Reforming Canada's Dairy Supply Management Scheme and the Consequences for International Trade

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March 2022

Abstract

Following Carter and Mérel (2016), we explore the export benefits of reforming supply management (SM) in Canada's dairy sector. A trade model with ten regions and five dairy product categories is developed and used to examine the potential benefits of opening international markets to Canadian dairy products. In addition to a baseline, three scenarios are compared—one with SM in place but with Canada able to export freely. Two other scenarios assume SM is eliminated and there is complete free trade, but with high- and low-cost structures. Findings indicate that, in the high-cost scenario, domestic consumers gain from lower prices as the domestic supply and exports fall compared to the status quo, but producers are less well off. However, under a low domestic cost structure, Canada becomes a major exporter of milk, with both producers and consumers gaining from free trade. This scenario assumes that domestic producers take advantage of economies of scale, enabling them to compete in international markets. Appropriate polices will be required to reform the quota regime, while minimizing the harm done to dairy farmers.

Acknowledgements: The authors wish to thank Michele Veeman, James Rude and other participants at the REES seminar at the University of Alberta, Rick Barichello, Jim Vercammen, Roel Jongeneel, Fatemeh Mokhtarzadeh and Andrew Schmitz for helpful comments, insights and suggestions. Research assistance from Hugh Scorah and Nancy Guo in development of the dairy trade model is also appreciated.

Politicians use economics in the same way that a drunk uses a lamppost—for support rather than for illumination—Alan S. Blinder (h/t Roel Jongeneel)

1. INTRODUCTION

Growing demand for agricultural products from quickly advancing developing countries has expanded the export opportunities for countries like Canada, because citizens in poorer nations view food from developed countries to be safer. But Canada's dairy sector is unlikely to benefit from this trend because its supply managed regime is considered to constitute an implicit subsidy under World Trade Organization (WTO) rules, thereby inhibiting exports. Thus, Canada's total dairy product exports only amounted to $430.7 million in 2019, compared to cash receipts from off-farm sales of milk equal to $6.991 billion; indeed, as discussed in section 3 below, exports could decline in the future if the status quo is maintained. This means that Canada is unable to benefit from increased international demand for dairy products. Meanwhile, imports of protein in the guise of ultra-filtered milk products and skim milk powder (SMP) have been granted greater access to the domestic market as a result of recently concluded trade deals with the United States and Mexico, the European Union, and Asia-Pacific countries, thereby competing with Canadian suppliers (e.g., Greene 2019; Karunagoda, Hedley and Mussel 2015).

It is clear that these developments have increased the pressure for Canada to reform its dairy sector. While it is obvious that dairy reform will constitute a benefit to Canadian consumers, who currently face higher-than-market prices for dairy products (Cardwell, Lawley and Xiang 2015, 2018), it is ambiguous whether dairy producers would be positively or adversely affected. Dairy reform could allow farmers and processors to benefit from economies of scale associated with increased production as a result of accessing a worldwide market. The downside is that producers will potentially be exposed to lower, less-predictable prices. The goal of the present study is to determine the potential that reform of Canada's dairy supply-management (SM) regime might have for dairy exports and overall domestic welfare.

The current study focuses on the dairy industry, although it may also help to inform policies regarding the other SM sectors (eggs, chicken and turkey). We construct a spatial price equilibrium (SPE) trade model for analyzing policies related to the dairy sector and use it to examine the potential benefits for the dairy sector and Canada's economy of freeing trade. Our study begins in the next section with a brief overview of Canada's supply-managed dairy sector. In section 3, we provide a background to trade issues in agriculture. Then, in section 4, we develop an SPE model of international dairy trade that links fluid milk production to butter, fresh fluid milk products, milk powder, cheese and other products (e.g. yoghurt). The model is then used to investigate the potential benefits to Canadian consumers and producers from greater participation in global dairy markets. This will help inform the structure of any compensation or buyout package that reform of the dairy SM sector might require. A concluding discussion ensues in section 5.

2. A REVIEW OF SUPPLY MANAGEMENT IN CANADA'S DAIRY SECTOR

In the mid-1900s, Canada's dairy sector was characterized by excess supply and low and volatile prices. To aid the struggling industry, the federal government offered producers deficiency payments to cover losses, but this became costly. In 1966, the Canadian Dairy Commission (CDC) was established to rectify this problem, with the mandate to administer and facilitate the implementation of Canadian dairy policy. The new goal of limiting dairy production to ensure quality products at fair and consistent prices originated with the formation of the National Milk Marketing Plan in 1970. Quebec and Ontario, along with the federal government, were the original participants, but all provinces except Newfoundland signed on to the Plan by 1974.

The SM system works as follows: The CDC coordinates with the provinces to maintain a farm-gate *target price* that is based on a survey of producers' costs. The CDC uses this information to calculate annual *support prices* for butterfat and skim milk powder (SMP) and agrees to purchase any excess product at these prices (see Table 1). Although dairy producers must purchase quota, this cost cannot be taken into explicit account in calculating the cost of production; yet, quota costs must implicitly be included to facilitate new entry and prevent losses to farmers, with the result that dairy prices are slowly ratcheted upwards (Busby and Schwanen 2013).[1] As a result, Canadian prices for supply-managed commodities exceed those in the U.S. (Cardwell, Lawley and Xiang 2015, 2018; van Kooten 2020a). This is a concern since high dairy prices disproportionally harm poorer citizens, who spend a higher fraction of their income on food.

[1] The cost of quota is not included as a particular line item in the survey used by the CDC to calculate the cost of production; rather, this cost will appear as a financial cost or payment (like a mortgage payment). See http://www.saskmilk.ca/media/1617/9_do_we_know_the_cost_of_milk_production_in_2017_dac.pdf [accessed 29 March 2020], where the author, David Christensen, demonstrates how the cost related to quota can be embodied in higher costs related to cows, labour and/or management.

Table 1: Estimated Support Prices and Milk Production, 2010 through 2020

Year	Butter ($/kg)	SMP ($/kg)	Production $\times10^6$ liters	Year	Butter ($/kg)	SMP ($/kg)	Production $\times10^6$ liters
2010	7.1024	6.1783	7,666.02	2016	7.7815	4.4176	8,440.86
2011	7.1922	6.2721	7,764.33	2017	8.0062	4.5302	8,968.61
2012	7.2810	6.3673	7,964.43	2018	8.3901	4.5302	9,218.75
2013	7.3379	6.417	7,806.77	2019	8.3901	4.5302	9,210.45
2014	7.4046	6.4754	7,812.34	2020	8.6034	4.5302	9,302.03[a]
2015	7.4046	6.3109	8,160.07	2021[b]	8.7149	4.5302	N.A.

Sources: Support prices found at https://cdc-ccl.ca/index.php/en/supply-management/support-prices/ [accessed 25 January 25, 2021]. Production data are from Statistics Canada, Table 32-10-0113-01, Milk production and utilization. DOI: https://doi.org/10.25318/3210011301-eng [accessed 29 January 2021].
[a] Production data are available only through November 2021. The value here is an extrapolation.
[b] Support prices for 2021 are for the first several months only; N.A. refers to not available

In addition to high domestic prices, there is also the fear that, as a result of the quota regime, Canadian dairy farmers are less efficient than those elsewhere. Efficiency relates to various components of milk production and processing. To improve efficiency, a variety of federal dairy programs provided *annual* subsidies of over $200 million to producers and processors over the period 1981-2002, with subsidies continuing in the form of the Dairy Farm Investment Programme and the Dairy Processing Investment Fund (Vercammen 2013; van Kooten 2020b). Thus Canadian dairy producers were able to increase the productivity of their animals, but the quota system prevented them from expanding herd size to take advantage of economies of scale. This is indicated in Figure 1. Average herd size in Canada is well below that of the major exporting countries, including the U.S., Australia, New Zealand and most of the EU. This suggests that Canadian farmers could benefit from increasing their production to decrease cost per unit of output.

Economies of scale are difficult to achieve within the SM framework, as costly quota prevent dairy producers from expanding their herds, despite average yields per cow that are higher than in other countries, except the U.S. and some European countries such as the Netherlands. In addition, it appears that Canadian yields per cow have increased faster than U.S. yields in recent years, making the two countries more comparable in that regard. This suggests that, if Canadian dairy producers were allowed to increase herd sizes, Canada's farmers would be able to compete effectively in international dairy markets.

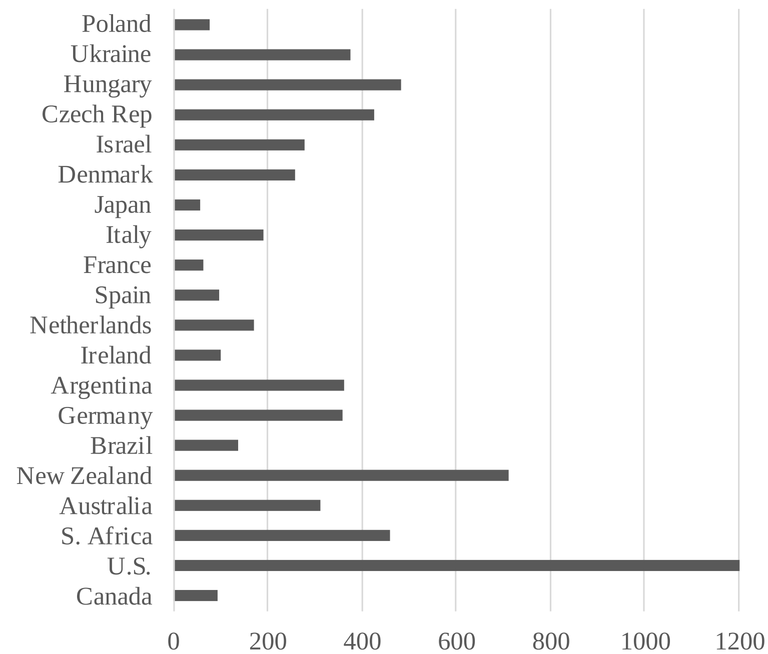

Figure 1: Average Size of Dairy Herds, Selected Countries, 2017
Source: IFCN (2017, p.7)

Politicians in several countries have employed SM in agricultural markets, with many of these regimes subsequently reformed or eliminated. Analyzing the history of these policies helps to inform Canadian SM policy as well as establish how Canada's global competitors operate. For example, the EU introduced country-level quotas on milk production in 1984 as a less expensive way to subsidize exports. Each EU member state was provided an export quota, but operated its internal SM regime based on its domestic demand and allowable exports. Canada did something similar in that provincial quota were determined on the basis of the industrial (butter fat) quota allocated to it by the Canadian Milk Supply Management Committee and the demand for fluid milk at the provincial level. Both Canada and the EU failed to take into account the relative efficiency (marginal costs of production) across regions and, in Canada's case, continues to do so (Schmitz, Haynes and Schmitz 2016). The main difference between the EU's dairy quota regime and that of Canada related to the export market. The EU was a net exporter of dairy products before, during and after SM, while Canada is a net importer.

The EU initially introduced SM in order to reduce and control the costs of export subsidies, and then reformed and eventually eliminated SM in dairy because export subsidies were no longer permitted under WTO rules.[2] The EU began in 2008 to dismantle its dairy quota system, completing the transition to a competitive market by mid-2015. Dairy producers were compensated using non-distorting deficiency payments (Jongeneel and Tonini 2009; Jongeneel, Burrell and Kavallari 2011). The transition involved a 2% increase in quota in April 2008, followed by a 1% increase in each year for 2009-2010 to 2013-2014.

Despite the increases in production as quota were eliminated, milk prices in the EU reached record-high levels in late 2013 at €40.21 per 100 kg, suggesting that "any price-depressing effect from increased EU production was more than compensated by the positive price signals coming from a rapid growth in world market demand" (Romijn 2016). The price subsequently dropped to just under €26/100 kg in mid-2016, but has maintained a steadier range of €32 to €38/100 kg from early 2017 onwards—higher than what was observed in the several years before quota began to rise, again suggesting that European farmers benefited from the reform.

Australia operated a quota system that only covered fluid (fresh) milk, and not industrial milk (cheese, powders, etc.). It dismantled the quota regime over a period of eight years beginning in 2001 (Edwards 2003). In the U.S., dairy producers were provided a deficiency payment if the market price fell below a threshold price, with an insurance product added in the 2014 Farm Bill (Novakovic and Wolf 2016). Although the U.S. placed some restrictions on dairy production, it never relied on a quota system. As an exporter of dairy products, New Zealand never employed supply management.

In Canada, various commentators have proposed ways of reforming the dairy sector. For example, policy analysts at the C.D. Howe Institute recommended that the government could retain supply management and, at the same time, slowly make the quota regime redundant by capping the support prices for butter, cheese and milk powder until dairy producers would be as efficient as their U.S. counterparts (Busby and Schwanen 2013). This would, according to the authors, eliminate the 'ratchet effect' of quota values on costs. It is questionable, however, if Canadian farmers could compete without achieving needed economies of scale, while wage and other cost increases associated with economic growth would inhibit the reductions in domestic milk prices

[2] Export subsidies here refer to actual, production-distorting payments to the dairy producers that required the EU effectively to dump product on the international market using subsidies. That is, the subsidies did not relate to implicit export subsidies resulting from the nature of the quota regime.

required to reduce them to the international level.

In their 2009 paper, Barichello, Cranfield and Meilke investigate whether dairy farmers should be compensated in the face of reform, and if so, by how much. They conclude that, while dairy producers should be compensated, it would be unrealistic to compensate farmers according to the value of the quota they hold ($25 billion in 2004). Rather, they recommend a compensation package that would target those producers who would experience the greatest losses. Barichello, Castellanos and McArthur (2013) suggest that growth in quota value over the past decades had created an asset price bubble, reaffirming that compensation should not equal the value of the quota asset. Subsequently, van Kooten (2020) estimated that a quota buyout program, based on theoretically correct welfare measures, should cost somewhere between $0.8 and $1.9 billion.[3]

3. BACKGROUND TO TRADE IN DAIRY PRODUCTS

The WTO was established in 1995 upon conclusion of the Uruguay Round of the General Agreement on Tariffs and Trade (1986-1994) in April 1994. One result was an Agreement on Agriculture (AA) that included a promise to continue negotiations on agricultural policy reform. A 2004 framework agreement for proceeding to lower agricultural trade barriers included, among others, elimination of export subsidies, reductions in the de minimis exemptions (which were set at 5% of total value of agricultural production, or TVP, for developed countries and 10% for developing countries), and a ceiling of 5% of individual product TVP in agriculture's Blue Box category where none existed before. An overall limit on total domestic subsidies (Amber Box plus Blue Box plus de minimis) was also proposed where none previously existed.

Subsequently, the Hong Kong Declaration on Agriculture adopted December 18, 2005 included the elimination of export subsidies by 2013—a target that only the EU met. Then, at a December 2015 meeting of WTO ministers in Nairobi, an approach to making progress on agricultural trade was reached under the auspices of the Trade Facilitation Agreement reached at Bali in 2013 (see WTO 2020, 2014b). Countries agreed to eliminate export subsidies on agricultural commodities by the end of 2018 (later revised to 2020), and set limits on the activities of state trading enterprises that might be construed as providing an export subsidy. Although

[3] The Canadian government intends to compensate dairy producers $1.31 billion over eight years for the loss of market share due to the USMCA alone. For further discussion, see Hedley and Mussell (2016).

import quotas were converted to a TRQ, a domestic quota regime (supply management) was looked upon as a mechanism that subsidized exports. The Agreement came into effect February 23, 2017 when two-thirds of the WTO membership had ratified it.

3.1 Canada and Global Dairy Trade

Global dairy production and exports have increased in recent years (as noted above), mainly because living standards have increased in many developing countries. According to the Food and Agricultural Organization (FAO 2020a), trade increased by 4.2% from 2017 to 2019, accounting for an increase in exports of 3.1 million tonnes of milk equivalent. At this time, milk production expanded in most regions to accommodate the increase in world demand. These changes can be seen in Figure 2, which shows the annual exports of fluid milk, butter, cheese and skim milk powder by the four major exporters—the EU, the U.S., New Zealand and Australia.

The EU dominates exports of fluid milk and cheese, while New Zealand has historically dominated the international butter market, although EU exports have recently increased. The EU and U.S. dominate the increasing global market for SMP, with New Zealand exports following closely behind. With the exception of fluid milk, Australia's role in export markets has declined slightly with cheese exports initially rising but then remaining stagnant since the beginning of the century. For comparison and for the period 2019-2020, Canadian exports of fluid milk, butter, cheese and SMP are, respectively, only 3%, 15%, 7% and 32% of those from Australia.

While export markets for dairy products have been growing, economic distortions in the dairy sector may be an impediment to Canadian participation in export markets. These distortions are evident upon an examination of Table 2, which shows government support payments as a percentage of gross commodity receipts for a variety of agricultural products for Canada, its main competitors in the dairy sector, and China as a representative of a net-importing, developing country. As seen in the table, milk in Canada has an average support level equal to 46.57% of gross farm receipts, more than twice that in the U.S., and over three times that in the EU.

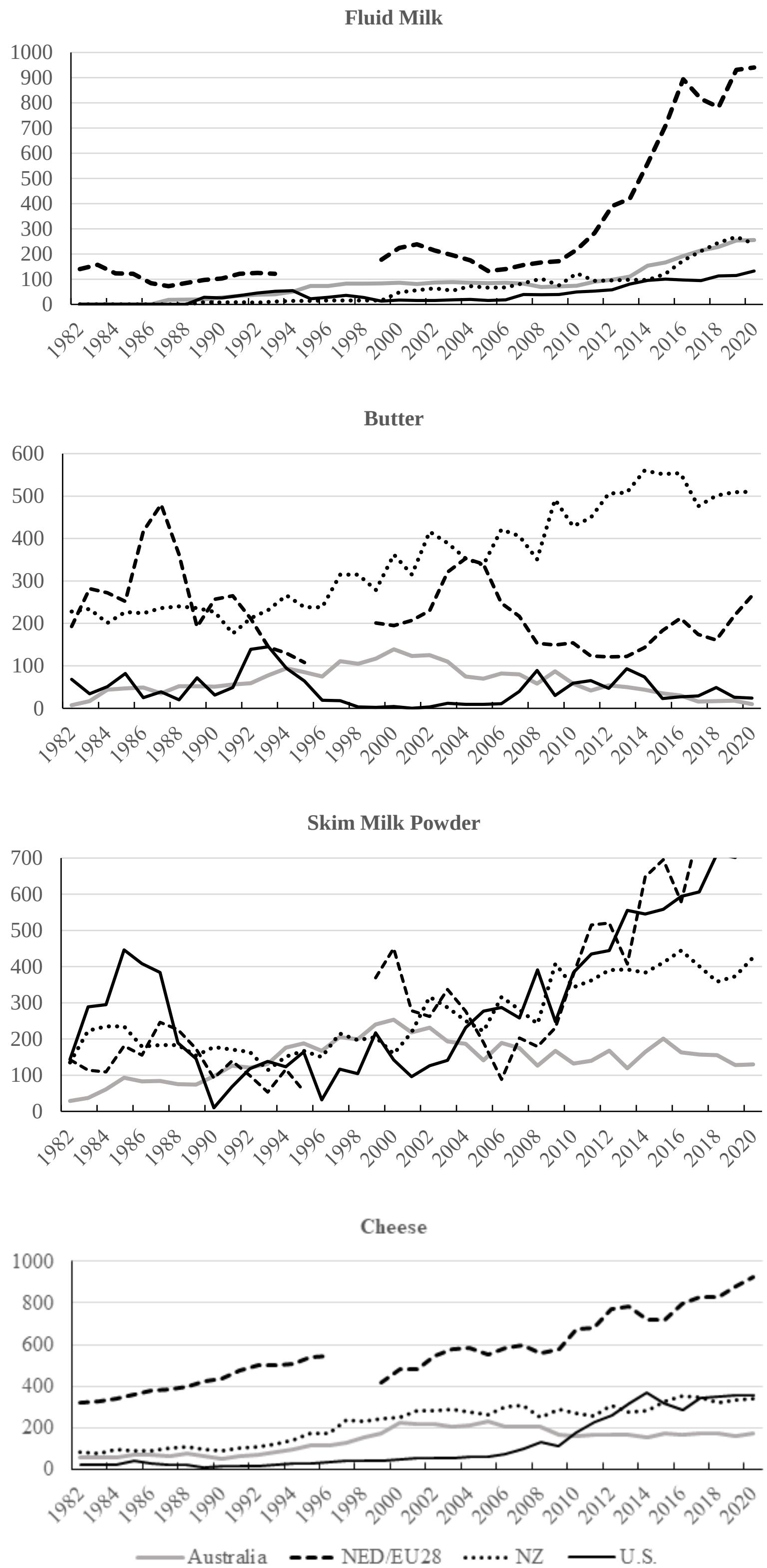

Figure 3: Annual Dairy Exports by Product (kt), 1982-2020 (Source: USDA 2020)

Table 2: Agricultural Market Price Support for Various Agricultural Commodities, Average for the Period 2000-2019, % of Gross Commodity Receipts

Commodity	United States	EU-28	Canada	New Zealand	Australia	China
Wheat	7.46	1.42[a]	2.74	0.00	0.00	17.58
Barley	5.02	3.14	3.90	0.00	0.00	n.a.
Maize	5.08	8.48	5.31	0.00	0.00	19.41
Oats	n.a.	4.74	4.42	0.00	0.00	n.a.
Sorghum	10.18	n.a.	n.a.	n.a.	0.00	n.a.
Rapeseed	n.a.	0.12	1.85	n.a.	0.00	21.57
Rice	9.39	25.13	n.a.	n.a.	0.10	5.85
Soybeans	5.57	0.39	4.04	n.a.	0.00	13.34
Sugar	38.48	29.65	n.a.	n.a.	2.16	29.51
Milk	21.27	14.08	46.57	0.00	0.01	21.01
Beef&Veal	0.09	40.29	2.44	0.00	0.00	6.08
Poultry	0.12	26.20	9.18	11.74	0.00	12.59
Eggs	0.00	0.99	11.52	26.82	0.00	-2.95
Cotton	18.50	n.a.	n.a.	n.a.	0.00	33.66
Potatoes	n.a.	9.30	1.41	n.a.	n.a.	n.a.

[a] For common wheat, whereas it is 10.20 for durum wheat
n.a. = not available from the OECD.
Source: OECD (2020)

Compared to other agricultural commodities in Canada and elsewhere, it is clear that the milk sector is more highly subsidized than other agricultural sectors. As argued above, the Canadian dairy sector is likely as efficient as that in other countries, with yields per cow comparable to those of the U.S. and Europe. By eliminating distortions caused by supply management and taking advantage of economies of scale in the dairy sector, namely, by expanding herd size per farm, there is an opportunity for Canada to expand milk production and processing to take advantage of strong export markets for dairy products.

3.2 Trade Negotiations and Canada's Dairy Sector

When Doha negotiations were suspended on July 24, 2006, the door was opened for countries to pursue bilateral and regional free trade agreements (FTAs).[4] Under various regional trade deals, Canada could lose up to 18% of its domestic milk production by 2024. Canada signed the Comprehensive and Economic Trade Agreement (CETA) with the EU on October 30, 2016, coming into effect on September 17, 2017. As a result, the industry gave up 2.0% of its domestic milk market. This was followed by the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), which was signed on January 23, 2018 by 11 countries, including Canada but not the U.S. or China. It required Canada to give up a further 3.25% of its domestic market.

Finally, the U.S. initiated renegotiation of the North American Free Trade Agreement with Canada and Mexico. During the NAFTA renegotiation talks, Canadian dairy producers lobbied the Prime Minister and other leaders, with all parties in Parliament resolving to protect SM in the dairy sector. Nonetheless, the resulting USMCA agreement (announced September 30, 2018 but not ratified until early 2020) provided the U.S. dairy sector tariff-free access to 3.59% of Canada's milk market. More importantly, tariffs on milk protein isolates, skim milk powder and infant formula—previously Canadian milk classes 6 and 7—were eliminated, which satisfied a major U.S. demand that Canada remove its implicit subsidization via the SM regime of these categories and the accompanying impediments to imports of milk protein isolates. Along with the preference of Canadian consumers for butter fat, this resulted in excess domestic protein production, while WTO rules are an impediment to greater exports of Canadian SMP. As the SMP price falls toward the world price (e.g., see Table 1), the farm-gate price of milk should decline, because farmers receive a blend of the SMP (protein) and butter fat prices, with the final price they receive dependent on the fat versus protein content of the milk they deliver. While the federal government had committed to compensate dairy producers by $1.75 billion for giving up the domestic market under CPTPP and CETA, the sector expects additional compensation for losses under USMCA.

What are the implications for Canada and dairy trade? First, the U.S., Australia and New

[4] For information on the suspension of negotiations, see https://www.wto.org/english/news_e/news06_e/mod06_summary_24july_e.htm#:~:text=The%20Doha%20Development%20Agenda%20negotiations,a%20setback%20for%20all%20members [accessed January 12, 2022]. This is not to suggest that there were no regional FTAs under consideration or in place prior to 2006. Rather, the suspension of negotiations provided an impetus for countries to look to regional agreements rather than a global FTA. See https://www.wto.org/english/tratop_e/region_e/region_e.htm [accessed January 12, 2022].

Zealand have targeted Canada's SM sectors at the WTO. Second, agricultural policy distortions account for nearly 65% of all policy-induced trade distortions, and some 80-90% of these are tariffs and TRQs (Hanrahan and Schnepf 2007). Thus, ongoing WTO negotiations will inevitably seek to eliminate TRQs by increasing quota levels and reducing tariffs on imports above the quota. Third, Canada's diary sector was specifically targeted during USMCA negotiations. It is clear that, until Canada opens up its SM sector to greater competition, including that from exporting countries, the dairy sector will remain a target that the country's trading partners will seek to reform. Therefore, we might contemplate how Canada might fare should it participate in global dairy product markets. Clearly, if the analysis by Carter and Mérel (2016) is correct, and if cow productivity in Canada is about the same as in the U.S. and much higher than elsewhere (Figure 2), perhaps lack of economies of scale (Figure 1) is the only obstacle to the creation of a vibrant, multi-billion-dollar export sector. Some answers can be provided by the dairy-sector trade model discussed in the next section.

4. GLOBAL DAIRY-SECTOR TRADE MODEL: IMPLICATIONS OF DAIRY REFORM FOR CANADIAN TRADE

In this section, we construct a spatial price equilibrium, bilateral trade model for global dairy products. As discussed by Vercammen (2011), a SPE trade model assumes that price differences across regions or countries are the result of shipping and handling (S&H) costs, including tariffs. The theory underlying construction of a SPE model and the appropriate welfare measures to use when dealing with vertical and horizontal chains can be found in van Kooten and Johnston (2021), although SPE modeling has been employed since at least the 1960s (Takayama and Judge 1971).

The objective in the SPE model is to maximize a quasi-welfare function (QWF) given as the difference of area below the demand and above the supply function, net of transaction costs. It can be stated as follows (Paris 2011):

Maximize:

$$QWF = \sum_{d=1}^{M}\left(\alpha_d - \frac{1}{2}\beta_d x_d^D\right)x_d^D - \sum_{s=1}^{N}\left(a_s + \frac{1}{2}b_s x_s^S\right)x_s^S - \sum_{d=1}^{M}\sum_{s=1}^{N} t_{sd}x_{sd}, \qquad (1)$$

Subject to: Dual Variable

$$x_d^D \leq \sum_{s=1}^{N} x_{sd} \qquad P_d^D \qquad (2)$$

$$x_s^S \geq \sum_{d=1}^{M} x_{sd} \qquad P_s^S \qquad (3)$$

$$x_{sd} \geq 0, \forall s,d. \qquad (4)$$

In this specification, there are *M* importing regions (denoted *d*) and *N* exporting regions (denoted *s*). As the current model does not distinguish an importing region from an exporting region, there are *M*=*N* known inverse demand and inverse supply equations, written as $P_d^D = \alpha_d - \beta_d x_d^D$ and $P_s^S = a_s + b_s x_s^S$, respectively. Coefficients α_d, β_d, a_s and b_s are known scalars, while demand and supply quantities are given by $x_d^D = \sum_{d=1}^{M} x_{sd}$ and $x_s^S = \sum_{s=1}^{N} x_{sd}$, respectively, with x_{sd} the amount of product *x* shipped from export region *s* to import region *d*. The x_{sd} are unknown and must be endogenously determined.

Finally, S&H costs were determined by taking differences between market-clearing (demand) prices in each region, with the differences in prices also adjusted for tariffs; in particular, we assume an average tariff rate of 270% on Canadian imports of dairy products. We calibrated the S&H costs using positive mathematical programming (see Paris, Drogué and Anania 2011) by forcing the model to replicate the bilateral trade values in each of the six product trade matrices. The values of the dual variables associated with these bilateral trade constraints are then added to (or subtracted from) the S&H costs to take into account any hidden subsidies or costs (e.g., bribes to offload ships).

For each country, except Canada, we assume the demand price equals the supply price; thus, it is assumed that there are no market distortions in other countries. Canada is assumed to be an exception because its quota regime. In that case, the dual values for the calibration constraints are zero for all regions except Canada. This then assumes there are no market distortions in other regions. Nonetheless, the dual values for Canada may be entirely or only partially due to the quota regime, although it is likely that the dual variables are determined by the difference between the demand and supply prices adjusted for the impact of the tariff and the initial S&H costs. Since the dual variable is positive for each traded product, it constitutes a subsidy that is added to the estimated S&H cost. The adjusted S&H costs are then used for policy analysis.[5]

The parameters of the model used in the current analysis are described in more detail in what follows. We then discuss our data, followed by some results that focus on how Canada might be impacted.

4.1 Model Specification

Objective function

Consider first the dairy processing sector. Each region is assumed to have a set of linear (inverse) demand and supply curves for each dairy product *k*:

$$P_d^k = \alpha_d^k - \beta_d^k q_d^k,\ \alpha_d^k, \beta_d^k \geq 0,\ \forall d = 1, \ldots, M,\ \forall k, \text{ and} \tag{5}$$

$$P_s^k = a_s^k + b_s^k q_s^k,\ a_s^k, b_s^k \geq 0,\ \forall s = 1, \ldots, N,\ \forall k, \tag{6}$$

where $k \in$ {fluid milk, butter, cheese, milk powder, other dairy products}, q_d^k refers to the quantity of commodity *k* consumed in demand region *d*, and q_s^k refers to the quantity of product *k* produced by supply region *s*.[6] There are *M* demand (import) regions and *N* supply (export) regions and, for convenience, it is assumed that each region is both a potential importer and exporter (each region produces and consumes *k*). The objective in the dairy trade model is to maximize the sum of the consumer and producer surpluses across all relevant product sectors. The consumer and producer surpluses are found by maximizing the sum of the areas under the *M* demand schedules (5) and subtracting the sum of the areas under the *N* supply schedules (6). These respective areas are given by:

[5] *As an example, suppose the demand price in Canada is $5 and the supply price is $3, while the (demand and supply) price in a trading partner is $4.50. The S&H cost is initially given by the difference between Canada's demand price and the demand price in the other country, namely, $0.50. However, the true difference is given by the Canadian supply price and the demand price in the partner country, or $1.50. The dual variable would be $1, indicating that the true S&H cost is $1.50.*

[6] For convenience, we use *d* to denote a net demand region and *s* a net supply region, although a region is simultaneously a supplier and demander of the commodity in question.

$$B_d^k = \int_0^{q_d^k} \left(\alpha_d^k - \beta_d^k x\right) dx = \alpha_d^k q_d^k - \frac{1}{2}\beta_d^k {q_d^k}^2, \text{ and} \tag{7}$$

$$C_s^k = \int_0^{q_s^k} (a_s^k + b_s^k x)\, dx = a_s^k q_s^k + \frac{1}{2} b_s^k {q_s^k}^2, \tag{8}$$

where *x* is an integration variable, B_d^k is the total benefit (area under demand) in demand region *d* for product *k*, and C_s^k is the total cost (area under supply) in supply region *s* for product *k*.[7] Given the nature of the objective function, the trade model is solved using quadratic programming.

Now consider the market for raw milk. The demand for milk is a derived demand that depends on the production of downstream fluid milk products, butter, cheese, milk powder, and other dairy products. For each product *k* (≠ farm or raw milk), the derived demand for milk is given by the output price of *k* multiplied by the marginal physical product of the milk input in its production: $P^k \times \text{MP}_{raw\rightarrow k}$, where P^k is the price of *k*. The total derived demand for milk produced on the farm (raw milk) is then given by the horizontal sum of the individual *k* derived demands. However, the change in consumer surplus in the milk market caused by a policy shock in that market (say, dismantling milk quota) can be evaluated in the downstream markets, namely, as the sum of the changes in the producer surpluses in the downstream processing markets—changes in the consumer surplus in the market for raw milk are measured by the changes in producer surpluses in the downstream markets (van Kooten and Johnston 2021). Now, if all raw milk was allocated to the various *k* downstream markets, it is necessary to include in the objective function only the producer surplus in the raw milk market and not the consumer surplus as it would be counted as producer surplus in downstream markets (van Kooten and Johnston 2021).

In the current analysis, farm fresh (raw) milk is distinguished from fluid milk products (see Appendix Table A1), which includes cream, reconstituted milk, evaporated milk and condensed milk. Raw milk is treated solely as an input into the production of other dairy products. To address this, a constraint allocates raw milk to the production of various milk dairy components according to the proportions of farm fresh milk used to produce the various components of the raw milk to products in each region (see Table A2).

The overall objective in the dairy trade model is then to maximize the sum of the producer and consumer surpluses in each of the six types of dairy products downstream from the farm, while

[7] Given lack of data, a supply elasticity of one is assumed (see Vercammen 2011, p.22).

subtracting the S&H costs and associated taxes. The objective function to be maximized can be written as:

$$W = \sum_{k=1}^{K}\left[\sum_{d=1}^{M} B_d^k - \sum_{s=1}^{N} C_s^k - \sum_{d=1}^{M}\sum_{s=1}^{N}\left(t_{s,d}^k + \tau_{s,d}^k\right) q_{s,d}^k\right], \tag{9}$$

where W refers to the overall global wellbeing from trade in dairy products, $t_{s,d}^k$ refers to the S&H costs of transporting processed dairy product k from supply region s to demand region d, and $\tau_{s,d}^k$ is the tax on dairy product k originating in supply region s and exported to region d. Objective (9) is maximized subject to a series of biological and economic constraints relating to milk supply and dairy product manufacturing limits (e.g., the quantities of butter fat and non-fat solids available in raw milk).

Constraints

The essential constraints are material flows and productivity constraints that ensure that total supply equals total demand for each region/country and each product, in addition to the linear demand and supply functions (5) and (6), respectively. Additional model constraints are summarized as follows. First, the sale of dairy products from supplying region s to all consuming regions must be no larger than what is produced in region s:

$$\sum_{d=1}^{M} q_{s,d}^k \leq q_s^k, \forall\, s, k, \tag{10}$$

where M is the number of demand regions. Similarly, the supply of dairy products from all supply regions to region d, and including domestic supply, must be greater than or equal to the demand of region d:

$$\sum_{s=1}^{N} q_{s,d}^k \geq q_d^k, \forall\, d, k. \tag{11}$$

These constraints are a restatement of the earlier equations (3) and (2), respectively.

Finally, to ensure that all of the raw milk is used in some capacity to produce the K dairy products, the model requires that

$$\sum_{k=1}^{K} \rho_s^k q_s^k \leq Q_s^{Raw}, \forall\, s, \tag{12}$$

where ρ_s^k is the proportion of raw milk in region s that is used to produce downstream dairy product k, and Q_s^{Raw} is the amount of milk produced on the farm in region s. To give some notion of the limits that are constraining in the real world, outside of water (which constitutes the largest component of fluid milk at the farm level), Table 3 provides some of the components available from raw milk (all measured in kg).

Table 3: Components of Raw Milk

Item	Proportion[a]
Butter fat	0.032
Cheese	0.119
Skim milk powder (SMP)	0.025
Whole milk powder (WMP)	0.022
Fluid	0.753
Other	0.050

[a] Based on global data for 2018 and proportioned by weight after a reduction factor (=0.2579) when removing water from raw milk at the farm gate. Compare with Table A2.
Source: FAO (2020).

Data Sources

The data used to construct the dairy products trade model come from three sources: the Comtrade website of the United Nations (2020), the Food and Agricultural Organization of the United Nations (FAO 2020b), and the Foreign Agricultural Service of the U.S. Department of Agriculture (USDA 2021). Quantities are in kilograms and values in U.S. dollars. The model is based on 2018 data because this was the latest year for which all the needed data were available.

The data are grouped into one input category, five dairy product categories, and ten regions. The data are categorized as follows: raw (farm-level) milk, which is an input into butter, cheese, powdered milk, fluid milk and other dairy products, and described in Table A1. The ten regions used in the model, and the production and consumption of dairy products in each region, are provided in Table A3. An example of the bilateral trade flow matrices used in the development of the SPE trade model is provided in Table A4 for butter; a similar matrix exists for each of the other five product categories.

Regional supply prices for commodity categories are determined by dividing the value of production by associated quantities. Export values are FOB, while import values are CIF. Therefore, demand prices are given by the import price where the country is a net importer and by the export price where it is a net exporter. In the case of Canada, data from the Canadian Dairy Information Center (2021) and Canadian Dairy Commission (2020) are used to infer Canadian supply and demand prices. Supply and demand elasticities are generally not available for each product category and certainly not for all regions. For simplicity, a supply elasticity of 1.0 is employed throughout because this implies that the supply function goes through the origin and that no adjustment is required to measure producer surplus, as is the case when the intercept of the linear supply function is negative (see Vercammen 2011).

Elasticities of demand are from Carter and Mérel (2016). These authors use a derived demand elasticity for milk in Canada of -0.47 and an elasticity of supply of 1.0, although they also consider supply elasticities of 5 and 10 (p.574). In this study, demand elasticities vary among product categories: -0.47 (raw milk), -0.89 (butter), -0.56 (cheese), -0.98 (milk powder), -0.76 (fluid milk), and -1.01 (other products), with the same elasticity of demand used in each region. Additional information about elasticities can be found in the supplementary material.

As a caveat, however, we should note a lack of finer data regarding product variety (e.g., there exist many varieties of cheese). A more disaggregated approach may be possible for a few regions, perhaps Canada and the U.S., but at the expense of excluding many developing countries that may well constitute primary markets for Canadian dairy products.

To examine the potential for Canadian exports of dairy products, four scenarios are examined.

(1) The baseline scenario assumes that Canada's trading partners are able to prevent Canada from exporting dairy products, while supply management in the Canadian dairy sector maintains a high tariff of 270% on imports of dairy products—Canada is essentially isolated from the rest of the world.

(2) The second scenario represents a situation where there are no impediments to Canadian exports of dairy products but assumes that SM remains in place. However, exports are limited by the production of milk at the farm level, while imports no longer face high tariff levels—a scenario more in line with WTO rules. Although neither of these scenarios is a likely real-world situation, they provide some notion regarding the impact that free trade could have on the dairy sector.

(3) The third scenario assumes the removal of SM in Canada, with the cost structure remaining unchanged (slopes of the marginal cost functions remain the same)—only more can be produced.

(4) Finally, we again assume elimination of SM, but further assume, arbitrarily, that the slopes of

the dairy product marginal cost (supply) functions in Canada are identical to those of the comparable U.S. supply functions. This latter case assumes Canada can be a low-cost producer and thus a global exporter of dairy products. The last two scenarios illustrate an upper and a lower range of possible outcomes for the Canadian dairy sector.

4.2 Results

The model outcomes for each of the four scenarios are provided in Tables 4 through 8; more detailed results are reported in the Supplementary Material.[8] Tables 4 and 5 provide Canadian domestic prices, and domestic production and consumption, respectively. With supply management and no trade with other regions, Canadian dairy market prices (those faced by consumers) are higher than those in other countries or regions, with supply prices also somewhat higher (Table 4).[9] Based on the second scenario, there is little advantage to Canada to allow imports as long as supply management remains in place. For example, the price of butter rises from $4.43/kg in the base case to $4.46/kg when Canada keeps SM in place but allows for freer trade; the price then falls to $3.84/kg and $3.04/kg under the respective high- and low-cost scenarios with completely free trade. With output restrictions in place, our model finds that domestic prices for butter and fluid milk are highest in Canada and among the highest (along with Asia, including China) for cheese, milk powder and other dairy products. If SM is eliminated and free trade is permitted, Canadian consumers will face lower prices and thereby increase consumption, but, unless there is a downward adjustment in the industry's cost structure, dairy farmers and processors do not benefit. From Tables 6 through 8, it is evident that Canadian consumers are the primary beneficiaries of free trade in dairy products.[10] Under supply management, Canadian dairy farmers benefit from the quota rents they receive. Dairy processors in Canada receive higher prices for their product, but their costs of production are higher as well. However, processors gain more than just a quasi-rent because the wedge between price and marginal cost leads to a quota rent—the restricted supply of milk reduces supply in downstream sectors, which results in markets not

[8] In the Supplementary Material, we provide a detailed description of the methods employed along with the input data used in the model and the output tables.
[9] As noted earlier, it is assumed that dairy markets elsewhere are not distorted so that supply and demand prices are equal in other countries.
[10] In the model, consumers do not realize any benefits from a relaxation of trade if the quota system remains in place. Canada will export more dairy products while imports continue to face high tariffs to the detriment of domestic consumers.

clearing at the free market price. That is, not all of the benefits of supply management accrue to farmers, with some benefits from market power likely 'leaking away' over time in a manner similar to that described by Matthews (2017).

Table 4: Prices of Dairy Products under Various Scenarios, Canada (USD/kg)

Product	Scenarios[a]					
	Baseline		Trade w quota		Free trade w high cost	Free trade w low cost
	Demand	Supply	Demand	Supply[b]		
Butter	4.43	0.40	4.46	0.76	3.84	3.04
Cheese	4.75	0.37	4.85	1.15	4.12	3.06
Milk powder	1.48	0.06	1.49	–	0.73	0.42
Fluid milk (incl. fresh)	1.98	0.19	2.00	–	1.35	0.93
Other dairy products	2.92	0.17	2.95	–	2.35	1.69

[a] Demand and supply prices differ only for the 'baseline' and 'trade with quota' scenarios; with no trade distortions, demand and supply prices are equal.
[b] No domestic production of milk powder, fluid milk and other dairy products occurs as domestic consumption is met by imports. While butter and cheese continue to be produced domestically, imports have also made inroads.

Table 5: Production and Consumption of Dairy Products under Various Scenarios, Canada ('000s tonnes)

Product	Ratio[a]	Scenarios: Baseline	Trade w quota	Free trade w high cost	Free trade w low cost
		Production			
On-farm (raw) milk	0.4673	1,330.5	9,218.8	1,064.9	6,707.9
		Consumption			
Butter	0.0126	179.7	179.1	189.0	201.8
Cheese	0.0601	603.7	597.6	642.7	708.4
Milk powder	0.0110	155.5	155.4	165.6	169.7
Fluid milk (incl fresh)	0.3746	3,831.2	3,807.6	4,555.7	5,041.5
Other dairy products	0.0090	99.2	98.8	110.6	123.6

[a] This is the ratio of farm milk utilized to produce six dairy products. Ratios vary by country, from a high of 57.3% in New Zealand to 45.0% in the EU and to a low of 8.5% in other Asia. Ratios are calculated from FAO and ComTrade data.

Table 6: Quasi-rent, Quota Rent and Total Welfare, SM in Dairy and No Trade in Dairy Products, Baseline Scenario ($2018 mil)

Country/Region	Quasi-rent	Quota rent	Consumer surplus	Total welfare[a]
Australia	2,720	-	4,393	7,112
Canada	4,800	813	11,508	17,121
New Zealand	8,490	-	8,735	17,225
USA	33,728	-	32,942	66,671
EU28	69,808	-	96,056	165,865
Other Europe	19,612	-	35,404	55,016
China	3,542	-	4,058	7,600
Other Asia	8,461	-	26,004	34,465
Latin America	8,036	-	19,540	27,576
Rest of World	10,413	-	22,580	32,993
TOTAL	169,611	813	261,220	431,643

[a] This is the value of total global net welfare—the sum of producer and consumer surpluses and quota rents.
Source: Authors' calculations

Table 7: Quasi-rent, Quota Rent and Total Welfare under Free Trade in Dairy Products with Quota Remaining in Place in Canada's Dairy Sector, Quota-with-Trade Scenario ($2018 mil)

Country/Region	Quasi-rent	Consumer surplus	Total welfare
Australia	2,784	4,330	7,114
Canada	11,109[a]	11,361	22,471
New Zealand	8,744	8,548	17,292
USA	34,936	32,077	67,013
EU28	71,472	94,433	165,905
Other Europe	20,096	34,858	54,954
China	3,607	3,983	7,590
Other Asia	8,673	25,628	34,302
Latin America	8,210	19,303	27,512
Rest of World	10,669	22,248	32,916
TOTAL	169,273	256,769	437,069[b]

[a] The surplus accruing to producers will show up primarily as quota rent in this case. Canada producers much less but the high tariffs result in high prices while domestic production falls precipitously.
[b] This is the value of total global net welfare—the sum of producer and consumer surpluses and quota rents.
Source: Authors' calculations

Table 8: Quasi-rent and Total Welfare, Free Trade without and No Quota in Canada's Dairy Sector, High- and Low-Cost Scenarios ($2018 mil)

	High-Cost Structure		Low-Cost Structure	
Country/Region	Quasi-rent	Total Welfare[a]	Quasi-rent	Total Welfare[a]
Australia	2,747	7,113	2,307	7,165
Canada	3,096	17,936	17,231	35,106
New Zealand	8,588	17,248	7,366	16,906
USA	34,087	66,800	28,274	65,903
EU28	70,500	165,877	60,345	165,946
Other Europe	19,812	54,989	17,146	55,502
China	3,573	7,597	3,269	7,781
Other Asia	8,547	34,406	7,592	35,458
Latin America	8,111	27,548	6,789	28,129
Rest of World	10,518	32,958	9,124	33,618
TOTAL	169,579	432,471	159,443	451,512

[a] The difference between total welfare and quasi-rent (producer surplus) is the consumer surplus.
Source: Authors' calculations

When SM is removed in the model, it is not clear that Canadian dairy producers and processors are better off. Under the high-cost scenario, Canadian consumption of all dairy products rises as domestic prices fall (with demand and supply prices equating), but production falls in the high-cost scenario as Canada imports dairy products from the U.S. and Europe (see supplementary material). While Canadian prices are lower for all dairy commodities, prices in other jurisdictions are unchanged or slightly higher. Under the low-cost scenario, however, Canada becomes a major exporter of dairy products to all other regions. Production of milk would increase fivefold, while consumption would rise by some 15% depending on the commodity (e.g., 12% increase in butter consumption, 17% increase in consumption of cheese).

If Canada eliminated SM and became a major exporter, global prices of dairy products would fall. Under the low-cost scenario, Canada would export nearly 680,000 tonnes of butter, mainly to the U.S. and Asia, and nearly 4 million tonnes of cheese, with significant exports of cheese to every region in the model. This scenario demonstrates that Canada does have the potential to become a significant player in global dairy markets, a case already made by Carter and Mérel (2016), among others.

Given that the focus of the current study is on the welfare effects, especially the impact of dairy reform on producers' wellbeing, we now turn to the insights one can draw from the trade modeling results in compensatory terms. A notion of the welfare measures under the current SM system can be deduced from Tables 6 and 7. Neither table adequately represents the current situation because no exports are permitted in the base case scenario in Table 6, while exports and imports are freely permitted in Table 7, but constrained by a quota system. Benefits to the dairy sector (including quota rents) are estimated to be between \$5.6 and \$11.1 billion annually, with this amount required to cover investments in land and capital associated with processing, marketing, machinery, buildings, equipment, land and animals—the annual payment needed to cover investments in these assets. When consumer surplus is included, the total surplus (welfare) from the dairy sector is estimated to be some \$17.1–\$22.4 billion annually (Tables 6 and 7). Under free trade, total social welfare increases to \$17.9–\$35.1 billion (Table 8), a potential increase of 4.7 to 56.7 percent. The surplus available to Canadian dairy producers (farmers and processors) could fall under free trade if the sector is not able to compete internationally, as indicated by comparing results in Tables 6 through 8. However, Canadian consumers benefit.

The results have an implication for the potential compensation that might be required if the SM system were eliminated. If we compare the total surplus received by producers in the base case (Table 6) and compare it to the surplus under free trade with a high-cost structure (Table 8), producers (processors and farmers) would lose some \$2.5 billion annually. However, much of the surplus accrues as quasi-rent (producer surplus) that is charged to fixed investments, rather than rent accruing to quota. One reason that producer surplus falls in the case of free trade and a high-cost structure is that returns to investments are lower so less is invested in the sector. We consider only the quota rent; this amounts \$813 million per year. Suppose the quota rent is discounted at 22% (see van Kooten 2020); it amounts to a loss of \$3.7 billion (=\$813 mil/0.22). Of course, this scenario assumes that neither Canada's dairy farmers nor downstream processors could gain from economies of scale.

Conversely, if the elimination of SM and implementation of unimpeded global trade leads Canada to become a major player in global dairy markets, there would be an increase in surplus accruing to producers from \$2.5 billion to \$17.2 billion, or gain of \$14.7 billion, including a loss of \$813 million annually associated with the elimination of the quota rent. Again, it is the benefits to consumers that should not be overlooked. Consumer surplus increases from \$11.5 billion to \$17.9 billion upon elimination of the quota system and a move to free trade, regardless of whether the Canadian dairy sector is more or less competitive with that of other regions.

5. DISCUSSION

Supply management has been the norm in Canada’s dairy sector for some 45 years. It has historically been an obstacle in international trade negotiations and a source of economic distortion in the domestic economy. While other states that adopted SM have subsequently found it wanting and abandoned it, Canada has steadfastly supported its quota regimes. However, if supply management were to be reformed in the future, dairy producers could then be covered under Canada’s existing business risk management programs, helping them manage risks in the same way that farmers do in other sectors. Nonetheless, to facilitate a transition away from supply management, it will be necessary to provide dairy farmers with compensation, especially those who have not yet recouped the cost of purchasing quota (van Kooten 2020a).

The benefits of restricting milk output accrue to very few in society, while imposing a large burden on consumers, especially the poorest in society. With the exception of a few dairy producers who have benefitted from rising quota values, even farmers themselves are harmed by a dairy quota regime as they carry unnecessary debt, have difficulty expanding output to take advantage of economies of scale, and are unable to take advantage of potentially lucrative export markets. In this study, we provided insights into the potential benefits of reforming the dairy quota system so that producers are free to expand their enterprises and thereby facilitate sale of dairy products in an expanding world market.

In the present analysis, we provide values that could be used to inform a compensation scheme. Overall, based on the research in this study, dairy sector producers could gain significant benefits if they are free to compete in international markets. The benefits that accrue to Canada outweigh any potential losses to producers in the high-cost scenario, thereby implying that compensation might be required. Under the low-cost scenario, the benefits to both producers and consumers are higher than in the baseline scenario, implying that there is a potential for a Pareto improvement without the need for compensation.

Overall, our research suggests that Canada could become a global competitor in multiple dairy trade markets to the extent that both producers and consumers likely stand to benefit from the removal of the current SM regime. The Canadian government should at least reconsider its position regarding supply management, particularly when negotiating free trade agreements such as USMCA.

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7. APPENDIX

Table A1: Source of Dairy Sector Production and Trade Data

Products	**Comtrade[a] HS07 Code**	**FAOSTAT Item Descriptions**
Farm fresh (raw) milk		**Livestock primary**:[b] milk from cows
		Livestock processed:[c]
Fluid products	0401.	Fresh cow whole milk; fresh cream
Butter	0405.	Butter of cow milk
Milk powder	0402.10	Skim milk powder
	0402.21 0402.29	Dry whole cow milk
Cheese	0406	Cheese from whole cow milk
		Cheese from skimmed cow milk
		Whey cheese
		Processed cheese
Other	0404	Condensed whey
		Dry whey
		Fresh whey
		Products of natural milk constitue, nes
	0403.10	Yoghurt
	0403.90	Buttermilk
	0402.99	Condensed whole milk
		Condensed skim milk
	0402.91	Evaporated whole milk
		Evaporated skim milk

[a] Source: United Nations (2020);
[b] Source: http://www.fao.org/faostat/en/#data/QL
[c] Source: http://www.fao.org/faostat/en/#data/QP

Table A2: Proportion of Raw (Farm-level) Milk Utilized to Produce Various Dairy Products and Overall Utilization

Country/Region	Butter	Cheese	Milk powder	Fluid product	Other dairy	Overall utilization of raw milk
Australia	0.011	0.041	0.037	0.251	0.010	0.350
Canada	0.013	0.060	0.011	0.375	0.009	0.467
New Zealand	0.023	0.018	0.119	0.407	0.006	0.573
USA	0.009	0.060	0.011	0.176	0.016	0.272
EU28	0.013	0.051	0.012	0.360	0.014	0.450
Other Europe	0.010	0.019	0.006	0.255	0.004	0.294
China	0.003	0.000	0.057	0.064	0.001	0.124
Other Asia	0.003	0.000	0.004	0.077	0.000	0.085
Latin America	0.003	0.013	0.014	0.069	0.001	0.100
Rest of World	0.009	0.015	0.001	0.232	0.003	0.260
AVERAGE	0.010	0.028	0.027	0.227	0.006	0.298

[a] Source: Authors' calculations based on production data from FAO (2020) and United Nations (2020).

Table A3: Production and Consumption, Trade Model Inputs (‘000s tonnes)

Region	Raw milk	Butter	Cheese	Milk powder	Fluid product	Other dairy
			Production			
Australia	9,289	101	377	341	2,336	97
Canada	9,219	116	554	101	3,454	83
New Zealand	21,392	502	380	2,537	8,699	130
USA	98,687	904	5,914	1,092	17,387	1,562
EU28	164,969	2,094	8,468	2,011	59,421	2,234
Other Europe	82,448	823	1,576	481	21,061	322
China	31,165	79	1	1,782	1,979	26
Other Asia	149,570	503	50	648	11,506	27
Latin America	97,025	261	1,291	1,313	6,701	112
Rest of World	49,897	455	736	67	11,570	150
			Consumption			
Australia		125	321	112	2,059	82
Canada		132	576	89	3,469	78
New Zealand		249	76	59	8,473	44
USA		909	5,734	442	17,341	1,072
EU28		1,975	7,742	957	59,785	1,761
Other Europe		827	1,705	447	20,214	200
China		169	115	2,960	2,554	438
Other Asia		589	594	1,971	11,676	584
Latin America		278	1,495	1,668	6,753	199
Rest of World		585	990	1,668	11,790	285

Source: Authors’ calculations

Table A4: 2018 Bilateral Trade Flows for Butter, based on FAO Production and UN Comtrade Data (kt)

	AUS	CAN	NZL	USA	EU28	OthEur	China	OthAsia	LatinAm	ROW
AUS	92,215	-	63	645	-	-	3,144	4,487	-	412
CAN	43	115,542	-	69	0	-	169	92	-	229
NZL	29,734	4,347	248,937	1,987	6,871	10,754	75,661	44,569	10,929	68,211
USA	377	12,316	54	876,914	2,117	51	171	2,287	5,341	3,873
EU28	2,066	156	63	27,743	1,962,753	15,067	11,041	27,900	4,123	42,869
OthEur	-	0	-	14	3,476	793,754	136	25,363	0	516
China	-	-	-	-	-	-	78,169	1,118	2	0
OthAsia	77	1	5	290	0	4,961	64	483,146	375	13,840
LatinAm	-	0	-	1,068	160	2,786	1	1	257,170	3
ROW	12	-	-	62	10	0	0	75	0	455,111
Consum-ption	124,525	132,362	249,123	908,792	1,975,388	827,373	168,554	589,039	277,941	585,065

Source: FAO (2020), United Nations (2020) and author’s calculations.