The competitiveness of Ontario dairy farms: A farm level analysis

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Abstract

The Canadian supply managed dairy sector is likely to face more competitive pressure from challenges through the World Trade Organization (WTO) and the changing global trade environment. Therefore, it is highly prudent for Canadian dairy producers to focus their concern on their level of competitiveness and how to improve it. This study investigated the competitiveness of Ontario dairy sector based on a sample of farm level data with a Box-Cox transformed econometric cost model. The data were gathered by the Ontario Dairy Farm Accounting Project, for the years 2005, 2006, and 2007. The impacts of output, yield per cow and several farm-specific characteristics on the average cost of milk production were examined. Results support the presence of significant size economies and yield economies within Ontario milk production. Minimum costs were achieved for farms with approximately 125 cows. The results also indicated that some farm-specific characteristics, breed and region, also had significant impacts on the cost of Ontario milk production. However, it appears that Ontario farms may find it difficult to survive if they are forced to face international competition. Even at their minimum, average costs were above an indicator international dairy price.

La compétitivité des fermes laitières ontariennes: Analyse au niveau des fermes

Résumé

La réglementation de l'offre dans le secteur des produits laitiers fera face à plus de pression compétitive à travers des recours devant l'Organisation Mondiale du Commerce (OMC) et en raison de l'évolution de l'environnement commercial global. Pour ces raisons, il est d'une grande prudence pour les producteurs de produits laitiers canadiens de se concentrer sur leur niveau de compétitivité et comment l'améliorer. Cette étude a examiné la compétitivité des fermes du secteur laitier de l'Ontario en se basant sur un échantillon de données du niveau des fermes avec un modèle de coûts économétrique transformé Box-Cox. Les données ont été rassemblées par le Projet de comptabilisation des fermes laitières ontariennes pour les années 2005, 2006 et 2007. Les impacts de production, de rendement par vache et de plusieurs caractéristiques spécifiques aux fermes sur le coût moyen de production du lait ont été examinés. Les résultats supportent la présence d'économies de taille significatives ainsi que des économies de rendement à l'intérieur de la production de lait en Ontario. Les coûts minimums ont été atteints avec approximativement 125 vaches. Les résultats ont aussi indiqué que certaines caractéristiques spécifiques aux fermes, races et région, ont aussi eu des impacts significatifs sur le coût de la production de lait ontarienne. Cependant, il semble que les fermes ontariennes pourraient trouver difficiles de survivre si elles sont forcées de faire face à la compétition internationale. Même à leur coût moyen de production minimal, les coûts moyens étaient au-dessus d'un indicateur du prix international des produits laitiers.

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Chapter 1 Introduction

1.1 Problem setting

1.1.1 Canadian dairy industry

The dairy industry is a significant part of the Canadian agri-food economy ranking fourth after grains, red meat and horticulture on the basis of net farm receipts (Canadian Dairy Commission [CDC], 2007). In Canada, during the 2006-2007 dairy year, there were 14,660 dairy farms and 1.04 million milk cows with milk production of 80.8 million hectoliters (CDC, 2007). In 2007, the total net farm cash receipts from the dairy sector reached $5.2 billion and sales of processed dairy products from 445 dairy processing plants (280 of which are registered by the Canadian Food Inspection Agency) were valued at $11.6 billion, which accounted for about 15 percent of all processing sales in the food and beverage industry in Canada (CDC, 2007.The industry). Moreover, the dairy industry sustains more than 142,600 jobs and involves more than $26 billion of economic activity (Froment, 2007).

In Canada, the marketing and pricing of milk and milk products are governed under a system of supply management that is intended to stabilize consumer prices and support farm income. The national supply management program was first introduced in 1971, which was stimulated by the attempt by government to solve the problems of overproduction and depressed prices in the industry (Schmitz, Furtan, & Baylis, 2002). There are three pillars of supply management: controlled prices, controlled imports and controlled production (Froment, 2007). Milk prices are controlled by provinces based on Canadian Dairy Commission (CDC) support prices, adjusted by the end use of the milk for industrial milk, and on a cost of production formula for fluid milk (Froment, 2007). CDC support prices are the prices at which the CDC purchases and sells butter and skim milk powder under its programs (CDC support price). Table 1.1 provides recent CDC support prices.

Table1.1: CDC support prices ($/kg) under supply management

Year	Butter	Skim Milk Powder (SMP)
2007	6.87	5.92
2006	6.87	5.83
2005	6.87	5.73
2004	5.30	5.39
2003	6.11	5.20
2002	5.90	4.99
2001	5.73	4.84
2000	5.54	4.68

[Source: Canadian Dairy Commission, Annual Report 2006-2007]

Dairy production is limited by quotas. There is a separate quota for both fluid milk and industrial milk. The fluid milk quota is determined by provincial marketing boards, while the industrial milk quota is established by the Canadian Milk Supply Management Committee (CMSMC) (CDC Quota). Imports have been restricted by government through the use of Tariff Rate Quotas (TRQs) since the 1994 General Agreement of Tariffs and Trade (GATT) agreement. Imports over TRQs are subjected to a high tariff of 200 to 300 percent (Froment, 2007). Table 1.2 gives the examples of TRQs and over-quota tariffs of a few dairy products.

Table 1.2: Examples of TRQ and over-quota tariffs (2007)

Product	TRQ (tonnes)	Tariff (%)
Dry whey	3,198	208.0
Butter	3,274	298.5
Cheese	21,412	245.5
Ice cream	484	277.0

[Source: Foreign Affairs and International Trade Canada & Canada Border Services Agency]

It is generally acknowledged that supply management is one way out of the dilemma of overproduction and low farm incomes. In fact, Canada's national supply management system sprang up as a result of depressed farm prices and overproduction in the 1960s (Schmitz, Furtan, & Baylis, 2002). Supply management effectively limits production by quotas and supports farm prices and incomes through price controls. However, the economic effectiveness of this supply management scheme has been subjected to a considerable debate since its inception. Domestically, the debate has been focused on market efficiency and rent seeking behaviours. The widely accepted conclusion is that because prices are set above the equilibrium price that would be observed in a competitive market, the supply management system causes a sizable income transfer from consumers to producers and a dead weight welfare loss for the whole economy, which induces inefficient markets and stimulates rent seeking behaviours. For example, the total efficiency loss from supply management in dairy in 1981 was $214 million. At a cost to consumers of $980 million, the income transferred to dairy producers was $955 million (Schmitz, Furtan, & Baylis, 2002). Besides, the fact that milk quotas are traded at extraordinarily high prices could be evidence of rent seeking behaviours. According to data for quota values provided by the CDC in 2006, it would cost a dairy farmer more than $29,000 to purchase quota to cover the milk production of only one cow, much higher than in 2000 at $20,663. Even though the debate surrounding supply management has a long history and is as vehement as ever, it continues to pose interesting issues for applied economics. A related issue concerns the future competitiveness of the Canadian dairy industry in a changing world.

1.1.2 Changes in the external environment for the Canadian dairy industry

Further pressures and challenges for supply management and the dairy sector come from the changing global trade environment. According to the Agreement on Agriculture reached through negotiations during the Uruguay Round in 1994, Canada was required to fulfill commitments in all three areas: domestic support reduction, improved market access (TRQs), and export subsidies reduction (DFC, 2004). As previously mentioned, controlled imports is one of three fundamental pillars of supply management. It is not possible to maintain a high farm price and control dairy supply in the domestic market without the effective restriction of imports (Dolphin, 1998). Before the 1994 GATT agreement, Canada controlled the imports of all dairy products by import quotas. The import quotas effectively limited the supply of dairy products in Canada to a pre-specified quantity (Haghiri & Tran, 2004). However, to open up markets, the 1994 GATT agreement required countries to convert quotas and non-tariff barriers to TRQs in 1995 and to reduce tariffs over a period of six to ten years (Schmitz, Furtan, & Baylis, 2002). Canada, therefore in response to the implementation of the 1994 GATT agreement, converted its import quotas into TRQs. Table 1.3 provides data for tariff equivalents of selected dairy products in Canada for 1995 and 2007. Through this table, it can be seen that tariffs on dairy products in 2007 decreased considerably from between 35.6% to 52.7%, compared that in 1995. In addition, the tariffs will further decline after 2007 according to Canada's commitment under the WTO agreement. Even though the 1994 GATT agreement did not result in a liberalized market for dairy products and the Canadian dairy market was still protected, the commitment to reduce import tariffs puts potential pressure on the dairy industry (Schmitz, Furtan, & Baylis, 2002).

Table 1.3: Tariff equivalents for selected dairy products in 1995 and 2007

Products	1995 Tariff (%)	2007 Tariff (%)
Milk	283.8 minimum $40.60/hl	241.0 minimum $34.50/hl
Cheddar	289.0 minimum $4.15/kg	245.5 minimum $3.58/kg
Butter	351.4 minimum $4.71/kg	298.5 minimum $4.00/kg
Yoghurt	279.5 minimum $0.55/kg	237.5 minimum $0.466/kg
Skim milk powder	237.2 minimum $2.36/kg	201.5 minimum $2.01/kg

[Source: Canada Border Services Agency]

Furthermore, the 1994 WTO agreement affected the Canadian dairy sector in another respect. In response to the agreement on export subsidies, Canada replaced its in-quota levy program with a P-9 pooling system which is a price pooling system involving all nine milk producing provinces (Newfoundland was not included in the pool). This is based on interprovincial pooling agreements with the aim to allow returns from exported dairy products to be shared equally among those nine provinces, and a new system of Special Milk Classes (Kuntz, 2003). This change in the Canadian system increased export opportunities for the Canadian dairy sector through special milk classes, 5(d) and 5 (e), which included dairy products developed specially for export. However, during a trade dispute in 1999, the United States and New Zealand accused Canada of providing export subsidies above the levels specified in its country schedule, through the use of special milk classes. The WTO decision favoured the US and New Zealand, so consequently Canada was forced to reduce its support for exports (Kuntz, 2003).

The Uruguay Round agreement on agriculture built up a framework of rules and began to diminish trade-distorting supports in agriculture. Meanwhile, the Doha Round that started in 2001 continues work on those issues through new negotiations and aims to set new mandates through making the objectives more explicit and setting deadlines (WTO, 2007. Agriculture Negotiations).

The main targets of the Doha Round are to eliminate all forms of export subsidies, make substantial reductions in trade-distorting domestic support, and improve market access (Gifford, 2005). Compared with the Uruguay Round, the Doha Round will likely proceed deeper and produce more significant reductions in agricultural domestic supports and trade barriers with the aim to further liberalize global agricultural trade. Different from the Uruguay Round, which required the same percentage reduction in agriculture supports, a basic principle of the Doha Round commitments is to reduce, by a greater percentage, supports by those countries and commodities with higher levels of protection (Gifford, 2005).

On July 31, 2004, the current Doha Round of WTO negotiations reached an agreement on a framework for reducing agricultural supports, giving a clear sign for the inevitable general trend toward reducing dairy supports (Suzuki & Kaiser, 2005). The framework here refers to an outline to be used to fulfill modalities on agriculture. Actually there are a number of framework proposals which deal with the main points of the modalities and were submitted for discussion at the fifth ministerial conference during the Doha Round.

During the Doha Round, the United States and the Europe Union have made proposals regarding export competition, domestic support and market access which could affect the Canadian dairy industry. The US proposed the reduction of the highest tariffs by 90% and to cap the maximum agricultural tariff at 75%. The US also suggested limiting sensitive products to 1% of tariff lines and the expansion of TRQs. Meanwhile, the EU proposal placed the overall reduction of trade-distorting support at 70% for the EU, 60% for the US, 50% for other countries, and also tariff cuts and expanded TRQs for sensitive products (Hanrahan & Schnepf, 2005). All of those could impact on both Canada's controlled pricing system and access to the Canadian dairy market.

Admittedly, Canada's current supply management system is very important to the dairy industry, therefore all major political parties have pledged their support. At the 2007 annual policy conference of the dairy farmers of Canada, the Hon. Chuck Strahl, the former Minister of Agriculture and Agri-Food Canada, stated "I would like to reiterate my strong support for supply management. This system has served dairy producers, processors and Canadian consumers well for many years and will continue to do so." (Hon. Chuck Strahl, 2007). Moreover, dairy farmers have aggressively lobbied the government to walk away from the WTO negotiation stating that "The negotiations underway at the WTO could result in the weakening, or even the disappearance of supply management." (DFC, 2008) However, Canada cannot walk away from the WTO negotiation because of its broad coverage of trade in goods such as grains, oilseeds, beef and pork. Besides, according to Gifford (2005), a successful negotiation will surely benefit not only farmers of all those agricultural sectors but also the Canadian government. Mike Gifford (2005), the lead agricultural negotiator during the Uruguay Round, concluded:" It is clear that the dairy sector will not be excluded from the Doha Round results. It is equally clear that Canada will have to open its market to the same extent as other developed countries." (Gifford, 2005, p. 57)

According to the 2004 Doha Round framework agreement for reducing all forms of export subsidies, the trade-distorting domestic support of the Canadian dairy sector could be reduced by 60 to 70 percent with a cap on the level of domestic support for specific products. Besides, based on the anticipated market access outcome of the Doha Round, tariffs above 100% are likely to be reduced by at least 60% and thus the main Canadian dairy tariffs will turn out to be 80% to 120% (Gifford, 2005). Current TRQs for Canadian dairy imports only account for 3% of domestic consumption. However, the Doha Round could probably increase it to 7% to 10% (Gifford, 2005). Therefore, further pressure will be put on the dairy sector to increase market access and reduce domestic supports.

Another challenge for the Canadian dairy sector that should be mentioned here is the increasing utilization of milk ingredients in dairy products that has been reducing the demand for domestic milk. In response, the Canadian government decided to initiate negotiations under GATT Article 28 with the objective to restrict imports of low-duty milk protein concentrates by establishing a new tariff-rate quota, which will subject all milk ingredients to equal tariff treatment (DFC, 2008).

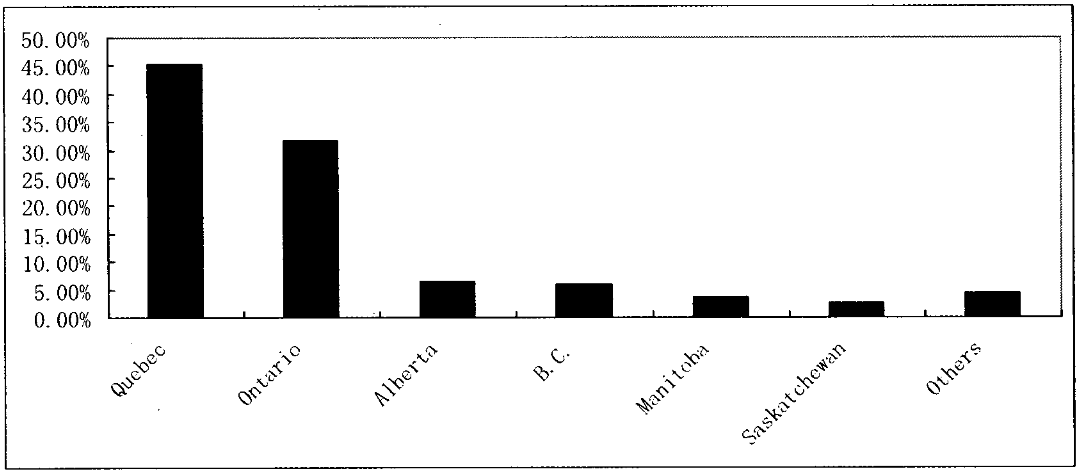
Under the increasing pressure from the WTO and other sources, supply management may gradually lose its power to protect the Canadian dairy industry from import competition. Now, it is the time to consider the following questions. First, how long can the Canadian dairy industry continue under the protection of supply management? Second, what are the key issues that the Canadian dairy industry should focus on if supply management really loses its power to protect Canadian dairy producers from competition in both domestic and foreign markets? However, apart from those two policy questions, one point should be clear: the focus must be on finding an answer within the dairy industry itself, and a dairy industry with a high level of competitiveness could be a winner, even in a deregulated environment. Therefore, improving the competitiveness of the dairy sector seems to be critical to its future. In support of this, research involving Canadian dairy producers' competitiveness and how to improve it is necessary.

1.1.3 The Ontario dairy industry

Dairy production in Ontario is important to the national industry. The Canadian industry is heavily concentrated in central Canada where Ontario and Quebec have 81% of dairy farms and account for more than 70% of total output (CDC, 2007). According to figures provided by the 2006-2007 Canadian Dairy Commission annual report, there were about 4,688 dairy farms in Ontario, which accounted for over 31% of the total for Canada (14,660 in 2006-2007) and Ontario accounted for 32% of the total Canadian market sharing quota of industrial milk production. There were 340 thousand cows in Ontario or about 33% of the Canadian total, while there were about 73 cows per farm in Ontario compared to 71 for all of Canada.

Over about the past 17 years, the Canadian dairy production sector has experienced significant structural changes. As shown in table 1.4, in 1990-1991 the average number of cows per farm was about 44. As farmers tried to maximize profits and reduce costs of production by obtaining economies of scale, the size of dairy farms rose to 71 cows by 2006. This was accompanied by an increase in farm size and a decline in the total number of dairy farms and cows. Dairy farms decreased significantly from 32,678 in 1990-1991 to 14,660 in 2006-2007, and the decrease of cows also was considerable, from 1.43 to 1.04 million head during the same period. The main reasons for this would be that as large farms became more efficient, small farms were unable to compete and finally went out of business, and there was a marked increase in output per cow.

Figure 1.1: Distribution of the National Market Sharing Quota (MSQ) (2006-2007)



(Total: 178.56 million kg of Butterfat)

[Source: Canadian Dairy Commission annual report in 2006-2007]

Table1.4: Structural change of the Canadian Dairy Industry (1990-1991 to 2006-2007)

	1990-1991	2006-2007	Change %
Number of farms	32,678	14,660	-65%
Number of cows (Million head)	1.43	1.04	-27%
Volume of milk produced (million hectoliters)	75.9	80.8	+6.5%
Volume of milk per farm (hectoliters)	2,323	5,512	+137%
Average cows per farm (heads)	44	71	+61%
Average output per cow (hectoliters)	53	78	+46%

[Source: Canadian Dairy Commission]

The Ontario dairy sector experienced the same main trends as the whole industry. One is the steady and predictable decline in the number of dairy farms, and the other is the significant increase in size. According to the CDC, between 1990-1991 and 2006-2007, the total number of dairy farms fell from 11,022 to 4,688 and the size of farms measured by cows per farm increased from about 42 to 73 (see table 1.5).

These trends could be explained by farmers striving to achieve an optimal long-run scale of production with lower average costs and a higher profit margin. Thus, it is reasonable to suppose that an examination of size economies in Ontario dairy production is essential to understanding what the future might look like. Economies of size here refer to how the cost of production per cow for large farms compares to that of smaller farms. Increasing the size of dairy farms may be one approach to improve their competitiveness, and this point will be the central focus of this thesis.

Table 1.5: Structural change in the Ontario Dairy sector (1990-1991 to 2006-2007)

	1990-1991	2006-2007	Change %
Number of farms	11,022	4,688	-57%
Number of cows (Million head)	0.46	0.34	-26%
Volume of milk produced (million hectoliters)	24	26.4	+10%
Volume of milk per farm (hectoliters)	2,177	5,631	+159%
Average cows per farm (heads)	42	73	+74%
Average output per cow (hectoliters)	52	78	+50%

[Source: Canadian Dairy Commission and Dairy farmers of Ontario]

1.1.4 Cost of production

Assuming that other factors are equal across Ontario dairy farms, such as technology and output prices, those farms with lower costs of production will be more competitive in the market place and more likely to remain profitable under a deregulated market (Nubern

1996). Given the potential changes in the domestic and external environment for the Canadian dairy sector, competitiveness in milk production will be more and more important in determining the future performance of dairy producers (Hailu, Jeffrey, & Unterschultz, 2005). Furthermore, cost competitiveness at the farm level is critical because the cost of raw milk accounts for the major share of the cost of dairy products (Cropp, 1999). Thus, a study of farm-level cost of production is a useful approach to estimate the performance of the Ontario dairy industry and could also provide a valuable guide for strategies to improve its competitiveness.

1.2 Objectives

The general objective of this study is to estimate and analyze the competitiveness of Ontario dairy farms with the competitiveness determined by costs of milk production.

Specific objectives are to:

1. Investigate the impacts of milk output, yield per cow and several farm-specific characteristics on the average cost of milk production.
2. Examine economies of size and economies of yield in Ontario milk production.
3. Estimate the profitability of Ontario's dairy farms under a deregulated market environment.
4. Explore strategies to improve the competitiveness of Ontario dairy farms.

1.3 Overview of thesis

In Chapter two, a literature review profiles the Canadian and Ontario dairy sectors and covers previous works in several areas such as defining competitiveness and cost competitiveness at the farm level. The empirical approaches, data sources and results of previous studies of cost competitiveness of dairy farms are also reviewed in this chapter. Chapter three describes the methodology and data adopted in this study. The results and analysis are described and discussed in the chapter four. The conclusions and limitations of this study are presented in final chapter.

Chapter 2 Literature Review

2.1 Background

This section is a review of literature that pertains to issues related to world dairy production, the dairy industry's profile, structure, development, and policy in Canada and Ontario. The objectives of this section are to provide descriptive analysis of the dairy industry and more detailed information of the dairy sector. Since competitiveness is based on the comparison of producers' performance, a clear understanding of their industry background, dairy markets and policy environments is necessary.

2.1.1 World dairy production

According to the data provided by the Food and Agriculture Organization of the United Nations (FAO) in their Dairy Market Assessment, world milk production reached about 678 million tonnes in 2007 with a growth rate of 2.3 percent from the previous year. Of total milk production, cow milk accounts for the majority at more than 80 percent and the remaining 20 percent or less was contributed by goats, sheep and buffalo. The buffalo milk sector has expanded most quickly in recent years. It has increased by about 85 million tonnes from 1996 to 2005, and accounted for more than 12.4 percent of total milk production in 2005 (O'Connor, 2007). Even though world milk production has increased in recent years, the growth rate has not been very high. From 1999 to 2007, the average annual growth rate of world milk production has been less than 2 percent (AAFC, 2005 and FAO, 2007). Especially, in 2004, there was only a 0.5 percent (3 million tonnes) increase in milk production compared with the previous year (AAFC 2005).

Slow growth in milk production accompanied by a rapid increase in dairy product prices have been two characteristic features of the world dairy market recently. The surge in prices of dairy products in the world market has taken prices to record levels during the last two years. In 2007, world market prices of many dairy products were almost twice their levels one year before. According to the FAO price index (base 1998-2000=100), the prices of dairy products increased from a value of 213 in April to 290 in September 2007, which is approximately four times the lowest value of 74 in 2002 (FAO, 2007). Among dairy products, prices of milk powders led the increase. In September 2007, the price of skim milk powder reached a record high of US$4950/tonne, while the price of whole milk powder rose to US$4750/tonne. Each of these was 125 percent over that the same period in the previous year. Historical prices for skim milk power had never exceeded US$2250/tonne before 2005 (USDA 2007). However, the increase in cheese prices was the least among dairy products at 88 percent over the levels of the previous year, reaching US$4900/tonne in September 2007 (FAO, 2007).

The reasons for this steep rise in prices can be attributed to the expansion of world demand, particularly for fast growth economies in Asia, and the limited supplies by the main world dairy exporters: European Union (25), the United States and Oceania (including Australia and New Zealand) (USDA 2007).

The European Union (EU 25) is the world leader in milk production. In 2007, it accounted for about 24% of the world total cow milk production (IDF, 2007). However, the milk production of the EU 25 declined slightly in 2007 and 2006 compared with 2005. The reasons for the decline are poor weather conditions, the announcements of cuts in support prices, and their de-coupling policy. The de-coupling policy benefits dairy farmers in the EU by direct payments independently from the level of production, which thus reduced the incentives for milk production to some extent (FAO, 2007).

The growth rate of milk exports from the US is sluggish as a result of strong domestic demand for dairy products such as cheese, higher feed prices for milk cows and the increased allocation of land to crop production. In the US, the world's second largest producer, the growth rate of milk production was only 2% in 2007 (FAO, 2007). As for

Oceania, milk production is stagnant largely due to the serious drought in Australia, which led to a big drop in milk production of 10% in first six months of 2007 (IDF, 2007). Another factor which could be responsible for the Oceania's limited milk production is the appreciation of their respective currencies, which has reduced the stimulation from high world prices to their local milk production. New Zealand, another big milk producer in Oceania, has continued to increase its milk production, but the rate is small, only 2.5% in 2007 (FAO, 2007). Consequently, exportable dairy product supplies from New Zealand are not expected to grow significantly due to slow growth in milk production.

Canada actually accounts for a very small percentage of world cow milk production, although the dairy sector is critical for the Canadian agri-food economy. Furthermore, Canada's share of world cow milk production has decreased to about 1.6% in 2007 after three consecutive year of decrease (FAO, 2007).

In contrast to these countries, there is a strong expansion of milk production in Asia, stimulated by strong economic growth, which has contributed to higher world milk prices and increased investments in milk production. The growth rate of milk production in Asia reached over 5% in 2007. Even though milk production in Asia has been increasing in recent years, rapid economic growth and the improvement of living standards foster a growth in demand that continuously outstrips domestic supply. Especially for China, although the growth rate in milk production reached more than 15% in 2007, even higher milk demand made China the largest importer in the world, despite the current high world prices (FAO, 2007).

Stimulated by the rise in prices and the expansion in demand for dairy products, world dairy producers will surely increase their production to gain profits and more market share. Even for those countries where the dairy sector is more protected and domestic prices are usually higher than international ones, the big rise in world dairy products' prices may also make it profitable for them to export. Thus, the structure of the world dairy market will likely be changed (FAO, 2007). Main producers, such as the EU and the US, will increase their milk production and struggle to maintain a larger share of the world market. Small milk producers, like Canada, may also try to increase their production and exports in the pursuit of profits. Therefore, this situation provides opportunities and also challenges for the world's dairy producers. The competition among dairy producers will be more severe, so that in the future, competitive dairy producers will more likely be successful.

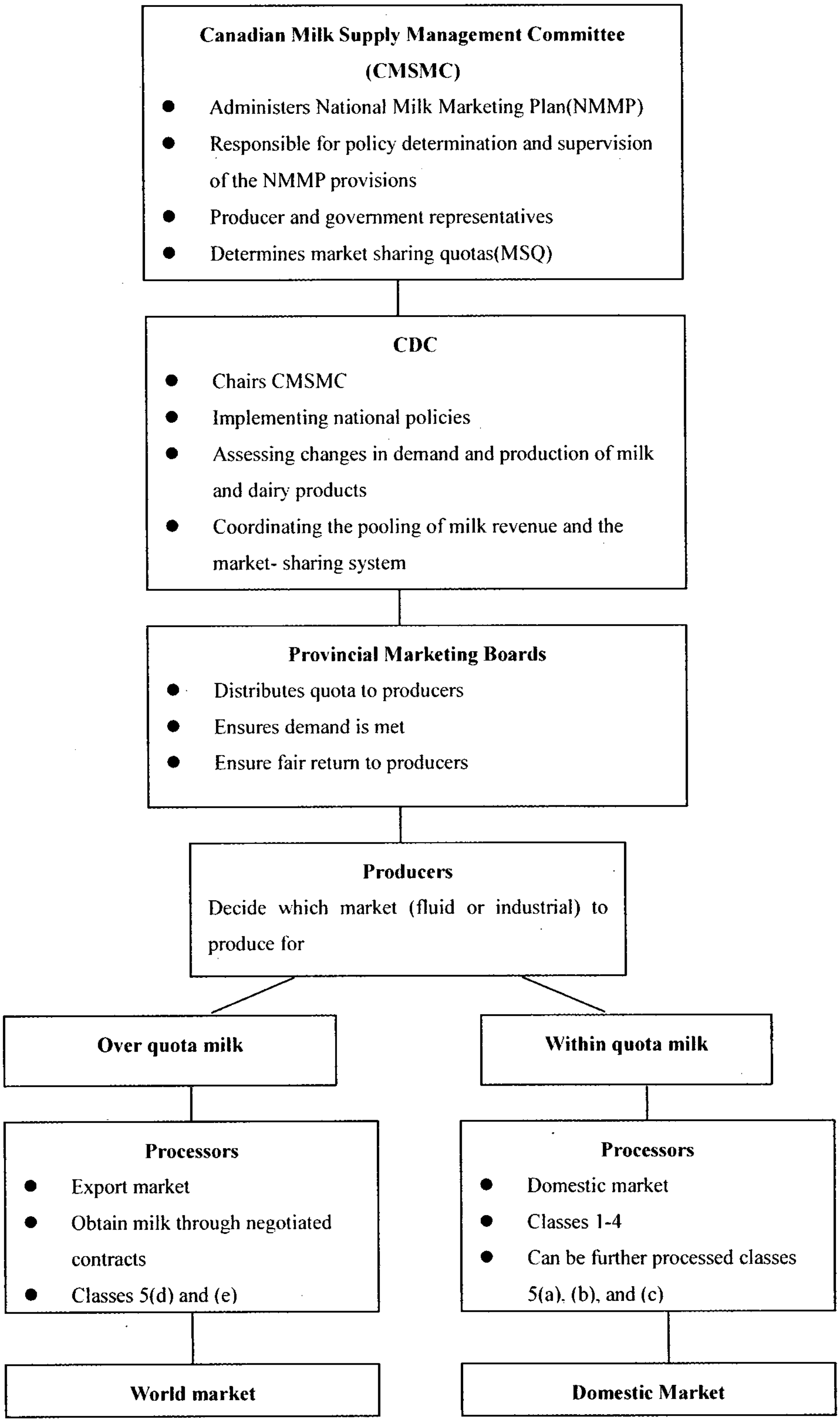
2.1.2 Profile of the Canadian dairy industry

2.1.2.1 The framework of national dairy policy

The Canadian dairy sector is a growing and critical part of the agri-food economy in Canada, and is governed by both the federal and provincial governments. Canada's dairy sector functions under the supply management system based on planned domestic production, administered pricing and controlled imports with the objectives of stabilizing domestic prices for dairy products and raising farm income. Figure 2.1 illustrates the institutions involved in the administration of supply management and briefly describes the operation of Canada's dairy sector.

There are two markets for milk in Canada, a fluid milk market and an industrial milk market. The fluid milk market consists of table milk and fresh cream, and the industrial milk market manufactures milk into dairy products such as butter, cheese, ice cream and yogurt. According to the Canadian Dairy Commission (CDC)'s data for 2007, the fluid milk market represents about 40 percent of milk production, or 32.2 million hectoliters, while the industrial milk market accounts for the remaining 60 percent, or 48.6 million hectoliters.

Figure 2.1 The Organizational Chart of Canadian dairy sector



[Source: CDC and Kuntz (2003)]

The CDC is a crown corporation that functions as the national facilitator and chief administrator for the milk supply management system. It was established with the proclamation of the Canadian Dairy Commission Act on October 31, 1966 (CDC, 2007. History of the CDC), and provides framework for federal and provincial participation in the Canadian dairy industry. Supply management in dairy is based on the National Milk Marketing Plan (NMMP), an agreement between the federal and provincial governments. Through the establishment of market sharing quotas (MSQ), outlined in the NMMP, national production at the farm level is controlled according to the level of domestic consumption of dairy products.

The NMMP is administered by the Canadian Milk Supply Management Committee (CMSMC) which is responsible for policy determination and supervision of the plan, and consists of representatives from producer organizations and provincial governments (All provinces except Newfoundland signed the NMMP and joined the CMSMC by 1974. Newfoundland however entered into the plan on August 1, 2001 through the agreement with the other nine provinces.).

Annually, based on the CDC recommendation, the CMSMC determines the national industrial milk production target or market sharing quota. Each province is allocated a share of the MSQ based on their historical market shares and distributes quotas to the producers according to its provincial policies (CDC, Supply management: CMSMC).

Besides the CDC, there are a number of other federal government departments which also have responsibilities relating to the dairy sector. Agriculture and Agri-Food Canada's responsibilities includes dairy research, policy development, animal health, livestock development, market and rural sector promotion, as well as a number of programs with a direct impact on milk producers (AAFC, 2007. Dairy Industry at a Glance). The

Canadian Food Inspection Agency is in the charge of the establishment of dairy product standards, plant inspection, nutritional labeling, regulating packaging, as well as the monitoring of the safety of dairy products, while Foreign Affairs and International Trade Canada administers the tariff rate quotas, within or over quota tariffs for dairy imports (AAFC, Dairy Industry at a Glance).

As for provincial responsibilities, provincial governments are responsible for the determination of annual production targets, and govern the production and the marketing of milk within their own borders. In order to administer milk marketing, the provincial governments delegate statutory powers to provincial marketing boards. These powers normally include the administration of the licenses for producers, establishment of fluid milk prices paid to dairy farmers and charged to processors, as well as distribution of fluid milk quota to producers (CDC, The Industry: Responsibilities).

2.1.2.2 Dairy supply management

Generally speaking, the essential principle of the supply management system is to attempt to achieve a balance between the supply and demand for dairy products through the management of production in order that it coincides with forecasts of demand in the same period. The general aim is to avoid the costs of surplus production. Moreover, according to Richards (1993), the main specific goals of Canadian dairy supply management are the attempt to maintain self sufficiency in the supply of milk and manufactured dairy products, guarantee the year round continuous supply of milk and milk products, maintain seasonal price stability, obtain fair returns to efficient producers' resources, and maintain interproducer equity in prices received for milk of a given quality. To achieve the above goals, Canadian dairy supply management operates with several important instruments: milk pricing, production quota and import control.

Milk pricing

Even though milk prices paid to producers vary between provinces, they are all priced by

Table 2.1 Milk Classification system

Classes	Milk Class Definitions (All Provinces)
1(a)	Fluid Milk
1(b)	Fluid Cream
1(c)	Milk-based beverages
1(d)	Fluid Milk and Cream for the Yukon, Nunavut and the Northwest Territories (1)
2	Yogurt, Sour Cream and Ice Cream
3(a)	Specialty Cheeses
3(b)	Cheddar Cheese
4(a)	Butter, Butter oil, Powders and Concentrated Milk for ingredient purposes
4(b)	Concentrated Milk for retail
4(c)	New products for the domestic market
4(d)	Inventories and Losses (2)
4(m)	Milk Components for marginal markets
5(a)	Cheese ingredients for further processing for the domestic and export markets
5(b)	All other dairy products for further processing for the domestic and export markets
5(c)	Domestic and export activities of the confectionary sector
5(d)	Planned exports and other exports, the total of which shall not exceed Canada's WTO Commitments

[Source: Canadian Dairy Commission approved by CMSMC]

[Footnote: (1) These markets are supplied by British Columbia and Alberta. (2) Losses: explained losses (dumps, fluid return, etc.) Unexplained losses: up to 2% for processing (west only)]

classified specific end uses of the milk. The prices for different classes of milk are determined according to their components, such as butterfat and protein, through a Multiple Component Pricing (MCP) system (Grant, 2001). The value of each component in a given class, however, is determined based on provincial price levels within that class (Kotowich et al, 1998). Table 2.1 presents a general description of the milk classification system.

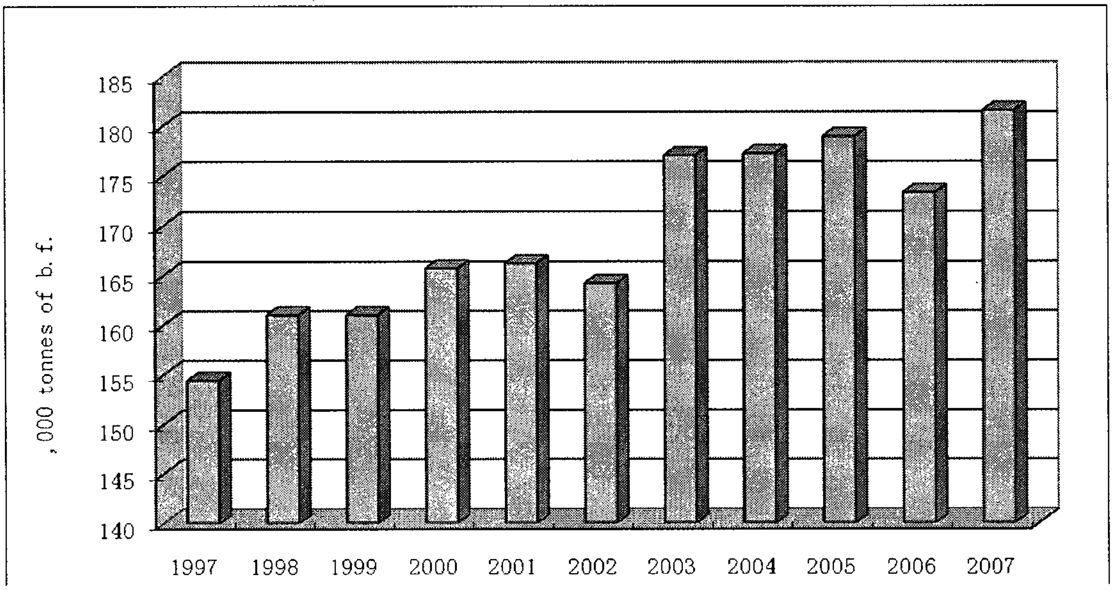
Generally speaking, dairy producers in Canada receive a wide range of prices for their milk, depending on the end use. In the industrial milk market, prices are determined by each province, taking the CDC support prices as the benchmark and adjusting with the end uses. As for the fluid milk market, prices however are determined by each province based on a calculated cost of production (COP) formula, although its format varies among provinces. The COP formula is designed to offer dairy producers a fair milk price that covers the cost of production plus a reasonable profit. This cost formula is an accounting formula and only reports the return of various inputs including labour spent on production. The costs presented by the COP formula are average costs based on a selected sample of producers. (Lippert, 2001).

Quota and import control

Controlled supply in the domestic market is another critical component of the supply management system. Balancing dairy supply with demand in the domestic market implies controlling both milk production and dairy imports according to the domestic consumption of dairy products. Domestic supply is controlled by the industrial milk quota (MSQ) and the fluid milk quota. The MSQ is constantly monitored and adjusted based on Canadian requirements and the production of all dairy products. Canadian requirements are identified as total domestic consumption plus planned exports of industrial dairy products. Figure 2.2 represents the evolution of the MSQ from 1997 to 2007. The different amount of MSQ for each year reflects the changes in demand of dairy products.

Table 2.2, however, shows the dynamic relationship among Canadian requirements, MSQ, and industrial milk production. Each dairy year, the MSQ is determined based on last year's requirement and production and adjusted according to other factors in that year. Therefore, the MSQ is close to, but not exactly equal to Canadian milk requirement in each year. On the other hand, actual production may be slightly more or less, since individual farms tend to over or under produce their quota, subject to penalties imposed by the system.

Figure 2.2 Evolution of the national market sharing quota (MSQ) on August 1st (1997-2007)



[Source: Canadian Dairy Commission (2007)]

As for controlled imports, the TRQ and import tariffs are essential instruments. The TRQ and high over-quota tariffs efficiently control the influx of foreign dairy products into the Canadian market. However, WTO negotiations, the current global situation as well as the trend towards global trade liberalization all represent challenges to the control of imports by the Canadian supply management system. As Hon. Chuck Strahl, the former Minister of Agriculture and Agri-Food Canada, stated "We have faced significant pressure in the WTO agriculture negotiations, and we will continue to face real challenges, including with regard to interests that are important to supply management (Hon. Chuck Strahl, 2007)." And "We are continuing to seek substantial reductions in trade-distorting domestic support, as well as significant improvements in market access and the elimination of all forms of export subsidies (Hon. Chuck Strahl, 2007)."

Table 2.2 Industrial Milk Production and Canadian Requirement (in million hl)

Year	Total MSQ	Canadian requirement	Production
2006-2007	49.6	50.9	48.6
2005-2006	48.4	47.8	48.7
2004-2005	49.9	49.0	49.9
2003-2004	49.8	49.0	50.2
2002-2003	48.7	48.8	47.2
2001-2002	45.6	46.1	47.2
2000-2001	46.4	46.0	47.1

[Source: Canadian Dairy Commission]

2.1.2.3 Dairy farming in Canada

The typical dairy farm in Canada is very specialized, with the majority of its farm revenue coming from milk production and the sale of dairy cows. Most dairy farms are operated in a family owned structure and with considerable equity built up. Moreover, with the impacts of research and technological improvement in milk production, the typical dairy farm now has access to the most advanced technology such as artificial insemination, breed selection and labour-saving milking systems. Also, many dairy farms benefit from the adoption of computerized feeding and herd management systems, biotechnological advances, as well as equipment innovations (CDC, 2007. Typical Canadian Dairy Farm).

As mentioned above, the operational structure of most Canadian dairy farms is based on a family and may operate based on a partnership between two family members, such as two brothers, or two spouses (AAFC, 2005). The average dairy farm in Canada provides one or two fulltime jobs, besides seasonal employment, and most dairy farm operators are family members (DFC, The Canadian Dairy Farm). As defined by Statistics Canada, a farm operator is a person who is responsible for the day-to-day management and financial decisions in the operation of a farm. Management decisions include planting and harvesting, the purchase of capital items, and the marketing and sales of outputs (AAFC, 2005). Most operators are farm owners or tenants. However, a hired manager can also be a farm operator. Besides, there can be more than one operator for a farm.

According to the CDC annual report, there were 14,660 dairy farms with 80.8 million hectoliters of milk production in Canada in 2006-2007, however the number of dairy farms has decreased dramatically over the last two to three decades. The sector has experienced about a 74 percent decline since 1980. This trend represents a continual structural adjustment at the farm level, fewer farms with more cows on each farm. In 2007, the average farm had about 70 cows, yet larger farms are becoming a larger proportion of the total. The number of farms with 178 cows and over increased most significantly compared with farms with 123-177 cows or 78-122 cows, while farms with 77 cows or less decreased markedly since 1960. Larger farms are typically more effective in management and operations. Besides, genetic advancements, feeding improvements and better disease controls have increased the milk production per cow by 332% since 1980. All these factors have improved the efficiency of dairy farms.

2.1.2.4 The Canadian dairy processing industry

The dairy processing industry is very important to the Canadian agri-food economy. In 2006, the value of products shipped by dairy processors reached approximately $13 billion, accounting for nearly 16.8 percent of the value of all shipped products in the Canadian food and beverage industry (CDC annual report, 2007). Yet, the Canadian dairy processing industry has experienced a significant downward trend in the number of plants over the past decades. Actually, this trend made the industry more competitive and productive with the merging of processors and shutting down of small processors. There were 1,413 processing plants in Canada in 1965, and as of 2007, the number had declined to 445. Among these plants, 280 are federal that are registered with the Canadian Food Inspection Agency (CFIA) and the remaining 165 are provincial which can only sell products within their respective provinces (CDIC, Dairy Processors in Canada).

This consolidation and rationalization in dairy processing industry began in the 1970s and continued ever since. As for the reasons behind this trend, several factors should be taken into consideration. First, the specialization of dairy farms as well as the reduction of transportation costs obtained through technological improvements and scale economies made consolidation possible. Second, changes to dairy policy helped to maintain this trend. Provincial government programs paid small processors to shut down their business with the aim to encourage consolidation (Doyon, 2001). Another factor, the processors stimulated by the static or decreasing industry output used consolidation as a method to increase market shares, reduce plant overcapacity, combine resources and skills, as well as reduce the average cost (CDC, Dairy Processing). Finally, globalization is increasing the competition between the Canadian dairy processors and foreign companies both in the domestic and foreign markets. As a result of the consolidation trend, now industry ownership is highly concentrated. Three leading processors: Parmalat, Saputo and Agropur own nearly 15 percent of the plants and process more than 70 percent of the milk in Canada.

Dairy processing plants are generally located in areas where milk production is concentrated to be closer to the raw milk supply. Therefore, the majority of the processing plants are located in Ontario and Quebec. In 2007, Quebec had 191 plants, among which 83 were registered with the CFIA, while Ontario had 122 plants, of which 97 were registered with the CFIA (CDIC, Dairy Processors in Canada).

2.1.2.5 Canadian dairy ingredients

A dairy ingredient is defined as any manufactured dairy product used as an ingredient in further processing (MILKingredient.ca, Ingredient Information). Dairy ingredients can be classified into two categories: traditional and non-traditional. Traditional dairy ingredients mainly include butter, skim or whole milk powder, evaporated milk, cheese and yogurt, while non-traditional dairy ingredients consist of whey powder, whey protein concentrate, milk protein concentrate, lactose, and other products (MILKingredient.ca, Ingredient Information).

Dairy ingredients, as inputs or outputs of processing plants, play an important role in dairy processing industry. Canadian dairy ingredients compete with imported ingredients on both price and quality in the domestic market. This competition has intensified with globalization, by the WTO, and trade agreements involving the agri-food sector. Admittedly, the increased availability of imported ingredients may provide domestic dairy processors with cheaper and better sources. However, the increasing access of imported dairy ingredients to the domestic market is really a challenge for milk producers in Canada, since these reduce the need for domestic dairy ingredients and the demand for raw milk. For Canadian farmers, this could mean a decrease in quota (Dairy Ingredients Information Centre, 2008). Thus, government regulations which involve or have effects on imports of dairy ingredients are perceived by farmers to be critical, however this strategy is subject to debate.

The government has responded to this challenge with the introduction of a new tariff-rate quota for imports of milk protein concentrates. Milk protein concentrates, as a non-traditional dairy ingredient, had not been subject to the Canadian tariff and quota system and thus could be imported into Canada freely (Frigon, 2007). However, as imports of this dairy ingredient increased unexpectedly in 2006, the neglect of imported milk protein concentrates in the tariff and quota system needed to be addressed. For example, the total of evaporated and condensed milk imported into Canada in 2006 was 495,369 Kg, a significant increase compared to 353,321 Kg in 2005 (CDIC, 2007). On February 7, 2007, the Minister of Agriculture and Agri-Food announced that Canada would introduce a tariff rate quota for milk protein concentrates through the employment of its right to re-negotiate with trade partners (DFC, the introduction of a new tariff-rate quota). According to Article 28 of the GATT, member countries of WTO have the right to rebalance tariff concessions. If a member country would like to increase its import tariffs or introduce a new TRQ, the country must negotiate compensatory adjustments with its main trade partners based on the expected impacts. For Canada, the main suppliers of its imported milk protein concentrates have been New Zealand and Switzerland and the negotiation proceeded between Canada and those two countries (DFC, the introduction of a new tariff-rate quota).

Another recent intervention has involved cheese. According to Statistics Canada, cheese always ranks first among Canadian imported dairy products. In 2005, specialty and cheddar cheeses accounted for more than 31 percent of total dairy imports. In Canada, the compositional standards for cheese are subject to two federal regulations, the Food and Drug Regulations (FDR) and the Dairy Products Regulations (DPR), which make cheese unique among dairy products because no other dairy product, like cheese, has been controlled by two federal regulations at the same time (Frigon, 2007). However, these two regulations for cheese are controversial and have been subjected to the lengthy debate. The reasons may be that the inconsistencies between the FDR and DPR in their different lists of acceptable level of use of non-milk products in cheese-making (Fifth town, Artisan Cheese Co., Canada's new cheese regulations). In particular, the FDR identifies milk, skim milk, buttermilk, whey cream or cream, as well as concentrated, dried, or reconstituted forms of those ingredients as milk ingredients that can be used for cheese-making. However, the DPR identifies the same ingredients and other milk solids as the ingredients for cheese-making (DFC, standards for cheese in Canada).

Consequently, it has been ambiguous as to what can be used in making cheese. Dairy processors prefer the DPR and argue that all milk solids should be used in cheese-making, while dairy producers may favour the FDR with a stricter list of ingredients in the production of cheese. Actually, the above controversy has economic implications. The permitted use of all milk solids, including isolates or milk protein concentrates, allows a processor to lower costs in the manufacture of cheese because of the lower prices of imported milk protein concentrates (Frigon, 2007). However, the DPR interpretation could cause an economic disadvantage for dairy producers. The increased use of imported milk proteins would definitely displace some use of Canadian ingredients in cheese production. Therefore, the demand for raw milk would decrease and dairy producers would suffer economic losses. Moreover, the reduction in revenues of dairy producers also may affect technology development and innovation, and thus affect the efficiency of dairy production.

To address this controversy, on December 26, 2007, the Canadian government published a new regulation on the compositional standards for cheese in Canada that will come into force on December 13, 2008 (DFC, standards for cheese in Canada). This revised regulation, proposed by the CFIA, attempts to identify and formalize which milk ingredients can be used in cheese-making, as well as to ensure harmonization and uniformity by the employment of minimum standards to administer the use of local fresh milk in the production of cheeses.

The reaction of Canadian dairy producers, represented by the DFC, to the new regulations has been generally positive. The DFC supports the regulation to ensure the consistency and integrity of Canadian cheeses On the other hand, the reaction of dairy processors, represented by the Dairy Processors Association of Canada (DPAC), has been negative. The DPAC opposed the regulation because it believes that the new regulations attempt to force dairy processors to buy more raw milk from Canadian dairy producers and leaves processors' profits to depend on productivity gains in dairy processing (DFC, standards for cheese in Canada, 2007). Furthermore, according to Dessureault and Myles (2007), the DPAC argues that the new regulations of cheese will severely affect the commercial operations of dairy processors including the increase of retail costs, will limit the processors' ability to supply low-fat dairy products, and even will decrease the competitiveness of Canada's dairy industry. Thus, dairy processors have struggled to lobby the government to delay or even cancel the new cheese regulations through trying to convince the government the regulations would be bad for processors, for Canadian consumers, and also for dairy producers.

2.1.3 Profile of the Ontario dairy sector

2.1.3.1 The Ontario dairy industry

Profiles of the dairy industry as well as their contribution to provincial economies vary greatly between provinces. As for Ontario, the dairy production and processing sector is regarded as among the major industries of its agri-food economy in terms of relative economic contribution. In 2006, the net cash receipts from milk and cream sold off farms reached $1.6 billion, accounting for 32.9 percent of the total of $4.8 billion in Canada (Statistic Canada, Table 003-0008).

After Quebec, Ontario is the second largest dairy production area in Canada. Based on the 2006-2007 CDC annual report, over 31 percent of Canada's 14,660 dairy farms are located in Ontario. Furthermore, Ontario roughly accounted for 32 percent of cows and national market sharing quota for milk production. About 33 percent of Canada's total of 80.8 million hectoliters milk production came from Ontario.

As previously stated, the total number of dairy farms and cows in Ontario has declined steadily and significantly during the past two decades. However, the milk production per farm and the milk output per cow have increased dramatically. According to the CDC, Ontario's average milk production per farm increased from 2,177 hectoliters in 1990-1991 to 5,631 hectoliters in 2006-2007, an increase of 159 percent. Besides, the average milk production per farm in Ontario exceeded that of Canada, 5,512 hectoliters in 2006-2007. As for milk output per cow in Ontario, it increased from 52 hectoliters per year in 1990-1991 to 78 hectoliters in 2006-2007, an increase of 50 percent. On-going technical change, continuous productivity and genetic improvements, as well as more effective operations are probably responsible for these considerable changes.

According to the CDC 2007 annual report, Ontario dairy farms milked, on average, 73 head of cattle in 2007. As in other areas in Canada, the Holstein is the most popular breed in Ontario. Based on the report from the Breed Association and Canadian Livestock Records Corporation (2006), approximately 92 percent of the Ontario's dairy cattle are Holstein while the remaining 18 percent are mainly Jersey and Ayrshire.

2.1.3.2 Ontario's dairy policy

From a provincial perspective, the control of the dairy sector under the supply management system is mainly held by provincial marketing boards or agencies which comply with the CMSMC,based on the NMMP. The primary functions of the provincial marketing boards are to allocate and govern the producer quota and ensure a fair return to producers. In Ontario, Dairy Farmers of Ontario (DFO) is the marketing organization for dairy farmers with its activities monitored by the Ontario Farm Products Marketing Commission. DFO is mainly responsible for the administration of producer quota and milk pricing under the Milk Act, the Agricultural Products Marketing Act and the Canadian Dairy Commission Act. Moreover, DFO also takes charge of the raw milk quality program in terms of raw milk quality testing, truck-tank inspections and Bulk Tank Milk Grader (BTMG) certification and monitoring.

DFO allots quota under the terms and conditions of its quota policies. It allots quota for both fluid milk and industrial milk only to a producer. Here the producer is defined as a person, partnership, corporation or other form of business enterprise which is licensed by DFO for the production and marketing of milk (DFO, 2007). Quota allotted by DFO cannot be loaned or rented. Moreover, quota is not permitted to be combined by producers using common milking and production facilities without approval. Producers are only permitted to market milk with DFO and the milk delivered to DFO must meet or exceed quality standards. When a producer no longer produces and markets milk, the license and quota must be returned to DFO by the producer (DFO, 2007).

Quota is administered on a monthly basis although it is issued on a daily basis. A monthly quota is determined by multiplying the daily quota by the number of quota days (DFO, 2007). Slightly over or under quota production is permitted through an overproduction and underproduction credit system. Producers who are slightly under the quota are allowed to carry the unused quota to future months to offset overproduction, while producers who are slightly over the quota are permitted to receive the normal price for the over-quota milk only if it can be offset by future underproduction (DFO, 2007). If milk marketed in one month by a producer exceeds the producer's total available quota and total available credits, the producer will not receive any payment for the over-quota production and will be subject to a deduction. The total loss for overproduction is about $1.44 per hectoliter including non-payment and deduction (DFO, 2007).

A quota exchange in Ontario is administered by DFO and operates on a monthly basis, with the price determined by the supply and demand of quota. For example, the price of quota in Ontario in June, 2007 was $26,837/kg b.f. /day (DFO, 2007).

As for milk pricing, the DFO is responsible for pricing strategies and the determination of milk prices within the province. Through Multiple Component Pricing, the prices of milk are based on the amount and the value of milk components such as milk fat, and milk protein. In Ontario, according to DFO milk pricing regulation, which came into force on the first day of February, 2008, all classes of milk supplied to a processor should be sold by DFO at a price equal to the total of the amount (Kg) of each milk component in per hectoliter milk multiplied by their respective value. As stated in the DFO milk pricing regulation, the weight of the milk protein is deemed to be 3.39 Kg per hectoliter and that of other milk solids is 5.85 Kg per hectoliter when considering prices for milk class 1(a), 1(c) or 1(d). Therefore, for example, the milk price for 1(a), 1(c) or 1(d) per hectoliter is equal to the sum of the value of milk fat ($/kg BF) multiplied by 3.6, the value of milk protein ($/kg protein) multiplied by 3.39, and the value of other solids

Table 2.3 average milk prices for 2006-2007 in Ontario

Class	$ per hl@3.6bf	$/kg BF	$/kg protein	$/kg other solids
Fluid milk 1(a)	81.22	7.37	6.12	6.12
Fluid Cream 1(b)	78.68	7.37	5.84	5.84
Yogurt, Sour and Ice cream 2	76.45	7.37	5.59	5.59
Specialty Cheese 3(a)	73.15	7.37	12.99	0.82
Cheddar Cheese 3(b)	71.65	7.37	12.53	0.82

[Source: AAFC, Dairy section]

($/kg other solids) multiplied by 5.85. However, for milk class 1(b) or 1(c), the weight of the milk protein is deemed to be 2.8478 Kg per hectoliter and that of other milk solids is 4.9155 Kg per hectoliter (DFO, 2008). Table 2.3 presents the average milk prices and the value of each milk component for the selected classes in Ontario in 2006-2007.

2.2 Defining competitiveness

Defining competitiveness is vital for this study of the competitiveness of Ontario's dairy sector at the farm level because it creates a benchmark for assessing the success of dairy farms in Ontario under the supply management system or in an open market economy. As stated by Feurer and Chaharbaghi (1994), a holistic definition of competitiveness is necessary for determining the competitive position of an organization in a measurable from which allows a comparison of the competitive position of the organization with its competitors. A review of various definitions and primal economic theories of competitiveness are conducted in this section.

2.2.1 Definitions of competitiveness

Competitiveness is an increasingly popular term that is frequently used by economists, politicians, and academics to describe the relative advance or decline of an industry or individual under the prevailing market forces and policy environments (Miller, 1997). Even though there is much agreement on the economic and social importance of competitiveness, the concept of competitiveness is somewhat ambiguous and has been intensely debated. There is no widely accepted definition of competitiveness and no specific economic criteria to measure it (West, 1993). The definitions, measures and concepts of competitiveness vary significantly, based on different levels of analysis and research goals. Belkacem (2002) found that almost every paper on competitiveness struggles with a range of definitions. However, the definition of competitiveness needs to be clarified and specified. Otherwise, a firm, industry or a whole nation may face a problem to know the reasons and the degree of its competitiveness (Henricsson, et al., 2004). According to Turner (2001), the improper understanding of or use of a concept of competitiveness risks useless debates and confused decision makers.

The meaning of the word, competitiveness, in a dictionary is an aggressive willingness to compete (Free Dictionary, 2008). Generally speaking, competition is a phenomenon when individuals and firms strive for a greater share of a market with limited resources. Through competition, firms develop new products, adopt new technologies and improve cost management strategies. Therefore, innovation is stimulated and efficiency is encouraged. Of course, not all firms will succeed in the competition. Competitiveness, however, represents the ability of a firm to survive or expand relative to others during competition (Sharples, 1990).

The literature on competitiveness provides a wide range of definitions. On a national level, competitiveness can be defined based on the success of trade performance in international markets through which the nation's standard of living is improved on a sustainable basis (Henricsson, et al., 2004). A pioneering definition of competitiveness at a national level was given by Scott and Lodge (1985) as: a country's ability to create, produce, and distribute services and/or products in international trade while getting rising returns on its resources. Another straightforward definition of competitiveness, formulated by the World Economic Forum (2002), is that competitiveness reflects the ability of a nation to gain high rates of growth in GDP per capita on a sustainable basis. The OECD uses a definition of competitiveness as "...the degree to which a nation can, under free trade and fair market conditions, produce goods and services that meet the test of international markets, while simultaneously maintaining and expanding the real incomes of its people over the long-term" (European Commission, 2003, p.17). One more specific definition of competitiveness, formulated in a report by the United Nations Conference on Trade and Development, is that it involves an evolution "...from meaning simply higher exports to diversifying the export basket, sustaining higher rates of export growth over time, upgrading the technological and skill content of export activity, to expanding the base of domestic companies able to compete globally" (UNCTAD, 2002, p.117).

Actually, these definitions are quite similar. They all focus on the ability of a nation to compete with other countries in international markets based on different cost structures and other trade characteristics. Simultaneously, competitiveness on a national level also implies the rising return on resources and thus the improvement of citizens' living standards on a sustained basis. To achieve this goal, that is to say to be competitive, costs and real incomes are the key points. As stated by Belkacern (2002), low costs and at the same time high incomes means that productivity is an indicator of competitiveness.

As for the definitions of competitiveness at the firm level, the Aldington Report (1985) gave a description of competitiveness as "a firm is competitive if it can produce products and services of superior quality and lower costs than its domestic and international competitors. Competitiveness is synonymous with a firm's long-term profit performance and its ability to compensate its employees and provide superior returns to its owners." (p.26). The Department of Trade and Industry (1998) in UK also provided a definition at the firm level by stated that competitiveness is a firm's ability to produce the right goods and services, at the right price, which means that a competitive firm can meet customers' needs more efficiently and more effectively than other firms. In fact, this definition is similar to that in the Aldington Report except without the emphasis on the long-term and the ability to compensate employees or owners. They all focused on a firm's market performance. The productivity, efficiency and low costs a firm could achieve are the key factors determining the firm's competitiveness (Henricsson, et al., 2004).

Since the 1990s, agricultural research into competitiveness has increased with the development of globalization in agricultural businesses. Therefore, definitions of competitiveness that are particular to the agriculture sector were formulated for this research. One is "the sustained ability to profitably gain and maintain market share" (Martin et al., 1991, p. 1456). This definition could be applied to an individual firm, an industrial sector or a national economy. According to Kennedy et al. (1997), agribusiness competitiveness was defined as "the ability of a firm or industry segment to offer products and services that meet or exceed the customer value currently or potentially offered by the products and services of rivals, substitutes, and possible market entrants"(p.385). Martin and Stirfelmeyer (2001), however, gave a definition of competitiveness in their study focusing on profitability, market share and growth.

The existence of all these different definitions of competitiveness implies that the concept of competitiveness is multidimensional in nature and should be formulated based on different research levels or goals. On a national or industrial level, the definition normally focus on a nation or an industry's ability to compete in international markets, gain returns on resources, as well as to improve the living standards of citizens. On a microeconomic level, the definition focuses on a firm's performance in markets. Even though definitions of competitiveness are diversified, one point should be clarified. True competitiveness is always measured by the productivity of a nation, an industry or a firm productivity (Porter and Ketels, 2003). Productivity depends on the value of the nation, industry, or firm's products and services, which measured by their prices in open markets, as well as the efficiency with which those products and services can be produced (Porter and Ketels, 2003).

2.2.2 Economic theories of competitiveness

For the theoretical treatments of competitiveness, based on a literature review, most could be classified into the following three categories: absolute and comparative advantage; business strategic management; resource based theory.

2.2.2.1 Absolute advantage and comparative advantage

Traditional economists interpreted competitiveness based on patterns of trade. Adam Smith thought that a nation could gain absolute advantage in trade if its production costs for a particular good were lower than others. Thus, this nation could be better off through exporting this kind of good (Houck, 1992).

David Ricardo improved on the theory by focusing the concern on opportunity costs instead of absolute costs of production. The opportunity cost is the cost of producing additional units of a particular product in terms of the reduction in the output of other products. Therefore, a nation would exploit its comparative advantage if it specialized in producing and exporting the goods with the lowest opportunity cost of production. In short, the implication of Ricardo's theory is that nations with differences in economic structure would trade and finally specialize production in industries with a comparative cost advantage. Therefore, the most efficient allocation of an economy's resources would be achieved, and its welfare maximized (Abbott and Bredahl, 1994).

However, traditional competitive advantage has proved too limiting for predicting actual production and trade patterns in the real world. According to Barkema, Drabenstott and Tweeten (1991), the main weakness of the theory of comparative advantage is that it considered the trade position of each nation in an undistorted world market without taxes, trade barriers and other interventions to free trade. Even though the term competitive advantage is sometimes used somewhat synonymously with comparative advantage, it is more acceptable because this term captures the ability to produce and trade in the real world. As stated by Barichello et al. (1996), competitive advantage is a more political than economic concept. An industry can have a trade advantage just because of subsidies, taxes, trade protection or other forms of intervention. Thus, in a real world, to determine the trade pattern and the specialization in production of a nation, the concept of competitive advantage is more reasonable.

2.2.2.2 Strategic management

According to Coffin et al (1993), productivity and market share were the most commonly employed indicators of competitiveness at the firm level. Productivity is defined as the relation of output to input in the manufacturing transformation process, which measures the efficiency of a firm in production (Tangen, 2002). Higher productivity could be achieved through lower cost of inputs, scale economies, scope, innovation and technological improvement. As for the other indicator of competitiveness at the firm level, market share of a firm is largely, although not entirely, affected by the governmental policy environment. The market share may not reflect the real competitiveness position of a firm due to subsidies, import controls or other interventions.

Admittedly, both productivity and market share of a firm could be influenced by forces outside the firm. However, as stated by West (1993), a firm can control, at least to some extent, its costs of production, scope of products, size, technology and process, while government controls the environment of business through taxes, subsidies and other tools. To exploit strategies for improving a firm's performance, clearly understanding the determinant factors of competitive advantage and their categories, classified in terms of whether it is the firm or government which controls them, seems vital for the firm. As for the concept of competitive advantage, according to Porter (1985), the competitive advantage grows out of the value "...a firm is able to create for its buyers that exceed the firm's cost of creating it" (p.3). Value here is what buyers are willing to pay.

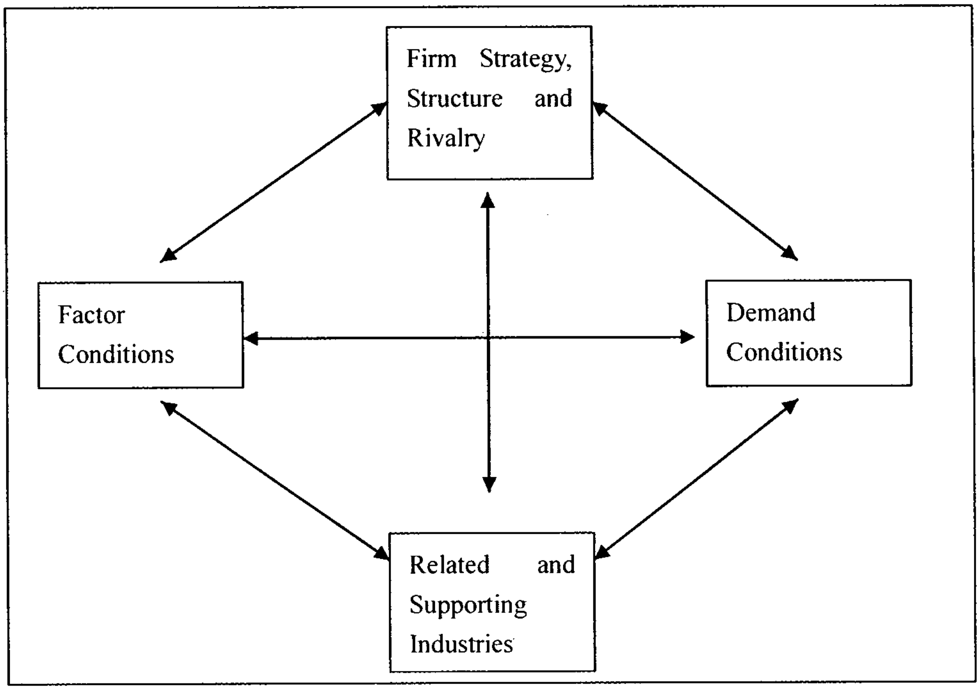
Determinant factors of Competitiveness

In Porter's theory of strategic management, the four main determinant categories of competitiveness could be described by a "diamond". (Figure 2.3) As stated by Porter (1990), these determinants shape the environment, which could favour or impede the establishment of competitive advantages for a firm or an industry.

1. Factor Conditions

Factors of production are necessary for a firm to compete in any industry (West, 1993). Porter (1990) classified factors of production into human resource, physical resource, knowledge resource, capital resource and infrastructure.

Figure 2.3 Determinants of competitiveness



[Source: Porter 1990, p72]

Unlike simple factor approaches of production models used in classical economics, which use only simple factors such as labour, capital and land, factors of production in Porter's theory are much more diversified. Porter (1990) identified natural resources, climate, location, unskilled and semiskilled labour, and debt capital as "basic factors" and deemed modern digital data communications infrastructure, highly educated personnel and university research institutes as "advanced factors", as well as "specialized factors" that involve narrowly skilled personnel and infrastructure with specific properties (p.77-p.78). Porter (1990) thought the most important factors of production to support competitive advantage are those which involve sustained and heavy investment and are specialized. He also argued that competitive advantage is the way by which factors are created, updated and specialized (p.76). Therefore, advanced factors and specialized factors are more crucial than basic factors for competitiveness because they are scarcer, more difficult to imitate by competitors and their creation requires sustained investment

(Porter, 1990).

2. Demand Conditions

According to Porter (1990), demand conditions represent the nature of domestic market demand for products or services provided by an industry. The composition and the size of domestic demands usually have an essential effect on a firm's competitive position (Porter, 1990). Here, the influence on competitiveness from the composition of domestic demand has proved to be much more significant than that from the size of demand. According to Porter, composition of domestic demand is reflected in growth rate of the market, and how sophisticated and demanding local buyers are. As stated by Porter (1990), sophisticated and demanding buyers give firms a clearer signal of buyers' needs and thus force local firms to innovate and respond faster to local buyers' demands. In Porter's theory, a larger and rapidly growing domestic market, with many sophisticated and demanding local buyers will facilitate the development of competitive advantages of the given industry.

3. Related and Supporting Industries

Another determinant of competitiveness is the presence of suppliers and other related industries in the nation, which are internationally competitive (Porter, 1990). For a given industry or a firm, domestic suppliers and related industries are more important than foreign ones. Competitive domestic suppliers can determine how efficient, fast and preferential the access is to low-cost and/ or high quality inputs for the focal industry (Porter, 1990). Furthermore, suppliers also contribute to technology development and productivity improvement activities by stimulating innovation and upgrade based on close working relations with the end-users (West, 1993). The related industries could accelerate the rate of innovation and upgrading through information flow and technical interchange (Porter, 1990). Besides, the demand for products or services provided by a related industry could also increase the demand for what the focal industry produces

(Heeks, 2006).

4. Firm Strategy, Structure and Rivalry

This broad determinant has been re-titled as "context for firm strategy and rivalry" in later studies (Heeks, 2006). However, the content and the explanation of the determinant are quite similar compared with those from Porter. The structure and the goals of an industry govern how individual firms in the industry are created, organized, and managed, as well as the nature of domestic rivalry (Porter, 1990). Porter (1990) argued that an industry tends to be successful when its management practices and organizational modes are favoured in the national environment and suited to the industry's sources of competitiveness (p.108). For example, in Germany, the management system works well in technical or engineering-oriented industries. Those industries tend to be successful in competition favoured by advanced development process, good after-sale service, and a highly disciplined management structure (Porter, 1990). Also, an industry will succeed when goals and motivations are aligned with the sources of its competitive advantages (Porter, 1990. p.110). Furthermore, according to Porter (1990), the presence of strong local rivals is a powerful stimulus to the creation and persistence of competitiveness because it forces firms to compete on cost and quality, to create new products and processes, and to look for higher-order factors of production (p.118).

Apart from the above four clusters of determinants in the "diamond", there are two further elements that should be considered as related to competitiveness. These are chance and government. Chance describes factors beyond the control of a firm or an industry, and are usually unrelated to a nation's situation, such as wars, major technological changes, surges in demand, or major changes in consumer preference (West, 1993). Chance can be a key determinant of competitiveness because it is unexpected and allows shifts in existing competitive positions (Porter, 1990. p.124). As for government policy, Porter considered it as an important influence on competitiveness, but not a direct determinant of competitive advantage (1990. p.128). It positively or negatively affects competitiveness in terms of impacts on the previous five determinants (West, 1993). Of course, government itself cannot create competitive advantage.

Competitive Strategy

According to Porter (1985), "Competitive strategy is the search for a favourable competitive position for a firm in an industry; it aims to establish a profitable and sustainable position against the forces that determine industry competition." (Chapter 1, p.2) These competitive forces identified for an industry include new entrants, the threat of substitutes, buyer bargaining power, supplier bargaining power and rivalry (see figure 2.4 for Porter's firm-level competitiveness analysis). Therefore, the choice of competitive strategy is very important for a firm because it could not only help the firm establish a competitive and profitable position in the existing industry environment but also attempt to change that environment towards the firm's favour (Porter, 1985).

To gain a competitive advantage or to choose a favorable competitive position in an industry, a firm could choose a competitive strategy from the following three broad generic strategies: lower cost, product differentiation and competitive scope.

A lower cost strategy involves a firm's attempt to become a low-cost producer in an industry compared with its rivals. A firm may gain the cost advantage through the pursuit of scale economies, propriety technology, and preferential access to raw materials. As stated by Porter (1990), if a firm can achieve a cost advantage, at equivalent or even lower output prices than its competitor, a lower cost could translate into a higher return.

Another competitive strategy is differentiation. In a differentiation strategy, a firm seeks to provide unique products or services in terms of some factors that would be widely valued by consumers (Porter, 1990). Differentiation can be based on the product itself, such as product image, product durability, and other features related with a superior quality. Differentiation can be also based on other factors such as after-sale service for products, or the positioning of counters in the stores. A firm can gain a price premium by a differentiation strategy. Therefore, it allows the firm to achieve superior profitability if the price premium exceeds the extra costs of differentiation.

Competitive scope is a strategy where the firm focuses on a niche market within an industry (Coffin et al. 1993). The key point is choosing a suitable target segment in the industry where the firm has a competitive advantage rather than attempt to achieve an overall competitive advantage. According to Porter (1990), this strategy has two elements: cost focus and differentiation focus. Cost focus implies that a firm attempts to gain a cost advantage in its target segment, while differentiation focus means a firm tries to achieve competitive advantage in its target segment through differentiation.

Figure 2.4 Porter's Framework of firm-level competitiveness analysis

Environmental determinants (influence firm strategy)

- Potential entrants
- Buyers' bargaining power;
- Suppliers' bargaining power;
- Substitutes

Firm's Competitive Strategies

- Lower cost
- Product differentiation
- Competitive scope

[Source: Coffin et al (1993)]

The choice of competitive strategy by a firm depends on the firm's structure, organization, management techniques, resource, goals, the industry environment and other related factors. No one strategy is always better than the other (Porter, 1990). The choice of competitive strategies is usually dynamic and needs to be adjusted according to the competitive environment.

2.2.2.3 Resource based theory

Resource based theory is developed on the origins of Porter's competitive advantage in strategy theory and has become one of the standard competitive strategy theories. Many researchers have contributed to extend this theory by linking it to industry condition or to innovation, such as Dierickx and Cool (1989), Amit and Schoemaker (1993), Mahoney and Pandian (1992), and Peteraf (1993). The core of the resource based theory is that it considers firms' heterogeneity in resources and capability as a source of sustained competitive advantage, which could be an explanation of the difference in the competitive position of each firm (Hoopes, Madsen and Walker, 2003). Resource based theory goes beyond the assumption of a homogenous resource endowment as found in the traditional theory of strategic management. In this theory, the focus is on the resources and capabilities of a firm and how these affect its performance.

According to the resource based theory, resources must meet three features to be sources of competitive advantage. First, resources must be valuable. For instance, resources obtained at prices lower than their discounted net present values will generate rents for the firm who owns those resources (Peteraf, 1993). Second, resources must be rare. In another words, resources must be available in short supply compared with the demand. Resources with this feature can be valuable to gain a competitive advantage for a firm (Hoopes, Madsen and Walker, 2003). Third, to be rare and valuable, resources must be isolated from imitation or substitution, which means it is hard and costly to imitate or substitute for those resources (Hoopes, Madsen and Walker, 2003).

A firm's resources can be classified into two categories: tangible and intangible. Tangible resources have physical features that can be quantified, and include physical capital resources, such as a building or equipment, financial resources, such as cash, or bank deposits, human capital resources, such as skilled workers, and organizational capital resource, such as a decision making process. Intangible resources for a firm are something of value that has no physical existence, such as a brand, patent, trademark, or reputation. According to Makadok (2001), a firm's resources can be identified as observable assets. Observable assets, which are not necessarily tangible, can be valued and traded, such as a brand, a license, or a parcel of land. However, a firm's capabilities, in marketing and production, are unobservable and necessarily intangible. These may be difficult to value and trade.

For a firm, a clear understanding of characteristics and categories of distinct resources and capabilities is essential. Then, the firm could well utilize its resources and capabilities through different operational and competitive strategies to achieve sustained competitive advantages.

2.2.3 A working definition of competitiveness for this study

The review of the competitiveness literature demonstrates that any study of competitiveness, whether it focuses on an industry or individual firm, should go beyond traditional trade theory, taking the impacts of government interventions and firm strategies into consideration (Miller, 1997). Since the Canadian dairy sector is governed under the supply management system, with a high level of governmental involvement, a careful consideration of the influence of government regulations is necessary to understand the competitiveness issues of the dairy sector. Besides, the study of competitiveness at the farm level requires a clear understanding and analysis of the determinants of competitive advantage. All these requirements can be met by the strategic management theory of competitiveness. Actually, as previously stated, that is just the core of strategic management theory. Therefore, the strategic management theory of competitiveness should be suitable to develop a working definition of competitiveness for Ontario dairy farms.

According to Sharples (1990), cost estimates are useful and should be emphasized in the analysis of competitiveness. Sharples also argued that cost comparisons could reveal the existing determinant forces driving competitiveness for each competitor through revealing the influences of input use and factor payments from these forces. Therefore, cost of production has been treated as a leading indicator of competitiveness for its good description of those economic forces (Ahearn, Culver and Schoney, 1990). Furthermore, some important features of the Canadian dairy sector reveal that the cost of production could be the most suitable approach for a competitiveness analysis of the Ontario dairy sector at the farm level. These features include the uniform marketing of milk for dairy producers, the homogeneity in milk produced at the farm level, and inelastic domestic demand (Grant, 2001). Therefore, the appropriate definition of competitiveness for Ontario dairy farms in this study is developed based on the analysis of the cost competitive advantage as an element of strategic management theory.

2.3 Cost Competitiveness studies for dairy farms

A farm that is most cost competitive implies that it has the least cost in milk production. To examine the competitiveness of Ontario dairy farms, a review of empirical studies of cost competitiveness at the farm level is necessary. According to Barichello et al. (1996), the estimation of competitiveness and comparisons cannot be made based on prices of products for heavily regulated industries, such as the Canadian dairy industry. However, production cost is usually employed as the metric for competitiveness issues. Therefore, a study about the cost efficiency of milk production is valuable for the evaluation of dairy farms' performance, and thus provides a useful guide for the improvement of cost management by dairy farmers. This section, therefore, presents an overview of various approaches, analysis and results from previous studies.

2.3.1 Empirical studies of cost competitiveness for dairy farms

Whether the evaluation and comparison of cost competitiveness are between provinces or international nations, one important goal is to determine the causes of differences in their costs of production. This can provide a guide to how to improve competitiveness. With this goal, different studies may emphasize different causes of cost differences in milk production. Based on a literature review, many studies have been conducted, using various approaches, to examine technical and economic efficiency, economies of farm size, or other regional factors, and their effects on dairy farms' cost competitiveness (Hailu, Jeffrey and Unterschultz, 2005). What follows is a review of several important studies of cost competitiveness, involving their methods, data sources, and results.

Moschini (1987) did a study to estimate the cost structure of Ontario dairy farms based on a large body of farm-level cost of production (COP) data to identify factors responsible for cost differences. In this study, the author used a micro-economic model of production based on a dual cost function approach. The form of cost function used was the translog functional form. All farms were assumed to have access to the same technology, but individual farm characteristics were taken into consideration by characteristic variables. Data used by Moschini (1987) were collected by the Ontario Dairy Farm Accounting Project (ODFAP), which spanned the period 1978 to 1983 and comprised 612 observations. The results of this study indicated that there existed large scale economies for a wide range of output levels of Ontario dairy farms. This result suggested that, in the long run, Ontario dairy farms would be characterized by a decrease in farm numbers and an increase in farm size. Besides, the results also suggested that farm-specific characteristics have a significant impact on the estimated cost structure of Ontario dairy production.

Barichello et al. (1996) made three independent studies about cost competitiveness in the

Canadian and US dairy sectors to identify the factors which contribute to cost competitive advantages. The first study conducted a comparison of productivity differences between Wisconsin and Alberta to show which had a competitive advantage in milk production. The authors used primal and dual measures of productivity to compare farms' performance across time between the two locations. The primal measure compares the amount of output produced from given amounts of inputs, while the dual perspective compares the cost of production of a given amount of output based on a constant set of input prices. Therefore, the primal rate of productivity growth is equal to the output growth rate minus the rate of change of an input index, whereas the dual productivity growth rate is equal to the change of costs less the output growth rate and the weighted average growth rate of input prices. As for the data, they used farm-level annual COP survey data for 1982 and 1989 in Wisconsin and Alberta. For the Alberta data, there were 54 observations in 1982, with the average herd size of 57 head and 58 observations in 1989, with the average herd size of 64 head. The Wisconsin data, however, include 1002 observations with sample average size of 50 head in 1982, and 482 observations with average size of 65 head in 1989. The results show that by 1989, Alberta milk producers faced an 11.39 percent higher cost to produce the same output as Wisconsin at the Wisconsin input prices. Therefore, the Wisconsin dairy sector was estimated to be cost competitive compared with that of Alberta. As for the causes of the productivity difference, the authors indentified higher labour input and lower feed as the source of the disadvantage in Alberta.

The second study of Barichello et al. (1996) used a multilateral cost of production (COP) comparison among selected regions in the US and Canada: New York, Wisconsin, California, Ontario, Quebec and Alberta. Because the comparisons of this study were conducted between areas in different countries, much emphasis was put on keeping costs on a consistent basis across different dairy production areas. Therefore, all costs were expressed in Canadian dollars with an assumed exchange rate of US $0.85/ Canadian dollar and on a hectoliter (hl) basis with 3.6 kg butterfat/hl. Data for this study came from annual farm-level COP data gathered by farm management societies or public agencies in 1988. The approach used to analyze costs of production was to estimate and aggregate each cost component directly from the survey data. Besides, the COP comparison was based on average costs instead of the long-run marginal cost of milk production. The results showed that Quebec was the highest cost region ($44.21/hl) followed by Ontario ($43.36/hl), Alberta ($35.88/hl), New York ($32.18/hl), Wisconsin ($31.77/hl) and the lowest cost region was California ($28.24/hl) in 1988. Alberta was the most cost competitive region in Canada compared with Quebec and Ontario, but its COP was over 10% higher than those in New York and Wisconsin. As for the causes of regional cost differences, the authors offered two main factors: milk yield per cow and herd size. They concluded that only those two factors accounted for more than 75 percent of the cost difference, with yield per cow always more important, which was consistent with the facts that among these six selected regions, Quebec had the lowest yield per cow of 59.61hl/year, while that of California was highest at about 83.26 hl/year in average.

As noted by Barichello et al. (1996), some studies about the cost structure of dairy farms have been conducted to determine the factors that contribute to cost competitiveness. According to National Dairy Policy Task Force (1991) and Gouin, et al. (1990), Canadian dairy farms are smaller in size and in production per cow as compared with those in the US. That may be one reason for the relative disadvantage in cost competitiveness of the Canadian dairy sector.

Romain and Lambert, in Barichello et al. (1996), investigated how dairy producers can reduce their COP by changes in herd size, technical efficiency, and production methods. The authors used a micro-econometric approach based on COP data from Quebec and Ontario. Regressions of COP on milk output, the level of technical efficiency, herd size and several socioeconomic variables, such as the producer's level of education, the quality of herd, were used to examine the effects of those factors on COP. The Quebec data consisted of 472 observations from the System d' information sur l'enterprise Agricole (AGRITEL) data bank, while the Ontario data came from the ODFAP. The authors indicated that there was a common limitation of studies in this field that a relationship between average COP and farm size was determined without the consideration of difference in yield per cow within each farm size group. Actually, the lower COP may also result from an increase of yield per cow, rather than the increase in farm size. In order to assess whether the lower COP was the result of the increase in farm size, or the increase in yield per cow, or both, the authors grouped farms based on both herd size and then yield per cow. The results of this study showed that there are no significant economies of size for dairy farms in Quebec. As for Ontario dairy farms, cash costs did decreased with the increase in herd size, with a COP reduction of $0.127/hl./cow for every cow increase in herd size, but this size economy for Ontario dairy farms wasn't statistically significant. Economies of yield, meaning that the average COP decreases significantly with the increase in yield per cow, was significant only for dairy farms with less than 50 cows in Quebec. For dairy farms with more than 50 cows in Quebec, or for any size subgroups in Ontario, no economies of yield appeared. The authors also claimed that technical improvements can reduce COP for dairy farms in both Quebec and Ontario based on the results of their study, that a 10% improvement in technical efficiency reduced COP by $5.25/hl. for Quebec dairy farms, and $ 4.84/hl. for Ontario dairy farms. As for the effects from socioeconomic variables, the authors indentified that education, participation in a milk-recording program, quality of forage, expenses per cow for veterinary care and artificial insemination, all characterized efficient farms in Quebec. In Ontario, factors that represented farm management ability were also shown to have statistical effects on COP.

Richards and Jeffrey (1996) did a study to investigate the relationships between farm size, milk yield, technical efficiency, and cost of production, which provided some insights into how to improve the competitiveness of Alberta dairy farms. The approach used in that study was to estimate stochastic production frontiers. The stochastic production frontiers revealed the statistical relationship between inputs and milk yields, given the assumption of efficient production. Then a simple linear regression model was used to determine the relationships between efficiency, costs of production and also some management characteristic variables. This method was similar to Romain and Lambert (in Barichello et al. (1996)). According to Richards and Jeffrey (1996), the overall economic efficiency of milk production can be decomposed into technical and allocative efficiency. Technical efficiency refers to the ability of a producer to achieve the maximum output from a given amount of inputs, while allocative efficiency is defined as the ability to choose the optimal production strategy, such as the proportion of each input, for given input prices (Farrell, 1957). In this study, the authors used both the composed-error (CE) method and the average frontier (AF) method to estimate the production frontier. The data used came from the Alberta Agriculture-Alberta Milk Producers' Society annual COP survey from 1989 to 1991, and there were 181 observations in this sample.

Based on the AF model, the results of the study showed that there existed significant economies of herd size for Alberta milk producers, which implied production costs decrease with an increase in herd size. Given the average herd size of the sample at 66 cows/farm, production costs decreased $0.073/hl./cow in average for every cow increase in herd size. Besides, the results also revealed that the optimal herd size in Alberta was 250 head. The existence of economies of herd size revealed in this study has been found in other previous studies. Weersink et al (1990) concluded that every 1% increase in herd size led to a 5% increase in efficiency for dairy farms in Ontario. Tauer (1993) reported that each cow added 1% to the technical efficiency of milk production in the short run for dairy farms in New York. Bravo-Ureta and Rieger (1991) showed that an increase in herd size would benefit the efficiency of dairy farms based on a sample in New England. As for milk yield, Richards and Jeffrey (1996) found that it did not have a significant effect on production costs, which means no economies of yield in Alberta. The authors also claimed that improvements in technical efficiency could reduce production costs for Alberta dairy farms such that every 10% improvement in efficiency would lead to the reduction of production costs by $3.37/hl.

According to Richards and Jeffrey's CE results, economies of size did exist with a decrease by $0.07/hl in production costs for each additional cow, given the average herd size of 66 cows. The optimal herd size was around 287 cows. Based on the CE model, the results revealed there were significant diseconomies of yield for dairy production in Alberta. Every one hectoliter increase in average milk yield per cow led to a 0.31/hl increase in production costs. This result was inconsistent with that based on the AF model. As for technical efficiency, CE results also showed there was a significantly positive relationship between technical efficiency and production costs, with a $5.99/hl reduction in production costs for a 10% improvement in technical efficiency.

One study of cost competitiveness for six US states was done by Cocchi, et al (1998). A growth accounting approach was used in this study to calculate and decompose cost efficiency into technical change, regional competitive advantages, as well as economies of herd size. The data used by Cocchi, et al (1998) included outputs, costs of production, and input prices for dairy farms from Connecticut, Maine, Michigan, Pennsylvania, New York and Vermont for the years 1968, 1970, 1977, 1980 and 1988. Data sources were annual reports published by dairy business record programs for each state and some USDA sources. Six input categories, Cow, labour, concentrate feed, forage, animal supplies, land and buildings, were included in the COP analysis. In their study, cow represented the opportunity cost of the herd by assuming it was equal to 33.3% of the livestock investment for each dairy farm. Labour represented the total expense of hired, family and operator labour. Concentrate feed was the expenses for purchasing dairy concentrate. Forage represented expenditures on nonconcentrate feed, seed and plants, energy and machinery, fertilizer and lime. Animal supplies represented the aggregate expenses of livestock supplies, breeding and veterinary. The last input category, land and buildings, represented the annual flow of those assets, assumed to be an annual expense of 3% of total investment in land and buildings. As for the cost shares of these six input categories, labour ranked first with 33%, followed by concentrate feed (23%), forage (20%), cows (14%), animal supplies (5%), and land (5%). The results of this study revealed that because of technical improvements, there was a 1.8% average annual rate of production cost reduction for each state over the period studied. Besides, economies of size did exist for dairy farms in those six states. Medium sized farms, with herds from 64 to 140, and larger farms, over 140, were shown to be 12% to 20% more efficient than small farms.

Saha and Hemme (2003) did a study to investigate technical efficiency and cost competitiveness of milk production of typical dairy farms in 23 main milk production countries in the world. All major dairy production and exporting countries were included, with a representation of 74% of world milk production. The main purpose of their study was to clarify the differences between cost competitiveness and technical efficiency for dairy farms through comparisons of both technical efficiency and cost competitiveness among dairy farms in those countries. The data used was a cross section of 68 dairy farms in 23 countries in 2001. The authors used a frontier production function method to estimate milk production functions. The input categories which were used for specification of frontier production function were feeds, labour, capital and land. Input price indexes used in the frontier production model were developed based on costs of each input item in terms of US$. The feed index was determined based on the costs incurred in milk production or expenses used for purchasing feed or fodder. Both cash and non cash costs were taken into consideration here. Cash costs included costs for fuel, fertilizer, purchased fodder and concentrates, maintenance of machinery, while non cash costs were annual depreciation of machinery and buildings. The labour index was estimated based on the costs for hiring labour per year per cow, and family labour costs were also considered on the basis of the average farm wage rate per hour in that region. The land cost index was calculated based on both rents paid by the farms for rented land and the calculated land rents for owned land. Finally, the capital cost index for their study was obtained based on the interest costs of capital used per cow per year. Here, owned and circulating capital used for dairying, excluding land, was considered as capital. The equation to estimate the capital index was:

Capital index = Non-land assets * interest rate (9% assumed for borrowed funds, 4% assumed for owner's capital).

The results of this study revealed that the most cost competitive dairy farms in the world were in New Zealand with the lowest COP of 12 US$ per 100 L. Dairy farms in Brazil, Australia, Estonia and India were all competitive in terms of cost of production, with COP less than 15US$ per 100 L. However, dairy farms from Switzerland, Austria and Finland were the least cost competitive with an average COP of about 48 US$. As for technical efficiency, the results showed that dairy farms in Australia and Spain were the most technically efficient with a technical efficiency index of 100%, while farms in India were the least technically efficient with an index of only 57%. Based on the results of their study, Saha and Hemme (2003) concluded that there was no significant correlation between cost competitiveness and technical efficiency for dairy farms.

There have been a few studies involved efficiency and its relative effects on cost competitiveness of dairy farms from different perspectives. Amara and Romain (1990) and Mbaga, et al (2003) assessed technical efficiency of Quebec dairy farms. Jeffrey (1992) compared milk production efficiency between dairy farms in the US and in Canada. Richards and Jeffrey (1996, 2000) estimated efficiency and its effects on COP for Alberta dairy farms. Weersink, Turvey and Godah (1990) assessed technical efficiency of Ontario dairy farms using non-parametric methods. However, the literature on comparisons of the cost efficiency of dairy farms across provinces in Canada is limited. Therefore, the study by Hailu, et al (2005) turns out to be important. Hailu, et al (2005) examined and compared the cost efficiency of Alberta and Ontario dairy farms by using a stochastic cost frontier approach with a main purpose to examine whether there was a significant difference in cost efficiency between dairy farms in Alberta and Ontario. The data used by them consisted of capital, labour, and feed cost components, output and other variables, for the period 1984 to 1996. The data sources were Alberta Agriculture and the ODFAP. Sample sizes for Alberta and Ontario were 799 and 1144, respectively. The results of their study suggested that dairy farms in Ontario were more cost efficient on average than Alberta. In detail, based on the distribution of cost efficiency indexes, 6.26%, 66%, and 28% dairy farms in Alberta exhibited cost efficiency indexes of 70% or lower, 70% to 90%, and above 90%, respectively. However, in Ontario, 0.35%, 19%, and 81% dairy farms exhibited cost efficiencies in the same categories.

Based on the above literature review, it is apparent that almost all literature in this field had a purpose to identify factors which had significant effects on production costs for dairy farms, although the factors they emphasized may differ. Moschini (1987) emphasized the effects of cost structure, some socioeconomic factors, and especially economies of farm size. Barichello et al. (1996), however, identified productivity differences as the factor which contributed to cost competitive advantage in their first study about cost competitiveness, while in their second study, economies of herd size and economies of yield were emphasized. Richards and Jeffrey (1996), however, focused on farm size, milk yield, and also technical efficiency. Romain and Lambert, in Barichello et al. (1996), constructed their study by investigating farm size, technical efficiency, as well as production methods, and their effects on production costs, while Cocchi et al. (1998) did their study with a focus on similar factors, except for production methods. Saha and Hemme (2003) put their emphasis on technical efficiency and its relationship with cost competitiveness. Amara and Romain (1990), Weersink, Turvey and Godah (1990) and Mbaga, et al (2003) assessed technical efficiency and their effects on dairy farms while Jeffrey (1992) focused on milk production efficiency.

Through the review of previous studies, another point is clear, that almost all studies on cost competitiveness at the farm level used a micro level cost of production data. Therefore, these studies can also be identified as cost of production (COP) studies. Most COP data came from farm-level annual COP survey data gathered by farm management societies, or public agencies. There are several important data banks frequently used for research in this field, such as the ODFAP data bank for Ontario dairy farms, and the AGRITEL data bank for Quebec.

2.3.2 Employing a farm-level cost of production data

Even though farm-level COP data has been widely used by researchers, there are some issues that have provoked controversy and debates on the use of COP data. Furthermore, impediments do exist in employing a COP data, which mainly result from overstated cost estimate based on farm level data. To improve the status of COP studies, a clear understanding of important issues about COP data, which have led to the debates, and the impediments of using COP data and their underlying reasons is necessary.

2.3.2.1 Important issues for farm-level COP data

Stanton (1986) and Barichello, et al., (1996) have identified some important issues which should be considered to avoid controversy when using a COP data. One issue is the estimation of input costs. They recommended that inputs should be valued at the supply price or opportunity cost in milk production when the measurement of costs is in the long run. However, if intermediate inputs are used in the cost analysis, inputs should be valued at the lower of an alternative supply or the value of required home-grown inputs. Another issue is the valuation of the cost of capital assets. Capital assets used in milk production should be valued based on an annual market rental rate. According to Stanton (1986), changes in the inflation rate should be considered, when constructing a COP study over a relatively long period. Besides, to improve the COP studies, Barichello, et al., (1996) recommend that economic rents should be excluded from land rental values or labour returns in cost analysis as they are not costs. According to Stanton (1986), one should also pay attention to the sampling procedures and the representativeness of the data when using these data for cost analysis.

Furthermore, there are a number of issues to take into consideration when making comparisons across different regions or countries. Firstly, when conducting a cost analysis for dairy farms across different regions, as stated by Richards and Jeffrey (1998), one should note that differences in milk production cost structures may arise from different policy environments. As stated by Barichello et al. (1996), Canadian dairy producers have to invest a large amount of financial capital in quota licenses, which may make their investment in other productive uses, such as cattle, expanded barns, or embryo transfer technology, lower than that of US dairy farms. This fact therefore may result in the lower productivity growth rate of Canadian dairy farms compared with those in US. Taking the results of studies by Barichello et al. (1996) for example, Alberta milk producers faced an 11.39% higher cost of production at the same output level compared with producers in Wisconsin. Second, the definitions of input variables should be maintained as consistent as possible when comparing costs of milk production across different areas. Third, one should compare dairy farms of different regions according to their size, differences in product quality, climate situation, and their economic and policy environment. Fourth, one should choose an appropriate currency exchange rate when conducting an international cost comparison, and use a consistent currency for all cost components in the analysis. Houck (1992) suggested that one should use the major currency employed to value international assets or the currency used to price the commodity in question.

2.3.2.2 Impediments for employing a farm-level COP data

According to Barichello, et al (1996), following the principles of appropriately using opportunity cost and other suggestions to treat cost data will not necessarily guarantee an unbiased estimation of cost competitiveness for dairy farms. They concluded that the cost data at the farm level usually leads to overstated cost estimates. Six reasons were summarized by them to explain why there are overstated cost estimates in terms of farm-level cost data. First, normally, the main purpose of cost data collection is for determining milk support prices. Therefore, milk producers have an incentive to provide cost reports that biased upward. The over-estimated costs of milk production then lead to over-assessed milk prices which will benefit to milk producers. Second, most dairy farms, especially small farms, record costs for tax purposes, instead of for management decisions. To decrease taxable income, dairy farms may tend to record their costs with an upward bias. Third, dairy farms in primary production usually have a high percentage of non-purchased raw materials and a relatively small percentage of purchased raw variable inputs. Therefore, farm owned inputs account for a large percentage of the farm sales. Besides, the valuation of farm owned inputs undertaken by the farm and tends to be over-estimated compared with the purchased inputs. Fourth, input prices of different farms vary widely, especially for farm owned inputs. The reason may be that there is no universal benchmark for the evaluation and quantification of farm owned inputs. As stated by Barichello, et al (1996), the supply prices for operator labours vary significantly across farms. Since typical operators of dairy farms are family members, the quantification of working hours and the valuation of labour costs vary widely across farms. Besides, regional differences, different skills of operators and different operators' performance all contribute to that variation. Furthermore, this problem seems more significant for small dairy farms because labour costs account for a large percentage of total variable costs for small farms. Fifth, when calculating capital depreciation, such as machinery and buildings, using the prices of new capital leads to overstated deprecation and then overstated costs of capital.

Finally, using the average cost of milk production instead of long run marginal cost will also induce an upward bias of cost estimations. According to Barichello and Stennes (1994), some farms which stay in the industry are active at the margin of production, while others may have a low production and high unit cost because their small size, outdated management and/or techniques in operation. However, the cost data may include relatively uncompetitive farms or farms with higher unit costs, which will overstate the average cost. To solve this problem, grouping of milk farms in terms of farm size, net farm income, or yield per cow may be an appropriate approach.

Even though the use of farm-level data will cause overstated cost estimations for the above six reasons, a COP study with cost data analysis is still the most common and appropriate approach for cost competitiveness issues. Furthermore, the upward bias of farm-level cost data is accepted because it occurs for all regions and over all time. The purpose of recognizing the above issues is to emphasize some of the inherent difficulties in using cost data and then to solve those problems. Thus, there is room to improve cost analysis and cost competitiveness studies.

2.3.3 Issues about economies of size and yield in dairy production

Based on literature review, many previous studies that farm size or yield per cow have a negative relation with average cost of milk production (Moschini, 1987; Lazarus et al., 1989; Barichello and Stennes, 1994; Barichello et al., 1996; Richards and Jeffrey 1996; Grant, 2001). That is to say, the average cost tends to decrease with the increase in farm size or yield, which indicates the economic efficiency of large farm or high yield farm.

However, another important issue about size economy and yield economy is investigating the underlying sources of the efficiency for large farm or the farm with high yield per cow. It is easy to understand why farms with higher yield tend to be economic efficient, achieving a lower average cost of production. In fact, the increase of yield per cow itself implies the improvement of economic efficiency in milk production. As yield per cow increases, fewer cows are needed for a farm to maintain a given profitability and productivity (Kohn, 1999). Thus, the overall and average cost per HL decreases. Technology improvement contributes much for the increase of yield per cow. According to Dahl, et al. (1996), one new technology, manipulation of photoperiod by provision of artificial lighting can improve yield of dairy cattle by up to 8%. The improvement in feed nutrients required by herd can also increase milk yield and it has been shown that it can improve milk yield by up to 4.1% (Dahl, et al., 1998).

As for the reasons of economies of size in milk production, there were several aspects through which to inquire into the sources for efficiency associate with farm size. First, large farms have apparent cost advantages over small farms. Overhead costs comprise the major cost advantage of large farms because they use capital and labour more intensively compared with small farms (MacDonald et al., 2007). That is to say, large farms can reduce their average cost by spreading fixed costs, such as machinery and equipment, and labor costs over more milk output (Hall and LeVeen, 1978). Labour cost is an important component of total or average cost of milk production. For small farms, nonpaid operator and family labour accounts for the majority of the labour cost. Even though most farm operators and their families do not likely pay themselves wages, they are opportunity costs and need to be included in the labour cost. Besides, the wage rate applied for operator and family labour is normally high than that for contract labour. Then, with this view, large farms have another cost advantage over small farms. Second, there exists the heterogeneity among different size of dairy farms for technologies to some extent. Large farms have the advantage to access new and advanced technologies above small farms (Chavas, 2001). Small farms may have some restrictions, such as budget or capacity to invest and employ some new production techniques. The relationship between technical efficiency and farm size has attracted considerable concerns of previous studies and most of these studies suggested a positive relation between farm size and technical efficiency (Dawson, 1985; Bravo-Ureta and Rieger, 1990, 1991; Finan et al., 1993). Third, according to Hall and LeVeen (1978), pecuniary economies of size existed, especially in volume discounts for purchase inputs which let large farms to be more efficient. Fourth, large farms have greater opportunity to access to high-quality resources than small farms. Fifth, large farms normally are more efficient in operation management, which suggests the better utilization of their resources, such as labor and machinery, and the larger output based on per unit input.

2.3.4 Employing the farm-level cost competitiveness study

The literature reviewed in this section provides a framework to construct a methodology for the study of Ontario dairy farms' competitiveness. Since the Ontario dairy sector is regulated under supply management, estimating competitiveness and making comparisons cannot be made based on prices of dairy products, because these prices are not likely to be equivalent to long run marginal cost. An appropriate alternative is to estimate the cost of production as the metric for making a competitiveness comparison. As stated by Barichello and Stennes (1994), in the long run, average milk prices should equal total production costs and the annual cost of quota licenses. Therefore, a more appropriate approach to the cost analysis is to estimate and aggregate cost components directly from the COP survey data. As stated previously, the potential for inherent bias and difficulties should be attended to when using the farm-level cost of production data for a COP study. Properly grouping dairy farms in terms of size or yield per cow is vital for using the cost data presented as the average costs instead of desired long run marginal costs. As for the cost structure, it is important to properly define the nature of cost components and use the supply prices and opportunity costs as the prices of inputs. Ensuring consistent data collection of farm-owned inputs, especially for the supply of labour, is also important.

To estimate the profitability of Ontario dairy farms in anticipation of further trade liberalization, using international milk prices, or competitors' cost of production, instead of Canadian support prices is a proper approach to provide an appropriate examine of the potential future financial position of Ontario dairy farms. Most studies of cost competitiveness at the farm level conclude that there exist economies of size or economies of yield for the dairy sector. It therefore seems vital to examine the size economies in Ontario dairy sector in terms of herd size or milk yield for a cost competitiveness study of Ontario dairy farms.

Chapter 3 Methodology

The primary objectives of this study are to estimate cost competitiveness of Ontario dairy farms and to give an insight into strategies to improve it. To achieve these objectives, a micro-econometric model based on an empirical cost equation approach is employed. It is used to investigate the relationship between the average cost of milk production, milk output level, milk yields per cow, and several other variables which represent farm specific characteristics. The analysis can point towards ways to improve the cost of milk production, and provide some insights into key factors to maintain or improve the competitiveness of Ontario dairy farms. Based on previous studies, there are some potential strategies that could lower costs, such as herd expansion, new feeding regimes, new milking routines, and improved breeding programs. Among those strategies, herd expansion is the most common and widely adopted strategy to improve the economic performance of dairy farms (Western Producer, 1999). To examine that view, the extent of economies of size in the Ontario dairy sector will be determined based on the estimation of the empirical cost equation. However, according to Romain and Lambert (1996) and some other studies in this field, the average yield per cow increase when the herd size increase, which implies that lower average cost of milk production may result not only from a herd size increase but also from an increase of yield per cow or a combination of these two elements. Therefore, to examine this view, the investigation of the relationship between the average cost of milk production and yield per cow is undertaken. Furthermore, the potential profitability of Ontario dairy farms under deregulated environment will be examined through the use of indictors of potential international milk prices. The methods and the data used in this study are elaborated in this chapter.

3.1 Model specification

3.1.1 An empirical cost equation model

Since the choice of an economic model is partly dependent on the behavioural assumptions adopted, an appropriate assumption of farmers' behaviour that is consistent with the objectives of the study is vital. The common assumption of producers' optimal behaviour for empirical studies is cost minimization or output maximization. Producers minimize the cost of production given the output level and exogenous input prices, or maximize the output given the input limitation (Fare and Primont, 1995). According to Kumbhakar and Lovell (2000), cost minimization is more likely to be the appropriate behavioural assumption in many environments, especially for environments in which output is driven by demand or limited by other exogenous factors. This assumption is regarded to be reasonable for dairy farmers, because normally the output of dairy farms is limited by their production quota, so it also can be considered as exogenous. Besides, the output of dairy farms, milk, is hard to store, and so the output maximization assumption is inappropriate. Therefore, the proper assumption of dairy producers' optimal behaviour is cost minimization. Dairy farmers try to minimize their cost of milk production with various constraints. Consistent with the main objective of this study, investigating the cost competitiveness of Ontario dairy farms, dairy farmers with lower costs of production per HL (per unit milk output) tend to be more competitive. The cost minimization assumption gives rise to an empirical cost equation approach for this study to achieve its objectives. Investigating the key factors and their effects on the cost of milk production per HL will give an insight into strategies to improve the cost competitiveness.

According to empirical studies, milk output level, yield per cow, and production technology, are key factors which influence the cost of milk production per HL. Because information on techniques for dairy production is widely available, it is reasonable to assume that all dairy farms have access to the same technology in production. However, in reality, there does exist some heterogeneity of milk production conditions and production techniques among farms, such as feeding regimes, milking systems, and breeding programs. To recognize this reality, these factors could be assumed to be farm-specific characteristics when constructing a cost equation (Moschini, 1987). Thus, an empirical cost equation is estimated to determine the relationship between cost of production, milk yield per cow, milk output, and several important farm-specific characteristics and employed to examine economies of size, to estimate competitiveness and to give an insight into strategies to improve it in the Ontario dairy sector.

3.1.2 The Box-Cox transformation

Before the cost equation can be specified in this study, the appropriate functional form of the model must be determined. First of all, one point should be clear that there exists the possibility that the effects of milk yield (milk production per cow) and milk output on the average cost of production may be non-linear (Richards and Jeffrey, 1996). Then, a simplistic linear regression model, such as $Y = \alpha + X\beta + \varepsilon$, may be not suitable for this study. According to Zarembka (1990), the choice of a simplistic functional form implies the danger of misspecification of the model and its attendant biases in estimating the statistical significance of results. To employ a simple linear model requires a set of restrictive assumptions: a linear relation between the dependent variable and all independent variables, X are non-stochastic, and the error term ε is normally distributed with zero expectation and constant variance, and the covariance between any pair of random errors is zero (Hill, Griffiths, and Judge, 2001). However, assumptions that are too restrictive will induce biases in assessing the magnitude of effects and significance of results. Zarembka (1990) claimed that some previous empirical studies would have had modified or even opposite results if their functional forms had been specified with a less restrictive functional relationship (Zarembka, 1968 and Spitzer, 1976).

So, this leaves the question of how to specify the functional form, since it is unknown a priori. A Box-Cox transformation of variables could be a solution for this problem.

Actually, transformations have been often used in statistical modeling as an approach to obtain simplicity of the model structure and homogeneity and normality of the error terms. Examples are the quadratic, logarithmic, interaction, and Box-Cox transformations (Yang, 1996). Among those transformations, the Box-Cox transformation is the most general and popular in application, as seen in the works of Matsuda (2006), Waijiers et al (2006), Freeman and Modarres (2005), Moschini (1987), Guerrero and Johnson (1982), and Poirier (1978). Actually, the quadratic and logarithmic transformations are both special cases of the Box-Cox transformation. With the utilization of a suitable Box-Cox transformation, a normal, homoscedastic model can be achieved with less restrictive assumptions (Box and Cox, 1964).

The form of the transformation proposed by Box and Cox (1964) is as follows:

$y(\lambda) = (y^{\lambda} - 1) / \lambda$, if $\lambda \neq 0$

$y(\lambda) = \log y$, if $\lambda = 0$

"The general idea is to restrict attention to transformations indexed by unknown parameters λ, and then to estimate λ and the other parameters of the model by standard methods of inference" (Box and Cox, 1964. p213.). Besides, it should be noted that the constant term must not be omitted, to preserve invariance of estimates of a transformed variable using the Box-Cox transformation (Schlesselman, 1971).

The Box-Cox transformation can be applied to both dependent and independent variables with additivity of effect preserved on the transformed variables (Zarembka, 1990). According to Box and Tidwell (1962), transformation of the independent variables can be applied without any influence on the normality of the error distribution and constancy of variance. In this study, the Box-Cox transformation is applied to output and yield per cow, in order to capture their possible nonlinear relationships with cost of production, as well to avoid biases in assessing the magnitude of effects and significance of results induced by using a restrictive functional form.

Then, the specific cost equation used in this study is structured as follows:

$$COP_i = \alpha+\beta_1(y_i^{\lambda}-1)/\lambda+\beta_2(Yield_i^{\lambda}-1)/\lambda+\beta_3 age_i+\beta_4 edu_i+\beta_5 breed_i+\beta_6 build_{1i}+\beta_7 build_{2i}$$
$$+\beta_8 milkingsys_{1i}+\beta_9 milkingsys_{2i}+\beta_{10} milkingsys_{3i}+\beta_{11} feedsys_{1i}+\beta_{12} feedsys_{2i}$$
$$+\beta_{13} region_{1i} +\beta_{14} region_{2i} + \varepsilon_i$$

COP_i is the average cost of milk production (\$/hectoliter), for the i^{th} producer. y_i is the output level of the i^{th} producer and $Yield_i$ refers to the average milk production per cow of the i^{th} producer. age_i represents the age of the principal operator of the i^{th} farm. edu_i, $breed_i$, $build_{1i}$, $milkingsys_{1i}$, $milkingsys_{2i}$, $milkingsys_{3i}$, $feedsys_{1i}$, $feedsys_{2i}$, $region_{1i}$, and $region_{2i}$ are binary variables that represent farm-specific characteristics of the i^{th} producer, respectively (see Table 3.2). Since the vector of attributes is expressed as a vector of binary variables, the transformation is normally not used for them. Following Moschini (1987), the interaction terms among those binary variables are ignored. ε_i is the error term reflecting random deviations for the i^{th} producer. The transformation parameter λ and β_1, ..., β_{14} are parameters to be estimated.

No prior restriction is put on the functional form of the above cost equation. Parameters estimated with the data will determine if the cost equation is nonlinear model or not. In other words, if the transformation parameter is estimated to be other than 1, the model is nonlinear.

One important task is to determine the appropriate method of estimation for the Box-Cox transformation parameter. According Li (2005), a commonly used approach is the method of Maximum Likelihood. With this approach, it is easy to obtain an estimator of the transformation parameter because of the asymptotic properties of the Maximum Likelihood estimator (Li, 2005). Following Li (2005) and others, the Maximum

Likelihood Method will be used in this study.

3.1.3 Defining variables

The dependent variable of the model is the cost of milk production per hectoliter of the i^{th} producer (COP_i). COP_i comprises of five general cost categories. These are feed, labour, intermediate inputs, capital and other. Cost items of all those categories are those that can be directly attributed or allocated to the dairy enterprise, and the detailed cost items included in these five categories are described in table 3.1. One point about labour should be noted is that labour costs include both hired labour expenses and an estimate of nonpaid family labour costs. The hired labour includes both expenses of labour directly used in milk production and hired labour expenses allocated to the dairy enterprise. As for nonpaid family labour, it is estimated on the basis of family nonpaid labour hours and corresponding labour wage rates. However, nonpaid family labour hours were not directly available, so were estimated as follows. First, hired labour expenses divided by the hired labour wage rate yielded an estimate of hired labour hours. Total labour hours were available, so total hours minus hired hours provides an estimate of operator and family labour hours. Family nonpaid labour hours are comprised of operator labour and family (non-management) labour and these have different wage rates. Based on supplements to the ODFAP labour data, it is assumed that 15% of labour hours worked by the operator and members of the producer family is management labour and the remaining 85% is non-management hours. Then, both nonpaid operator labour costs and family labour costs can be estimated using the corresponding labour wage rates.

In this study, the operator and family (non-management) labour wage rates used are those in 2007 for Ontario dairy producers. The operator labour wage rate was $28.55/hr and that of family (non-management) labour was $22.37/hr (CDC, COP information 2007-Ontario). For the capital category, the capital depreciation attributed and allocated to the dairy enterprise is included.

Table 3.1 Description of the cost items

Cost categories	*Cost items included in each category*
Feed	dairy ration, protein supplements, salt & minerals
	milk replacer & calf ration
	bulk grain & forage purchases
	other purchased feeds
	bulk grain& forage purchase
Intermediate inputs	seed, fertilizers, herbicides & pesticides
	fuel & lubricants
	telephone & hydro
	vet & drugs
	insurance
	stable& milk house supplies
Labour	hired labour expense
	nonpaid family and operator labour
Capital	barn equipment and building repairs
	field machinery repairs
	capital depreciation
Other	A.I. fees
	milking transport& license fees
	livestock marketing
	land rent
	interest fee and taxes
	other dairy, crop, and overhead expense *

[Note*: other dairy expense includes bedding materials, feed processing expense, livestock testing and registration, livestock insurance, livestock promotion expense and building rent. Other crop expense includes twine, seed cleaning, crop insurance and machine rentals, while other overhead expense includes hardware, car expenses and miscellaneous expense.]

For the milk output y, it should be noted that milk is an undifferentiated commodity, even though it is classified into fluid milk and industrial milk based on how it is marketed. Therefore, milk is considered as a homogeneous commodity and measured in hectoliters corrected to 3.6 percent fat content. Including this variable in the model, the effect of farm size on the cost of production can be estimated and then economies of size can be examined. As for the variable, milk yield per cow ($Yield_i$), it represents the average milk production per cow for the i^{th} farm. For the variable age, it should be noted that if there is more than one principal operator, the age of operator represents the elder one.

In addition to above variables, binary variables which represent farm specific characteristics are also included in the cost model. The selection of these variables was based on the available information, and also meets the criteria that variables selected should be correlated to some definition of farm specific efficiency. These include education level of the principal operator, breed of cows, ODFAP dairy region, building condition, milking system, and feed system (Table 3.2).

Education level of the principal operator specifies two levels: Agri. Diploma or better and other. Similar to the age variable, when a farm has more than one operator, the education level of the principal operator represents the higher one. Breed of cows includes six categories: Holstein, Ayrshire, Jersey, Guernsey, Mixed breed, or other. Holstein, as the world's highest production dairy cow breed, is popularly used by milk producers. Based on the data used for this study, more than 95% of Ontario dairy farms in the sample use Holsteins. The Ayrshire is a breed of dairy cattle widely known for its ability to convert grass into milk efficiently, easy calving and longevity. Another important trait of the Ayrshire that is attractive to dairy producers is that it is a moderate butterfat and relatively high protein breed (Wikipedia, Ayrshire cattle). The Jersey is a small breed of dairy cattle. It is known for relatively high butterfat and protein, and the lower maintenance costs for its smaller bodyweight (Wikipedia, Jersey cattle). The Guernsey is a breed of dairy cattle known for rich flavour of its milk. The milk produced by the Guernsey also has a moderately high butterfat content and relatively high protein content (Wikipedia, Guernsey cattle). Since the Ayrshire, Jersey and Guernsey are all relatively high butterfat and protein breeds, it is reasonable to put them into one category. Then, breed of cows is specified into two categories in the model: Holstein and other. ODFAP dairy regions comprise six regions from region 1 to region 6 which are specified into three categories because of geographical proximity, as region 1&2, region 3&4, and other (see Appendix 1). Building condition takes three levels as good, excellent and other. Milking system is classified into four classes: Pipeline, Parlour, Robotic (see Appendix 2), and other (Bucket, Bucket/Transfer), while feed system is specified into three levels: semi-automated, fully automated, and manual.

Table 3.2 Summary descriptions of dummy variables

Variable Label	Symbol	Description
Education of principal operator	edu	edu=1 if level is Agri. Diploma or higher, edu=0 otherwise
Breed of cows	breed	breed=1 if breed is Holstein, breed=0 otherwise
Building condition	$build_1$	$build_1$=1 if building condition is good, $build_1$=0 otherwise
	$build_2$	$build_2$=1 if building condition is excellent, $build_2$=0 otherwise
Milking system	$milkinsys_1$	$milkinsys_1$=1 if system is Pipeline, $milkinsys_1$=0 otherwise
	$milkinsys_2$	$milkinsys_2$=1 if system is Parlour, $milkinsys_2$=0 otherwise
	$milkinsys_3$	$Milkinsys_3$=1 if system is Robotic, $milkinsys_3$=0 otherwise
Feed system	$feedsys_1$	$feedsys_1$=1 if system is semi-automated, $feedsys_1$=0 otherwise
	$feedsys_2$	$feedsys_2$=1 if system is fully automated, $feedsys_2$=0 otherwise
ODFAP dairy region	$region_1$	$region_1$=1 if farm in region 1 or region 2, $region_1$=0 otherwise
	$region_2$	$region_2$=1 if farm in region 3 or region 4, $region_2$=0 otherwise

Therefore, these six characteristics are specified in the model using seventeen binary variables. To avoid singularity, one dummy of each set of dummy variables must be dropped (Barten, 1969). Thus, eleven binary variables are left in the model, whose coefficients are estimated simultaneously with the other variables. Table 3.2 gives the descriptions of dummy variables specified in the model.

3.2 The data

The model used in this study requires farm-level COP data for cost of production per hectoliter, milk output, herd size, and several variables which represent farm specific characteristics. This study uses farm-level data collected by the Ontario Dairy Farm Accounting Project (ODFAP). The ODFAP is a co-operative project of the Canadian Dairy Commission, Agriculture and Agri-Food Canada, the Dairy Farmers of Ontario, and the University of Guelph with the purpose of collecting regular, representative and consistent farm production and management data from the Ontario dairy sector to meet farm-level data requirements in policy and research (ODFAP, 2007). The ODFAP is annual project initiated in 1976. Through this project, an extensive body of information is collected for each farm on both their financial and physical structure.

Normally, dairy farms are multiproduct farms, which means there are other outputs in addition to milk, such as livestock products and crops. Computerized accounting programs used in data collection for the ODFAP permits the information of each farm to be disaggregated in terms of the source of revenue and costs for each enterprise. The main enterprises registered in the project are the dairy enterprise, replacement enterprise, crop enterprise and others. However, this study focuses only on the dairy enterprise. Only milk output, costs and other factors of milk production are taken into consideration in the model specification and parameter estimation.

Farm-level annual data from the ODFAP are analyzed for the most recent three consecutive years: 2005, 2006, and 2007. The sample comprised a total of 233 observations, with 75 observations in 2005, 74 in 2006, and 84 in 2007. Table 3.3 provides basic average descriptive statistics for the sample.

Table 3.3 Basic descriptive statistics of the sample

	2007	*2006*	*2005*
Number of farms	84	74	75
Dairy cows per farm (hd)	77.4	69.3	68
Milk sold per farm (hl)	6596	5736	5555
Milk sold per cow (hl)	82.5	79.8	78.4
Butterfat test (kg/hl)	3.9	3.9	3.9
Workable land farmed (hectares)	140	132	123
Age of principal operator	47	46.9	47

For the ODFAP data, the sample is a regionally stratified random sample of farms, which means farms in the sample were randomly selected on the basis of regions and the number of farms in the sample within each region reflects the proportion of dairy farms in each region. Six dairy regions of southern Ontario were identified based on similar land capabilities, climatic factors, and non-dairy opportunities (see Appendix 1 for the map of Ontario dairy regions). These are:

Region 1: Elgin, Essex, Kent, Lambton, Middlesex, Norfolk.

Region 2: Brant, Huron, Oxford, Perth, Waterloo.

Region 3: Bruce, Dufferin, Grey, Simcoe, Wellington.

Region 4: Durham, Haldimand, Halton, Niagara, Northumberland, Ontario, Peel, Prince Edward, Wentworth, York.

Region 5: Frontenac, Hastings, Lanark, Leeds, Lennox & Addington, Peterborough, Victoria.

Region 6: Carleton, Dundas, Glengarry, Grenville, Prescott, Renfrew, Russell, Stormont.

Table 3.4 describes the composition and structure of the 2005, 2006 and 2007 samples in terms of these six regions.

Table 3.4 Sample composition and structure in terms of regions

	Region 1	*Region 2*	*Region 3*	*Region 4*	*Region 5*	*Region 6*	*Total*
2007	5	29	17	8	7	18	84
2006	7	25	15	9	4	14	74
2005	7	22	15	11	5	15	75
Total	19	76	47	28	16	47	233

Another characteristic of the ODFAP data is that the sample is chosen on the basis of a five year rotation. That is to say, any given farm participates in the project for 5 years and will be excluded from the project in their sixth year. Thus, the sample for each year does not comprise of the same farms because there are newly enrolled farms each year. Taking the 2007 sample for example, it comprises five sub-samples of dairy farms. The first sub-sample is composed of 19 farms which enrolled in the project for 2003. The second one comprises 3 farms which enrolled in 2004. The third one consists of 14 farms which enrolled in 2005 and the fourth with 18 farms enrolled in 2006, while the final one is composed of 30 farms which enrolled in 2007. Table 3.5 represents the sample composition and structure in terms of farm enrolment year for the other two years 2005 and 2006.

Table 3.5 Sample composition and structure in terms of farm initial enrolment year

Enrolment year	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*Total*
2006 Sample		14	20	5	14	21	74
2005 Sample	8	15	26	7	19		75

As previously stated, observations from these three consecutive years were included in the sample of this study. Since the time span of the sample is not very long, only three years, and these years are consecutive, the simplification of ignoring time is adopted supposing that time will have little effect on the results for this study, and follows the method of Moschini (1987). Thus, the sample has 233 observations.

3.3 Economies of size and economies of yield

The parameter estimates can provide an indication of the relationship between average costs of production (per HL milk) and milk output, as well as yield per cow. If the data show that average costs of production decrease as milk output increases, this suggests the existence of economies of size in Ontario dairy sector. This would imply that there are unexploited economies for producers if they have relatively low output or a smaller herd size. Then, herd expansion could be a good strategy to improve the competitiveness and the economic performance of these producers. Similarly, if the results reveal that average costs decrease as yield per cow increases, this implies the existence of yield economies. Then, an increase yield per cow would be another strategy to improve competitiveness for dairy farms with relatively lower yield per cow.

3.4 Farm profitability

According to Jeffrey (1992), Canadian dairy farms are compensated for higher costs of production with higher milk prices compared with American farms. Therefore, it is not recommended to regard farm net income as an indicator of Canadian dairy farms' economic performance. Instead, using international milk prices could provide a more appropriate metric of the dairy sector's competitive position when considering the implications of potential trade liberalization.

The assessment of Ontario dairy farm profitability under a liberalized situation is conducted through comparing costs of milk production of Ontario dairy producers with various indicators of the international milk price. Since comparable international COP data are not readily available to make a comparison with that of Ontario, using international milk market prices to evaluate Ontario dairy farm profitability may be a good alternative to provide an insight into the relative competitive situation of Ontario dairy farms.

Two different international milk price indicators could be used. Their selection is based on the respective nation's potential impact on Canadian dairy trade and domestic milk prices in the event of deregulation. First are milk prices in the U.S., due to its geographical proximity to Canada. Second are the national milk prices of New Zealand because of its relatively low cost of production (Grant, 2001).

The preferred indicator of international milk prices chosen for this study is the farm received price in the U. S. First, the U.S. is one of the largest milk producers in the world. Second, the U.S. has a close trade relationship with Canada, and is a major supplier of dairy products to Canada. Third, the U.S. has regional proximity to Canada, and could supply much of Canada with fluid milk.

U.S. dairy policy focuses on producer milk prices and stability of the market. To support its milk price, the milk support price program was designed and has been applied in the U.S. dairy sector. However, since the 1990s, the milk support price has been generally set far below market prices. Especially in recent years, it has been set at a low level that can only provide protection against extremely low milk prices for producers (Miller and Blayney, 2006). As for U.S. milk pricing policy, the pricing of all raw milk produced in the U.S. is regulated under milk marketing orders (Sumner and Balagtas, 2002). U.S. milk marketing orders use price discrimination and establish the minimum price that processors must pay for Grade A milk according to its end use to support the average milk price received by producers (Sumner and Balagtas, 2002). There are four classes of milk in the U.S. marketing order system based on its use. Class 1 is for fluid milk. Class 2 is for fluid cream products, yogurt, and perishable manufactured products. Class 3 is for cream cheese and hard manufactured cheese and Class 4 is for butter and dry milk.

Among these four classes, the price of Class 1 is the highest, recognizing higher costs for supplying fluid milk products (Miller and Blayney, 2006). All classified prices are set through pricing formulas which reflect dairy market conditions. Federal marketing orders set minimum prices for Class 3 and Class 4 milk each month according to formulae with consideration of the wholesale prices determined by markets of related dairy products such as cheese, butter and dry milk (Miller and Blayney, 2006).

However, the producer price is not the direct class price but a blended price based on the four class prices. That is to say, although milk producers sell their milk to different types of processors, they still have the same minimum blend price for their milk (Miller and Blayney, 2006). In fact, producer prices are generally higher than the minimum blend prices because of market forces. That is to say, received prices are affected by market forces when open market prices are higher than the minimum blend prices.

The use of U.S. farm received milk prices as the indicator of the international milk prices provides an insight into Ontario dairy producers' potential profitability under a deregulated competitive environment. Furthermore, the comparison between this indicator of the international milk price and the average cost of production of Ontario dairy producers will provide an indication of the potential for dairy producers to survive in an open competitive market environment. In other words, those dairy producers with average costs of milk production higher than the international milk price may not survive in a deregulated market.

Chapter 4 Results and Discussion

This chapter presents the results of analyzing the descriptive statistics and the regression results of the cost equation. The analysis of the effects of milk output level, yield per cow, as well as several farm specific characteristic factors on the average cost will also be conducted based on the regression results. Besides, the results embodied the relationship between the average cost, output, as well as yield per cow will be employed to examine the existence of size economies and yield economies, respectively. Furthermore, estimating cost competitiveness of Ontario dairy producers under a deregulated market environment will be discussed on the basis of the results of this study with farm received milk prices in the U.S. as the indictor of international milk prices. Then, strategies to improve competitiveness are discussed according to the results.

4.1 Analysis of descriptive statistics

Before the regression results of the cost model are illustrated and analyzed, some results revealed by the descriptive statistics will be described in this section. Table 4.1 gives a summary description of continuous variables in the cost model and herd size of the sample farms.

Table 4.1: Summary Statistics of the sample

	Mean	Max	Min	Std. Dev.
Average Costs ($/HL)	78.56	273.15	44.46	23.84
Output (HL)	5984.08	28399.12	972.78	5098.77
Yield per cow (HL/cow)	80.32	114.02	26.36	13.19
Herd size (hd)	71.80	288.5	24	53.26
Age of operator	46.96	71	25	8.35

According to table 4.1 and figure 4.1 (see Appendix 3), the cost of production per HL of those 233 farms in the sample ranges from $44.46 to $273.15, with the mean of $78.56. Most observations fall into the range from $50 to $100, with 203 farms accounting for

87.1% of the total. Only 26 observations (11.2%) have an average cost higher than $100 and 4 observations (1.7%) have an average cost lower than $50. All of the farms with average costs less than $50 use a parlour milking system, Holstein breed, semi-automatic or automatic feed system, and have good or excellent building conditions. As for the farms with an average cost higher than $100, 27% of those farms use a manual feed system, while the remaining 73% use semi-automated or automated system. 77% of these 26 farms use a pipeline milking system, 15% use a parlour and the remaining 8% use bucket/transfer. Besides, 23% of the farms have an average building condition and the remaining 77% are good or excellent. Holstein is still dominant for those farms, but there are 7 farms out of 26 that use Jersey or some other breed. For farms with an average cost higher than $50 and lower than $100, 12% of those 203 farms use a manual feed system, while the remaining 88% use semi-automated or automated system. Besides, 64% of the farms use a pipeline milking system, 33% use a parlour and the remaining 3% use robotic or bucket/transfer. 90% of the farms have a building condition in good or excellent. Furthermore, 4 out of those 203 farms use mixed or other breeds instead of Holstein. Compared the above characteristics for farms in different average cost categories, it suggests a larger percentage of farms with higher average costs use a manual feed system compared to those with lower average costs. Moreover, more of higher cost producers use a pipeline milking system instead of a parlour and the percentage of farms that use bucket/transfer is higher for those farms with higher average costs. The percentage of farms with a good or excellent building condition is also lower for those farms with higher average costs.

As for the herd size and milk output, herd size ranges from 24 to 289 head, with a mean of 72, while milk output ranges from 972.78 HL to 28399.12 HL, with an average output level of 5984.08 HL. Most observations (87.6%) have an annual milk output lower than 10,000 HL. Only 29 farms (12.4%) have an output level higher than 10,000 HL (see Figure 4.2 in Appendix 3).

Yield per cow ranges from 26.36 to 114.02 HL/cow with an average level of 80.32 HL/cow. About 89.3% of the observations fall in the range from 60 to 100 HL/cow (see Figure 4.3 in Appendix 3). According to the CDC (annual report 2007), yield per cow for the whole Canadian dairy sector was 77.69 HL/cow, while that of Quebec, Alberta were 78.68 HL/cow and 81.76 HL/cow, respectively in 2007. In the US, yield per cow in 2007 was 90.51HL/cow on average (USDA, 2008).

The distributions of 233 farms in the sample in terms of several farm characteristics specified in the cost model provide useful information for a further insight into key characteristics. Table 4.2 (Appendix 3) represents the distribution of farm according to the education level of operators. More than 59% of operators have an education level of Agriculture Diploma or higher (including Community College, BSc. Degree, and Post Grad. Degree). No operator in the sample holds a Post Grad. Degree. Among those education levels, high school accounts for the largest proportion (27.9%), followed by Agriculture Diploma (24.9%).

As for cow breed, more than 95% of farms use Holstein, the dominant breed for the Ontario dairy sector. No farm in the sample uses Ayrshire or Guernsey. Only 11 farms (4.7%) use Jersey, mixed, or other breed (see Table 4.3 in Appendix 3).

Most sample farms have a good or excellent dairy building condition. The building condition of 63.1% (147 farms) of total is good and that of 25.3% of farms is excellent. Only 2 farms (0.9%) have a poor building condition and the remaining 10.7% of farms are in an average level (see Table 4.4 in Appendix 3). For milking system, the data suggests that the most popular milking system for Ontario dairy farms is pipeline. About 64.8% of the sample farms use the pipeline, followed by parlour accounting for 31.3%. Only 2 sample farms use bucket and another 2 farms use bucket/transfer, while the remaining 5 farms use a robotic system (see Table 4.5 in Appendix 3). As for the feed system, most sample farms (62.7%) use a semi-automated feed system, followed by automated system (24%) and then manual system (13.3%) (see Table 4.6 in Appendix 3).

4.2 Estimation results

First, the correlation matrix of all variables in the cost model is used to examine the data for the existence of collinearity (see Table 4.7 in Appendix 4). According to Greene (1997), very high pair-wise correlation coefficients, normally in excess of 0.8, will induce imprecise indications of a variable' effects. On the basis of the correlation matrix (Table 4.7), only the correlation coefficient between $milkingsys_1$ and $milkingsys_2$, -0.91, has an absolute value greater than 0.8. Besides, the P-value of this correlation coefficient is 0, which implies it is significant. Admittedly, one way to treat the above problem is to drop either $milkingsys_1$ or $milkingsys_2$ from the model. However, according to Greene (1997), dropping variables from the model may cause the potential bias more serious than the effect of collinearity. Since $milkingsys_1$ (Pinpline) and $milkingsys_2$ (Parlour) are interesting variables of this study, both of them are kept in the cost model.

The maximum likelihood estimates for the Box-Cox transformed cost equation are presented in Table 4.8. The cost equation is estimated by using STATA software with Box-Cox regression procedure. The significance of each regressor is examined using a P-value associated with a likelihood ratio test (LR chi2 (.) statistic). The P-value is the probability of obtaining an estimate at least as extreme as the one observed. When the P-value is equal to or smaller than the chosen significance level, the null hypothesis that the coefficients are not jointly significant can be rejected.

According to the above estimate results, the Box-Cox transformation parameter λ of the output and yield per cow is negative and significantly different from zero. This suggests a

Table 4.8 Estimated parameters

	Parameter	Estimate	P-value
	λ	- 3.016143	0.000
_cons	α	6.63e+10	
y	β_1	-2.00e+11	0.000
Yield	β_2	-9049863	0.000
age	β_3	0.0331358	0.8
edu	β_4	-.8956412	0.738
breed	β_5	-11.42159	0.047
$build_1$	β_6	7.107641	0.084
$build_2$	β_7	6.360329	0.181
$milkingsys_1$	β_8	-5.433461	0.524
$milkingsys_2$	β_9	-13.69121	0.129
$milkingsys_3$	β_{10}	-7.304842	0.524
$feedsys_1$	β_{11}	.5966383	0.882
$feedsys_2$	β_{12}	-.2894381	1.000
$region_1$	β_{13}	-4.224681	0.122
$region_2$	β_{14}	-6.570129	0.019

[Number of obs = 233, LR chi2(15) = 199.87, Prob>chi2 = 0.000, Log likelihood = -969.06216, Significant level = 5%]

nonlinear and inverse relationship between output and the average cost, as well as yield per cow and the average cost.

Before an analysis of the estimation results of output and yield per cow can proceed, one important point should be noted, that the estimated coefficients of output and yield reflected by the above estimate results indicate the effects on the COP from the transformed output and yield variables. To investigate the relationships between average cost, output and yield directly, a transformation must be undertaken. The slopes, $\frac{\partial COP}{\partial y}$ and $\frac{\partial COP}{\partial \text{Yield}}$, calculated on the basis of the cost model (see the following equations) and the corresponding results can indicate the direct effects of output and yield per cow on average cost.

$$COP_i = \alpha+\beta_1(y_i^{\lambda}-1)/\lambda+\beta_2(Yield_i^{\lambda}-1)/\lambda+\beta_3 age_i+\beta_4 edu_i+\beta_5 breed_i+\beta_6 build_{1i}+\beta_7 build_{2i}$$
$$+\beta_8 milkingsys_{1i}+\beta_9 milkingsys_{2i}+\beta_{10} milkingsys_{3i}+\beta_{11} feedsys_{1i}+\beta_{12} feedsys_{2i}$$
$$+\beta_{13} region_{1i} +\beta_{14} region_{2i} + \varepsilon_i$$

$$\frac{\partial COP}{\partial y} = \beta_1 y^{(\lambda-1)}$$

$$\frac{\partial COP}{\partial \text{Yield}} = \beta_2 \text{Yield}^{(\lambda-1)}$$

First of all, the effects of both output and yield per cow are statistically significant (with P-value both equal to 0). For the relationship between output and average cost, the calculation results of differential coefficients suggest that the average cost decreases when output increases with a declining rate of change, holding other things equal. $\frac{\partial COP}{\partial y}$ ranges from -0.20006 to -2.61e-07. It is approximately equal to zero when output reaches 10,000 HL and roughly equal to -0.00014 at the mean output, 5984.076 HL. This implies that average cost roughly decreases $0.00014 with a one unit (HL) increase of output around its mean level. As for the relationship between yield per cow and average cost, the average cost also decreases when yield per cow increases with a declining rate of change, holding other things equal. $\frac{\partial COP}{\partial \text{Yield}}$ ranges from -17.7879 to -0.0657 when yield per cow increases from 26.36 to 106.33 HL/cow. It equals to -0.20272 when yield per cow takes its mean value, 80.32 HL/cow, which suggests that the average costs roughly decrease $ 0.20272 with a one HL increase in yield per cow around its mean level. General speaking, the results support the hypothesis of this study that both output and yield per cow have significant negative effects on average costs. The higher the output level or yield per cow, the lower the average costs, with other things held constant.

As for the variables which represent farm-specific characteristics in the model, the results indicate that two of the seven characteristics have a significant impact on the average costs at a 5 percent significance level. They are breed and ODFAP regional location. Age, education level of the operator, milking system and feed system do not have significant effects on the average costs. Building condition was marginally significant with a P-value of 0.084. That is to say, there is weak statistical evidence to suggest that building condition is related to average cost. The effect of building condition is positive, which implies that, holding other factors constant, farms with a good building condition have average costs $7.11 higher than those with average or poor building conditions. This result runs contrary to the expectation that farms with a good building condition tend to have a lower average cost than those with average or poor building condition. However, there is a possible rational reason for this result. Farms with relatively new or good buildings usually have a much higher charge for depreciation than those with old or poor buildings. Since depreciation was included in the average cost estimation, this result is reasonable. The estimated coefficient of breed is -11.42 (P-value = 0.047), which suggests that, holding other things equal, dairy farms that use Holstein have average costs $11.42 less than those who use other breeds. This result supports the expectation that Holstein is the most productive and popular breed for the Ontario dairy sector. As for the region, the estimated coefficient of $region_2$ is -6.57 (P-value = 0.019), which indicates that, holding other things equal, dairy farms located in ODFAP dairy region 3 or region 4 have average costs $ 6.57 less than those located in region 5 or region 6, on average (see Appendix 1 for the map of ODFAP dairy regions).

Even though the results reveal that only the effects from two farm-specific characteristics considered are statistically significant, the consideration of farm-specific characteristics is necessary and important when analyzing the impact of factors on average costs. That is to say, the above results support the hypothesis that some farm-specific characteristics have a significant effect on average costs of milk production. This point agrees with some other studies. Moschini (1987) suggested that farm-specific characteristics have a significant impact on the estimated cost structure of Ontario dairy production. He investigated the impacts of twelve farm-specific characteristics on the estimated cost structure of Ontario dairy farms. Seven farm-specific characteristics, regional location, debt-equity ratio, milking technique, building quality, education, cow type, and horse power of the largest tractor, had a significant effect while the remaining characteristics, such as feeding techniques, land quality, age, seasonality, and capacity utilization, had no significant effect. Romain and Lambert's study in Barichello et al. (1996) investigated the relationship between cost production, herd size, milk yield, technical efficiency and several socioeconomic variables in Ontario and Quebec dairy operations. They suggested that some farm characteristics, such as level of education, participation in a milking-recording program, forage quality and year in which the manager joined a management club, had a significant effect on the cost of production.

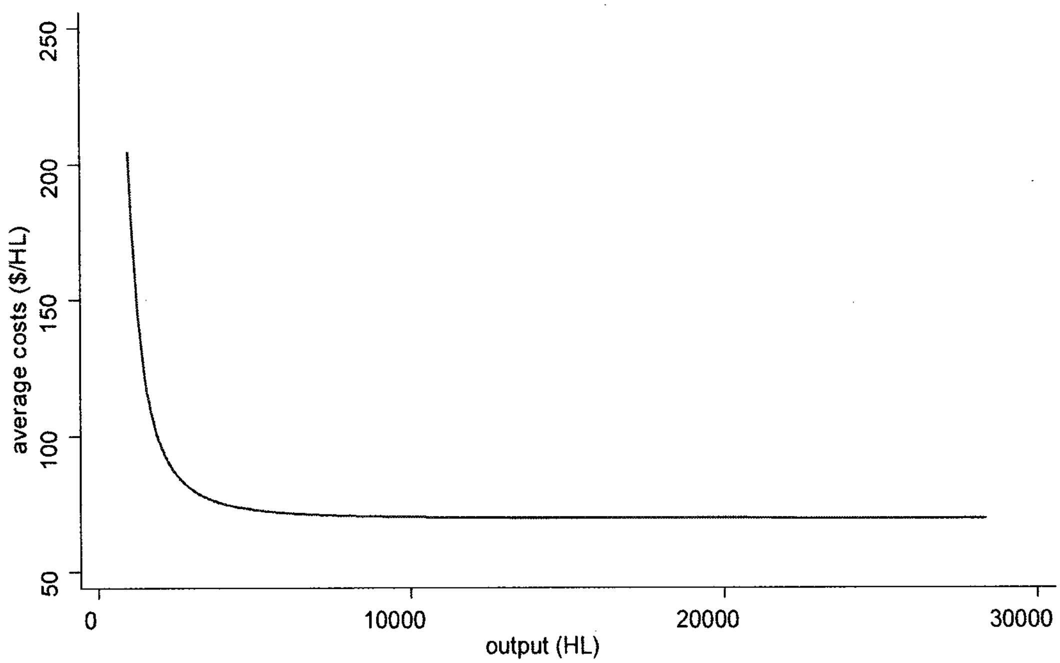
4.3 Investigating economies of size and yield

Economies of size

As previously stated, according to the estimation results of this study, milk output level has a significant impact on the average cost of milk. Holding other things equal, average costs decrease with an increase in output, with a decrease in the absolute value of the slope. The slope is roughly equal to zero when output reaches 10,000 HL or approximately a 125 cow herd. Figure 4.4 illustrates the relationship between average costs and milk output and indicates the existence of size economies for Ontario dairy farms. Dairy farms with a bigger herd size are more cost competitive than those with smaller herds. About 12% of sample farms achieved a size where milk production costs were minimum. The result supports the hypothesis of this study that there exist size economies for Ontario dairy farms.

Based on the literature review, many studies concerning cost competitiveness of dairy production have paid attention to the existence of size economies of dairy farms. The result regarding size economies of this thesis agrees with many previous studies in this field. According to the study by Moschini (1987), there existed significant size economies for a wide range of output levels, which indicated that in the long run, the Ontario dairy sector would be characterized by a fall in farm numbers and increase in

Figure 4.4: Estimated average cost curve versus output



farm size. In his study, average incremental cost (AIC) in terms of milk units was used to examine the existence of the size economies. The incremental cost of milk production was defined in his study as the difference between the cost of producing the whole output and the cost of production with a zero output. The results revealed that Ontario dairy farms during the period 1978 to 1983 could achieve a minimum AIC at an output level of 5,095HL per farm and at that point average costs were estimated at 30.33$/HL. The results of this study estimates that a minimum average cost of 68$/HL can be achieved at an output level of about 10,000 HL. However, compared to Moschini (1987), the minimum average cost estimate is quite different. One important reason is the time difference. Although the data used in both studies came from the same source, ODFAP, 25 years separates the two studies. Thus, inflation for those 25 years could explain the difference. Based on Canadian Consumer Price Index (CPI) provided by Statistics Canada, the average CPI for the period 1978 to 1983 was about 48 (2002=100) and that for 2007 was 111.5, which implies the minimum average cost estimated by Moschini (1987) would equal $30.33(111.5/48) = $70 in 2007. This number is quite similar to the minimum average cost ($68/HL) estimated by this study. Barichello et al. (1996) compared cost of production of diary producers among several selected regions in the US and Canada: New York, Wisconsin, California, Ontario, Quebec and Alberta. Their results suggested that economy of size was one important factor to explain regional cost differences. Among those regions, Quebec was the highest cost region ($44.21/hl) followed by Ontario ($43.36/hl), Alberta ($35.88/hl), New York ($32.18/hl), Wisconsin ($31.77/hl) and the lowest cost region was California ($28.24/hl) in 1988. According to their results, the large farms in New York had a saving of costs of about $10/HL over the Ontario farms. Besides, farms in Canada with fewer than 45-50 cows had costs which were significant higher than their US rivals. All of the above suggests the existence of size economies for diary farms in these regions. Richards and Jeffrey (1996) investigated the relationships between farm size, milk yield, technical efficiency and cost of milk production of Alberta dairy farms during the period from 1989 to 1991 in their study. The authors used both the composed-error (CE) method and the average frontier (AF) method to estimate the production frontier. The results of their study indicated that there did exist significant economies of herd size for Alberta milk producers based on each method. The results based on AF model showed that given the average herd size of the sample at 66 cows/farm, production costs decreased $0.073/hl./cow on average for every cow increase in herd size and the optimal herd size in Alberta was 250 head. The results according to the CE model suggested that there was a decrease by $0.07/hl in production costs for each additional cow, given the average herd size of 66 cows and the optimal herd size was around 287 cows. Cocchi, et al (1998) examined cost competitiveness of six US states, Connecticut, Maine, Michigan, Pennsylvania, New York and Vermont for the years 1968, 1970, 1977, 1980 and 1988. The results of this study suggested that economies of size did exist for dairy farms in those six states. Medium sized farms, with herds from 64 to 140, and larger farms, over 140, were shown to be 12% to 20% more efficient than small farms for those dairy regions. Besides, Weersink et al (1990) concluded that every 1% increase in herd size led to a 5% increase in efficiency for Ontario dairy farms. Bravo-Ureta and Rieger (1991) also concluded that an increase in herd size increased the efficiency of dairy farms, based on a sample in New England.

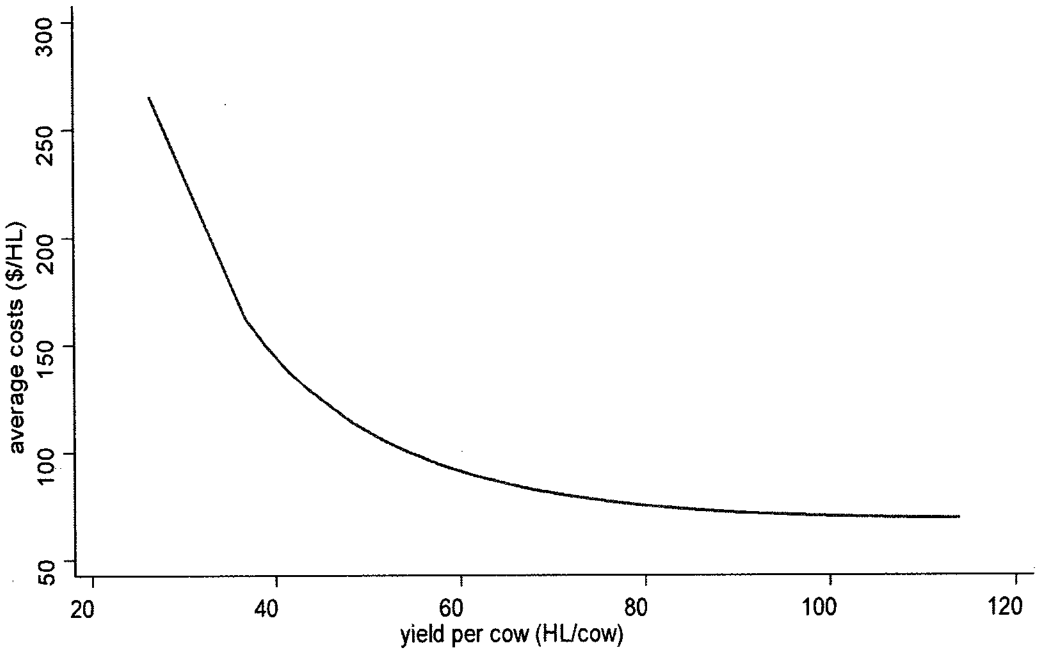
The National Dairy Policy Task Force (1991) and Gouin, et al. (1990) both concluded that size economies is an important factor one should consider when investigating the causes of cost differences for dairy production. It also could be an important reason for the relatively lower competitiveness of Canadian dairy farms with smaller herds compared with those in the US.

Economies of yield

On the basis of the estimation results of this study, yield per cow also has a significant effect on the average costs for Ontario dairy farms. Figure 4.5 illustrates the relationship between average costs and yield per cow. Average costs also decrease with an increase of yield per cow with a decreased absolute value of slope. This result supports the corresponding hypothesis of this study that yield per cow has a significant effect on the average costs.

Previous studies of cost competitiveness of dairy farms also investigated the relationship between yield per cow and cost of production. As previously stated, Barichello et al. (1996) compared costs of dairy production among those selected regions in the US and

Figure 4.5: Estimated average cost curve versus yield per cow



Canada. They concluded that in addition to size economies, economy of yield was another important cause for the cost difference among regions. Of those six regions, three Canadian dairy regions had relatively lower yield per cow than those in the US and the results indicated that the higher the yield per cow, the lower the average costs of milk production. For example, annual yield per cow in California, the region with the lowest average regional costs of CA$28.24, ranged from 77.82HL/cow to 87.74HL/cow, which was much higher than Quebec and Ontario, 59.61HL/cow and 67.52HL/cow, respectively. Their results suggested size economies and yield economies accounted for more than 75% percent of the cost difference and yield per cow had larger effects.

Grant (2001) did a study to assess the cost competitiveness of Alberta dairy producers through the analysis of costs of milk production and physical and economic efficiency.

The effects of herd size and yield per cow on costs of production were analyzed using farm level COP data for 1994, 1995 and 1996. To examine size economies, the farms were classified into three size categories: 40-50 cows (H1), 50-70 cows (H2) and over 90 cows (H3). Their results indicated that the average cost decreased as farm size increased. For the 1996 sample, the average cost was $56.22/HL for H1, $54.80/HL for H2 and $50.62/HL for H3. For the 1995 sample, the average cost was $55.81/HL for H1, $55.38/HL for H2 and $45.59/HL for H3, while for the 1994 sample, it was $58.45/HL for H1, $54.65/HL for H2 and $44.81/HL for H3. According to the results reported in this thesis, the average cost of milk production for farms in Ontario with 40-50 cows was $87.06/HL, 50-70 cows was $80.48/HL, and farms with over 90 cows was $62.08/HL. While these costs are greater than Grant (2001), about ten years separate these two sets of results. If an average of 4% inflation is assumed over this period, then the costs are quite similar. To examine the yield economies, Grant (2001) also used three categories according to yield per cow. They were farms under 80HL/cow (M1), 80 to 90 HL/cow (M2) and over 90HL/cow (M3). The results indicated that the average cost decreased as yield increased for the 1996 sample, while for the 1994 and 1995 samples, it had a U shape and minimum average cost was achieved for farms with 80-90 HL/cow. Specifically, for the 1996 sample, the average cost for M1 was $57.08/HL, $53.41/HL for M2 and $51.43/HL for M3. As for the 1995 sample, the average cost was $57.09/HL for M1, $51.03/HL for M2, and $51.85/HL for M3, while for the 1994 sample costs were $55.11/HL for M1, $51.71/HL for M2 and $52.36/HL for M3. Therefore, there existed significant economies of yield for milk production in Alberta dairy sector. In the present study, the average cost of milk production for Ontario farms with yield less than 80HL/cow was $86.21/HL, 80 to 90 HL/cow was $74.38/HL, and that of farms over 90HL/cow was $70.11/HL, which indicate that yield economies existed within Ontario dairy production. Comparing these costs with Grant (2001), they are higher, but quite similar once inflation is taken into account.

4.4 Farm profitability under a deregulated environment

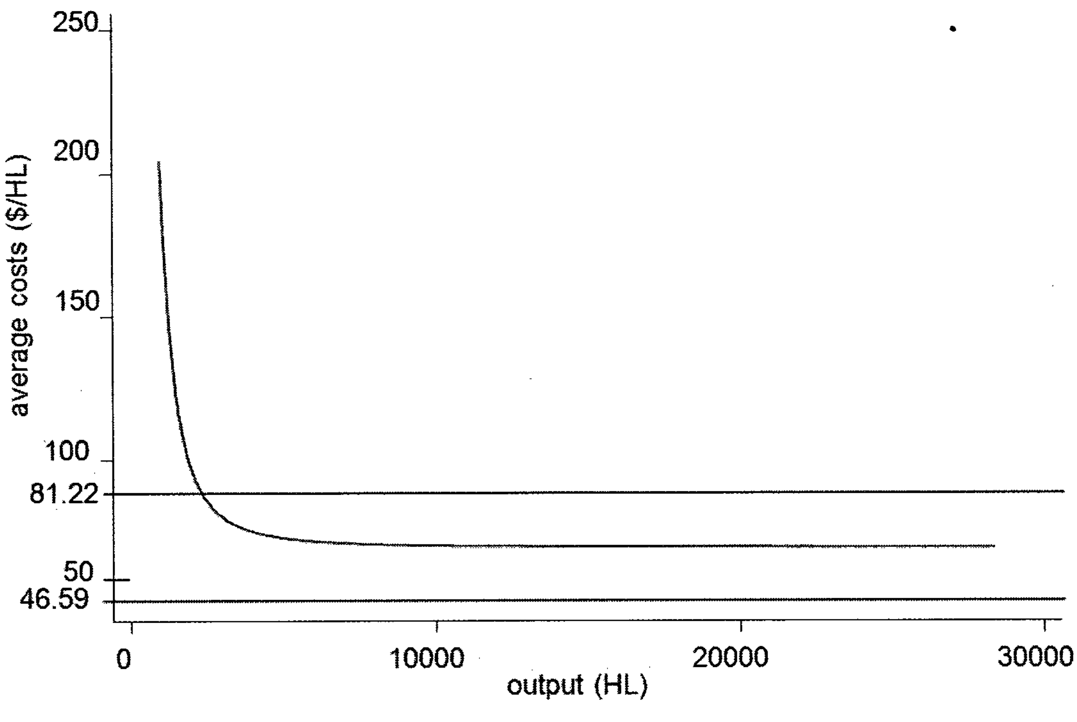
Profitability can be expressed as the ratio of total revenue to total cost, which indicates the additional proportion of revenue after covering the costs of resources (Ruch et al, 1992). Farm profitability can also be measured by net farm income, which is calculated by subtracting total costs from total revenue. In this study, the profitability of milk producers is measured by milk revenue per HL minus average cost. Actually, the milk revenue per HL is equal to milk price. This is the compared to profitability using an international indicator of the price of milk.

The U.S. milk price received by farmers is used as the indicator of the international milk price to assess Ontario dairy producers' potential profitability under a deregulated competitive environment. Here, this is the U.S. blended price based on the prices of four milk classes. Comparing this international milk price indicator with the average cost of milk production of Ontario dairy farms provides an insight into the potential survival issue of dairy farms under a deregulated environment.

The price indicator is the annual average U.S. farm received milk price in 2007, US$19.13/cwt (source: Agricultural Statistics Board, USDA). Before the comparison can be undertaken, the U.S. milk price must be converted to that of Canadian measures. For fluid milk, 1 cwt (3.5% b.f.) is equal to 0.441HL (3.6% b.f.) (Ageconsearch, Canada/United States Data Conversion). The exchange rate to convert US dollars into Canada dollars used here is the 2007 average, 1.074 Canadian dollar/US dollar (x-rates.com, 2007-Canadian Dollars to 1USD). Thus, the international milk price indicator for dairy farm is CAD46.59/HL.

The comparison between the average costs and the international indictor milk price is illustrated in Figure 4.6. Farms with an average costs higher than CAD46.59/HL may not be able to survive under a deregulated environment. The result of the comparison indicates that no dairy farm in Ontario could survive in an open competitive market. Admittedly, the comparison implies poor profitability under a deregulated environment, however, before accepting this result, an important potential cause of the result should be considered, that is the composition of the average costs used in this study. To reflect the actual economic costs of milk production, opportunity costs were used to calculate average costs. Thus, even if the profit is zero, this just means a normal economic return instead of loss. Nearly all costs were accounted for, including all costs directly attributed to or allocated to the milk operation, as well as both cash expenses and noncash expenses, such as capital depreciation. For example, nonpaid family labour was estimated and

Figure 4.6: Estimated average cost curve versus output



included into average costs and these increased average costs of milk production. The average nonpaid family labour costs reached $25.22/HL for dairy farms in Ontario based on the data used in this study. Therefore, the comparison with the US price can only approximate cost competitiveness profitability of Ontario dairy farms. According to the data provided by the AAFC, dairy section, the average milk price for the 2006-2007 dairy year in Ontario was $81.22/HL. This price is also identified in Figure 4.6 to give another price indicator for the comparison with the average costs of Ontario dairy farms. Admittedly, facing this price, not all dairy farms in Ontario were profitable, however about 68% of Ontario farms would earn an economic profit and survive in the long run.

4.5 Strategies to improve the competitiveness of Ontario dairy farms

The above analysis and discussion of the results provide some insight into reasonable strategies to improve the competitiveness of Ontario dairy farms. Since the results indicate that Holsteins have a significant negative effect on average costs, it could be a good strategy for some dairy farms to switch breeds. Region also has a significant impact on the average costs. Holding other things equal, dairy farms located in ODFAP dairy region 3 or 4 have average costs $ 6.57/HL less than those located in region 5 or region 6. Admittedly, it is not feasible for all dairy farms in region 5 or 6 to move to region 3 or region 4 in order to capture this cost advantage. However, this result provides a reasonable motive to consider the reasons for the cost difference among different regions. Regions 5 and 6 have relatively worse land capability and climatic factors compared with other regions. Considering differences in land capability, climatic factors and non-dairy opportunities of those dairy regions, farms might improve their competitiveness by using favorable factors and taking steps to mitigate their disadvantages.

According to the Western Producer (1999), herd expansion had been the most widely adopted strategy to improve the economic performance of dairy farms. On the basis of the results of this study, economies of size were significant. This suggests that herd expansion could be a good strategy for Ontario dairy farms to improve their cost competitiveness, which agrees with the view of Western Producer (1999). The results also reveal there existed significant yield economies for Ontario dairy farms, which implies lower average costs of milk production can also be achieved by an increase of yield per cow. Therefore, the increase of yield per cow could be another strategy to improve the competitiveness of dairy farms in Ontario.

Chapter 5 Conclusions

5.1 Summary and conclusions

In Canada, the dairy sector is an industry that is highly regulated by government. The marketing, pricing, and production of milk and milk products are governed under a system of supply management, which is intended to stabilize consumer prices and support farm income. However, with the increasing pressures and challenges confronting supply management from the WTO and the changing global trade environment, the likelihood of changes in Canadian dairy supply management system increases. Undoubtedly, those changes would have great impacts on the Canadian dairy sector as the competition within or from outside the sector would greatly increase. Therefore, the competitiveness of the Canadian dairy industry is becoming a more and more important issue.

This study investigated the competitiveness of the Ontario dairy sector using a farm level data and a working definition of competitiveness based on the strategic management theory of competitiveness. On the basis of this theory, determinants of competitiveness for Ontario producers are analyzed. According to some important features of the Ontario dairy sector, such as the uniform marketing of milk for dairy producers, the homogeneity of milk produced at the farm level, and inelastic domestic demand, the cost of production was determined to be an appropriate metric to evaluate the competitiveness of Ontario dairy farms. Specifically, dairy producers with lower average costs of milk production on the basis of per unit output are considered to be more competitive.

To estimate the cost competitiveness of Ontario dairy farms, and to give an insight into strategies to improve it, a micro-econometric model was employed based on an empirical cost equation approach. A cost of production model was used to investigate the relationship between the average costs of milk production, milk output, milk yield per cow, and several other variables which represent farm specific characteristics. In order to capture the possible nonlinear relationships between output, yield per cow and average cost of production, as well to avoid biases in assessing the magnitude of effects and significance of results induced by using a restrictive functional form, the Box-Cox transformation was applied to those two independent variables. The data used in this study are farm-level COP data collected by the Ontario Dairy Farm Accounting Project (ODFAP) for the most recent three consecutive years: 2005, 2006, and 2007 with a total of 233 observations.

The analysis of estimation results of the cost model described the effects of milk output level, yield per cow, as well as several farm specific characteristic factors on average costs of milk production. It was anticipated that these might point towards ways to improve the cost of milk production, and then provide insights into key factors or strategies to maintain or improve the competitiveness of Ontario dairy farms. The estimation results indicated that size of milk output has a significant impact on the average cost of milk production. Average cost decreased with an increase of output, but at a decreasing rate. $\frac{\partial COP}{\partial y}$ ranges from -0.20006 to -2.61e-07 and it was approximately equal to zero when output reached 10,000 HL. This means that the minimum average cost is achieved at an output level of about 10,000 HL, or approximately 125 cows. Only about 12% of sample farms were operating at or above this size. Besides, it was indicated that average cost roughly decreased \$0.00014 with a one unit (HL) increase of output around its mean level, 5984.076 HL. Thus, significant economies of size were indentified for Ontario milk producers, which implies that larger farms were more competitive than smaller farms. Thus, herd expansion could be a good strategy for small Ontario dairy farms with a herd size less than 125 head to improve their cost competitiveness. Moschini (1987) suggested that Ontario dairy farms during the period 1978 to 1983 could achieve a minimum average incremental cost at an output level of 5,095 HL per farm. According to Richards and Jeffrey (1996), Alberta dairy farms during the period from 1989 to 1991 also had size economies for their milk production. The results of their study based on their AF model showed that production costs decreased \$0.073/hl./cow on average for every unit increase in herd size and the optimal herd size in Alberta was 250 head, while the results according to the CE model suggested that there was a decrease by \$0.07/hl in production costs for each additional cow and the optimal herd size was around 287 cows.

Yield per cow was also revealed to have a significant negative effect on the average costs. Average costs decreased with an increase of yield per cow with a decreasing absolute value of the slope. The slope ($\frac{\partial COP}{\partial \text{Yield}}$) ranged from -17.7879 to -0.0657 when yield per cow increased from 26.36 to 106.33 HL/cow. Average costs roughly decreased \$ 0.20272 with a one HL increase in yield per cow around its mean level, 80.32 HL/cow. This result suggested that there also exist economies of yield for Ontario dairy farms. Farms with higher yield per cow tend to be more competitive. Actually, the average cost kept decreasing with each unit increase in yield per cow, which implies that for all sample farms, the cost competitiveness could be improved with each unit increase in their yield per cow. The results of Grant (2001) concluded that there existed significant economies of yield for milk production in Alberta dairy sector for 1994, 1995 and 1996. He compared the average cost among different farm categories in terms of yield per cow, 80HL/cow, 80 to 90 HL/cow and over 90HL/cow and found that the average cost decreased with yield in a U shape. The minimum average cost was achieved for farms yielding 80-90 HL/cow.

As for farm-specific characteristics specified in the cost model, only two had a statistically significant effect. The results suggested that using Holsteins has a significant negative effect on average costs of milk production, as opposed to other breeds. Holding other things constant, farms using Holsteins had average costs $11.42/HL less than those who used other breeds. This might suggest that adopting Holsteins could be a strategy to improve the cost competitiveness for those farms which used other breeds. However, since Holsteins already accounted for over 95% of the herd in Ontario, this strategy can only provide a marginal improvement to the competitiveness of the Ontario dairy industry. Region was also revealed to have a significant negative impact on the average costs. Holding other factors constant, dairy farms located in ODFAP dairy regions 3 or 4 (Central Southern Ontario) had average costs $ 6.57/HL less than those located in region 5 or region 6 (Eastern Ontario). It is not clear why regional differences exists, but it could have to do with differences in land capability, climatic factors and non-dairy opportunities in those dairy regions.

To investigate the profitability of Ontario dairy producers under a deregulated environment, this study compared the average costs of milk production of Ontario dairy farms with an indicator of the international milk price, the annual average U.S. farm received milk price in 2007, CAD46.59/HL. The result suggests that no dairy farm in Ontario could survive at that price in an open competitive market. However, an important cause of this result should be also considered, that is the composition of the average costs in this study. To reflect the actual economic costs of milk production, all costs directly attributed or allocated to milk operation as well as both cash expenses and noncash expenses, such as capital depreciation were included in average costs. For example, nonpaid family labour was estimated and included into the average costs. Therefore, the average costs of milk production increased compared with those studies that excluded this opportunity cost from the average cost estimation. Thus, the result may understate the competitiveness of Ontario dairy farms under a deregulated environment. Besides, since all relevant opportunity costs were included, even if the profit is zero, a normal economic return would be achieved.

5.2 Limitations and suggested further research

First, the cost model used in this study is a static model, which reflects the impacts of output, yield per cow, and farm specific characteristics on the average cost of milk production in the short run. A more precise estimate of competitiveness might be obtained by employing a dynamic model which can reflect changes over time.

Moreover, there are some limitations in terms of the available data. The sample used in this study has only 233 observations. It is relatively small in size even though it is representative of Ontario dairy farms. With a larger sample size, more of the farm specific factors might have been significant. Another limitation is due to the observations in the sample. Some farms have very low output, for example 972.78 HL, and very large average cost, for example, $273.15/HL. These were not excluded from the sample, thus the slope of the average cost in terms of output decreased very fast at low output levels. Besides, the herd size of farms in the sample was not very large with a mean level of only 71.8 and a maximum at 288.5 head. Thus, large farms with herd size more than 288.5 were not observed in this study. In other words, the results could not capture economies that might exist for larger farms. By excluding the very small farms and including more large farms, a better estimate of size economies might be possible. Besides, one cost component of labour, nonpaid family labour costs, had to be estimated because of a data limitation. It is possible that nonpaid family labour costs were somewhat under-estimated. Thus, the estimated average cost of milk production is somewhat an approximation of the real average cost.

Besides, the assessment of farm profitability under a deregulated environment employed an indicator of an international milk price. The price used is the milk price received by US dairy farms. Since the price indicator is not truly a price determined in an open competitive market, it may not provide a precise estimate of profitability and competitiveness of Ontario dairy farms. Nevertheless, even though many Ontario farms could not compete at that price, the same conclusion would obtain for many farms in the US. Therefore, if a better open market milk price was available, the profitability and competitiveness outlook for Ontario dairy farms might look brighter.

Finally, although the results suggest a significant impact of dairy region on the average cost of production, the reasons for this are unclear. Thus, this study provides a reasonable motive to investigate the reasons for the cost difference among dairy regions. These could have to do with differences in land capability, climatic factors or non-dairy opportunities in those regions. Once the reasons are identified, then future research could focus on how to utilize favourable factors and mitigate disadvantages in each dairy region.

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Appendices

Appendix 1: ODFAP Ontario dairy regions

Six dairy regions of southern Ontario were identified based on similar land capabilities, climatic factors, and non-dairy opportunities in this study. Region 1 and 2 are classified into one category because of their geographic proximity. The reason is same for regions 3 and 4, 5 and 6. Refer to the following map, the map of ODFAP dairy regions.

Appendix 2:

* Note: In the questionnaire, category 5 represents the milking system used by farms in the sample except for Bucket, Bucket/Transfer, Pipeline, and Parlour. Based on several characteristics of the five farms in this category, it was presumed that the system used was Robotic, the most advanced milking system used today. All five farms have a relatively large herd size and higher yield per cow. Among the five farms, four have

excellent dairy building condition and that of the remaining one is good. The feed systems of the five farms are fully automated or semi-automated. All use Holsteins. Besides, the education levels of the operators of those farms are relatively higher than average.

Appendix 3:

Figure 4.1: The distribution of COP

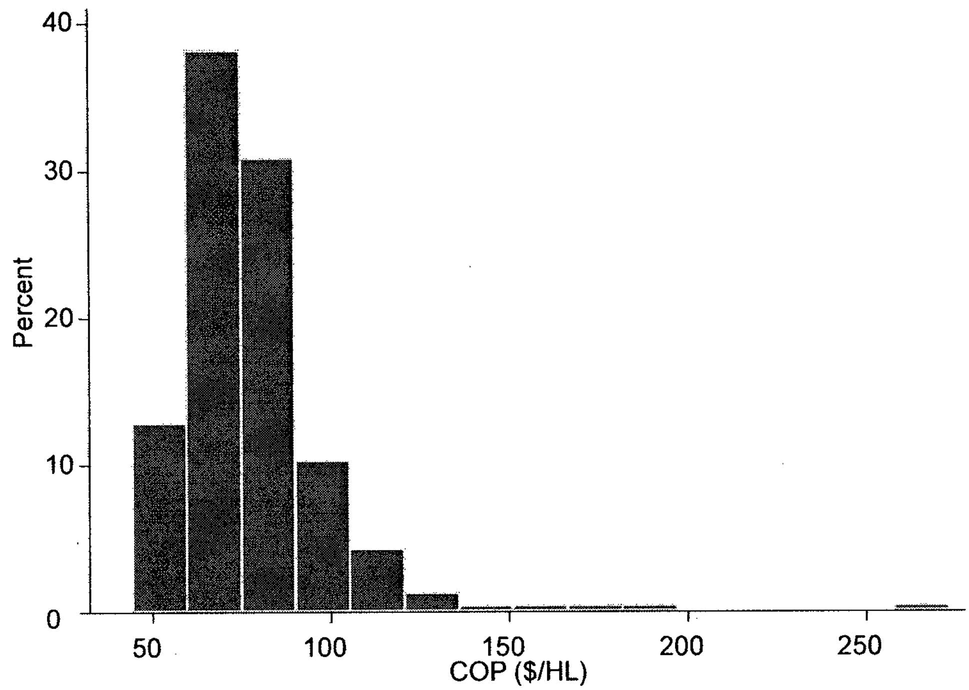

Figure 4.2: The distribution of total output per farm

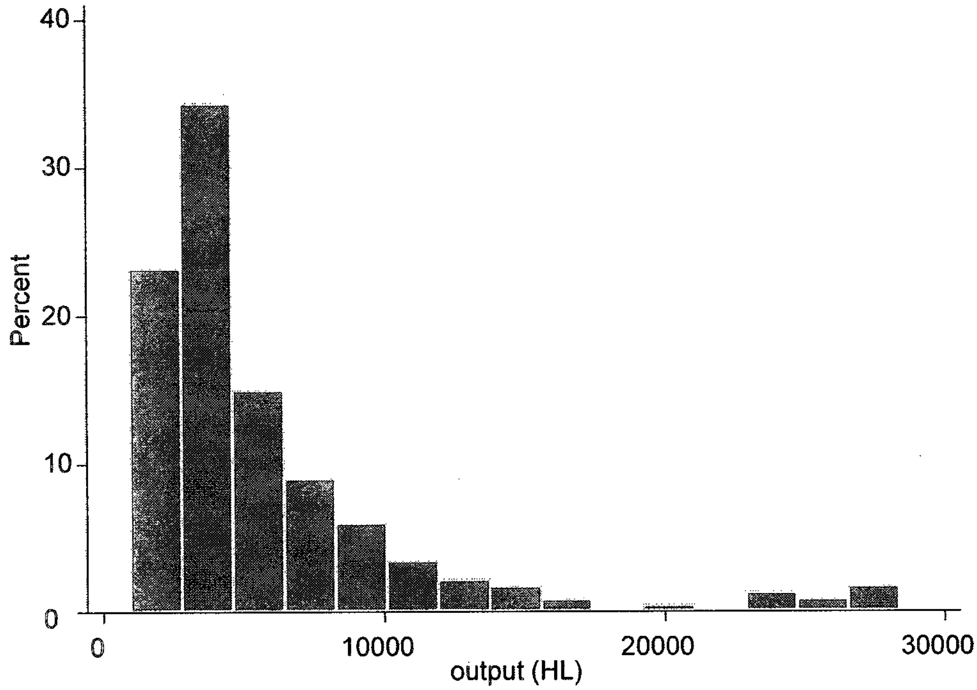

Figure 4.3: The distribution of yield per cow

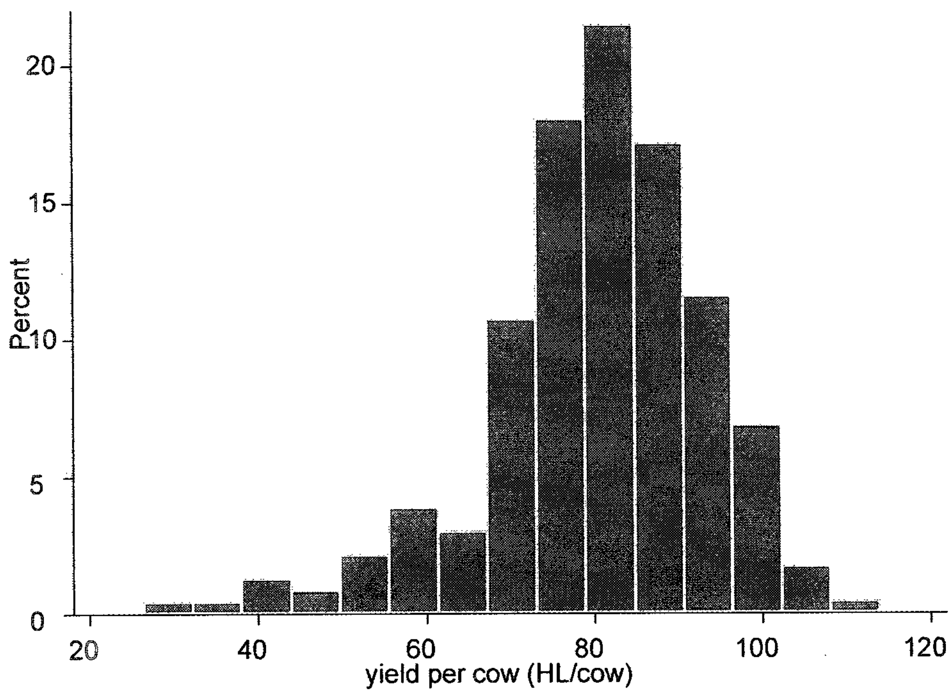

Table 4.2: Farm distribution by education level of principal operator

Education level	Number of farms	Percentage
1: Primary school	29	12.5%
2: High school	65	27.9%
3: Agr. Diploma	58	24.9%
4: Community college	35	15.0%
5: BSc. Degree	46	19.7%
6: Post Grad. Degree	0	0%
Total	233	100%

Table 4.3: Farm distribution by breed of cows

Breed	Number of farms	Percentage
1: Holstein	222	95.3%
2: Ayrshire	0	0%
3: Jersey	4	1.7%
4: Guernsey	0	0%
5: Mixed Breed	3	1.3%
6: Other	4	1.7%
Total	233	100%

Table 4.4: Farm distribution by dairy building condition

Building condition	Number of farms	Percentage
1: Poor	2	0.9%
2: Average	25	10.7%
3: Good	147	63.1%
4: Excellent	59	25.3%
Total	233	100%

Table 4.5: Farm distribution by milking system

Milking system	Number of farms	Percentage
1: Bucket	2	0.9%
2: Bucket/Transfer	2	0.9%
3: Pipeline	151	64.8%
4: Parlour	73	31.3%
5: Robotic*	5	2.1%
Total	233	100%

Table 4.6: Farm distribution by feed system

Feed system	Number of farms	Percentage
1: Manual	31	13.3%
2: Semi-automated	146	62.7%
3: Fully automated	56	24.0%
Total	233	100%

Appendix 4:

Table 4.7: Correlation matrix of variables

	cop	y	yield	age	edu	breed	build1	build2	region1	region2	milkingsys1	milkingsys2	milkingsys3	feedsys1	feedsys2
cop	1.00														
y	-0.41	1.00													
yield	-0.52	0.44	1.00												
age	0.08	0.10	-0.17	1.00											
edu	-0.25	0.33	0.16	-0.08	1.00										
breed	-0.37	0.17	0.37	0.04	0.11	1.00									
build1	0.04	-0.29	-0.08	0.08	-0.3	0.08	1.00								
build2	-0.21	0.45	0.31	-0.06	0.26	0.13	0.76	1.00							
region1	-0.06	0.07	0.22	-0.14	0.06	-0.03	-0.11	0.21	1.00						
region2	-0.03	-0.08	-0.11	0.07	-0.13	0.02	0.07	0.00	-0.55	1.00					
milkingsys1	0.28	-0.54	-0.26	0.05	-0.44	-0.08	0.26	-0.40	-0.15	0.02	1.00				
milkingsys2	-0.30	0.54	0.29	-0.03	0.42	0.15	-0.19	0.37	0.11	0.01	-0.92	1.00			
milkingsys3	-0.04	0.11	0.02	-0.05	0.12	0.03	-0.13	0.19	0.13	-0.04	-0.20	-0.10	1.00		
feedsys1	0.01	-0.26	-0.04	0.00	-0.04	0.12	0.2	-0.16	-0.06	-0.11	0.27	-0.22	-0.3	1.00	
feedsys2	-0.19	0.48	0.19	0.1	0.28	0.08	-0.17	0.32	0.21	-0.04	-0.44	0.42	0.19	-0.73	1.00