on a per hectolitre basis, used to calculate the described cost control ratios are also measures of economic efficiency. Therefore, the conclusions drawn from Section 5.2 of this study provide another extension of the cost efficiency of Alberta dairy farms.

5.3.2.1 Calculated economic efficiency: herd size distribution of data

5.3.2.1.1 Calculated cost efficiency for the 1996 dairy year

Table 5.19 presents the estimated cost efficiency of each category of herd size for 1996. The F statistic of the single factor / one-way ANOVA indicates the significance of differences in efficiency values. When a given measure of cost efficiency was found to be significantly different among Groups H1, H2, and H3, three additional analyses of variance were run to determine from which group or groups the detected variation was originating.

During 1996, cost control ratios computed for feed, capital, and the total cost of production did not differ significantly between study groups. However, the labour cost control ratio calculated for the large herd size group (Group H3) was significantly lower compared to the labour cost control ratios of the small and average sized herd groups (Group H1 and Group H2). This significantly higher labour cost efficiency demonstrated by farms milking over 90 cows is the result of the significantly lower 1996 per unit total labour production cost imputed for the large herd size group in Section 5.2.1.1. This labour cost efficiency of Group H3 reconfirms the link between increased herd size, labour efficiency, and the lower total labour costs identified above in Section 5.3.1.1. Again, it is suggested that economies of size facilitates the adoption of labour-saving technology which in turn lowers the labour costs of farms milking over 90 cows. For example, milking parlours, robotic milkers, and computerized feeding systems are more feasible for large herds.

5.3.2.1.2 Calculated cost efficiency for the 1995 dairy year

The estimated cost efficiency of each study group for the 1995 dairy year is displayed in Table 5.20. The F statistic of the single factor / one-way ANOVA indicates the significance of differences in efficiency values. If a cost efficiency estimate was found to be significantly different among the categories of herd size, three additional analyses of variance were conducted to assess from which group or groups the detected variation originated.

The cost control ratios calculated for feed and the user cost of farm capital did not differ significantly between categories of herd size during 1995. As was observed in the 1996 data set, the large herd size group (Group H3) reported a significantly lower labour cost control ratio. This finding corresponds to the significantly lower 1995 per unit total labour expense (due to significantly lower family and operator labour costs) reported by Group H3 in Section 5.2.1.2. Once again, a relationship between herd size, labour productivity, and lower labour costs is identified. It is therefore appears that labour-saving technology employed by the province's largest dairy operations tends to reduce imputed family labour and operator labour costs, allowing farms milking over 90 head to be more cost efficient in their use of labour.

Reflecting a significantly lower 1995 average total cost of production, farms milking over 90 head were found to be the most cost efficient overall, reporting a significantly smaller total cost control ratio compared to farms with less than 90 milking cows. In fact, in terms of overall economic efficiency, Group H3 may be considered the only cost-efficient category of herd size. Because the total cost control ratios of the small herd size group (Group H1) and the average herd size group (Group H2) are greater than 1.00, the estimated economic costs of these two groups were greater than the revenue of their dairy enterprises.

5.3.2.1.3 Calculated cost efficiency for the 1994 dairy year

Table 5.21 presents the estimated cost efficiency of each category of herd size for the 1994 dairy year. The significance of differences in the estimated efficiency of study groups is revealed by the F statistic of the single factor / one-way ANOVA. If cost efficiency measures were found to differ significantly among Groups H1, H2, and H3, three additional analyses of variance were performed to determine from which group or groups the detected variation originated.

The estimated cost efficiency of each study group for the 1994 dairy year mirrors the 1995 efficiency measures. As was observed with the 1995 data set, the cost control ratios derived for feed and the user cost of capital did not differ significantly between the three categories of herd size. Farms milking over 90 head (Group H3) reported a significantly lower cost control ratio for labour. As in 1995, this result coincides with significantly lower 1994 family labour and operator labour expenses estimated for the large herd size group in Section 5.2.1.3. As when investigating labour productivity in Section 5.3.1.1, and when examining the cost efficiency of categories of herd size during 1996 and 1995, a link between herd size, labour productivity, and the cost efficient use of labour is recognized.

As was observed with the cost ratios derived for the 1995 data set, the large herd size group was found to be the most cost efficient overall with a significantly lower total cost of production cost control ratio. This finding is a reflection of a significantly lower total production cost imputed for Group H3 in Section 5.2.1.3. Again, farms milking over 90 cows may be considered the only cost-efficient category of herd size. Farms milking between 40 and 50 cows (Group H1) reported a total cost control ratio greater than 1.00, indicating that estimated 1994 economic costs of production were greater than the dairy enterprises' sources of revenue. Herds comprised of 50 to 70 head (Group H2) broke even during 1994 with a total cost control ratio of 1.00.

Recall from Section 5.2.1.4 that the family labour expenses of the small herd size group (Group H1) were found to decrease by $3.34 per hectolitre from 1994 to 1996. It was thus assumed that farms milking between 40 and 50 head have become increasingly more labour efficient. An ANOVA test comparing the group's labour cost control ratios for 1994 and 1996 was conducted to verify this inference. Results showed the labour cost control ratio reported by Group H1 to significantly decrease over this time period. The average sized group (Group H2) also reported a fall in its labour cost control ratio between 1994 and 1996; however, the large herd size group showed no significant change in its labour cost control ratio. It can therefore be concluded that between 1994 and 1996 the small and average herd size groups increased their labour productivity while at the same time decreasing total labour costs.

5.3.2.2 Calculated economic efficiency: milk yield distribution of data

5.3.2.2.1 Calculated cost efficiency for the 1996 dairy year

The 1996 cost control ratios calculated for each category of farm milk yield are found in Table 5.22. The F statistic of the single factor / one-way ANOVA indicates the significance of differences in the estimated efficiency values. When a specific cost efficiency estimate was found to differ significantly among the categories of milk yield, three additional analyses of variance were performed to assess from which group or groups the detected variation originated.

Cost control ratios computed for feed and capital were not significantly different among the three study groups for 1996. Farms averaging less than 80 hectolitres of milk per cow (Group M1) reported a significantly higher labour cost control ratio compared to farms with an average production level above 80 hectolitres of milk per cow (Groups M2 and M3). This finding is a reflection of the significantly higher 1996 total labour expense estimated for the low yielding group in Section 5.2.2.1. Because the individual cost components comprising Group M1's total labour expense (hired, family, and operator) did not differ significantly during 1996, and due to the fact that labour productivity measures for 1996 were not significantly different among study groups, the cost inefficiency reported by the low yielding group is considered to be the result of economies of yield. It is thus implied that there exits no relationship between labour productivity and labour cost efficiency. It can therefore be suggested that unlike the differentiation in capital inventory identified between groupings of herd size, the technology employed by the three categories of milk yield is more uniform, resulting in non-significant differences in labour productivity.

Although the total cost of production ratio imputed for each category of milk yield did not differ significantly, it is worth noting that because the efficiency ratio for the average and high yielding groups were below 1.00, revenues of these dairy enterprises were greater than estimated economic production costs. The low yielding group; however, reported dairy enterprise revenues to equal costs of production with a cost ratio of 1.00.

5.3.2.2.2 Calculated cost efficiency for the 1995 dairy year

Table 5.23 presents the estimated 1995 cost efficiency of each category of milk yield. The significance of differences in the calculated efficiency is revealed by the F statistic of the single factor / one-way ANOVA. When cost efficiency values were found to differ significantly among Groups H1, H2, and H3, three additional analyses of variance were performed to determine from which group or groups the detected variation was originating.

As was observed for the 1996 dairy year , the cost control ratio for feed, and total production costs did not differ significantly between categories of milk yield. As with 1996 cost efficiency results, the average and high yielding groups (Group M2 and Group M3) reported dairy enterprise revenues to be greater than estimated production costs. The low yield group (Group M1) saw total operating expenses exceed revenue with an overall cost ratio of 1.06.

In contrast to the cost efficiency measures derived for 1996, labour cost control ratios were not significantly different between study groups during 1995. This finding corresponds to 1995 total labour cost estimations in Section 5.2.2.2 not differing significantly between categories of milk yield.

The capital cost control ratio calculated for the low yielding group was significantly higher than that of the average yielding group during 1995. A correlation between this observation and Group M2 reporting a significantly lower 1995 per hectolitre user cost of farm machinery and equipment compared to Group M1 in Section 5.2.2.2 is identified.

5.3.2.2.3 Calculated cost efficiency for the 1994 dairy year
Estimated 1994 cost efficiency of each subgroup of milk yield is presented in Table 5.24. The F statistic of the single factor / one-way ANOVA indicates the significance of differences in efficiency measures. When cost efficiency values differed significantly among study groups, three additional analyses of variance were performed to assess from which group or groups the detected variation was originating.

A significant difference in computed cost control ratios was not detected among study groups. Each category of milk yield demonstrated the same level of cost efficiency with respect to feed, labour, capital, and total costs during the 1994 dairy year. This insignificance in cost control ratio differences corresponds to an insignificance among study groups in feed, labour, and total capital expenses and the total cost of production estimated in Section 5.2.2.3. As was observed with the total cost control ratios calculated for the 1995 data set, the low yielding group reported total economic costs of production to be greater than dairy enterprise revenue.

Table 5.19 Economic Efficiency: 1996 Cost Control Ratios According to Farm Herd Size[a]

COST CONTROL RATIO	GROUP H1 40 - 50 Dairy Cows	GROUP H2 50 - 70 Dairy Cows	GROUP H3 Over 90 Dairy Cows	F STATISTIC
Feed Cost	0.36	0.33	0.35	0.82
Labour Cost	0.21	0.20	0.15	9.36*
Capital Cost	0.17	0.17	0.17	0.05
Total Cost	0.98	0.96	0.89	2.82

a * denotes statistical significance at a 95 percent confidence interval

Table 5.20 Economic Efficiency: 1995 Cost Control Ratios According to Farm Herd Size[a]

COST CONTROL RATIO	GROUP H1 40 - 50 Dairy Cows	GROUP H2 50 - 70 Dairy Cows	GROUP H3 Over 90 Dairy Cows	F STATISTIC
Feed Cost	0.30	0.31	0.31	0.04
Labour Cost	0.31	0.27	0.11	19.39*
Capital Cost	0.20	0.22	0.20	0.58
Total Cost	1.05	1.04	0.84	5.43*

a * denotes statistical significance at a 95 percent confidence interval

Table 5.21 Economic Efficiency: 1994 Cost Control Ratios According to Farm Herd Size[a]

COST CONTROL RATIO	GROUP H1 40 - 50 Dairy Cows	GROUP H2 50 - 70 Dairy Cows	GROUP H3 Over 90 Dairy Cows	F STATISTIC
Feed Cost	0.30	0.30	0.28	0.10
Labour Cost	0.33	0.25	0.11	18.64*
Capital Cost	0.29	0.21	0.21	2.50
Total Cost	1.16	1.00	0.83	5.38*

a * denotes statistical significance at a 95 percent confidence interval

Table 5.22 Economic Efficiency: 1996 Cost Control Ratios According to Farm Milk Yield[a]

COST CONTROL RATIO	GROUP M1 Under 80 hl/cow	GROUP M2 80-90 hl/cow	GROUP M3 Over 90 hl/cow	F STATISTIC
Feed Cost	0.35	0.33	0.33	0.33
Labour Cost	0.22	0.18	0.17	6.58*
Capital Cost	0.19	0.18	0.16	1.21
Total Cost	1.00	0.92	0.91	2.39

a * denotes statistical significance at a 95 percent confidence interval

Table 5.23 Economic Efficiency: 1995 Cost Control Ratios According to Farm Milk Yield[a]

COST CONTROL RATIO	GROUP M1 Under 80 hl/cow	GROUP M2 80-90 hl/cow	GROUP M3 Over 90 hl/cow	F STATISTIC
Feed Cost	0.31	0.30	0.30	0.55
Labour Cost	0.27	0.22	0.21	1.92
Capital Cost	0.24	0.20	0.22	3.63*
Total Cost	1.06	0.96	0.96	1.91

a * denotes statistical significance at a 95 percent confidence interval

Table 5.24 Economic Efficiency: 1994 Cost Control Ratios According to Farm Milk Yield[a]

COST CONTROL RATIO	GROUP M1 Under 80 hl/cow	GROUP M2 80-90 hl/cow	GROUP M3 Over 90 hl/cow	F STATISTIC
Feed Cost	0.29	0.27	0.30	0.72
Labour Cost	0.27	0.24	0.21	1.72
Capital Cost	0.26	0.21	0.23	1.38
Total Cost	1.06	0.95	0.97	1.42

a * denotes statistical significance at a 95 percent confidence interval

6. SUMMARY and CONCLUSIONS

6.1 Summary

With the high degree of government involvement in Canada's dairy industry, determining the fundamental competitiveness of dairy farmers requires the analysis of trends in the determinants of competitiveness. Because of a) the uniform marketing of milk by dairy producers, resultant of Canada's supply management system, b) the homogeneity of milk production at the farm level, and c) the inelastic nature of domestic milk demand, the most appropriate determinant to evaluate is cost of production. Thus, the working definition of competitiveness employed by this study was based on the cost competitiveness of Alberta dairy producers. Specifically, the dairy farm or group of dairy farms achieving the lowest per unit cost of production was identified as being the most competitive.

To investigate the possibility of economies of size and economies of yield existing within the Alberta dairy industry, the farm-level cost data employed were divided into categories of herd size and milk production per cow. To quantify the unpaid family labour component of farms and to account for the opportunity cost of producers investing in the province's dairy sector, the economic costs associated with milk production were estimated. To explain differences in production costs across herd size and milk yield groupings, the physical and economic efficiency of producers was derived. The impact of varying milk prices on Alberta's dairy farms was assessed by imputing the economic profit of farms under select international milk price simulations.

6.2 Conclusions

With the World Trade Organization (WTO) currently formulating an agenda for a new round of global trade negotiations, the likelihood of increased competition in the Canadian dairy industry is probable. Changes in Canada's supply management dairy system would undoubtedly have implications at the farm level. Consequently, there may be a greater need for producers to be concerned with their *competitiveness*. This study focused on the competitiveness of Alberta dairy producers. The major conclusions found are outlined below.

(1) Economies of size were observed for the 1994 and 1995 dairy years. Specifically, total operating expenses were significantly lower for the large herd size group, farms milking over 90 cows. This economies of size is attributed to lower family and operator labour costs reported by farms milking over 90 head.

(2) Economies of yield were observed for the 1995 and 1996 dairy years. Specifically, average total COP per hectolitre of milk decreased significantly when moving from an average production level below 80 hectolitres of milk per cow to an average milk yield over 90 hectolitres per cow. This total cost disadvantage reported by the low yielding farm group is credited to a significantly higher user cost of machinery and equipment, and a higher user cost of cattle.

(3) Labour costs and user costs of capital were identified as having the most significant impact on the total costs of production of Alberta dairy producers. Feed costs represent a significant potential savings for farmers.

(4) A link between increased herd size, labour productivity, and lower total labour costs was identified. It is suggested that economies of size facilitates the adoption of labour-saving technology by farms milking over 90 head and in return lowers labour expenses.

(5) The estimated labour productivity of all herd size categories increased their labour productivity between 1994 and 1996.

(6) Labour productivity was not influenced by milk yield per cow.

6.3 Limitations and Suggested Further Research

The competitiveness of a particular sector is only as strong as the weakest link in its "value system" of related and supporting industries. Thus, to accurately predict the competitive position of Alberta's dairy producers in a global marketplace, a cost analysis incorporating the processing, distribution and marketing sectors is imperative.

This study employed a static methodology where the cost competitiveness of Alberta dairy farmers was examined in the short run. A more concise prediction of the fate of Alberta dairy producers in a free trade scenario could have been achieved by constructing a model simulating the long run where supply responses are observed and both production and prices may adjust in response to changes in demand and supply. This study was conducted using the most recent cost data available for Alberta dairy farms, the examination of current cost data would address the concern that the province's largest herds may be losing their cost competitive position.

The annual data sets examined contained production costs only for the dairy enterprise of each farm. Having cost data from all business ventures of each farm would answer questions on the role of diversification on Alberta's large-scale dairy operations.

BIBLIOGRAPHY

Appleby, T. 1994. *The Economics of Milk Production 1994.* Economics Service Division, Alberta Agriculture, Food and Rural Development, Alberta.

Appleby, T. 1995. *The Economics of Milk Production 1995.* Economics Service Division, Alberta Agriculture, Food and Rural Development, Alberta.

Appleby, T. 1996. *The Economics of Milk Production 1996.* Economics Service Division, Alberta Agriculture, Food and Rural Development, Alberta.

Bank of Canada. 2000. *Selected Government of Canada Benchmark Bond Yields- Long Term.* Bank of Canada, Department of Monetary and Financial Analysis. http://www.bank-banque-Canada.ca. (accessed: October 2, 2000).

Barichello, R.R., R. Lambert, T.J. Richards, R.F. Romain and B.K. Stennes. 1996. "Cost Competitiveness in the Canadian and US Dairy Industries." Andrew Schmitz, Garth Coffin and Kenneth Rosaasen (Ed.) *Regulation and Protectionism under GATT: Case Studies in North American Agriculture*. Westview Press Inc.

Barichello, R.R. and B. Stennes. 1994. "Cost Competitiveness of the Canadian Dairy Industry: A Farm Level Analysis." Working Paper No. 94-6, Department of Agricultural Economics, University of British Columbia.

Bauer, L. 1988. *Risk in Agriculture and its Management*. University of Alberta, Edmonton.

Berenson, M. L. and D. M. Levine. 1996. *Basic Business Statistics, Concepts and Applications: Sixth Edition*. Prentice Hall, New Jersey.

Binger, B. and E. Hoffman. 1998. *Microeconomics with Calculus*. Addison Wesley Longman Inc., Ontario.

Black, J. 1997. *Oxford Dictionary of Economics*. Oxford University Press, New York.

Bravo-Ureta, B. 1986. "Technical Efficiency Measures for Dairy Farms Based on a Probabilistic Frontier Function Model." *Canadian Journal of Agricultural Economics*. 34:399-415.

Bravo-Ureta, B. and L. Rieger. 1991. "Dairy Farm Efficiency Measurement Using Stochastic Frontiers and Neoclassical Duality." *American Journal of Agricultural Economics*. 73:421-428.

Brigham, E. and L. Gapenski. 1991. *Financial Management Theory and Practice, Sixth Edition.* The Dryden Press, Toronto.

Canadian Dairy Commission. 2000. *Subsidy Payments to Milk Producers*. Canadian Dairy Commission. http://www.cdc.ca/dairsub.html. (accessed: January 31,2000).

Coffin, G., B. Larue, M. Banik and R. Westgren. 1993. "Competitiveness in the Canadian Food Industry." *Canadian Journal of Agricultural Economics*. 41:459-473.

Fare, R., S. Grosskopf and C. Lovell. 1985. *The Measurement of Production Efficiency.* Kluwer-Nijhoff, Boston.

Farrell, M. 1957. "The Measurement of Production Efficiency." *Journal of the Royal Statistical Society.* Ser. A. 120:253-81.

Grant, H. 1998. *The Competitiveness of Nova Scotia Dairy Production: A Cost of Production Study*. Nova Scotia Agricultural College, Truro, Nova Scotia.

Grisley, W. and A. Mascarenhas. 1985. "Operating Cost Efficiency on Pennsylvania Dairy Farms." *Northeastern Journal of Agricultural and Resource Economics*. 14(1): 88-95.

Hazeldine, T. and D. J. Freely. 1991. *Productivity, Costs and Competitiveness of Canadian Food Manufacturing Industries*. Final Report for the Food Policy Task Force, Industry Science and Technology, Canada.

Houck, J. 1992. *Elements of Agricultural Trade Policies*. Waveland Press Inc., Illinois.

Jeffrey, S. 1992. *Relative Technical and Economic Efficiency for Canadian and US Dairy Farms*. Working Paper No. 92-4, Department of Agricultural Economics and Farm Management, University of Manitoba.

Kotowich, J., A. Presiznuk and P. Van Biert. 1998. *Economic of Milk Production 1998.* Markets and Economics Division, Alberta Agriculture, Food and Development.

Lazarus, W., D. Streeter and E. Jofre-Giraudo. 1989. "Impact of Management Information Systems on Dairy Farm Profitability." Staff Papers Series P89-30, Department of Agricultural and Applied Economics, University of Minnesota.

Martin, L. J., R. E. Westgren and E. van Duren. 1991. "Agribusiness Competitiveness Across National Boundaries." *American Journal of Agricultural Economics*. 73: 1456-1464.

Matulich, S. 1978. "Efficiencies in Large-Scale Dairying: Incentives for Future Structural Change." *American Journal of Agricultural Economics*. 60:642-647.

Moschini, G. 1988. "The Cost Structure of Ontario Farms: A Microeconometric Analysis." *Canadian Journal of Agricultural Economics*. 36:187-206.

Phillips, R., J. White and P. Stonehouse. 1989. *The International Competitive Status of Canada's Milk Production Sector*. Working Paper No. 1/89, Policy Branch, Agriculture Canada.

Porter, M. 1985. *Competitive Advantage: Creating and Sustaining Superior Performance*. The Free Press, New York.

Porter, M. 1990. *The Competitive Advantage of Nations*. The Free Press, New York.

Richards, T. and S. Jeffrey. 1996. *Cost and Efficiency in Alberta Dairy Production*. Staff Paper 96-13, Department of Rural Economy, University of Alberta.

Ross, C., R. Susko and R. Jaipaul. 1998. *An Analysis of the Competitiveness of Alberta's Dairy Industry*. Production Economics and Statistics Branch, Alberta Agriculture, Food and Rural Development, Edmonton.

Ruch, W., H. Fearon and C. Wieters. 1992. *Fundamentals of Production/Operations Management, Fifth Edition*. West Publishing Company, New York.

Statistics Canada, Agriculture Division. 1996. Agriculture Profile of Canada. Catalogue No.93.356-XPB.

Stanton, B. 1986. "Comparative Statements on Production Costs and Competitiveness in Agricultural Commodities." Working Paper No. 86-27, Department of Agricultural Economics, Cornell University.

Weersink, A., G. Turvey and A. Godah. 1990. "Decomposition Measures of Technical Efficiency for Ontario Dairy Farms." *Canadian Journal of Agricultural Economics*. 38:439-456.

West, D. 1987. *Productivity and the International Competitiveness of the Canadian Food and Beverage Processing Sector*. Food Market Commentary 9: 18-36. Agriculture Canada, Ottawa.

West, D. 1993. "Framework for Analyzing the Competitiveness of the Agri-Food Sector." Working Paper No. 3-93, Policy Branch, Agriculture Canada.