AN ECONOMIC ANALYSIS OF PRODUCT QUALITY WITHIN THE CANADIAN CHEESE INDUSTRY

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Paper prepared for presentation at the Canadian Agricultural Economics Society NAREA-CAES Conference, June 20-23, 2004, Halifax, Nova Scotia

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1. INTRODUCTION

Dairy production often occurs in distorted, highly protected environments, which affect both the price and quality of the end product. In Canada, high import tariffs, implemented in conjunction with a supply management policy, provide support for dairy farmers, and increase the price of milk to processors. Over the past decade, technological change has induced processors to substitute alternative inputs for the traditional ingredients, which in turn have affected the quality of final products such as cheese. Because some alternative ingredients can be imported without tariffs, it is natural to examine the link between protective policies for Canadian milk and the quality of processed milk products such as cheese. This paper uses theoretical and empirical analysis to examine this linkage.

There has been a great deal of research on the price and efficiency effects of Canada's supply management system for dairy production, but little (or no) work has been done on the effects of supply management on the quality of processed milk products at the consumer level. In this paper, we develop a theoretical and empirical model to examine the effect of Canadian regulations, technological change and industry consolidation on cheese quality. The analysis helps explain current quality trends in the Canadian cheese and dairy industry, as well as the social cost of Canadian supply management in milk products.

Because production quotas and high import tariffs have raised the price of milk for Canadian cheese manufacturers, it is natural for these firms to search for ways to substitute away

from national milk inputs to lower costs and maximize profit. According to the Canadian Dairy Commission, processors are reducing costs in an increasingly consolidated industry by replacing domestic dairy ingredients with less expensive imported ingredients, even though they pay a special (world) price for those ingredients[1]. These trends have been exerting considerable competitive pressure on the Canadian dairy industry in recent years. This competitive pressure may have led to a greater use of extenders. We want to know whether this trend has been exacerbated by supply management.

The dairy industry provides an important illustration of how trade barriers, subsidies and international trade agreements can influence production decisions in a domestic market. Whereas milk, cheese and other traditional dairy products face prohibitive import barriers, some ingredients that replace milk in dairy products, such as casein (the main protein in milk), butteroil-sugar blends and some milk protein concentrates, are not subject to import tariffs in Canada. Canadian dairy producers argue that dairy ingredients and substitutes entering the country without effective tariffs undermine the supply management system (Wilson, 2003). For example, butteroil-sugar blends are able to circumvent the import tariffs on dairy products, making it possible for importers to access cheap butteroil. The butteroil is then separated from the sugar and used in ice cream manufacturing, thereby competing with domestic cream and butter. Butteroil is also used in bakery and confectionary products, and thus it also competes with other national dairy ingredients. These substitution possibilities have been an important issue for the Dairy Farmers of Canada, since around 30% of ice cream production in Canada is now produced using butteroil.

There have been a number of studies on the effects of both supply management and the high level of protection on the Canadian dairy industry. Previous studies on productivity conclude

[1] The world price is lower that the domestic, for example, for Quebec in December 1996, the price for milk used to produce cheddar cheese was 51 dollars/hl, the price for milk used in cheese for further processing was 34.91 dollars/hl, and the price for milk used in products for the export market was 27.20 dollars/hl.

that Canadian dairy producers will be at a disadvantage if import protection is removed because of overinvestment (Richards, 1996), slower adjustment rates, lower rates of productivity growth and loss of competitiveness with dairy producing industries in countries without supply control (Richards, 1997). As a result of all of these factors, the producing sector has higher costs which translate into higher prices for raw milk.

From the literature dealing with costs, Barichello and Stennes (1994) find that provincial average farm costs for Ontario and Quebec are approximately fifty percent higher than that of California. These authors note that variable costs are similar when cost sub-components are examined, but the comparison is dependent on scale. Additionally they find that most of the differences in costs between the United States and Canada correspond to differences in herd size and yield per cow. As a result, raw milk prices are higher in Canada than in the United States.

Barichello (1999) suggests that Canadian farmers and processors may be competitive with the United States, but only if the value of the Canadian dollar remains low relative to its U. S. counterpart, the costs for raw milk are comparable across the border, and there is new capital investment in processing plants. These studies show that Canadian farmers, to be competitive with the United States, will need to make changes under the current supply management system.

Other studies show that the Canadian dairy industry may be able to compete with the United States if supply management was ended. Vercammen and Schmitz (1994) show that, once the production and import controls are eliminated, fewer rather than more imports may enter the country. The reason for this counter–intuitive result is precisely that supply management allows importers to earn great profits, whereas the producers themselves would be able to produce at similar cost to their U. S. counterparts. Meilke, Sarker and Le Roy (1988) obtain a similar result. They conclude that the net trade between Canada and the United States under free trade will be

small or zero. They argue that current quota holders will experience large welfare losses, which will be offset by the welfare gains of new entrants. Barichello (1999) confirms these findings.

Some studies have also looked at the effect of supply management on market structure. It is important to consider the decreasing trend in the number of Canadian processing plants over the last decade. According to Romain (2001), there have been structural adjustments in Canadian dairy processing that are independent of supply management. Because of the quota system and the law of one price, these structural changes have tended to be slower and less important than in the United States, making the Canadian dairy sector (producers and processors) relatively less competitive.

Rude and Goddard (1995) found evidence that suggests that the processing sector has a significant amount of market power and that they operate with increasing returns to scale. Schmitz and Schmitz (1994) found no evidence to support the claim that supply management has reduced processor and retailer market power. They found that there appears to be little relationship between farm gate price, the wholesale price and the retail price.

We are not aware of any study looking at the effect of supply management or market power in the dairy industry on product quality. A somewhat related study examines the consequences of allowing the sale of reconstituted fluid milk in the United States (Whipple, 1983). This study finds that as a result of this policy, prices have fallen, which causes quantity produced and total producer revenue to fall as well. Although total fluid milk consumption will increase because of the lower price, the net effect is still a decrease in total expenditure. The results obtained in Whipple (1983) are similar to our theoretical results.

With the theoretical model we want to know the effect of supply management in the quality, quantity and number of firms doing some comparative statics analysis. The empirical component of this paper examines the residual demand for casein as a function of the demand for

all products (outputs), the marginal costs, and the number of plants. Specifically, we test whether casein was used as a substitute for milk and whether a higher price of milk therefore caused a greater use of extenders. We also test whether extender use was increased with consolidation in the dairy processing industry.

The rest of the paper proceeds as follows. The next section consists on the description of the Canadian cheese industry. Then we present a theoretical model that highlights the linkage between regulated milk price and cheese quality. The theoretical analysis is followed by the empirical analysis and data description. After the discussion of the results, the paper ends with some brief conclusions.

2. BACKGROUND ON THE CANADIAN CHEESE INDUSTRY

This section contains a brief summary of the regulations (supply management), and the technical and industry background.

Supply Management

The three main elements of the supply management system are production quotas, support prices and import controls. Through these elements the Canadian Dairy Commission (CDC) attempts to stabilize prices for producers, processors and consumers, provide producers with a returns that covers their cost of production and results in an adequate supply of dairy products to consumers.

The CDC sets a national quota of industrial milk based on butterfat self-sufficiency (CITT, 1998). This national quantity is then allocated to the provinces based on historical shares at the time supply management was introduced: this allocation has remained virtually fixed since then (Romain, 2001). In 1997, Quebec had 46.6 % of the industrial milk quota (called MSQ) and

Ontario had 31.5% (CDC, 2003). Individual processors can buy or sell their quota on a provincial exchange. It is done through auction sales, on a monthly basis, under provincial jurisdiction (boards or agencies) and the price is set by supply and demand (Canadian Dairy Industry Profile, 2002).

In 1975, a Returns Adjusted Formula was used to determine the support price for butter and skim milk powder. This formula used the consumer price index, the dairy cash input price index and judgment factors to obtain a fair return for farmers (Barichello 1981). To achieve the desired price, the government used a combination of direct subsidies and support prices. In 1988, this formula was replaced by a more accurate price mechanism that captured the cost production information at the farm level. In 1990, assistance payments for exports of dairy products and support prices for industrial milk were implemented. In August 1995, the Harmonized Milk Classification System[2], which includes the special (competitive) prices for further processing, was established. These special classes were created to allow Canadian products to compete internationally. Currently, the special classes include cheese and other dairy products for further processing, dairy ingredients for confectionary and planned exports (CDC, 2003).

Following the Staff Report from the Canadian International Trade Tribunal (1998), the CDC is in charge of establishing the support prices based on advice received from the industry, cost of production, market conditions and the general state of the Canadian economy. According to the CDC Act, the support prices are determined to be adequate to cover the costs and allow producers to obtain a fair return on their labour and investments. Support prices take into consideration the manufacturing margin obtained by processors. This margin is assumed to cover costs of production and provides a fair return.

[2] See Appendix I for the definition of the actual classes.

The provincial authorities use the support prices as a guidance to determine the actual milk price paid to producers. With the actual pooling system the milk classes became harmonized for all provinces. Also, a common price was established for classes 1 to 4. Nevertheless, there exists some variation in the final price according to each province (see Figure 2.1).

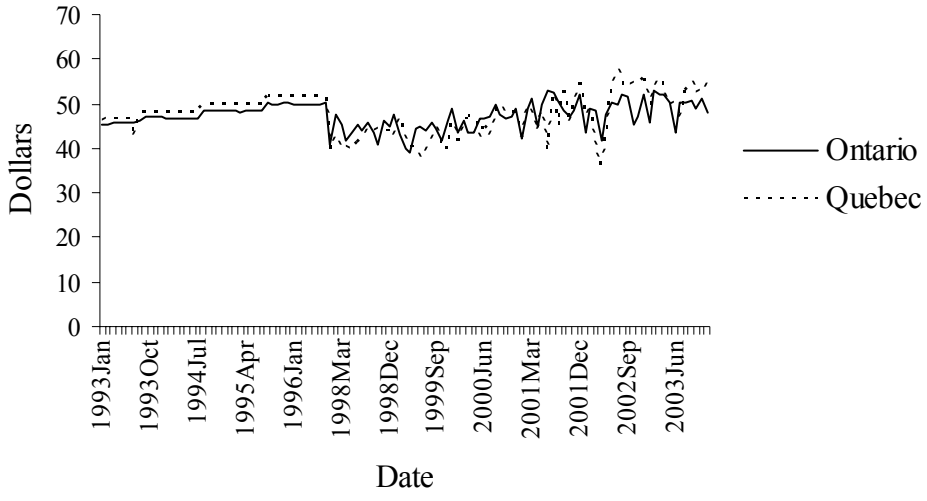

Figure 2.1: Weighted Average Price over Time for Ontario and Quebec[3]

Another change that occurred in the mid–nineties was the introduction of a Multiple Component Pricing (MPC) system. The previous system only took into consideration the butterfat content of milk. The MPC system is based on the content of butterfat, protein (mainly casein) and other solids (lactose and minerals). This change is due to the decreasing value of butterfat in the market (Canadian International Trade Tribunal, 1998).

Before the 1995 WTO Agreement, Canada primarily used import quotas to control the imports of dairy products to maintain the supply management system. The WTO forced countries

[3] The period from August 1996 to December 1997 is not considered for the reasons discussed in the Data Section.

to convert import tariffs to Tariff Rate Quotas (TRQ), which allow a certain percent of past domestic consumption (Canada's "access commitment") to be imported at relatively low tariffs, and any quantity above that amount (that is, over the "access commitment") faces high, usually prohibitive tariff rates (for cheese the over access commitment rate of duty is 267.3% —DFAIT, 2003). The TRQs are allocated to historical importers, mostly individual private firms (Canadian Dairy Industry Profile, 2002). These quotas can be rented and sold. In addition to the TRQs, there are import permits for processors to import dairy ingredients or products for further processing or re-export (Barichello, 1999).

As a consequence of the 1995 WTO negotiations, Canada implemented a number of changes to the supply management structure. These changes include the elimination of export subsidies, organizing pooling arrangements, quota exchanges and new programs like the Surplus Removal Program (Food Bureau, 2003). Producers had received subsidy payments for industrial milk and cream produced to meet estimated domestic requirements through this program and this program was phased out by August 2000. The support prices went up to allow producers to recover from the subsidy elimination (CDC Annual Report, 2001–2002).

This research is important in the current trade environment. Exporting countries are carefully analysing other countries' export and domestic support policies and can challenge them in the WTO (World Trade Organization) if they produce trade distortions. The recent dispute about Canada's special milk classes is an example of this. The special milk classes provide competitive (low) prices for exports and further processing. New Zealand and the United States started the dispute and, in 1998, a WTO dispute Panel was established. After several appeals, the panel concluded that the special classes constituted an export subsidy. In response, Canada had to change its policy.

Technical Background

Casein[4] is the main protein in milk and the main component of cheese. As an ingredient, it can be used in several products due to its different functional properties, including a higher yield in cheese and stability in yogurt and ice cream. It is also used in bakery and confectionary products. Milk protein concentrates (MPCs) are dairy blends without a strict definition and regulation in most countries (including Canada and the United States). This lack of definition and regulation enables exporting companies to label a wide range of products under this category, including mixes of skim milk, casein, caseinates and whey protein concentrates, or even mixes of cheese and other ingredients.

Some of these products can be categorized as extenders, which are mixes of functional ingredients such as dairy ingredients (skim milk powder, whey, whey protein concentrates, casein, caseinates, etc), starch, gums, stabilizers and enzymes; sometimes even flavours. These extenders are used in a variety of dairy products to increase yield. The most common use is in cheese. Since several years ago, extended cheese is produced in all countries. The type of extended cheese depends on each country's regulation and market (consumers' taste and budget). Usually processed cheese includes extenders, not only to increase yield, but to provide stability and other functional properties. Cheese for further processing, such as mozzarella or pizza cheese, is also a good candidate for extenders. But any cheese can be produced with extenders. There are also differences in the amount of extender used; it all depends on the characteristics and price of the final product that the processor wants to obtain.

In general, 100 litres (lt) of milk produce 10 kilograms (kg) of cheese. To see the effect of extenders, in particular casein, if we add 1.5 kg of casein and 1.5 kg of fat to the 100 lt of milk, we obtain a 50% yield increase (Mangold, 2001). For yogurt, 1 lt of milk yields 1 lt of yogurt. The

milk equivalents for ice cream are 3.8 lt of ice cream for 6.8 kg of milk; this is 100 lt of milk yield 57.67 lt of ice cream (Potter and Hotchkiss, 1995).

Casein in yogurt and ice cream is used in fixed proportions given that it is a functional ingredient to provide stability. In cheese, casein is used as an extender to increase yield. This is the only functional property in cheese other than processed cheese (where it also provides stability). Unfortunately, there is no data available regarding production of processed cheese for the period studied. The production of process cheese data is only recorded for Canada and it ends in 1995 (Statistics Canada Table 303-0041).

The use of extenders is generally associated with a lower–quality product. Consumers are often unaware that they are being sold an "extended" product, which is inferior in quality when compared to traditionally manufactured products. Extenders are not harmful to human health, but the "extended" products may have different characteristics (specially flavour) than the traditional ones. As an example, high-end (boutique) cheese and premium ice cream exclusively manufactured using milk, and cream (for ice cream). Extenders are used in lower-priced products, like cheese for further processing, and dairy spreads.

Industry Background

Casein, caseinates and MPCs are not subject to high import tariffs, making it less expensive for the processor to use them in their formulation rather than milk or other milk ingredients. Supply of casein is assumed to be perfectly elastic. The imports of casein and caseinates (Figure 2.2), and whey and whey products have increased significantly since 1995, 178% and 75% respectively (Western Dairy Digest, 2003).

[4] See Appendix II for a list of definitions.

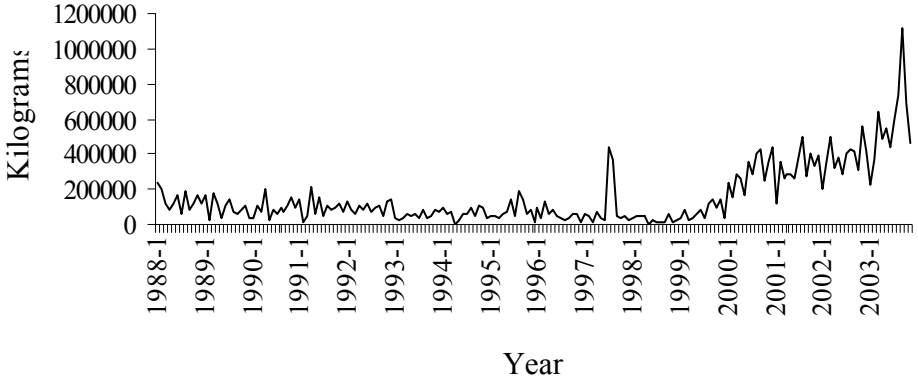

Figure 2.2: Casein Imports over Time

Casein is not produced in Canada anymore[5]. The last available information regarding casein production[6] is for 1977, but it has always been a small percentage of casein imports into Canada. The domestic casein production in 1977 is 14.42% of the imports in that year. If we make the comparison with more recent data, we find that the domestic production of casein in 1977 is only 0.108% of the 1988 imports.

Along with the regulations, other changes have occurred in the Canadian cheese processing industry, which may explain the move to increase the use of extenders in cheese production. The structure of the Canadian dairy processing industry has undergone a significant rationalization process in the last decade. The shift into fewer and larger plants has been necessary to achieve the efficiency level and economies of scale to remain competitive. Currently, 70% of the milk produced in Canada is processed by the three major companies, who own 36% of the plants (Canadian Dairy Industry Profile, 2002). Almost 27% of the plants operating in 1990 have been

[5] Based on conversations with an industry representative, and with an economist from Agriculture and Agri-Food Canada (Mario Casavant), March 2004.
[6] According to Statistics Canada Table 003-0048.

closed (Figure 2.3). Consolidation has also occurred at the retailing level, where the three major retailers account for more than 70% of the trade (Western Dairy Digest, 2001).

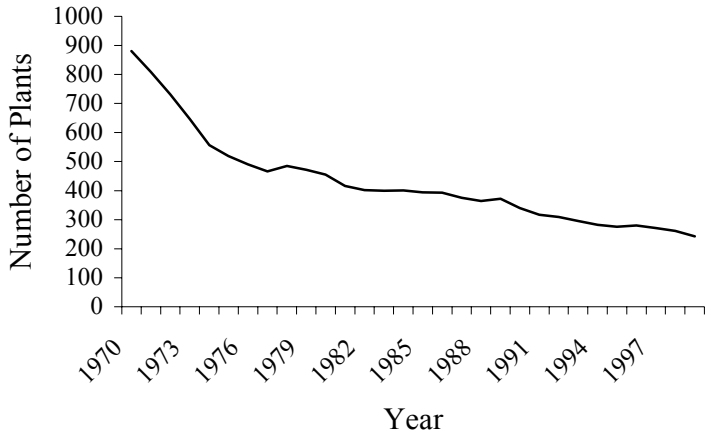

Figure 2.3: Number of Dairy Processing Plants over Time

Ontario and Quebec have the greatest number of dairy processing plants (130 and 166, respectively in 2002). In 1997, Quebec had 46.6% of the MSQ and Ontario 31.5%; and these two provinces accounted for about 83% of the total value of industrial milk shipments. Regarding production, the percentages are really similar: 85% of cheese production is in Quebec (50%) and Ontario (35%) (CDC, 2003).

According to a series of consultations of the Canadian Dairy Commission (CDC's Stakeholder Consultations, 2002) with all groups involved in the dairy industry, the trends in the industry are as follows. Processors are concerned by the reduction in the use of cheese. Major food-service companies are deciding to use less cheese in their products, or to import the final product at a less expensive cost than the one of producing it with Canadian ingredients. Further processors are trying to reduce costs by replacing dairy ingredients with cheaper imported

ingredients; even though they receive a special price (competitive). Another issue influencing this trend is the volatility of the special classes' price, which creates some uncertainty. Consumers are also moving away from dairy products. They are in favour of a competitive market.

3. THEORETICAL MODEL

In this section, we examine how the equilibrium quantity and quality of cheese and how the number of processing plants is affected by the supply management system. In the context considered, quality is measured by the proportion of extended cheese in total production.

We are assuming monopolistic competition since the products are differentiated and there are fixed costs in cheese production. There are markets for both extended and non-extended cheese and the two products are substitutes. The regular demand equations and inverse demand equations are linear functions of the two prices:

$$Q^n = a - P^n + bP^e \tag{3.1}$$

$$Q^e = c - P^e + dP^n \tag{3.2}$$

$$P^n = \frac{a + bc - Q^n + bQ^e}{1 - bd} \tag{3.3}$$

$$P^e = \frac{c + ad - Q^e + dQ^n}{1 - bd} \tag{3.4}$$

where Q^n and Q^e are the non-extended and extended market quantities; and P^n and P^e are the corresponding prices. Marginal cost (m^n and m^e) is lower for the extended cheese market, because milk substitutes are relatively less expensive. Fixed costs (F^n and F^e) exist in each market.

Firms set their quantity such that marginal revenue equals marginal cost in both markets:

$$\frac{a + bc - Q^n - bQ^e - \lambda^0 q^n - \lambda^1 bq^n}{1 - bd} - m^n = 0 \qquad (3.5)$$

$$\frac{c + ad - Q^e - dQ^n - \lambda^0 q^e - \lambda^1 dq^e}{1 - bd} - m^e = 0 \qquad (3.6)$$

These are the first order conditions for profit maximization, where the lambdas are the conjectural variations. When the value of lambda equals zero, the market is competitive, and when the value equals one, it is a monopoly.

$$dQ^n/dq^n = \lambda_0 \qquad (3.7)$$

$$dQ^e/dq^e = \lambda_0 \qquad (3.8)$$

$$dQ^e/dq^n = \lambda_1 \qquad (3.9)$$

$$dQ^n/dq^e = \lambda_1 \qquad (3.10)$$

We also have the zero-entry conditions, where price equals average cost:

$$\frac{a + bc - Q^n - bQ^e}{1 - bd} - m^n - \frac{F^n}{q^n} = 0 \qquad (3.11)$$

$$\frac{c + ad - Q^e - dQ^n}{1 - bd} - m^e - \frac{F^e}{q^e} = 0 \qquad (3.12)$$

The total number of firms is represented by n, all of whom produce non-extended cheese, but only a fraction of these firms enter the extended market because firms differ with respect to the cost of entering this market (entry costs may vary because of different age of machinery). Because of firm heterogeneity, the marginal firm earns zero profits and inframarginal firms earn positive profits. The firms entering the extended cheese market are assumed to have uniformly distributed fixed costs θ. The fixed cost of the marginal producer is denoted θ^*.

The equations for market supply of non-extended and extended cheese are given by:

$$Q^n = \frac{n}{\bar{\theta} - \underline{\theta}} \int_{\underline{\theta}}^{\bar{\theta}} q^n d\theta = nq^n \tag{3.13}$$

$$Q^e = \frac{n}{\bar{\theta} - \underline{\theta}} \int_{\underline{\theta}}^{\theta^*} q^e d\theta = \left(\frac{\theta^* - \underline{\theta}}{\bar{\theta} - \underline{\theta}} \right) nq \tag{3.14}$$

The comparative statics[7] results, which show how equilibrium quantity is impacted by fixed cost and marginal cost, are described in Table 3.1. The effect of supply management is simulated by raising the marginal cost for non-extended cheese because supply management makes the main input (milk) more expensive. The consolidation effect is simulated by reducing the fixed costs for producing extended cheese because economies of scale and scope lowers the costs of adopting the technology for extended cheese. The effect of extenders is simulated by setting comparatively low variable costs for extended cheese production because, as noted above, extenders are less expensive than milk when used as a raw ingredient for cheese. We are primarily interested in the effect of supply management on the total quantity and number of firms that operate in the industry.

Table 3.1: Comparative Statics Results

	dq^n	dq^e	dn	$d\theta^*$	dQ^n	dQ^e
dm^n	0	0	-	+	-	+
dm^e	0	0	+	-	+	-
dF^n	+	0	-	+	-	+
dF^e	0	+	+	-	+	-

[7] The analytical solution was obtained using MATLAB 6.1.

As Table 3.1 shows, the effect of supply management is to decrease total quantity for non-extended cheese and increase total quantity for extended cheese. As well, there is a decrease in the total number of firms and an increase in the fraction of firms that shift into the extended market. Specifically, a higher number of firms and firms with higher fixed costs will be able to adopt the technology and produce extended cheese. These results together suggest that supply management yields lower quality cheese.

Industry consolidation implies a decrease in the total quantity of non-extended cheese and an increase in the total quantity of extended cheese. The effect on the number of firms is to decrease the total number of plants, and increase the fraction of firms into the extended market. The effect of extenders is to decrease the quantity for non-extended cheese and increase the quantity for extended cheese. The number of total plants will decrease and the fraction of firms entering the extended market will increase.

These three factors (supply management, consolidation and the use of extenders) have analogous results. This was expected since supply management increases variable costs for non-extended cheese and consolidation and the use of extenders decrease fixed and variable costs for extended cheese.

4. EMPIRICAL MODEL

Using the results obtained in the previous section, we wanted to estimate the actual change in quality, quantity and number of firms as a function of the marginal and fixed costs. We are mainly interested in the quality changes. The first problem we encountered was the lack of data regarding extended (vs. non-extended) cheese and several of the other variables of interest. Because we cannot differentiate between the two types of cheese in the data set, it is necessary to estimate the demand for extenders as a function of the price of all inputs, price of all outputs, and

number of firms. But there is also some limitations regarding extenders. Given that extenders can be mixes of different ingredients, they are categorized into broad definitions, making it impossible to get information about production, utilization, imports and exports. To solve this, we decided to use casein as a proxy for extenders. As mentioned in the Technical Background part of section 2, casein is considered as an extender on its own (since it increases yield in cheese), and it is also included in cheese extenders that contain other ingredients. We are estimating the demand for casein as a function of outputs, marginal costs and number of plants. With these results we want to determine what has been the effect of these high levels of protection on the product quality.

As noted above, Canada did not produce casein in the period studied (1993 to 2002). The casein available for domestic consumption is all imported. There are a few exports of casein but they are negligible[8]. Because of this we can assume that Canada is a price taker for casein.

We estimated the residual demand for casein as a function of the demand for all the products (cheddar, specialty cheese, ice cream and yogurt), the marginal costs (the price of milk, metal index, and wage), and the number of plants. In the estimation equation, the cheese, ice cream and yogurt quantities are instrumented with their own demand equations. We also added a time trend, a dummy variable for the years post–GATT and a dummy for the years after the elimination of the export subsidy because of the WTO ruling.

The estimation equation is:

$$\begin{aligned} \text{Casein} = {} & \beta_0 + \beta_1 \text{Cheddar} + \beta_2 \text{SpecialtyCheese} + \beta_3 \text{Yogurt} + \beta_4 \text{IceCream} \\ & + \beta_5 \text{Milk Price} + \beta_6 \text{Metal} + \beta_7 \text{Wage} + \beta_8 \text{Plants} + \beta_9 \text{GATT} \\ & + \beta_{10} \text{ES} + \beta_{11} \text{Time} + \varepsilon_0 \end{aligned} \qquad (4.1)$$

Where:

- Casein is the quantity of casein imported.

[8] The total exports as a % of imports for 1993-2002 is 4.8%.

- Cheddar, Specialty Cheese, Yogurt and Ice Cream are the respective quantities produced, instrumented by the demand equations for each product.
- Milk Price is the weighted average for all the milk classes except class 1 (fluid consumption).
- Metal is the index price for metal (primary steel products).
- Wage is the fixed weighted index of average hourly earnings for all employees for non-durable industries.
- Plants is the number of dairy processing plants.
- GATT is a dummy variable for the years post–GATT (1995–2002).
- ES is a dummy variable for the period after the export subsidy was eliminated (August 2000–December 2002).
- Time is the time trend.

We use this estimation to test the following hypotheses:

1. Casein imports are positively correlated with the weighted milk price. Because of the results in the theoretical model, we are expecting β_5 to be positive.
2. Casein imports are positively affected by the production of cheese. The coefficients β_1 and β_2 are expected to be positive.
3. Casein imports are negatively correlated with number of firms. The coefficient β_8 is expected to be negative.

The demand equations for each product are:

$$\begin{aligned}\text{Cheddar} = {} & \alpha_0 + \alpha_1 \text{Cheddar}_{t-1} + \alpha_2 \text{GDP} + \alpha_3 \text{CPI} + \alpha_4 \text{Unemployment} \\ & + \alpha_5 \text{Population} + \alpha_6 \text{Time} + \alpha_7 \text{Time}^2 + \varepsilon_1\end{aligned} \tag{4.2}$$

$$\begin{aligned}\text{SpecialtyCheese} = {} & \gamma_0 + \gamma_1 \text{SpecialtyCheese}_{t-1} + \gamma_2 \text{GDP} + \gamma_3 \text{CPI} \\ & + \gamma_4 \text{Unemployment} + \gamma_5 \text{Population} + \gamma_6 \text{Time} + \gamma_7 \text{Time}^2 + \varepsilon_2\end{aligned} \tag{4.3}$$

$$\begin{aligned}\text{Yogurt} = {} & \delta_0 + \delta_1 \text{Yogurt}_{t-1} + \delta_2 \text{GDP} + \delta_3 \text{CPI} + \delta_4 \text{Unemployment} \\ & + \delta_5 \text{Population} + \delta_6 \text{Time} + \delta_7 \text{Time}^2 + \varepsilon_3\end{aligned} \tag{4.4}$$

$$\begin{aligned}\text{IceCream} = {} & \varphi_0 + \varphi_1 \text{IceCream}_{t-1} + \varphi_2 \text{GDP} + \varphi_3 \text{CPI} + \varphi_4 \text{Unemployment} \\ & + \varphi_5 \text{Population} + \varphi_6 \text{Time} + \varphi_7 \text{Time}^2 + \varepsilon_4\end{aligned} \tag{4.5}$$

Where we included a lagged variable for the production quantities. GDP is the Gross Domestic Product for Canada; CPI is the Consumer Price Index, 2001 basket content; Unemployment is the number of unemployed persons, and Population is the quarterly data by province. Time is the time trend and Time^2 is the time trend squared.

The only two provinces used for the estimation are Ontario and Quebec. We are assuming that technology is homogeneous across provinces[9]. The production data includes exports. The weighted average price takes into consideration all prices and volumes, this means also the lower (competitive) prices for the special classes. The special classes are cheese for further processing (mainly mozzarella and pizza cheese, some cheddar), other dairy products for further processing, dairy products for confectionery, and planned exports.

We estimated the above system using three-stage least squares in STATA. This command allows estimating a system of structural equations (equations 4.1 to 4.5), where the left–hand side variables in equations 4.2 to 4.5 are explanatory variables in equation 4.1. In this way, we instrument the production quantities used in the main estimation equation (equation 4.1) with their own demand equations (equations 4.2 to 4.5). All other variables are treated as exogenous to the system and they are used as instruments for the endogenous variables. Three-stage least squares also assumes that the error terms may be correlated across the equations.

5. DATA

Most of the data used was obtained from Statistics Canada and it is monthly by province (unless otherwise noted). The information regarding milk volumes and prices is recorded by the provincial marketing boards and agencies. The recent data is available to the public through the CDC webpage. The milk prices and volumes were obtained from the CDC webpage from 1997 to 2003. The data from 1993 to 1996 was provided by Agriculture and Agri-Food Canada. Milk prices were all converted into dollars per hectolitre of milk and milk volumes into hectolitres.

The weighted price was calculated as a weighted average using prices and volumes for all classes. This was done to take into account the lower (competitive) prices for the special classes.

Only data from Ontario and Quebec was used. This is because the other provinces either were not producing some of the products, or were not importing casein or, because of the small number of processing plants, production information was confidential. Besides, as we mention in the Industry Background section, these two provinces account for the vast majority of the industrial milk production (85%).

Casein is the casein imports in kilograms, obtained through the "Trade: Import and Exports" section of Statistics Canada. The following tables were obtained from the CANSIM section. The production data comes from Table 003-0010; the units are tonnes, except ice cream is in kilolitres. These units were scaled according to the yield mentioned in the Technical Background section so they would correspond to the yield from one hl of milk. Later, they were scaled again to obtain homogeneous results in terms of magnitude of the coefficients. Specifically, the units used to run the regressions are: cheese in 100,000 kg, yogurt in 1,000,000 kg and ice cream in 576,700 lt.

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[9] Based on a conversation with Michel Britten, Research Scientist Food Safety and Quality, Agriculture and Agri-Food Canada, March 2004.

Metal is the index price for metal (primary steel products) for Canada by month, where 1997 equals 100 (Table 329-0044). The Table for wage is 281-0039; it is the fixed weighted index (1996=100) of average hourly earnings for all employees, unadjusted for seasonal variation, for selected industries (non–durables) classified using the North American Industry Classification System (NAICS). GDP comes from: Gross Domestic Product (GDP) at basic prices for all industries, for Canada, unadjusted at 1997 constant millions of dollars (Table 379-0019). This variable was also scaled, the final units are dollars $x10^{10}$. Table 326-0001 is Consumer Price Index (CPI), 2001 basket content, by province, all-items; the index is 1992 equals 100. The unemployment data comes from Table 282-0001: Labour force survey estimates (LFS), both sexes, 15 years and over and it is in thousands of persons. The only population data available by province for the period of time studied is quarterly data (Table 051-0005: Estimates of population, Canada, provinces and territories, quarterly, persons). This data was transformed to a monthly basis by taking the difference by quarter, dividing it by 12 and adding it for each month. It was also scaled, to obtain units of 10,000 persons.

The number of dairy processing plants from 1983 to 1999 was obtained from the Manufacturing Census (Manufacturing Industries of Canada: National and Provincial Areas, Statistics Canada). The data for 2000 to 2002, from Table 301-0003: Annual survey of manufactures (ASM), principal statistics by NAICS. And finally, the information for 2002 was taken from the Canadian Dairy Industry Profile, 2002. This data is annual; we left it constant through the year. Since there is no information regarding number of plants for 1996, we used an interpolation of the adjacent years. The code for dairy plants changed[10] in 1998 when Canada moved from the Standard Industrial Classification System (SIC) to the NAICS system.

[10] SIC code: 1040, NAICS code: 3115.

The milk volumes for Ontario from October 1996 to December 1997 and Quebec from August 1996 to December 1996 are missing. This data is recorded only by component and according to Roger Heard, economist at Agriculture and Agri-Food Canada (May 2004), there is not a standard test per class that would allow converting from component volume in kg to hl. Since this information is used to compute the weighted price, we are not using this period of time for the analysis. For this reason, the number of observations is 220 instead of 240 which is what corresponded to ten years for the two provinces.

The Harmonized Milk Classification System started in 1995. Prior to this, each province had a different classification system. The classes are not exactly the same but a careful harmonization was done to have consistent data. For Ontario, the milk price information is divided into four regions (Southern Ontario, Northern Ontario, Thunder Bay, and North-western Ontario) for 1993 to 1994. We took the average for the prices by class.

Most of the data regarding milk prices is collected only in terms of the milk components (Ontario from October 1996 to December 2002, Quebec from January 1993 to December 1996 and from September 1997 to December 2002) or in terms of the differential (Ontario from January 1993 to September 1996). We obtained price by class by using the composition of milk according to the Supply Management Department of Agriculture and Agri-Food Canada: butterfat 3.66 kg/hl, protein 3.2 kg/hl, other solids 5.68 kg/hl. The price for each component is multiplied times its content in milk and then added to the differential (if it is available).

Finally, as mentioned earlier, some variables were scaled to obtain homogeneous results in terms of magnitude of the coefficients. To achieve this, Casein, Cheddar, Specialty Cheese, Yogurt, Ice Cream, GDP and Population were divided by 10,000. The following table presents the summary statistics of the variables, excluding the time trend and the dummy variables.

Table 5.1: Summary Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Casein Imports, 10,000 kg	220	6.89	8.41	0.00	41.90
Cheddar, 100,000 kg	220	41.86	12.20	18.05	76.45
Specialty Cheese, 100,000 kg	220	71.14	26.28	34.61	144.62
Yogurt, 1,000,000 kg	220	4.30	1.56	1.55	8.88
Ice Cream, 576,700 lt	220	14.60	10.68	0.28	40.18
Milk Price, dollars/hl	220	47.51	4.60	36.25	69.66
Metal, index (1997=100)	220	96.18	6.04	79.30	103.00
Wage, index (1996=100)	220	104.08	7.23	92.30	116.00
Plants, number	220	100.45	27.87	68.00	166.00
GDP, 1997 constant dollars x10^{10}	220	7.07	0.81	5.58	8.88
CPI, index (1992=100)	220	108.05	6.01	99.30	121.80
Unemployment, 1,000 persons	220	421.47	83.14	286.20	667.30
Population, 10,000 persons	220	922.36	205.38	713.60	1215.29

6. RESULTS

The main results of casein as a function of dairy product quantity and other inputs are displayed in the following table[11].

Table 6.1: Estimation Results

Dependent Variable: Casein Imports, 10,000 kg		
Variable	**Coefficient**	**Standard Error**
Cheddar, 100,000 kg	0.213[b]	0.101
Specialty Cheese, 100,000 kg	0.114[b]	0.056
Yogurt, 1,000,000 kg	-4.580[a]	1.072
Ice Cream, 576,700 lt	0.149[c]	0.088
Milk Price, dollars/hl	0.221[b]	0.099
Metal, index (1997=100)	-0.088	0.125
Wage, index (1996=100)	-0.277	0.297
Plants, number	0.162[a]	0.030
GATT, 1 after 1994	-2.454	2.234
ES, 1 after the export subsidy was eliminated in August 2000	5.277[a]	1.703
Yearly time trend	2.408[a]	0.868
R^2	0.564	
Number of Observations	220	

Note: a, b and c denotes significance at the 1%, 5% and 10% levels, respectively.

We have a relative good fit of the equation, with the R^2 equal to 0.564. The R^2 statistics for the demand equations are higher. Returning to our hypotheses, we want to test whether casein imports are positively correlated with the weighted milk price (β_5 is positive), and with the

[11] See Appendix III for the results of the demand equations (4.2 to 4.5).

production of cheese (β_1 and β_2 are positive); and negatively correlated with number of firms (β_8 is negative).

The coefficients for milk price, cheddar and specialty cheese are positive and significant at the 5% level. The milk price is the average weighted price taking into account the lower (competitive) prices for the special classes. If the milk price rises 1 dollar per hectolitre, it increases the casein imports by 2,210 kg, holding everything else constant. For cheddar and specialty cheese to obtain 10 extra kg of cheese we are using 0.213 kg or 0.114 kg more of casein, respectively. If, according to the example described in the technical background, adding 1.5 kg of casein to 1 hl of milk yields 5 kg extra of cheese; this would imply that an equivalent of 7.1% and 3.8% of the production of cheddar and specialty cheeses respectively was extended. Needless to say, this result should not be interpreted literally. It is just to give us an idea of the magnitude of the percentage of extended cheese if all processors in the extended market were using 1.5 kg of casein per 1 hl of milk.

Following these calculations, we could estimate the amount of milk that is being displaced by casein. If milk price increases 1 dollar/hl, the 2,210 kg increase per month in casein imports will displace 736.67 hl of milk per month. Thus, a one dollar increase in the price of milk would imply a loss for the Canadian dairy farmers of 38,432 dollars for Ontario and 41,010.42 dollars for Quebec, per month (using the weighted price for milk of December 2002); or approximately 35,000 dollars per month using the average weighted price for the period studied (1993 to 2002).

The coefficient for yogurt is negative, and the one for ice cream is positive. Both coefficients are significant. These coefficients are not as meaningful as those for cheddar and specialty cheese, because the functional properties of casein in yogurt and ice cream are different than in cheese. For these we have that a 100 kg increase in yogurt production decreases casein imports in 4.58 kg and an increase in 57.67 lt of ice cream, increases casein imports in 0.149 kg.

The coefficient on the number of plants is positive and highly significant. We were originally assuming this coefficient to be negative, because of the results obtained with the theoretical model. However, some authors claim that a monopolist might choose the same level of quality for a good as the social optimum, if the quantity is low and the price is high (Acharyya, 1998; Beath and Katsoulacos, 1991 and Lambertini, 1998). This is consistent with our findings. Removing one plant from the market is associated with a 1,620 kg decrease in casein imports.

Variable costs (metal and wage) are negative as expected, although not significant. We have that an increase of one in the metal index, decreases casein imports by 880 kg. For wage, the decrease is higher: 2,770 kg.

The dummy variable for the years post–GATT is negative and highly not significant. We tried running the regression without it, and the results were the same. The dummy variable for the years after the export subsidy was eliminated (August 2000 to December 2002), is positive and significant at the 1% level. This result is really interesting because it measures the average difference in kilograms of casein with and without the export subsidy. That is, imports of casein are being more than doubled since the elimination of the export subsidy. Time has an increasing effect on the imports of casein. This coefficient is significant at the 1% level. The time trend may be capturing the effect of improving technology that allows greater use of alternative inputs in cheese processing.

From these results, we found evidence that suggests that casein is highly affected by changes in the price of milk, and they have a positive relation. Because of a one dollar increase in the price of milk, around 737 hl of milk are displaced per month, which translates in a great loss for farmers, approximately, 35,000 dollars per month. We also observe this for the output quantities cheddar, specialty cheese and ice cream. As we mention above, an equivalent of 7.1% and 3.8% of the production of cheddar and specialty cheeses respectively is implied to be

extended. For yogurt, the coefficient is negative and highly significant. This result can be explained because casein may be making other products easier and/or less expensive to produce relative to yogurt, and therefore we are seeing a substitution away from yogurt. Besides, yogurt may also be reflecting some other trends, like demand for healthier food.

We can conclude that supply management is negatively affecting the quality in cheese, because it is making the price of milk more expensive. On the other hand, we found the positive effect on quality (lowering the imports of casein) of the decreasing number of plants. We cannot make any assumptions of what is driving this decrease, or what would happen to the number of plants without supply management. Besides, consolidation is a trend observed world wide in many industries. However, there are other factors that are also negatively affecting the quality in cheese. We capture this effect in the dummy for the elimination of the export subsidy.

With the export program the processors had access to less expensive milk. Once the program was eliminated, they had to keep the costs low to be able to export. One option is to switch technology and produce extended cheese. Since 1993, exports have been steadily increasing. Even after the elimination of the export program the dairy exports have continued to increase. The only decreases have been in 1999 and even more in 2000. Table 6.2 summarizes the average exports per year in dairy products for some selected products (Dairy Trade Bulletin – Dairy Year 2001–2002).

Exports of cheese have been decreasing, but dairy spreads and products made from milk ingredients have been substantially increasing. These are the products that use more casein. Unfortunately, we cannot test for this because of the broad classification of these products and the lack of data regarding production. But this suggests that also production for these products has been increasing, which accounts for the significant coefficient on the weighted price for milk. These findings are also reflected in the result for the dummy variable for the years after the

elimination of the export subsidy. Technological change may have as well induced some of these findings.

Table 6.2 Average Exports per year for Selected Dairy Products

Product	Average per year (tonnes)	
	1998–2000	2000–2002
Cheese	25,399	17,412
Dairy Spreads	6,381	14,370
Products consisting of Natural Milk constituents	8,439	13,102
Total Dairy Products	159,407	180,997

One can attempt to measure the effect of supply management by comparing the milk price difference between Canada and the United States. The U. S. price for industrial milk in December 2002 is 24.13 USD/hl (according to the Economic Research Service of the U. S. Department of Agriculture, making the appropriated conversion to milk hl). If we use the exchange rate for 2002, as reported by the Pacific Exchange Rate Service (http://fx.sauder.ubc.ca), that is 0.63722 USD/CAD, the price is 37.87 dollars/hl. The weighted milk price for December 2002 is 52.17 dollars/hl for Ontario and 55.67 dollars/hl for Quebec. The difference is 14.3 dollars/hl for Ontario and 17.8 dollars/hl for Quebec. The average difference in price for both provinces is 16.05 dollars/hl. Having a higher price for industrial milk in Canada than in the United States increased the imports of casein by 35,470.5 kg. This means that 11,823.5 hl of milk have been displaced, causing a 637,523.12 dollars loss in farmer's revenue (using the average weighted milk price for Ontario and Quebec in December 2002).

We want to know how much of the increase in casein imports has been due to supply management and how much to the elimination of the export subsidy, since these two factors seem

to be the more important ones. To obtain this, we compared the quantity of casein imported because of the elimination of the export subsidy and the quantity imported due to the increase in the weighted milk price from the beginning of the period studied to the end compared to the extra casein imported due to the higher price of milk in Canada due to supply management.

Milk prices in Canada increased during this period at least in part due to the end of the industrial milk subsidy, and we wanted to consider this price change separately to that caused by supply management. At the beginning of our study period in January 1993, the price for Ontario is 45.28 dollars/hl and for Quebec is 46 dollars/hl; the final ones, in December 2002, are 52.17 dollars/hl and 55.67 dollars/hl, respectively. The increase in the weighted milk price for Ontario is 6.89 dollars/hl and for Quebec is 9.67 dollars/hl. This price rise would lead to an increase of 15,227 kg of casein imported for Ontario and 21,371 kg for Quebec, or an average of 18,299 kg. This translates into 289,811 dollars in revenue loss for the farmers (using the average weighted milk price for 1993-2002), because this casein would displace 6,100 hl of milk.

The quantity of casein imported because of the elimination of the import subsidy is 52,770 kg. It displaced 17,590 hl of milk and produced a revenue loss for the farmers of 835,701 dollars. Comparing these effects, we see that the elimination of the import subsidy caused more than one and a half times as much revenue loss compared to the higher milk price caused by supply management. The effect of the loss of the industrial milk subsidy was smaller yet, only affecting a little more than one-third as much of a revenue loss compared to the export subsidy. That said, the end of the export subsidy may only have precipitated faster technical change that may well have occurred anyway. Therefore, this result should not be interpreted literally but it gives us an idea of the impact that the Canadian regulations have had on the increase in the imports of casein.

For robustness we tried several alternatives to the model. Some of the experiments include adding lags for casein and metal, running the first differences equations, using fixed effects, and

adding a seasonal dummy for summer. The results we obtained with all these experiments were either really similar to the original ones or completely insignificant. This gives us certain confidence about the robustness of our results.

7. CONCLUSIONS

This paper is an attempt to fill the gap in the literature, examining the effects of supply management in the quality of the dairy industry. To address this issue, we use theoretical and an empirical analysis. Specifically, for the theoretical model we want to know the effect of supply management in the quality, quantity and number of firms doing some comparative statics analysis. For the empirical model, we use the derived demand equation for casein as a function of the demand of the outputs (cheddar, specialty cheese, yogurt and ice cream), the marginal costs (milk price, wage and metal) and the number of plants to determine the effect of the high levels of protection on the product quality.

We obtain some similar and some different results with the theoretical and empirical models. In both models we find evidence that suggest that supply management negatively affects the quality of cheese. Because of supply management, through higher marginal costs, the quantity of extended cheese increases in the theoretical model. In the empirical model, the quantity of casein imports increases with an increase in the price of milk. In the empirical model we were able to get an approximate calculation of how much cheese was produced using casein, 7.1% for cheddar and 3.8% for specialty cheese. Furthermore, we were able to estimate the amount of milk that is being displaced by casein, 736.67 hl of milk per month; and the implied loss for the Canadian dairy farmers, 38,432 dollars for Ontario and 41,010.42 dollars for Quebec per month, or in average, 35,000 dollars per month.

We obtained different results regarding the number of plants. In the theoretical model, there is a decrease in the total number of firms and an increase in the fraction of firms that get into the extended market. More firms and firms with higher fixed costs will be able to adopt the technology and produce extended cheese. On the other hand, in the empirical analysis, we find that if we decrease the number of plants, the quantity of casein also decreases. Removing one plant from the market is associated with a 1,620 kg decrease in casein imports. Over the time-frame of our study, the processing industry has undergone a great deal of rationalization. This could be because of the economies of scale and scope achieved through rationalization; firms are able to lower costs without the need to use extenders in the products. It could also be due to the fact that market power allows firms to better capture rents associated with quality.

The overall results of the theoretical model suggest that supply management yields lower quality of cheese. For the empirical analysis, we cannot make such a strong conclusion because there are many factors affecting the results. It is generally accepted that supply management has increased the price of milk (as we discussed in the literature review part of the introduction). As a consequence, we found evidence that supply management has increased the imports of casein (2,210 kg for each dollar/hl), with the corresponding loss in farmer's revenue and quality of cheese. Comparing the Canadian and U. S. prices, the imports of casein increased by 35,470.5 kg because of the higher price due to supply management. This means that 11,823.5 hl of milk have been displaced, causing a 637,523.12 dollars loss in farmer's revenue. In this respect, we could say that supply management is negatively affecting the quality of cheese. However, in August 2000 Canada totally eliminated the export subsidy because of the WTO negotiations. This effect is captured in the dummy variable for the years after the export subsidy was eliminated. This coefficient is positive and significant, meaning that there is a difference in imports of casein with and without the export subsidy. We found that imports of casein are being more than doubled

since the elimination of the export subsidy. This is because the processors that want to continue exporting had to find other ways to keep the costs low. The availability of technology to extend cheese certainly influenced this big increase in imports of casein highly related with the elimination of the import subsidy.

There is a need for further study in this area. It is important to take into consideration that casein imports are not subject to import tariffs. It would be interesting to calculate how import tariffs (or reclassification) would affect the quantity of casein imports and whether casein would again be produced in Canada.

We are aware that the processing industry is able to charge higher prices on their products due to supply management. As we mention in the literature review, there is evidence that suggest that the processing sector has a significant amount of market power (Rude and Goddard, 1995). The current regulations in Canada, together with the consolidation trend world wide, have allowed the dairy processors to charge higher prices. Unfortunately, at this stage, we cannot incorporate this effect into the study, but it is an area open for further consideration.

Nowadays, we have more and better (in terms of taste and appearance) substitutes for the traditional products made from alternative sources, but this does not mean that we are exposed to better quality products. Actually, in most cases it is the other way around. The incentive for firms to launch these products is to create niche markets to obtain better profits for lower–cost products, and this incentive is exacerbated by regulations that increase the price of traditional ingredients while allowing low–cost substitutes to be imported barrier–free. The effect of these regulations has a significant effect on the quality of the end product and farmer's revenue.

REFERENCES

Acharyya, R. (1998). Monopoly and Product Quality: Separating or Pooling Menu? Economic Letters. 61(2): 187-194.

Barichello, R. R. (1981). The Economics of Canadian Dairy Industry Regulation. Economic Council of Canada Technical Report #E/12.

Barichello, R. R. and B. K. Stennes (1994). Cost Competitiveness of the Canadian Dairy Industry: A Farm Level Analysis. Paper prepared for the "Supply Management in Transition" Conference, Quebec, Canada, June 28-30, 1994.

Barichello, R. R. (1996). Capitalising Government Program Benefits: Evidence of the Risk Associated with Holding Farm Quotas. The Economics of Agriculture, Vol. 2. Papers in Honour of D. Gale Johnson. Edited by John M. Antle and Daniel A. Sumner. The University of Chicago Press, U. S. A. 283-299.

Barichello, R. R. (1999). The Canadian Dairy Industry: Prospects for Future Trade. Canadian Journal of Agricultural Economics. 47(5): 45-55.

Beath, J. and Y. Katsoulacos (1991). The Economic Theory of Product Differentiation. Cambridge University Press, First Edition, Great Britain. 75-83.

CDC's Stakeholder Consultations on the Market Situation for Dairy Products in Canada (2002). Prepared by the Canadian Dairy Commission. June 3, 2002.

CDC (2003). Canadian Dairy Commission. <http://www.cdc.ca/>

Canadian Dairy Industry Profile (2002). Agriculture and Agri-Food Canada. <http://www.dairyinfo.gc.ca/pdf_files/dairyprofile.pdf>

Canadian International Trade Tribunal (1998). Profile of the Canadian Dairy Industry. Staff Report (GC-91-001). March 16, 1998.

DFAIT (2003). Department of foreign affairs and international trade.

<http://www.dfait-maeci.gc.ca/>

Dairy Trade Bulletin – Dairy Year 2001–2002. Agriculture and Agri-Food Canada. <http://www.dairyinfo.gc.ca/pdf_files/bulletin0102.pdf>

Food Bureau (2003). The Canadian Dairy Processing Industry Sub-sector Profile. Agriculture and Agri-Food Canada. October 10, 2003. <http://www.agr.gc.ca/food/profiles/dairy/dairy_e.html>

Lambertini, L. (1998). Does Monopoly Undersupply Product Quality? Working Papers from Universita degli Studi di Bologna. <http://www.dse.unibo.it/wp/317.pdf>

Mangold, P. (2001). Milk Proteins and More. Presentation prepared for La foundation des Gouverneurs, October 31, 2001.

Meilke, K., R. Sarker and D. Le Roy (1998). The Potential for Increased Trade in Milk and Dairy Products between Canada and the United States under Trade Liberalization. Canadian Journal of Agricultural Economics. 46(2): 149-169.

Potter, N. N. and J. H. Hotchkiss (1995). Food Science. AVI Publishing Company, Fifth Edition, U. S. A. 279-315.

Richards, T. J. (1996). The Effect of Supply Management on Dairy Productivity. The Canadian Journal of Economics. 29(Special Issue Part 2): S458-S462.

Richards, T. J. and S. R. Jeffrey (1997). The Effect of Supply Management on Herd Size in Alberta Dairy. American Journal of Agricultural Economics. 79(2): 555-565.

Romain, R. (2001). The Future of the Dairy Industry in Canada. Discussion Series SD.01.01 Centre de Recherché en Economie Agroalimentaire Universite Laval.

Rude, J. and E. W. Goddard. 1995. Analysis of the Cost Structure for Processed Products: The Case of the Canadian Dairy Processing Sector. Working Paper WP95/05 Department of Agricultural Economics and Business, University of Guelph.

Schmitz, A. and T. G. Schmitz (1994). Supply Management: The Past and Future. Canadian Journal of Agricultural Economics. 42(2): 125-148.

Vercammen, J. and A. Schmitz (1994). Deregulating Supply-Managed Industries: The Unexpected Trade Effects. Paper presented at "Supply Management in Transition Towards the 21st Century", June 28-30, 1994, Quebec, Canada.

Western Dairy Digest (2001). Volume 2 Number 3, Spring 2001. <http://www.westerndairyscience.com>

Western Dairy Digest (2003). Volume 4 Number 3, Spring 2003. <http://www.westerndairyscience.com>

Whipple, G. D. (1983). Pricing Policy. American Journal of Agricultural Economics. 65(2): 209-213.

Wilson, B. (2003). Dairy farmers want butteroil problem fixed. The Western Producer, April 25, 2003. < http://www.producer.com/>

APENDIX I

Harmonized Milk Classification System (CDC, 2003)

Class 1	a) Fluid milks b) Fluid creams c) Milk-based beverages d) Fluid milks for the Yukon, Nunavut, and Northwest Territories (supplied by Alberta and British Columbia)
Class 2	Yogurt, sour cream and ice cream
Class 3	a) Specialty cheeses b) Cheddar cheese
Class 4	a) Butter, butteroil, powders and concentrated milk for ingredient purposes b) Concentrated milk for retail c) New products for the domestic market d) Inventory milk and plant losses m) Domestic marginal markets
Class 5	a) Cheese for further processing b) All other dairy products for further processing c) Confectionery d) Planned exports

APPENDIX II

Dairy Products Definitions[12]

- **Cheddar Cheese**: the product made by coagulating milk, milk products or a combination thereof with the aid of bacteria to form a curd and subjecting the curd to the cheddar process or any other process other than the cheddar process that produces a cheese having the same physical, chemical and organoleptic properties as those of cheese produced by the cheddar process. It contains not more than 39 percent moisture and not less than 31 percent milk fat and may contain salt, bacterial cultures to aid in the further ripening, colour and other permitted agents. Cheddar is the principal cheese used to make process cheese.

- **Edible casein:** main protein of milk. Dry product obtained by separating, washing and drying coagulum of skimmed milk, here the coagulum is obtained by precipitating with food grade acid.

- **Processed cheese:** processed cheese or processed cheese spreads are made by grinding, mixing, melting and emulsifying with the aid of heat and emulsifying agents of some or more varieties of cheese with a selection of ingredients or additives.

- **Specialty cheese:** all those varieties of cheese other than cheddar, cottage and processed cheese.

- **Whey:** the liquid part of milk that remains after the separation of curd in cheese making.

- **Yogurt:** coagulated milk product obtained by lactic acid fermentation through the action of Lactobacillus bulgaricus and Streptococcus thermophilus from milk and milk products. The micro-organisms in the final product must be viable and abundant.

[12] These definitions were taken from Canadian International Trade Tribunal (1998). Profile of the Canadian Dairy Industry. Staff Report (GC-91-001). March 16, 1998.

APPENDIX III: Results for the Demand Equations (4.2-4.5)

Table A3.1: Demand for Cheddar (equation 4.2)

Dependent Variable: Cheddar, 100,000 kg		
Variable	**Coefficient**	**Standard Error**
Lagged Cheddar, 100,000 kg	0.286[a]	0.062
GDP, 1997 constant dollars x10^{10}	-3.848[a]	1.323
CPI, index (1992=100)	0.398	0.413
Unemployment, 1,000 persons	-0.029[a]	0.010
Population, 10,000 persons	-0.033[a]	0.005
Time	1.612	4.555
Time^2	-0.022	0.088
R^2	0.784	
Number of Observations	220	

Note: a, b and c denotes significance at the 1%, 5% and 10% levels, respectively.

Table A3.2: Demand for Specialty Cheese (equation 4.3)

Dependent Variable: Specialty Cheese, 100,000 kg		
Variable	**Coefficient**	**Standard Error**
Lagged Specialty Cheese, 100,000 kg	0.598[a]	0.053
GDP, 1997 constant dollars x10^{10}	6.666[a]	1.609
CPI, index (1992=100)	0.688	0.506
Unemployment, 1,000 persons	0.015	0.012
Population, 10,000 persons	-0.056[a]	0.008
Time	12.410[b]	5.651
Time^2	-0.241[b]	0.109
R^2	0.930	
Number of Observations	220	

Note: a, b and c denotes significance at the 1%, 5% and 10% levels, respectively.

Table A3.3: Demand for Yogurt (equation 4.4)

Dependent Variable: Yogurt, 1,000,000 kg		
Variable	**Coefficient**	**Standard Error**
Lagged Yogurt, 1,000,000 kg	0.323[a]	0.054
GDP, 1997 constant dollars x10^{10}	0.414[a]	0.121
CPI, index (1992=100)	-0.214[a]	0.038
Unemployment, 1,000 persons	0.001	0.001
Population, 10,000 persons	-0.002[a]	0.000
Time	-2.674[a]	0.448
Time^2	0.057[a]	0.009
R^2	0.888	
Number of Observations	220	

Note: a, b and c denotes significance at the 1%, 5% and 10% levels, respectively.

Table A3.4: Demand for Ice Cream (equation 4.5)

Dependent Variable: Ice Cream, 576,700 lt		
Variable	**Coefficient**	**Standard Error**
Lagged Ice Cream, 576,700 lt	0.754[a]	0.046
GDP, 1997 constant dollars x10^{10}	-2.240[a]	0.866
CPI, index (1992=100)	0.044	0.285
Unemployment, 1,000 persons	0.012[c]	0.007
Population, 10,000 persons	0.008[a]	0.003
Time	2.308	3.093
Time^2	-0.030	0.060
R^2	0.883	
Number of Observations	220	

Note: a, b and c denotes significance at the 1%, 5% and 10% levels, respectively.