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# **Product Quality in the Canadian Dairy Industry**

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# Product Quality in the Canadian Dairy Industry

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August 2004

*Abstract: Supply management has been shown to increase the price of milk. Technological change has induced (and allowed) processors to substitute alternative inputs, many of which can be imported tariff-free, for the traditional ingredients to lower costs and maximize profit. Meanwhile, there has been a great deal of consolidation in the dairy processing industry. We analyse the effect of these trends on cheese quality by measuring the increase in casein imports. Results suggest that supply management is negatively affecting cheese quality, by increasing casein imports due to the higher milk price. Furthermore, we were able to calculate that approximately 9.8% of specialty cheese is produced using casein. A 22% ad valorem tariff is needed to drive casein imports down to zero.*

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## 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<sup>3</sup>. Over the past decade, technological change has induced processors to substitute alternative inputs, many of which can be imported tariff-free, for the traditional ingredients, which in turn has affected the quality of final products such as cheese. In this paper,

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<sup>3</sup> In this context, producer is the farmer and processor is the manufacturer.

we ask what effect supply management has had on the quality of processed dairy products in Canada.

There has been a great deal of research on the price and efficiency effects of Canada's supply management system for dairy production (Barichello and Stennes, 1994; Barichello, 1999; Meilke, Sarker and Le Roy, 1988; Richards, 1996; Richards and Jeffrey, 1997; Romain, 2001; Vercammen and Schmitz, 1994; etc.) 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.

It is generally accepted that supply management, though production quotas and high import tariffs, has raised the price of milk for Canadian cheese manufacturers (Barichello and Stennes, 1994; Barichello, 1999; Richards, 1996; Richards and Jeffrey, 1997; Romain, 2001; etc.), thereby causing these firms to search for ways to substitute away from national milk inputs to lower costs and maximize profit. Even though processors can pay a special world price<sup>4</sup> for dairy ingredients, according to the Canadian Dairy Commission, processors are reducing costs by replacing domestic dairy ingredients with less expensive imported ingredients. Meanwhile, there has been a great deal of consolidation in the dairy processing industry. 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<sup>5</sup>. A vital research question is 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

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<sup>4</sup> The world price is lower than the domestic, for example, in Quebec in December 1996, the price for milk used to produce cheddar cheese (domestic price) was \$51/hl, the price for milk used in cheese for further processing (based on U.S. milk price) was \$34.91/hl, and the price for milk used in products for the export market (based on world market milk price) was \$27.20/hl.

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 (Task Force on National Dairy Policy, 1991 and Wilson, 2003). Ishikawa and Spencer (1996) argue that subsidies that are supposed to increase rents for the producers of a final good may also shift rents to foreign firms who supply intermediate goods, assuming Cournot competition for both goods.

Butteroil–sugar blends are able to circumvent the import tariffs on dairy products, making it possible for importers to access cheap butteroil. After importation, butteroil is separated from the sugar and used in ice cream manufacturing, thereby competing with domestic cream and butter. 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.

Specifically, the hypotheses we want to test are the effects of the higher milk price due to supply management, cheese production and consolidation on casein imports. The rest of the paper proceeds as follows. The next section consists on the description of the Canadian cheese industry. Then we present the development of the empirical model. After the discussion of the results, the paper ends with some brief conclusions.

## **BACKGROUND ON THE CANADIAN CHEESE INDUSTRY**

Casein 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 various functional properties, including a higher yield in cheese and stability in yogurt and ice cream. It is also used in bakery and confectionary

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<sup>5</sup>Extenders are mixes of functional ingredients such as dairy ingredients (skim milk powder, whey, whey protein concentrates, casein, caseinates, etc), starch, gums, stabilizers, enzymes and sometimes flavours.

products. Milk protein concentrates (MPCs) are dairy blends without a strict definition and are not regulated 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.

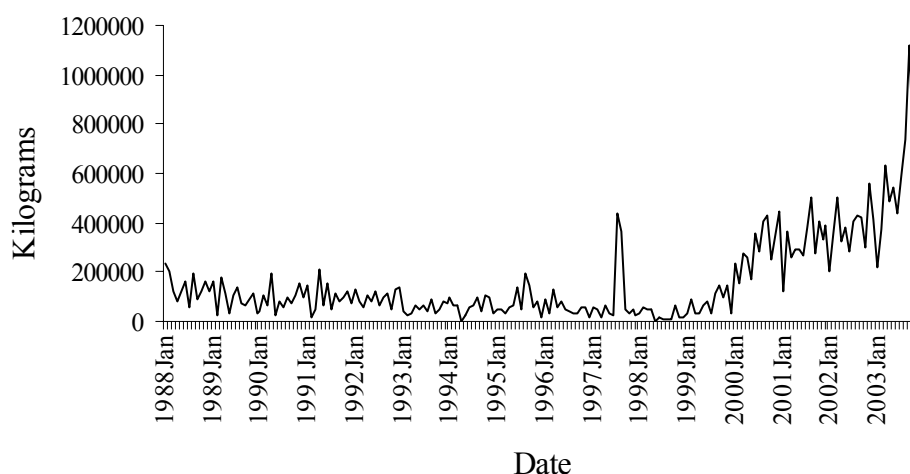
Some of these products can be categorized as extenders, which are mixes of functional ingredients such as dairy ingredients (skim milk powder, whey, whey protein concentrates, casein, caseinates, etc), starch, gums, stabilizers and enzymes; sometimes even flavours. These extenders are used in a variety of dairy products to increase yield. The most common use is in cheese. Extended cheese has been produced in many countries for several years. The type of extended cheese depends on each country's regulation and market (consumers' tastes 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, also may use extenders. Any cheese can be produced with extenders. The amount of extender used varies depending on the desired characteristics and price of the final product.

In general, 100 litres (lt) of milk produce 10 kilograms (kg) of cheese. To see the effect of extenders, in particular casein, adding 1.5 kg of casein and 1.5 kg of fat to 100 lt of milk, results in 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, or 100 lt of milk yields 57.67 lt of ice cream (Potter and Hotchkiss, 1995).

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 (especially flavour) than the

traditional good. As an example, high-end (boutique) cheese and premium ice cream are exclusively manufactured using milk and cream (for ice cream). Generally, extenders are used in lower-priced products, like cheese for further processing and dairy spreads.

Casein, caseinates and MPCs are not subject to high import tariffs, making it less expensive for the processor to use them in the formulation rather than using only milk or other milk ingredients. The imports of casein (Figure 1) and caseinates, and whey and whey products have increased significantly since 1995, 178% and 75% respectively (Western Dairy Digest, 2003).



**Figure 1: Casein Imports over Time**

Casein is not produced in Canada anymore<sup>6</sup>. The last available information regarding casein production<sup>7</sup> is for 1977, but it was always a small percentage of casein imports into Canada.<sup>8</sup> According to the Task Force on National Dairy Policy (1991), it is not profitable for

<sup>6</sup> Based on conversations with an industry representative and with an economist from Agriculture and Agri-Food Canada (Mario Casavant), March 2004.

<sup>7</sup> According to Statistics Canada Table 003-0048.

<sup>8</sup> Domestic casein production in 1977 was equivalent to 14.42% of the imports in that year. Making the comparison with more recent data, domestic production of casein in 1977 is found to be only 0.108% of the 1988 imports.

Canadian processors to manufacture casein because of the high price of raw milk (the primary input in casein production) in the supply management system.

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 to fewer and larger plants has been necessary to achieve the efficiency level and economies of scale required to remain competitive. Currently, the three major companies (Parmalat Canada, Agropur and Saputo Inc), who own 36% of the plants, process 70% of the milk produced in Canada (Canadian Dairy Industry Profile, 2002). Almost 27% of the plants operating in 1990 have been closed. Consolidation has also occurred at the retailing level, where the three major retailers account for more than 70% of the total grocery trade (Western Dairy Digest, 2001). There are concerns that this consolidation reflects a significant degree of market power<sup>9</sup>.

There have been many regulations to deal with the fact that the increased milk price will make Canadian processors less competitive, such as the industrial milk subsidy and several export subsidies and programs. All of these (including the industrial milk subsidy) have been ruled as violating the GATT and have subsequently been removed. However, while in place, they affected the relative price of inputs, and hence presumably affected the demand for extenders. Therefore, to understand the evolution of cheese quality in Canada, we need to review these rules.

By raising the price of milk, the supply management system may increase casein imports. By implementing programs to mitigate against the higher milk price, the Canadian government

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<sup>9</sup> Schmitz and Schmitz (1994) find no evidence in their theoretical study to support the claim that supply management has reduced processor and retailer market power.



may be reducing the increase in casein imports. As Canada is forced to eliminate these programs due to the GATT, there may be a further increase in casein imports. One can compare the effect of supply management and the effect that the elimination of regulations, like the industrial milk subsidy and the export program has had on casein imports.

In August 1995, a new pricing and pooling system, the Harmonized Milk Classification System, was established. The Harmonized system classifies industrial milk in relation to its end use. Prices and allocation of industrial milk vary according to the class (CDC, 2003).

The milk classification system includes classes that have special (competitive) prices for further processing. These special classes were created to allow Canadian products to compete internationally. Currently, the special classes include cheese (class 5a), other dairy products for further processing (class 5b), dairy ingredients for confectionary (class 5c) and planned exports (class 5d) (CDC, 2003). These special milk classes may mitigate the increase in casein imports by offering a lower price than the other classes, but the actual quantity of milk produced under these classes is low compared to the other ones<sup>10</sup>.

Canada implemented a number of changes to the supply management structure because of the 1995 WTO negotiations. These changes include the elimination of both payments on dairy product exports financed by levies on milk producers and the industrial milk subsidy, organizing both pooling arrangements and quota exchanges and the introduction, modification and termination of several programs, like the Surplus Removal Program, the Optional Export Program and the Commercial Export Milk system (Food Bureau, 2003). With these export programs, processors had access to less expensive milk. Once the programs are eliminated, they

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<sup>10</sup> The quantity of milk produced under class 5a (cheese for further processing) has been between 7 and 13% of the milk produced under class 3a (specialty cheese) for Canada, from 1997 to 2003.

had to keep costs low to be able to continue to export. One option is to switch technology and produce extended cheese.

## EMPIRICAL MODEL

We want to estimate how the use of extenders changed as a function of milk price and market structure. Because it is not possible to differentiate between the two types of cheese in the dataset, 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 are 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 Background section, 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. Therefore, we estimate the demand for casein<sup>11</sup> as a function of outputs, marginal costs and number of plants. With these results, we can infer the effect of these high levels of protection on cheese quality.

We estimate the derived demand for casein<sup>12</sup> as a function of the reduced form demand for the outputs (cheddar, specialty cheese, ice cream and yogurt), the marginal costs and the number of plants. As noted above, Canada did not produce casein in the period studied (1993 to 2002). The casein available for domestic consumption is all imported<sup>13</sup>. The marginal costs are the costs for the main inputs, that is milk price, metal index (because is the major component for machinery) and wage (labour costs).

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<sup>11</sup> We did not use the variables in logarithm form since some observations for casein imports are zeros.

<sup>12</sup> Casein is used in a variety of products. In the food industry casein is also used in bakery and confectionary products. But casein is also used in other manufacturing industries. Unfortunately there is not information regarding other uses for casein.

<sup>13</sup> There is some re-exportation of casein, but it is supposed to be imported under a different category.

The derived demand was obtained from the reduced form demand equations for the primary dairy products that use casein, that is, cheddar, specialty cheese, yogurt and ice cream taking into account the marginal costs (the price of milk, metal index and wage) and the number of plants. This yields the estimation equation 1 in which casein is a function of the outputs (cheese, ice cream and yogurt quantities instrumented with their own reduced form demand equations, the marginal costs (milk price, metal index and wage) and the number of plants. A lag for casein imports, the (instrumented) casein price and yearly dummy variables are also used in the estimation equation 1.

As the supply of the final product (cheese, yogurt and ice cream) could be affected by the quantity of an input (like casein), we instrumented the quantities of cheddar, specialty cheese yogurt and ice cream using variables that affect their demand (unemployment, population, income, Consumer Price Index (CPI) for all products, cheese and dairy products, Industrial Price Index (IPI) for ice cream, one lag, yearly dummy variables and a dummy variable for the months April to August and December in the cheddar and yogurt equations, April to August in the specialty cheese equation and March to August in the ice cream equation, when sales for each product were elevated). The casein price was instrumented because of concerns of endogeneity and variables that affect the supply price of Canadian casein imports were used as instruments: the U.S. industrial milk price, the U.S. energy index, the U.S. wage and the Canada–U.S. exchange rate. Yearly dummies were used to capture technology changes in supply and taste changes in demand, as well as changes in regulations. The lags are included to correct for autocorrelation.

$$\begin{aligned} \text{Casein}_{it} = & \beta_0 + \beta_1 \text{Casein}_{it-1} + \beta_2 \text{Casein Price}_{it} + \beta_3 \text{Cheddar}_{it} + \beta_4 \text{SpecialtyCheese}_{it} \\ & + \beta_5 \text{Yogurt}_{it} + \beta_6 \text{IceCream}_{it} + \beta_7 \text{Milk Price}_{it} + \beta_8 \text{MetalIndex}_{it} + \beta_9 \text{Wage}_{it} \quad (1) \\ & + \beta_{10} \text{Plants}_{it} + \beta_{11} \text{Time}_{it} + \sum_j^Y \beta_j \text{YearDummy}_{j_{it}} + \varepsilon_0 \end{aligned}$$

where:

- Subscript  $i$  refers to the province (Ontario or Quebec) and  $t$  to the date (monthly from January 1993 to December 2002).
- Casein is the quantity of casein imported and  $\text{Casein}_{t-1}$  is the lag for casein imports in period one.
- Casein Price is the price for casein calculated as the value of casein imports divided by the quantity of casein imports and instrumented with the U.S. industrial milk price, the U.S. energy index, the U.S. wage and the Canada–U.S. exchange rate.
- Cheddar, Specialty Cheese, Yogurt and Ice Cream are the respective quantities produced, instrumented with the reduced form demand equations for each product in equation 1.
- Milk Price is the weighted average for all the milk classes except class 1 (fluid consumption).
- Metal Index 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.
- Subscript  $j$  refers to the year.
- Year Dummy is 1 when the year equals  $j$  and 0 otherwise.

This estimation is used to test the following hypotheses:

1. Casein imports are positively correlated with the weighted milk price. The coefficient  $\beta_7$  is expected to be positive.

2. Casein imports are positively correlated with cheese production. Thus, the coefficients  $\beta_3$  and  $\beta_4$  are expected to be positive.
3. Casein imports are negatively correlated with number of firms. The coefficient  $\beta_{10}$  is expected to be negative because of the consolidation trend discussed in the Background section. There is a pressure for the firms to become competitive. Some options they have to reduce costs are through economies of scale and scope and to produce extended cheese.

The only two provinces used for the estimation are Ontario and Quebec, since 85% of cheese production is in Quebec (50%) and Ontario (35%) (CDC, 2003). Technology is assumed to be homogeneous across provinces<sup>14</sup>. The time frame considered is from 1993 to 2002 and most of the data are monthly by province, obtained through Statistics Canada. The production data include exports. The weighted average price of milk takes into consideration all prices and volumes, including 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.

The system of equations was estimated using three-stage least squares in STATA. This command allows estimating a system of structural equations, where the left-hand side variables in the reduced form demand equations are explanatory variables in equation 1. In this way, we instrument the production quantities used in the main estimation equation (equation 1) with their own demand equations. The casein price is also instrumented. 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.

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<sup>14</sup> Based on a conversation with Michel Britten, Research Scientist Food Safety and Quality, Agriculture and Agri-Food Canada, March 2004.

## RESULTS

The main results of the regression of casein as a function of dairy product quantity and other inputs are displayed in Table 1<sup>15</sup>. The casein equation fits relatively poorly, with an  $R^2$  equal to 0.256. This poor fit can be explained by the fact that casein is used in a variety of products, some of which we were not able to include in the regression. In the food industry casein is also used in bakery and confectionary products. But casein is also used in other manufacturing industries. Unfortunately there is not information regarding other uses for casein. The  $R^2$  statistics for the demand equations are higher (Appendix I).

**Table 1: Estimation Results**

<b>Dependent Variable: Casein Imports, 10,000 kg</b>		
<b>Variable</b>	<b>Coefficient</b>	<b>Standard Error</b>
<b>Lagged Casein Imports, 10,000 kg</b>	0.225 <sup>a</sup>	0.063
<b>Casein Price, \$/kg</b>	-4.589 <sup>a</sup>	1.025
<b>Cheddar, 100,000 kg</b>	-0.281 <sup>b</sup>	0.124
<b>Specialty Cheese, 100,000 kg</b>	0.295 <sup>a</sup>	(0.067)
<b>Yogurt, 1,000,000 kg</b>	-3.517 <sup>a</sup>	(1.317)
<b>Ice Cream, 576,700 lt</b>	0.223 <sup>a</sup>	(0.080)
<b>Milk Price, \$/hl</b>	0.217 <sup>b</sup>	(0.111)
<b>Metal, index (1997=100)</b>	-0.567 <sup>b</sup>	(0.254)
<b>Wage, index (1996=100)</b>	-0.383	(0.297)
<b>Plants, number</b>	0.014	(0.034)
<b>R<sup>2</sup></b>	0.256	
<b>Number of Observations</b>	238	

Note: a and b denote significance at the 1% and 5% levels, respectively.

<sup>15</sup> See Appendix I for the results and discussion of the demand equations.

In accordance with our hypotheses, we test whether casein imports are positively correlated with the weighted milk price ( $\beta_7$  is positive) and with the production of cheese ( $\beta_3$  and  $\beta_4$  are positive); and negatively correlated with number of firms ( $\beta_{10}$  is negative). The coefficients on milk price and specialty cheese are positive and significant (specialty cheese at the 1% level and milk price at the 5% level), whereas the coefficient on cheddar is negative 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 per hectolitre, it increases the casein imports by 2,170 kg (3.34% of the average monthly casein imports), *ceteris paribus*. The elasticity of substitution between casein and milk is 1.53.

To obtain 10 extra kg of specialty cheese, 0.295 kg more casein is required. If, according to the example described in the Background section, adding 1.5 kg of casein to one hl of milk yields 5 kg extra of cheese, then an equivalent of 9.8% of the production of specialty cheeses is extended. This result should not be interpreted literally, rather it gives 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 one hl of milk. The coefficient on cheddar is negative, suggesting that cheddar is manufactured in the traditional way. The positive sign on the coefficient on specialty cheese is driven by mozzarella cheese, which makes up the majority of this class. Mozzarella cheese is mainly used in pizza. As discussed in previous chapters, there is a trend to decrease costs for cheese for further processing, even with the lower price assigned to the milk used for this class.

Next, we estimate the amount of milk that is being displaced by casein<sup>16</sup>. If milk price increases \$1/hl, the 2,170 kg increase per month in casein imports will displace 722.65 hl of milk per month. Thus, a one dollar increase in the price of milk would suggest that there is a spillover

effect of supply management that increases input substitution away from domestic milk, which decreases the revenue created by supply management by \$37,701 per month for Ontario and \$40,230 per month for Quebec, per month (using the weighted price for milk of December 2002); or \$33,033 per month using the average weighted price for the period studied (1993 to 2002).

Variable costs are negative as expected. Metal is significant at the 5% level, whereas wage is not statistically significant. An increase of one in the metal index, decreases casein imports by 5,674 kg (8.7% of the average monthly casein imports). For wage, the decrease is lower: 3,830 kg (5.9% of the average monthly casein imports).

The coefficient on the number of plants is positive, although not significant. This result may be driven by the manipulation needed to obtain consistent data<sup>17</sup>. However, some authors show theoretically that, if the quantity is lower and the price is higher than socially optimal, a monopolist might choose the same level of quality for a good as the social optimum (Acharyya, 1998; Beath and Katsoulacos, 1991 and Lambertini, 1998). Given that processors may be thought to have market power and face a protected market, this may be the case. Certainly their results are consistent with our findings. Removing one plant from the market is associated with a 140 kg (0.21% of the average monthly casein imports) decrease in casein imports.

The coefficient on yogurt is negative and the one on ice cream is positive, both are significant at the 1% level. These coefficients are not as meaningful as those on cheddar and specialty cheese because the functional properties of casein in yogurt and ice cream are different than in cheese. The results, however, imply that a 100 kg increase in yogurt production decreases casein imports 3.52 kg, and an increase of 57.67 lt of ice cream increases casein imports 0.22 kg.

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<sup>16</sup> To estimate the amount of milk displaced by casein, we took the formula to extend cheese (1.5 kg of casein yield 5 extra kg of cheese) and used the coefficient on milk price to calculate the corresponding amount of extra cheese being produced. Then, we multiplied that number times the yield for cheese (10%) to obtain the quantity of milk.



The coefficient on the lagged casein imports is positive and significant at the 1% level, as expected, because demand is usually based on past consumption. The casein price coefficient also has the expected negative sign and it is significant at the 1% level. This result suggests a negative own price effect for casein, giving an own price elasticity of -4.63. The effect of a one dollar increase in the price of casein, for example due to the implementation of a tariff, is to decrease casein imports by 45,890 kg per month (70.7% of the average monthly casein imports). This translates into 15,296 hl per month more milk being used in cheese manufacturing, and an average increase in farmers' revenue of \$699,175 per month. The value of casein imports for Quebec in December 2002 is \$1,137,695. Adding a 10% *ad valorem* tax on casein imports increases the amount of money paid to \$1,251,465. Using the quantity imported for this period, the casein price before the tariff is \$6.34/kg and after the tariff is \$6.98/kg. The increase in price decreases casein imports by 29,103 kg per month (45% of the average monthly casein imports), translating into 9,701 hl more milk per month being used in cheese processing and an average increase in farmers' revenue of \$443,428 per month. To drive casein imports down to zero, a 22% *ad valorem* tariff is needed. These results provide justification for Canadian dairy farmers' concern about implementing tariffs on casein and similar products.

The results suggest that casein is highly positively affected by changes in the price of milk. A one dollar increase in the price of milk causes around 723 hl of milk to be displaced per month, which means that there is a spillover effect of supply management that increases input substitution away from domestic milk, which decreases the revenue created by supply management by approximately \$33,000 per month. This correlation is also observed between casein and the output quantities specialty cheese and ice cream. As mentioned above, the

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<sup>17</sup> The methodology for the Annual Survey of Manufactures (ASM) changed in 2000 when the data universe was expanded to include all manufacturing units. To obtain a consistent dataset, we transformed the number of plants

regression results suggest an equivalent of 9.8% of the production of specialty cheese is extended. The results for cheddar suggest that this kind of cheese is manufactured in the traditional way. For yogurt, the coefficient is negative. This result can be explained because casein may be making other products easier and/or less expensive to produce relative to yogurt and, therefore, a substitution away from yogurt is observed. The coefficient on yogurt may also be reflecting some other trends, like demand for healthier food. According to the Food Bureau (2003), “growth in yogurt demand since the late–eighties has been driven by demand for more health–oriented food”.

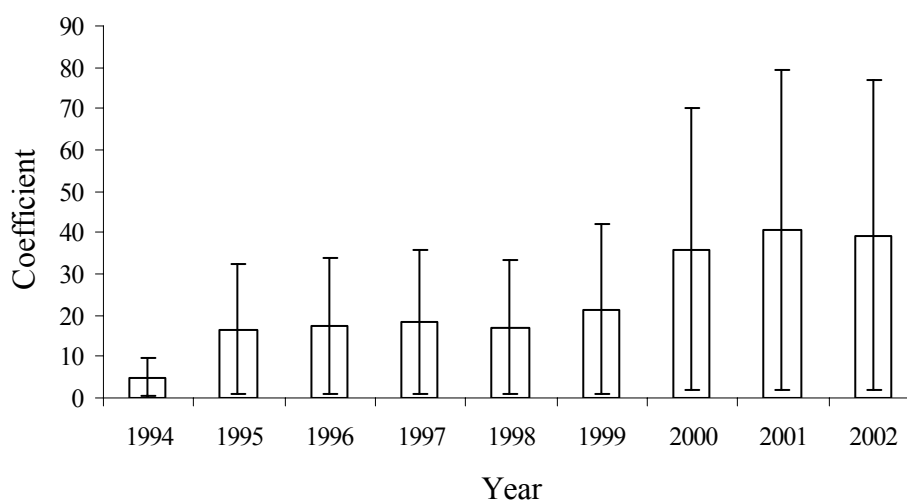
We conclude that supply management, by increasing the price of milk, is negatively affecting cheese quality. On the other hand, the decreasing number of plants has a positive effect (although not significant) on quality (lowering the imports of casein). We cannot make any assumptions concerning the driving forces of this decrease, or what would happen to the number of plants without supply management. Besides, consolidation is a trend observed worldwide in many industries.

The use of casein did change substantially over time. These changes may have been caused by changes in regulations (such as the implementation of the GATT) and technological improvements. These changes are captured in the yearly dummies (Figure 2). There is some evidence of an increasing step function<sup>18</sup>. The first occurs at the same time as the implementation of the GATT in 1995 and the second one coincides roughly with elimination of the export program (August 2000). The elimination of the industrial milk subsidy started shortly after the GATT and was completed by February 2002.

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from 1993 to 1999 to the new methodology based on the annual change from the old methodology.

<sup>18</sup> We tested for aggregation of the year dummies. The results suggested that the coefficients for the years 1995 to 1999 and 2001 to 2002 were statistically equal. Once incorporated into the model as dummy variables for 1995-1999 and 2001-2002, the model presented heteroskedasticity and autocorrelation problems, but the other coefficients were quite similar.



**Figure 2: Coefficients on the Year Dummies in the Casein Equation**

By forcing Canada to import some quantity of dairy products in with a low tariff, and changing the production quotas to tariffs, GATT may have affected the demand for casein. For example, if it caused Canadian processing firms to face more competition, it could have induced them to lower their costs of production. With the export program, processors had access to less expensive milk. Once the program was eliminated, they had to keep costs low to be able to continue to export. One option is to switch technology and produce extended cheese.

The effect of supply management can be measured by comparing the milk price difference between Canada and the United States. The U.S. price for industrial milk in December 2002 was 24.13 USD/hl. Using the exchange rate for December 2002, 1.56 CAD/USD, the price is \$37.64/hl. The weighted milk price for December 2002 is \$52.17/hl for Ontario and \$55.67/hl for Quebec. The difference is \$14.52/hl for Ontario and \$18.03/hl for Quebec. The average difference in price for both provinces is \$16.28/hl. The higher price for industrial milk in Canada than in the United States increased casein imports by 35,294 kg (54.4% of the average monthly casein imports). This means that in December 2002, 11,765 hl of milk were displaced, causing a

spillover effect that decreases farmers' revenue by \$634,358 (using the average weighted milk price for Ontario and Quebec in December 2002).

In December 2002, the total volume of milk produced in Quebec was 2,222,428.2 hl, generating \$36,181,131 in extra revenue for farmers due to supply management. At the same time, supply management also caused a spillover effect that decreased farmers' revenue by \$654,946. The spillover effect is 1.81% of the extra revenue, which is a considerable amount for Canadian farmers.

For the next part of the simulation, we use the average of the coefficients on the yearly dummy variables for the years 1995 to 1999 (first step in Figure 2) and on the yearly dummies for the years 2001 to 2002 (second step in Figure 2). We examine the different effects of supply management (as captured by the difference in price between Canada and the United States), the elimination of the export program (as captured in the average for the years 2001 to 2002) and the elimination of the industrial milk subsidy and the implementation of the GATT (as captured by the average for the years 1995 to 1999) on the imports of casein by comparing the extra quantity of casein imported because of these three factors.

All the coefficients on the yearly dummy variables for the casein equation are positive and significant at the 1% level (except 1994, significant at the 10% and 1998, significant at the 5%). The average of the coefficients on the yearly dummies for 1995 to 1999 is 18.187. This positive result was expected given the changes in regulation, like the elimination of the industrial milk subsidy, occurred after the GATT. The average of the coefficients on the years 2001 to 2002 (subtracting the average for the years 1995 to 1999 to get the increase only) is 21.886. This result is interesting since it coincides with the elimination of the export program in August 2000. It can be considered as an approximate measure of the average difference in kilograms of casein with

and without the export program. Thus, imports of casein greatly increased after the elimination of the export program.

The quantity of casein imported after the GATT (elimination of the industrial milk subsidy) is 181,780 kg (280% of the average monthly casein imports) and after the year 2001 (elimination of the export program) it increased to 218,863 kg (337% of the average monthly casein imports). These two dates mark changes in the supply management system as well as technological changes. After the year 2001, 72,955 hl of milk were displaced, producing a decrease in farmers' revenue of \$3,334,748 due to the spillover effect. After the GATT, 60,593 hl of milk were displaced and the spillover effect decreased farmers' revenue by \$2,769,725. As mentioned before, the effect of supply management as captured by the difference in milk price between Canada and the United States increased casein imports by 35,294 kg (54.4% of the average monthly casein imports), displacing 11,765 hl of milk and causing a spillover effect that decreases farmers' revenue by \$634,358.

Comparing the three effects, one can see that the elimination of the export program, as captured by the average of the yearly dummies for the years 2001 to 2002, caused the greatest decrease in farmers' revenue due to the spillover effect, followed by the elimination of the industrial milk subsidy (average of the yearly dummies for the years 1995-1999) and then the effect of supply management. The effect of supply management caused around 19% of the revenue loss to farmers due to the elimination of the export program and 23% of the revenue loss to farmers due to the elimination of the industrial milk subsidy. That said, the end of the export program and the industrial milk subsidy may only have precipitated faster technical change that may well have occurred anyway, especially in the last two years. Therefore, this result should not be interpreted literally but it gives an idea of the impact Canadian regulations have had on the increase in the imports of casein.

## CONCLUSION

This paper uses empirical analysis to examine the effects of supply management on quality in the dairy industry, thereby filling a gap in the literature. Specifically, we use the derived demand equation for casein as a function of the reduced form demand for the outputs (cheddar, specialty cheese, yogurt and ice cream), the instrumented casein price, the marginal costs (milk price, wage and metal) and the number of plants to determine the effect of high levels of protection on product quality.

The results provide evidence that suggests that supply management negatively affects cheese quality. The quantity of casein imports increases in response to an increase in the price of milk. The results suggest that approximately 9.8% of specialty cheese is produced using casein. Furthermore, we estimate the amount of milk displaced by casein if milk price increases one dollar, 722.65 hl of milk per month; and the implied spillover effect on Canadian dairy farmers, which, on average, decreases their revenue by \$33,033 per month.

The results, regarding the number of plants, are that a decrease in the number of plants decreases the quantity of casein. Removing one plant from the market is associated with a 140 kg (0.21% of the average monthly casein imports) decrease in casein imports. Over the time-frame of this study, the dairy processing industry has undergone a great deal of rationalization. Economies of scale and scope, which enable firms to lower costs without the need to use extenders in the products, are one possible explanation for this rationalization. Another possible explanation is that market power allows firms to better capture rents associated with quality.

It is generally accepted that supply management has increased the price of milk (as discussed in the Introduction). Consequently, we find evidence that supply management has increased imports of casein (2,170 kg for each \$/hl, which is 3.34% of the average monthly

casein imports), while decreasing farmers' revenue (due to the spillover effect) and cheese quality. In December 2002, imports of casein increased by 35,294 kg (54.4% of the average monthly casein imports) given the relatively higher Canadian milk price (compared to the U.S. milk price) due to supply management. This means that 11,765 hl of milk have been displaced, causing the spillover effect to decrease farmers' revenue by \$634,358.

The spillover effect for Quebec in December 2002 is 1.81% of the extra revenue produced by supply management due to the higher Canadian milk price compared to the U.S. milk price. This evidence suggests that supply management is negatively affecting cheese quality. However, in August 2000, Canada eliminated the export program because of WTO negotiations. This effect is captured in the average for the coefficients on the yearly dummy variables for the 2001 to 2002. The coefficient is positive, suggesting that the export program affects imports of casein. This effect is causing the greatest spillover effect decreasing farmers' revenue. This is because processors that want to continue exporting need to explore alternative production techniques to keep costs low. The availability of technology to extend cheese contributed to the increase in imports of casein.

This area requires further study, since casein imports are not subject to import tariffs. Import tariffs (or reclassification), for example, a 10% *ad valorem* tariff would decrease casein imports by 29,103 kg per month (45% of the average monthly casein imports), translating into 9,701 hl more milk being used in cheese processing and an average increase in farmers' revenue of \$443,428 per month. To drive casein imports down to zero, a 22% *ad valorem* tariff is needed. Another interesting issue is whether casein will be produced again in Canada.

The processing industry is able to charge higher prices for their products due to supply management. As mentioned in the Background section, evidence suggests that the processing sector has a significant degree of market power (Schmitz and Schmitz, 1994). Regulations in

Canada, together with the worldwide consolidation trend, have allowed dairy processors to charge higher prices. Furthermore, processors are able to price and quality discriminate among consumers using different brands. Unfortunately, at this stage, we cannot incorporate this effect into the study, but it is an area open for further consideration.

Currently, there are more and better (in terms of taste and appearance) substitutes, made from alternative sources, for traditional products. However, this does not mean that products are of higher quality. Actually, in most cases it is the other way around. The incentive for firms to launch substitute products is to create niche markets to obtain better profits for lower-cost products. This incentive is exacerbated by regulations that increase the price of traditional ingredients, while allowing low-cost substitutes to be imported barrier-free. These regulations have a significant effect on the quality of the end product and farmers' revenue.

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## **APPENDIX I**

### **Results for the Reduced Form Demand Equations**

The results for the reduced form demand equations A1 to A4 are displayed in the following tables (Tables A1 to A4). These equations include yearly dummies in all equations and a dummy variable for the months April to August and December in the cheddar and yogurt equations, April to August in the specialty cheese equation and March to August in the ice cream equation, when sales for each product were elevated.

The reduced form demand equations are:

$$\begin{aligned} \text{Cheddar}_{it} = & \alpha_0 + \alpha_1 \text{Cheddar}_{it-1} + \alpha_2 \text{Unemployment}_{it} \\ & + \alpha_3 \text{Population}_{it} + \alpha_4 \text{Income}_{it} + \alpha_5 \text{CPI}_{it} \\ & + \alpha_6 \text{CPI\_Cheese}_{it} + \alpha_7 \text{CPI\_DP}_{it} + \alpha_8 \text{IPI\_IC}_{it} + \varepsilon_1 \end{aligned} \quad (\text{A1})$$

$$\begin{aligned} \text{SpecialtyCheese}_{it} = & \gamma_0 + \gamma_1 \text{SpecialtyCheese}_{it-1} + \gamma_2 \text{Unemployment}_{it} \\ & + \gamma_3 \text{Population}_{it} + \gamma_4 \text{Income}_{it} + \gamma_5 \text{CPI}_{it} \\ & + \gamma_6 \text{CPI\_Cheese}_{it} + \gamma_7 \text{CPI\_DP}_{it} + \gamma_8 \text{IPI\_IC}_{it} + \varepsilon_2 \end{aligned} \quad (\text{A2})$$

$$\begin{aligned} \text{Yogurt}_{it} = & \delta_0 + \delta_1 \text{Yogurt}_{it-1} + \delta_2 \text{Unemployment}_{it} \\ & + \delta_3 \text{Population}_{it} + \delta_4 \text{Income}_{it} + \delta_5 \text{CPI}_{it} \\ & + \delta_6 \text{CPI\_Cheese}_{it} + \delta_7 \text{CPI\_DP}_{it} + \delta_8 \text{IPI\_IC}_{it} + \varepsilon_3 \end{aligned} \quad (\text{A3})$$

$$\begin{aligned} \text{IceCream}_{it} = & \phi_0 + \phi_1 \text{IceCream}_{it-1} + \phi_2 \text{Unemployment}_{it} \\ & + \phi_3 \text{Population}_{it} + \phi_4 \text{Income}_{it} + \phi_5 \text{CPI}_{it} \\ & + \phi_6 \text{CPI\_Cheese}_{it} + \phi_7 \text{CPI\_DP}_{it} + \phi_8 \text{IPI\_IC}_{it} + \varepsilon_4 \end{aligned} \quad (\text{A4})$$

There is a good fit for all the equations. The coefficient on the lagged variable for all demand equations is positive, significant at the 1% level for specialty cheese, yogurt and ice cream, and significant at the 5% for cheddar. This is an intuitive result, since production and demand are usually based on past consumption. Somewhat counter-intuitively, the coefficient on unemployment is positive for cheddar (not significant) and ice cream (significant at the 5% level); negative for specialty cheese (significant at the 1% level) and yogurt (not significant). For population, the coefficient is negative for all products. The coefficient on income is positive for all products, but only significant for ice cream (1% level). These results suggest that there is a positive income effect on cheddar, specialty cheese, yogurt and ice cream. This was expected for yogurt, since it is perceived by consumers to be healthier or nutritionally beneficial. Also, mozzarella is included in specialty cheese and its main use is in pizza and prepared meals, which have been increasing in popularity in the last years.

The coefficient on CPI is positive for cheddar, specialty cheese and ice cream (significant at the 5% level), and negative and significant at the 1% level for yogurt. This implies that as inflation increases, people demand less yogurt. The CPI for dairy products is assumed to be capturing the overall trend in dairy products. The coefficient on this variable is negative for cheddar (significant at the 1% level) and ice cream, and positive for specialty cheese (significant at the 1% level) and yogurt. The CPI for cheese and the IPI for ice cream reflect the own price and cross price effects of each product. For cheddar, there is a negative own price effect and positive cross price effect with ice cream, both of them are not significant. For specialty cheese, both effects are negative and not significant. For yogurt, the cross price effect captured by the CPI for cheese is positive, but the cross price effect captured by the IPI for ice cream is negative, both of them are significant at the 1% level. Ice cream presents a negative cross price (cheese) effect and a positive own price effect, both of them not significant.

**Table A1: Reduced Form Demand for Cheddar**

<b>Dependent Variable: Cheddar, 100,000 kg</b>		
<b>Variable</b>	<b>Coefficient</b>	<b>Standard Error</b>
<b>Lagged Cheddar, 100,000 kg</b>	0.147 <sup>b</sup>	0.062
<b>Unemployment, 100,000 individuals</b>	0.487	1.013
<b>Population, 100,000 individuals</b>	-0.606 <sup>c</sup>	0.340
<b>Income, \$100</b>	0.385	1.147
<b>CPI, index (1992=100)</b>	0.212	0.460
<b>CPI Cheese, index (1992=100)</b>	-0.297	0.322
<b>CPI Dairy Products, index (1992=100)</b>	-1.146 <sup>a</sup>	0.318
<b>IPI Ice Cream, index (1997=100)</b>	0.124	0.204
<b>R<sup>2</sup></b>	0.806	
<b>Number of Observations</b>	238	

Note: a and b denote significance at the 1% and 5% levels, respectively.

**Table A2: Reduced Form Demand for Specialty Cheese**

<b>Dependent Variable: Specialty Cheese, 100,000 kg</b>		
<b>Variable</b>	<b>Coefficient</b>	<b>Standard Error</b>
<b>Lagged Specialty Cheese, 100,000 kg</b>	0.415 <sup>a</sup>	0.056
<b>Unemployment, 100,000 individuals</b>	-3.182 <sup>a</sup>	1.233
<b>Population, 100,000 individuals</b>	-1.245 <sup>a</sup>	0.417
<b>Income, \$100</b>	2.052	1.403
<b>CPI, index (1992=100)</b>	0.784	0.561
<b>CPI Cheese, index (1992=100)</b>	-0.412	0.401
<b>CPI Dairy Products, index (1992=100)</b>	1.103 <sup>a</sup>	0.393
<b>IPI Ice Cream, index (1997=100)</b>	-0.158	0.252
<b>R<sup>2</sup></b>	0.937	
<b>Number of Observations</b>	238	

Note: a and b denote significance at the 1% and 5% levels, respectively.

**Table A3: Reduced Form Demand for Yogurt**

<b>Dependent Variable: Yogurt, 1,000,000 kg</b>		
<b>Variable</b>	<b>Coefficient</b>	<b>Standard Error</b>
<b>Lagged Yogurt, 1,000,000 kg</b>	0.255 <sup>a</sup>	0.055
<b>Unemployment, 100,000 individuals</b>	-0.017	0.093
<b>Population, 100,000 individuals</b>	-0.028	0.031
<b>Income, \$100</b>	0.051	0.105
<b>CPI, index (1992=100)</b>	-0.180 <sup>a</sup>	0.042
<b>CPI Cheese, index (1992=100)</b>	0.108 <sup>a</sup>	0.030
<b>CPI Dairy Products, index (1992=100)</b>	0.008	0.029
<b>IPI Ice Cream, index (1997=100)</b>	-0.049 <sup>a</sup>	0.019
<b>R<sup>2</sup></b>	0.903	
<b>Number of Observations</b>	238	

Note: a and b denote significance at the 1% and 5% levels, respectively.

**Table A4: Reduced Form Demand for Ice Cream**

<b>Dependent Variable: Ice Cream, 576,700 lt</b>		
<b>Variable</b>	<b>Coefficient</b>	<b>Standard Error</b>
<b>Lagged Ice Cream, 576,700 lt</b>	0.488 <sup>a</sup>	0.043
<b>Unemployment, 100,000 individuals</b>	1.517 <sup>b</sup>	0.593
<b>Population, 100,000 individuals</b>	-0.343 <sup>b</sup>	0.192
<b>Income, \$100</b>	1.703 <sup>a</sup>	0.661
<b>CPI, index (1992=100)</b>	0.541 <sup>b</sup>	0.281
<b>CPI Cheese, index (1992=100)</b>	-0.282	0.187
<b>CPI Dairy Products, index (1992=100)</b>	-0.223	0.181
<b>IPI Ice Cream, index (1997=100)</b>	0.017	0.116
<b>R<sup>2</sup></b>	0.918	
<b>Number of Observations</b>	238	

Note: a and b denote significance at the 1% and 5% levels, respectively.