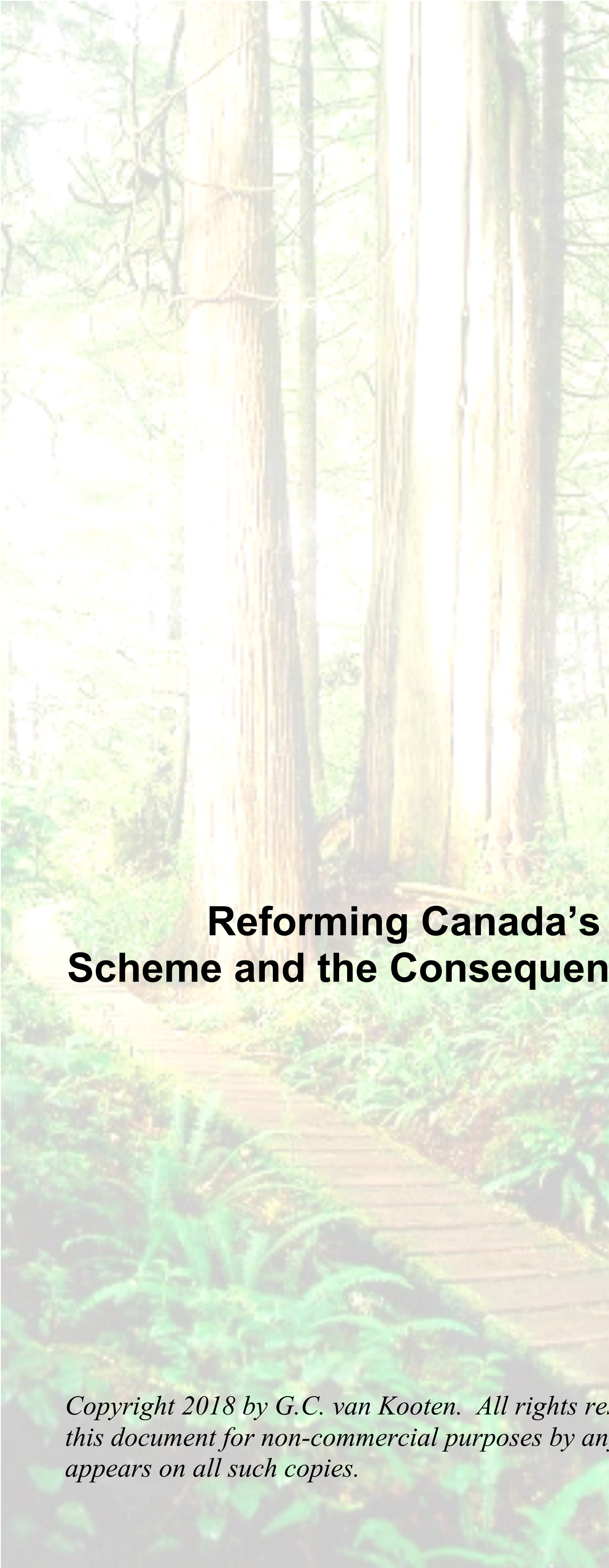

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2018-03

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

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May 2018

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

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March 27, 2018

Acknowledgements: Subject to the usual qualifier that they not be held responsible for any errors of commission or ommission, the author wishes to thank Rick Barichello, Jim Vercammen, Roel Jongeneel 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. The research was conducted as part of the author's general program of agricultural economics research related his Canada Research Chair program; the views expressed herein and any errors and omissions are solely his responsibility.

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

Canada's supply-restricting marketing system has come under fire on many occasions. When conclusion of the Doha round of trade negotiations under the auspices of the World Trade Organization (WTO)[1] appeared imminent, Canadian agricultural economists asked "whether the current supply-managed system should be realigned only to be consistent with the new trade rules [that had yet to be determined], or if more fundamental changes should be undertaken to better position the industry for the future" (Barichello et al. 2009). Although the Doha round of multilateral trade negotiations has not yet been concluded, regional trade negotiations have taken over the agenda. Thus, Canada concluded a Comprehensive Economic and Trade Agreement (CETA) with Europe, signed the Comprehensive and Progressive Agreement related to the Trans-Pacific Partnership (TPP-11, sans U.S.), and is in the middle of re-negotiating the North American Free Trade Agreement (NAFTA). Although CETA and TPP-11 had a minor impact on Canada's supply-managed sector (the limit on imports of EU cheese has been increased slightly), NAFTA has the potential to have a much greater impact as the U.S. targets greater access to Canada's dairy market (e.g., see PBS 2018; BBC 2017; Dewey 2018).

Recently, Stephens (2017) noted that:

> *"One issue on which currently there is little clarity is that of supply management. Both the US and New Zealand pressed Canada for more access to its closed dairy market, and the US continues to do so in the context of NAFTA. In the original TPP, Canada agreed to open 3.25 percent of its market to dairy imports from TPP countries. Even this limited and long overdue reform came with a hefty price tag as the then-Conservative government promised over Cdn$4 billion in compensation to Canada's 12,000 dairy farmers (plus chicken and egg producers) to offset this minimal opening. The Trudeau government, like all previous governments, has signed on publicly to the myth that supply management is good for the Canadian economy. More realistically, it does not want to pay the political or financial price for opposing this powerful lobby. ... NAFTA discussions on this topic are still ongoing so nothing is going to happen regarding supply management until the NAFTA angle is sorted out."*

It is clear that pressure for Canada to reform its supply management (SM) programs, especially in dairy, will not easily go away (e.g., see Barichello et al. 2009). The potential benefits to

[1] The WTO was formerly known as the General Agreement on Tariffs and Trade (GATT).

Canadian consumers are obvious, but there are also benefits to producers as they could then take advantage of economies of scale and gain access to international markets, especially markets in rapidly developing countries whose citizens prefer dairy products from rich countries like Canada because of food safety concerns.

The current study focuses on the dairy industry although it also helps to inform policy regarding the other supply-managed sectors (eggs, chicken and turkey). It has two objectives:

1. To recommend one or more avenues for reforming and/or eliminating the dairy quota system, and provide estimates of the potential cost of compensating producers.
2. To construct a spatial price equilibrium, international trade model for analyzing policy related to Canada's dairy sector.

Our study begins in the next section by providing background information about Canada's supply-managed sector, focusing specifically on dairy. As part of the background discussion, I examine the economic theory and literature on this topic in the Canadian context. This is followed, in section 3, with a review of how other jurisdictions have reformed or eliminated SM in tobacco (U.S., Canada), peanuts (U.S.), dairy (Australia, EU) and sugar beets (EU). In section 4, I discuss a theoretical framework proposed by van Kooten (2018b) for reforming Canada's dairy sector. Then, based on the theoretical framework, data on milk sales, prices, quota levels and the value of quota, and assumptions about supply and demand elasticities will be used in section 6 to estimate the costs of compensating dairy producers under various assumptions (e.g., see Jongeneel et al. 2011). In this regard, information on buyouts in other countries and sectors and economic theory will serve to guide the analysis.

Finally, a spatial price equilibrium (SPE) dairy trade model that links fluid milk production to butter, milk powder, cheese and other products is developed. A background to trade issues in agriculture is provided in section 7, while the trade model is discussed and then used, in section 8, 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/buyout package. A concluding discussion ensues in section 9.

2. ECONOMICS OF SUPPLY-RESTRICTING MARKETING BOARDS IN CANADA: A REVIEW

Canada maintains a stronghold on its supply managed dairy sector, despite a spate of economic studies that oppose supply management (e.g., Veeman 1982, 1987, 1997; van Kooten and Spriggs, 1984; van Kooten 1988). In 2005, for example, the House of Commons unanimously passed a motion asking the government not to give up any protection for supply-managed sectors in international trade negotiations; this was re-affirmed in the Government's 2011 Speech from the Throne (Busby and Schwanen 2013). What accounts for this gulf between the politics and economics of SM in Canada? To get perspective, I begin in the next subsection by examining the economics of SM and why it leads to rent seeking by farmers and acquiescence by politicians. This is followed by a discussion of the origins and implications or repercussions of SM in Canada's dairy sector.

2.1 Supply Management: Background Economic Theory

By restricting supply, no cost is imposed on the public treasury, except perhaps expenses related to the implementation and governance of a quota scheme – the costs of maintaining a supply-restricting marketing board that sets production levels, allocates output across producers, sets rules for transferring quota, sets import quotas (if any), and monitors compliance. A quota scheme essentially transfers income from consumers to producers. The economic implications of a quota system can be demonstrated with the aid of Figure 1.

By restricting the supply of milk to q^R, the relevant supply curve becomes vertical as indicated by the dark curve S^R – producers are allocated a production quota to prevent output from exceeding q^R. In Figure 1, q^R is chosen so that the profit to the producers as a group is maximized, which occurs where the marginal cost function, represented by the sector supply curve S, intersects the marginal revenue (MR) function. With less output entering the market, producers receive P_S which is also the price consumers pay, but the producers' supply cost is only c. The deadweight loss is $d+e<h$, where h measures the deadweight loss associated with a support program that sets the producer price at P_S but allows the market to clear at (q^C, P_C), and the cost to the treasury is given by the large rectangle $(P_S - P_C)\times q^C$.

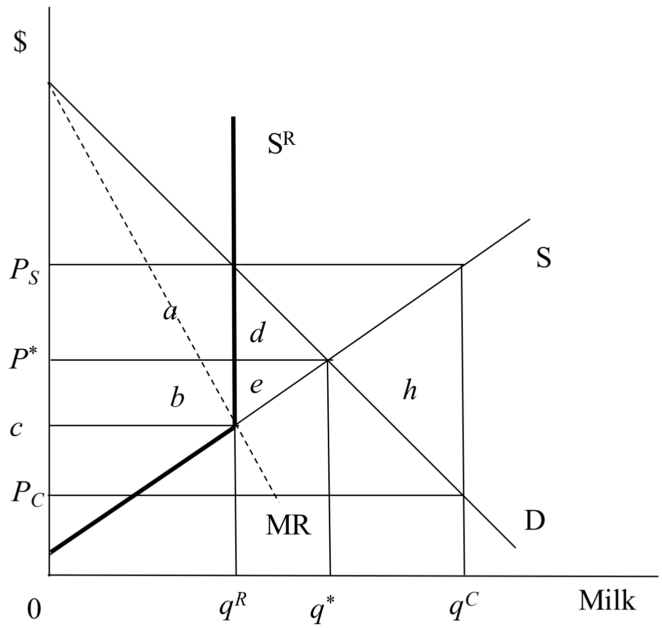


Figure 1: Welfare Impacts of Restricting Supply

In going from free trade, given by (q^*, P^*) to restricted trade (q^R, P_S) in Figure 1, consumers lose surplus rectangle *a*, which constitutes an income transfer to producers, plus triangle *d* which constitutes a deadweight loss. Producers, on the other hand, gain area *a* but lose triangle *e*, which constitutes the second component of the deadweight loss. It is important to recognize that there is a leakage or the loss that occurs when income is transferred from consumers to producers in regulated industries. This loss is often greater than estimated: Van Kooten and Taylor (1989) proved that, for linear supply and demand functions, the marginal leakage (ML), or marginal welfare loss, is always more than twice as large as the average leakage (AL), which is the measure usually employed by economists. For more general demand and supply functions, the ML = $-\varepsilon\ \delta$, where ε is the price elasticity of demand (at point q^R) and δ is the Lerner index (= 1 – MC/P) (van Kooten and Taylor 1989). Thus, the marginal leakage from supply restrictions depends only on the elasticity of demand, the output price (P) and the marginal cost of production.[2]

In Figure 1, the wedge between price (P_S) and the marginal cost to producers (*c*) results in

[2] ML is defined as the marginal social loss divided by the marginal consumer loss. If we define K = (marginal gain to producers)/(marginal loss to consumers), then K = 1 – ML; K=1 at q^* and K=0 at the monopoly solution. We can judge how close q^R is to the monopoly outcome from values of K. For the late 1980s, van Kooten and Taylor (1989) estimate K to be 0.4 for poultry, 0.35 for eggs and 0.30 for dairy.

a policy-induced scarcity rent equal to area $a+b$, which is known as the quota rent. That is, the right-to-produce now has value, determined as follows. The annual rent R_A received by a dairy producer is given by producer's quota q multiplied by the difference between the market price and the marginal cost of production: $R_A = q \times (P_s - c)$. However, R_A should not be confused with the gain to producers from the establishment of a quota regime. Compared to the free trade situation, producers gain area (a–e), as noted above; one expects that this area is generally smaller than R_A. Further, as argued below, compensation should be based on area (a–e) as opposed to R_A.

Nonetheless, the quota rent is correctly measured by R_A. Thus, if the quota scheme is assumed to continue into perpetuity, the value of quota would equal $QV = R_A/r$, where r is the rate used to discount future quota income. One unit of quota is worth $(P_s - c)/r$. Since the quota scheme is not likely to continue into perpetuity as there is a risk that outside lobbying will result in the eventual demise of the quota regime, the discount rate r used to discount the annual stream of quota rents will be high, although r will vary from one producer to another.

The true value of quota can only be determined in a market where quota is bought and sold, although estimates of quota value can be made on the basis of farm management studies and/or estimates of demand and supply elasticities. An example of the latter occurs when quota is attached to a factor of production, such as land, equipment or livestock. In that case, information from farm management studies, which compare the true costs of various factors of production with the quota-inflated costs, could help determine the value of quota. In other cases, farm management studies can provide estimates of the marginal operating costs, thereby enabling one to identify the gap between the known selling price and marginal cost.

The last piece of information that is then needed to determine value of milk quota – in order to determine QV – is the rate producers employ in discounting the future stream of annual quota benefits. During the early 1990s, the discount rate employed by farmers in valuing quota averaged between 20 and 49 percent (Chen and Meilke 1998), suggesting that they perceived a high risk that the quota system might be reformed; when the Uruguay Round of the GATT was completed in 1994 (see section 7 below), the value of quota rose dramatically indicating that the perceived discount rate (and risk factor) declined accordingly (see Barichello et al. 2009). It is important to recognize that, because a dairy producer pays for quota, the costs of buying quota will ratchet upwards the costs of production. The original quota owners capture the initial windfall (assuming they did not pay for quota) with other producers also reaping a windfall in situations where the government provides quota at no cost to the producer.

Now suppose that a quota regime is implemented so that the world price is below the domestic support price P_S. Then there are two other drawbacks to restricting domestic supply of a commodity. First is the need to restrict imports, which leads to lobbying by trading partners to open up the supply-restricted market. As discussed in section 7, trade negotiations could result in an increase in the tariff-rate quota and a reduction in the over-quota tariff rate, and eventually to the elimination of the quota scheme. Further, a quota system could potentially impede exports of the supply-restricted commodity if the domestic price is above the world price for three reasons: (1) The authority may prevent exports (as in Canada); (2) domestic production costs may be too high because producers cannot access sufficient quota to benefit from economies of scale; or (3) exports are a 'red flag' that elicit charges of dumping from trading partners.

To the extent that producers have a right to or an investment in quota, governments may need to compensate producers to get them to acquiesce to changes in a supply-restricting marketing system. This might be required if the authority agrees to modify or eliminate a quota system as part of international free trade negotiations. The authority might need to buy back quota, which requires a determination of a fair buy-back price. If a market for quota exists, prices for quota can be used as a basis for determining compensation, but are an overestimate of the actual compensation that should be paid. If data on quota values are not available, and as a check on the level of compensation if such data are available, it is necessary to determine the quota value based on estimates of areas *a*, *b* and *e* in Figure 1.

2.2 Origins and Challenges of Supply Management

Supply management in Canada's dairy sector began with the establishment of the Canadian Dairy Commission (CDC) in 1966. This was followed in 1970 by a National Milk Marketing Plan to control supply, with Quebec and Ontario along with the federal government as the original participants. The enabling legislation for SM in agriculture was not passed until two years later, with the Farm Products Agency Act (1972), which became the enabling legislation that established SM boards in eggs (1973), turkey (1974), chicken (1978), and chicken hatching eggs (1986) – the 'feather industries'. By 1974, all provinces except Newfoundland had signed on to the National Milk Marketing Plan – the start of a dairy quota system.

In the dairy sector, separate SM boards were established in each province. The Canadian Milk Supply Management Committee (CMSMC) measures consumer demand for milk and sets the national target for production of butterfat accordingly; the CDC serves as a secretariat of the CMSMC. Meanwhile, the federal government abrogated its responsibility over trade in dairy by suppressing interprovincial trade and permitting provinces to ban exports of dairy products by quota holders and non-quota holders alike (Busby and Schwanen 2013). Because exports are banned, Canada has not benefitted from the rapid growth in demand by China and other developing countries for dairy products from rich countries as such products were considered safer than domestic product. Nonetheless, Canada's SM regime seems more entrenched than those in other jurisdictions, particularly the dairy marketing system. The main reason is the lobbying power of the industry, particularly in Quebec.

Since the mid-1970s, the price of milk in Canada has been guided by a cost of production formula that includes the cost of purchasing quota, so that costs and thus prices are continually ratcheted upwards.[3] It works as follows: The CDC coordinates with the provinces to maintain a farm-gate *target price* that is based on a survey of production costs. Based on this information, the CDC calculates annual *support prices* for butter fat and skim milk powder, and agrees to purchase any surplus butter and milk powder at those prices. In practice, farmers sell to their province's milk marketing board, which establishes prices for the various milk classes so that the weighted average price is close to the target price. One cost of production that somehow needs to be covered is the quota asset – farmers need to pay for any quota they purchase and this becomes a cost of production that must somehow show up in the CDC's annual cost of production survey (see Table 3, section 6.2). The value of quota is discussed in section 5 below, but it amounts to approximately $30,000 per cow (Barichello et al. 2013).

The impact of SM on consumers is important because high prices hurt the least well off more than middle and upper class citizens. The farm-level price of milk (nominal US$/cwt) averaged $29.9 in Canada over the period 2007-2010 (~$33 in January 2010), $16.4 (~$16) in the U.S., $19.2 (~$17) in the EU, and $14.5 (~$16) in New Zealand (Barichello et al. 2013). The

[3] It is unlikely that the cost of quota is a particular line item on the survey used by the CDC to calculate the cost of production (see Table 3, section 6.2 below); rather, this cost will appear as a financial cost or payment (much like a mortgage payment).

cost to Canadian consumers is particularly pronounced at the retail level; as shown in Figure 2, the retail price of whole milk in Canada diverged significantly from that in the U.S. beginning around 2001.[4]

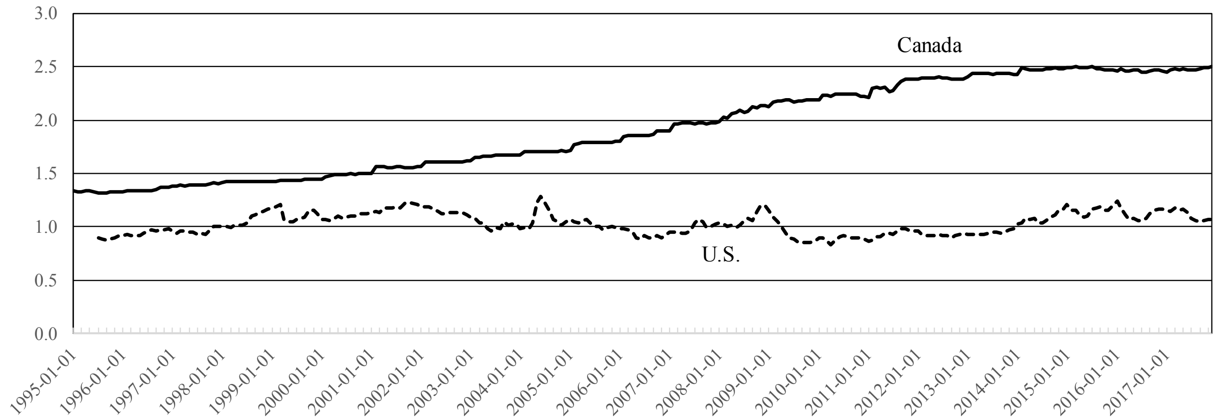


Figure 2: Whole Milk Retail Price, 1995-2017, $CDN/liter
Source: Statistics Canada, US Bureau of Labor Statistics

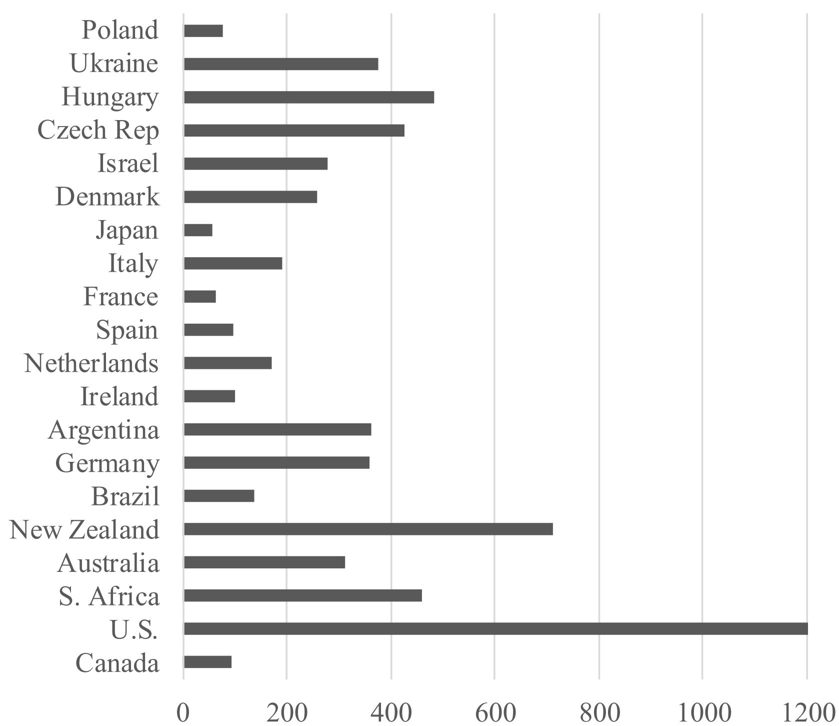


Figure 3: Average Size of Dairy Herds, Selected Countries, 2017
Source: IFCN (2017, p.7)

[4] Data are in Canadian dollars per liter, with U.S. data converted from USD per gallon using a conversion of 3.78 liters per U.S. gallon and the monthly exchange rate.

There is also the argument that, as a result of the quota regime, Canadian dairy farms are less efficient that those elsewhere. As indicated in Figure 3, average dairy herd size in Canada is well below that of the U.S., Australia, New Zealand, Brazil, Argentina, Israel, South Africa, and many European countries. It is about the same size or slightly higher than countries such as Japan and Norway (not shown) that protect their agricultural sectors from outside competition, and higher than that of most but not all developing countries (not shown). Interestingly, average herd sizes in France, Poland, Spain and Ireland are also low, while those of Germany, the Netherlands, Czech Republic, Hungary and Ukraine are much higher. Low average herd sizes in France and Spain are associated with a large number of marginally small operations, while large average herd sizes in Hungary, Czech Republic and Ukraine are the result of collectivization that occurred during communism; collectivization had not taken root in Poland, so it has many smaller farms.

Compared to the major exporting countries of New Zealand, the EU28 (as opposed to individual countries), Australia and the U.S., which is its main trading partner, the average cow herd size in Canada is quite small. Nonetheless, average yields per cow are higher than those in almost all other countries, except the U.S. and certain European countries (such as the Netherlands). This is evident from Figure 4.

Overall, it would appear that SM in dairy has prevented dairy producers from achieving economies of scale with respect to herd size, but still provided sufficient incentives to ensure that production per cow was above that in most other jurisdictions. This suggests that Canadian dairy farmers would be able to compete effectively with those in other countries if they were able to expand their herds. One obstacle in this regard is the ability to purchase quota and its high cost; but, if farmers could export dairy products without needing to purchase quota, they should be able to compete on a world scale. Nonetheless, without open borders, trading partners would lobby against Canadian dairy exports as they already do with regards to Canada's exports of skim milk powder (see PBS 2018).[5]

[5] Since supply of the fat component of milk is controlled, the high-protein non-fat component in the form of skim milk powder is often excessive and exported, although such exports are to be prohibited under international rules by 2020.

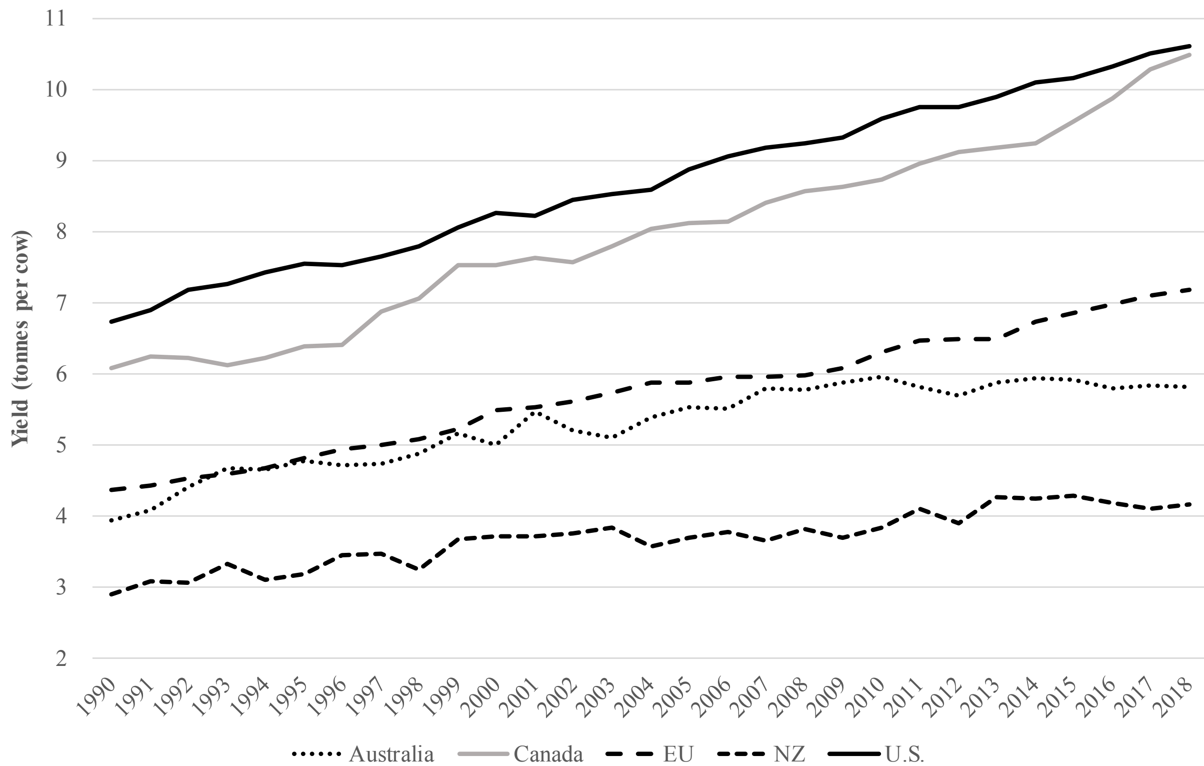
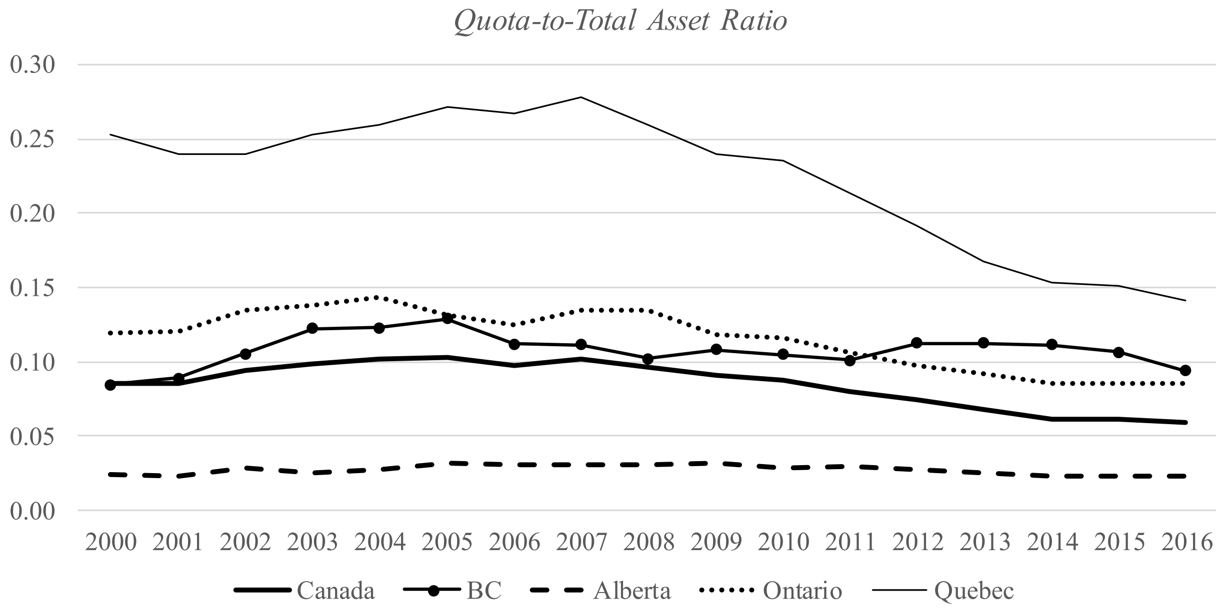


Figure 4: Yield per Cow, Selected Countries and EU28 (Source: OECD 2018)

How important are quota assets to the Canadian farmers' balance sheets? Data are not available for separate sectors within the supply managed segment of agriculture, so it is not possible to examine the importance of dairy quota directly. The value of quota assets is plotted against total assets, and against non-quota assets, in Figure 5 for the period 2000-2016. This information complements that provided by Barichello et al. (2009), who found that quota value rose dramatically after 1994 (as discussed above). As a proportion of total assets (non-quota assets), national quota assets peaked at 10.3% (11.5%) in 2005, but they peaked in 2007 at 27.8% (38.5%) in Quebec and at 14.4% (16.8%) in Ontario in 2004. As indicated in Figure 5, quota values have declined significantly since the mid 2000s, especially in Quebec; this suggests that perhaps the rate used to discount quota rents has risen due to the potential risk of reform. Even so, it is clear that Quebec and Ontario hold the greatest quota assets (bear the greatest risk of potential reform of the SM system), and that these assets constitute a primary component of farm wealth.



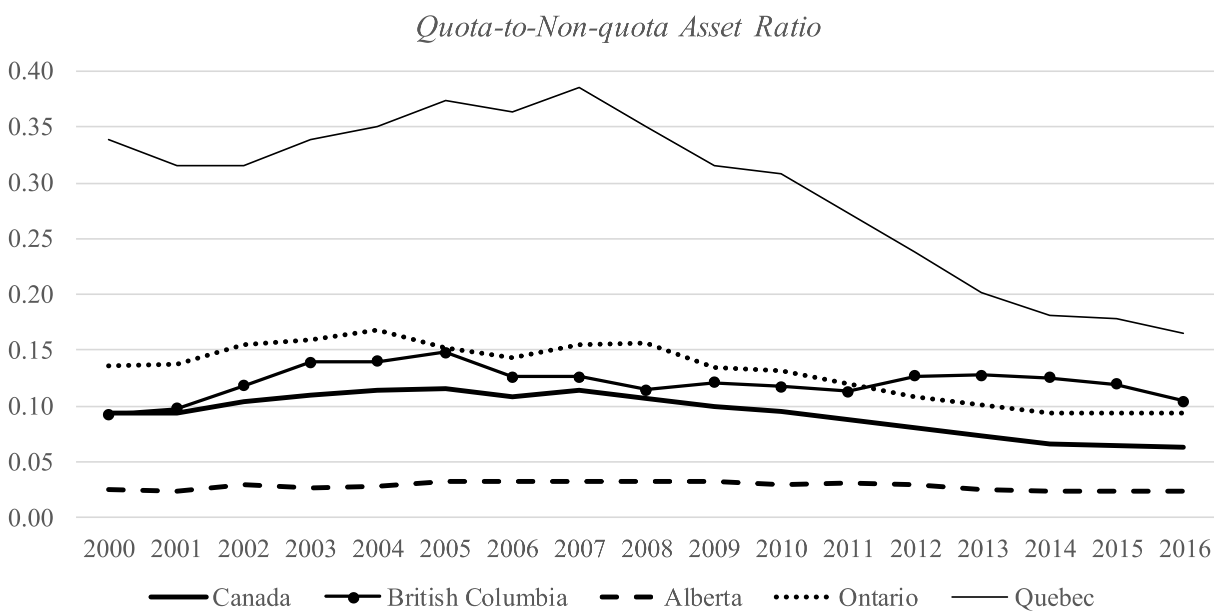


Figure 5: Value of Quota Assets to Total Farm Assets and to Non-quota Farm Assets, 2000-2016
Source: Statistics Canada (2017)

2.3 Reforming Supply Management

Given the forgoing discussion and despite entrenchment of supply management in Canada, various commentators have proposed means for reforming SM, particularly in 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 price for butter, cheese and milk powder until a benchmarking exercise indicates that dairy producers are as efficient as their U.S. competitors (Busby and Schwanen 2013). The argument suggests that, if the Canadian Dairy Commission were required by law to cap its support prices, there would be a "trickle down impact on industrial milk prices [set by the provinces] and, then, on fluid milk prices since all these products come from the same source" (Ibid., p.16). 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 the needed economies of scale, while wage and other cost increases associated with economic growth would inhibit the reductions in domestic milk prices required to bring them down to the international level.

Agricultural economists had earlier considered how Canada might dismantle its dairy quota (Barichello et al. 2009). While arguing that dairy producers would need to be compensated, they concluded that it would be unrealistic to compensate farmers the $25 billion value of the quota in 2004. Rather, they recommended a compensation package similar to that used in Australia – payments targeted where the largest losses occurred (e.g., targeting most recent entrants, regions most reliant on dairy production) with payments provided quarterly over a period of eight years (although the authority also helped facilitate a lump sum payout through commercial banks). The policy package also focused on reform of the sector to reduce the negative impact on producers. Barichello et al. (2013) did not recommend compensation equal to the value of the quota asset because they believed the growth in quota value over the past decades had created an asset price bubble.

It is clear that reform of SM in the dairy sector will likely require some form of compensation for producers. In the next section, compensation for reform of quota systems in other jurisdictions and for other agricultural products is reviewed. A particular focus is on the elimination of SM in the EU's dairy program. These investigations help to guide policy considerations for potential reform of Canada's dairy sector.

3. DAIRY REFORM AND QUOTA BUYOUTS IN OTHER JURISDICTIONS

Politicians have employed SM to control the supply of a variety of agricultural commodities, and many of these regimes have subsequently been reformed or eliminated. In this section, I examine some of these beginning with reforms to non-dairy sectors, namely, tobacco in Canada and the U.S., peanuts in the U.S., and sugar beet in the EU. When it comes to dairy, at one time or another, Australia, Canada, New Zealand, the European Union (EU) and, in the U.S., California flirted with some form of quota. The most comprehensive supply-managed dairy marketing regimes were implemented in Canada (1974) and the EU (1984), both of which are characterized by a supra-government with independent states (provinces) that have jurisdiction over domestic agricultural policy but not over foreign trade or even inter-state (provincial) trade. In the next subsections, I first examine reforms in sectors other than dairy; then I focus on the experience of various countries in reforming their dairy sectors, ending with an analysis of the EU reforms.

3.1 Reform in Non-dairy Sectors

As far as I am aware, there exists no analytic framework for analyzing how a dairy quota might be dismantled and compensation paid to producers. There are economic analyses of the tobacco buyouts in the U.S. and Ontario, and a peanut buyout program in the U.S. (Schmitz and Schmitz 2010; Schmitz et al. 2016a, 2016b). The U.S. peanut program paid producers a total of $0.55/lb, with payments spread over five years, costing the government $US 264 million while benefitting society by less than $US 40 million. U.S. tobacco producers were compensated $US 9.6 billion spread over ten equal annual payments. The tobacco buyback program in Ontario based payments on a producer's basic production quota rather than total marketing quota (actual production), where the latter was significantly lower than the former (although based on it). Almost all farmers participated in the voluntary buyout, receiving $275,000 each and costing government $286 million; but the enabling legislation did not prevent tobacco farming and so production increased after the buyout. In effect, producers were highly overcompensated in at least two of the three programs. Thus, the U.S. tobacco buyback program was relatively successful, but the Ontario program failed to prevent current tobacco producers from increasing output and new farmers from entering.

The EU's Common Market Organization for sugar was set up in 1968 and included a quota mechanism to regulate total sugar production, combined with an intervention and trade measure that protected the sugar price from market disruptions.[6] The system included a reference price and a minimum guaranteed price to growers. The total EU production quota of 13.5 million

[6] Information on sugar beets comes from Jongeneel et al. (2018).

tonnes (Mt) of sugar was divided among 19 of the 28 EU member states. Production in excess of the quota ('out-of-quota' sugar) was allowed, but there were strict rules that governed its use. It could be exported up to the EU's annual WTO-determined limit of 1.374 Mt, sold for biofuel or other industrial non-food uses, or counted against the following year's quota (carry-over stocks). The quota regime, price-support system ended 30 September 2017.

Since the previous significant reform in 2006, major reforms resulted in the merger of the so-called A and B quotas, public storage became limited, reference prices for sugar were reduced by more than 30 percent, and, as a result of a 2005 WTO ruling that the rents accruing from A- and B-quota constituted a subsidy to out-of-quota sugar exports (C-quota), export limits were imposed. As a result, the area allocated to sugar beets declined by 873,000 ha (or 40%) during the period 2005-2015. To soften the pain of moving from a quota regime to a free market, member states provide growers with a voluntary coupled support (VCS) payment. Each country could use eight to 13 percent of their direct payment envelope to support a wide range of products, including sugar beet. VCS payments have been widely used to support various farm commodities by all EU countries, except Germany; eleven countries applied VCS to the sugar beet sector. VCS is a direct payment for each hectare allocated to sugar beet production. This payment effectively operates as a price subsidy, the value of which is equal to the per hectare payment divided by the sugar beet yield. Voluntary coupled support (expressed as a price equivalent) lowers marginal costs, thereby incentivizing farmers to produce more – the VCS subsidy induces additional production that is likely to have a downward impact on market prices thereby counteracting the VCS incentive.

3.2 Dairy Sector Reform

Australia's dairy quota system only covered fluid (fresh) milk and not industrial milk (cheese, powders, etc.). While industrial milk could be exported and traded across state lines, fluid milk sales were restricted by state-level supply management authorities under the umbrella of the Australian Dairy Industry Council. The Australian Dairy Industry Council proposed deregulation of fluid milk in early 1999, so that, in 2001, the government removed price supports, providing dairy producers quarterly compensatory payments for a period of eight years to assist farmers in adjusting to the new market. The idea was for Australian dairy producers to use these payments to make investments in machinery and equipment, and in animals; as a result, the Australian dairy industry became more efficient (Balcombe et al. 2007). One interesting aspect of the Australian buyout program was that compensatory payments were targeted at farmers who had most recently purchased quota and at regions more disadvantaged than others. That is, not all quota was compensated at the same level – equity, 'fairness' and factors dictated how payouts were allocated.

EU dairy policy was originally formulated in 1968 under CAP Regulation 804/68.[7] Quotas on milk production were introduced in 1984, but the basic mechanism of public regulation had remained unchanged since 1968. Policy instruments included support prices for butter and skimmed milk powder (SMP), import tariffs and TRQs, stock holding, export subsidies, and, after 1984, country-level marketing quotas on milk. Multilateral trade negotiations during the 1990s led to ceilings on the quantities and value of subsidized exports, which became increasingly constraining over the period 1995 to 2000. Then, beginning in 2008, the EU began to dismantle its dairy quota system, completing the transition to a competitive market by mid 2015, although many member states continue to intervene to protect their domestic dairy sectors. Indeed, if markets had functioned perfectly, dairy production would likely have gravitated to the lowest-cost producers, perhaps the Netherlands and Ireland.[8] Dairy producers in the EU were compensated using deficiency payments, which also facilitated retention of dairy farmers in each state. This is discussed in more detail below.

In the U.S., dairy producers had been supported by the Milk Income Loss Contract (MILC) that provided a deficiency payment if the market price fell below the threshold price, limited by the pre-set quantity of milk produced (Novakovic and Wolf, 2016). When grain prices increased as a result of biofuel policies, the threshold price was increased. Then in the 2014 Farm Bill an insurance product was added to the MILC. Thus, although the U.S. dairy program placed some restrictions on dairy production, it never relied on a true supply-restricting management system. Somewhat similarly, New Zealand has not adopted supply management because 94% of its dairy output is exported, mainly to Southeast Asia (Conforte et al. 2008).

[7] Here and throughout CAP refers to the Common Agricultural Policy of the European Union.
[8] Indeed, Dutch farmers greatly expanded their herds when the quota was lifted, but the EU subsequently declared potassium found in manure to be a hazardous waste, which meant that Dutch farmers could not dispose of the manure without being in violation, nor could potassium be exported as it was a hazardous waste. As a result, the Netherlands was required to cut back its dairy herd. Thus, the opening of dairy markets did not come without controversy.

3.3 Reforming the EU's Dairy Quota: Welfare Economic Analysis

In this section, I examine the elimination of the EU's dairy SM regime using the tools of applied welfare economics. Although this stylized analysis is meant to shed light on how we might approach major SM reform in Canada's dairy sector, the main difference between the two situations is that the EU has been a net exporter of dairy products both with and without a quota regime, while Canada is a net importer.

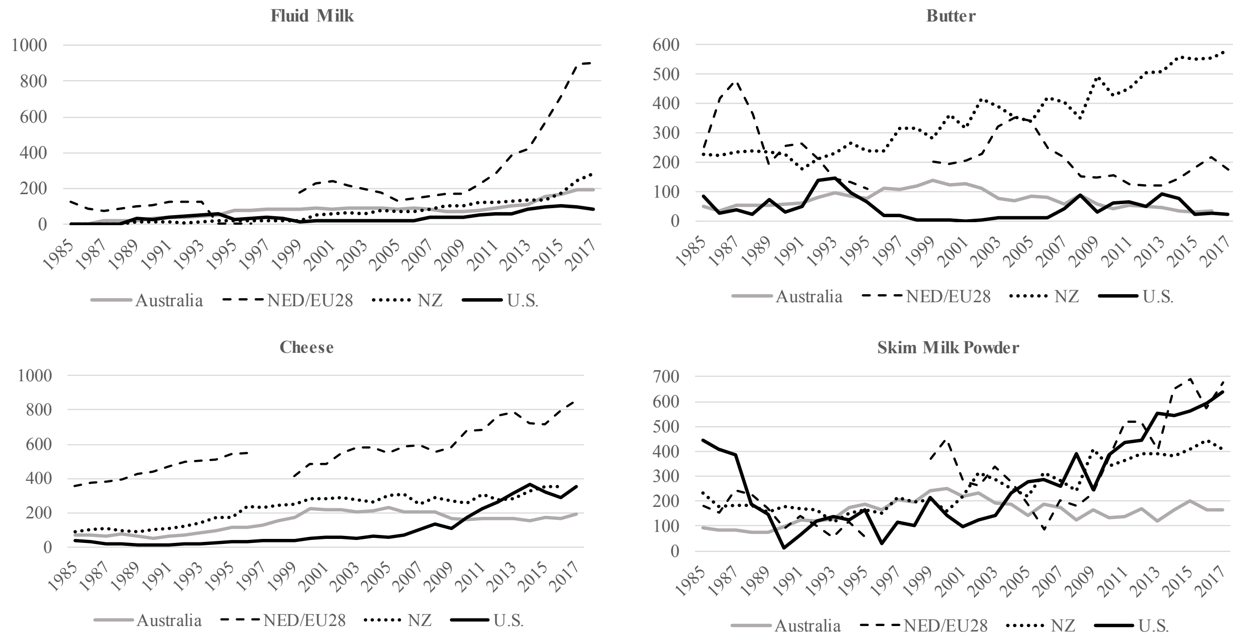


Figure 6: Exports of Fluid Milk, Butter, Cheese and Skim Milk Powder by Selected States, 1985-2017 ('000s tonnes) Source: USDA (2017)

Consider Figure 6. It shows that, at least since 1985, the European Union has dominated the export market for dairy products, both in terms of quantity and value even though only quantity data are provided in the graphs. Since EU28 export data are only available from 1999 to 2017, data for the period 1985 to 1995 are for the Netherlands, which was and continues to be a major exporter of butter and cheese.[9] Within the EU, the largest producers of milk are Germany and France, followed by Poland, the Netherlands and Italy, with the Germany, France and the Netherlands the largest exporters (and the Netherlands ahead of France in the export value of cheese). Despite its relatively small size compared to the other four countries mentioned here, the

[9] Export information for the Netherlands is not comparable to that of the EU because it includes sales to other EU member states. Nonetheless if provides a picture of the importance of dairy exports to EU countries.

Netherlands is considered the most efficient producer of dairy products, which has resulted in some friction as markets were liberalized.[10] What is also notable in Figure 6 is the importance that Australia and especially New Zealand (NZ) play in export markets.

Beginning with the 2003 Mid-term Review, the EU began to phase out its dairy quota system.[11] This was done by reducing intervention prices for some products and increasing the quota allocated to each member state. Only butter and skim milk powder (SMP) were considered eligible for intervention because these products could be stored. To prepare for phasing out quota, intervention prices were reduced beginning in 2003/2004 as indicated in Table 1, but buying at the support prices was restricted to March 1 through August 31 in a calendar year. There were also limits as to how much the EU would purchase at the intervention price – 109,000 tonnes (t) of SMP over the period from 2004 until the quota system ended; for butter, a maximum of 70,000 t would be purchased in 2004, but the amount would decline by 10,000 t annually until it leveled off at 30,000 t/year from 2008 onwards; the Commission could, however, purchase more in times of emergency (Jongeneel et al. 2011, p.75). Simultaneously, the quota was slowly increased: by 15.5% in 2004-2006, 0.8% in 2006-2007, 3.3% in 2007-2008, 2.3% in 2008-2009, and by approximately 1% annually thereafter. Compensation for the consequent price reductions was paid in the form of a *milk premium* that was based on the producer's reference quota. The premium was €8.15/t in 2004, €16.31/t in 2005, and €24.49/t in 2006 and 2007, with the latter premium multiplied by the farmer's reference quota then converted to a single farm payment. The dairy quota regime was eliminated in 2015, with producers then receiving a basic (direct) payment.

Table 1: Reductions in Intervention Prices on Butter and Skim Milk Powder, €/100 kg

Year[a]	Butter	Skim Milk Powder
2003/04	328.20	205.52
2004/05	305.23	195.24
2005/06	282.44	184.97
2006/07	259.52	174.69
2007/08	246.39	174.69
2008 onwards	246.39	169.80

[a] The agricultural year begins April 1 and ends March 31.
Source: Jongeneel et al. (2011, p.74).

[10] See footnote 6 for example.
[11] Information in this paragraph is based on Jongeneel et al. (2011). See also Jongeneel and Tonini (2009).

The EU dairy policy over the period from the establishment of the quota regime in 1984 through its demise in 2015 can be analyzed with reference to Figure 7.[12] Price and quantity in the absence of trade are given by P^* and q^*, respectively, in panel (b). With trade, EU producers face demand D_T, which is the sum of the domestic demand function (denoted D_E) and the excess demand by the rest of the world (ED_R). Abstracting from shipping and handling costs, the world price would be P^W with trade, q^{wd} would be consumed domestically, and the difference $q^W - q^{wd}$ in panel (b) exported to the rest of world – with equivalent imports indicated in panel (a) for P^W.

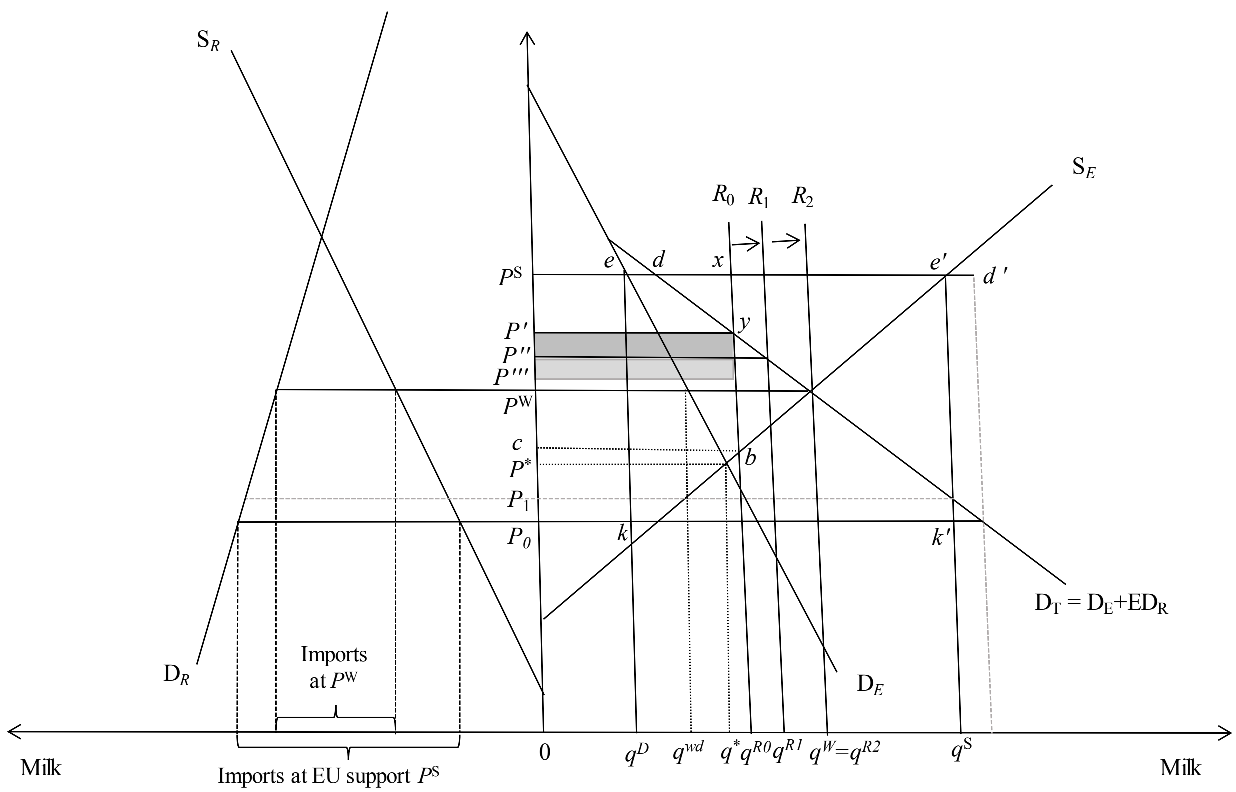


Figure 7: Europe's Dairy Regime and its Demise
Source: Adapted from van Kooten (2017)

When the EU's dairy farmers faced support price P^S, they produced q^S but only q^D would be consumed within the EU at that price. Thus, the EU needed to store the excess production or subsidize exports. The cost of purchasing the overproduced dairy products (butter and SMP) is given by the area bounded by ($ee'q^Sq^D$). Since excess production equals ee′ (=*dd*′), this amount was then used to establish the foreign price based on D_T, because amount *ed* is not sold at P^S.

[12] The following analysis is based on van Kooten (2017).

That is, the correct price in foreign markets is P_0 and not P_1, so that the export subsidy equals ($ee'k'k$) < ($ee'q^Sq^D$).

To avoid accumulating stocks of dairy products and/or the high costs of export subsidies while still supporting prices, the EU employed a quota beginning in 1984. Assume the quota was initially set at R_0. The dairy sector would produce q^{R0}, and receive a price (P^S) greater than the marginal cost of production (c), thereby capturing a rent equal to the area bounded by (P^Sxbc). EU consumers still pay P^S, so amount ex must be exported. Assuming for convenience of explanation that ed ($=e'd'$) $= R_1–R_0$, the price foreigners pay would be P'' and the EU would still be subsidizing exports by $ex \times (P^S – P'')$ in Figure 7(b).

To eliminate the quota, the support price was initially removed while the quota remained. This causes the price to fall from P^S to P', with farmers provided an annual deficiency payment equal to the level of their initial individual quota (i.e., reference quantity) multiplied by the price difference (or *milk premium*), with the total deficiency payment equal to (P^SxyP').[13] The quota is then increased in steps to the level that would lead to the free market outcome, price P^W and output q^W. In the first step, the quota is increased to R_1, which causes price to fall from P' to P''. The milk premium paid to dairy producers increases from $P^S – P'$ to $P^S – P''$ (or by $P'– P''$). Thus, the total milk premium increases by the darker shaded area. In the next steps (but shown as one step in the figure), the quota is increased to R_2 ($=q^{R2}$), but the increase in the milk premium is $P'' – P'''$ and not the full drop in price $P'' – P^W$; the increase in the total milk premium paid to producers is equal to the light-shaded area, which is a reduced proportion of the total decline in producer rent. That is, as the quota is slowly increased, the milk premium becomes a declining proportion of the fall in price. Increases beyond q^W are not needed as this is where price equals the marginal cost.

Once quotas on milk production were removed, the milk premium that dairy producers received was converted to a basic payment similar to what farmers producing other commodities received. That is, dairy farmers were treated identical to other farmers. They could stay in the industry, possibly expanding their cow herds to achieve economies of scale, or they could exit dairying altogether, although their land had to remain in agriculture in order to receive a basic

[13] In practice, the milk premium was €8.15 per tonne of milk, but the decline in price was €22.97/100kg of butter and €10.28/100kg of SMP (Table 1). Thus, compensation was not as great as indicated in the figure.

(single farm) direct payment that is uncoupled from production.

Direct payments can become a problem, however, and should only be considered a temporary measure. From the perspective of the EU, it is "hard to rationalise direct payments as compensation for price reductions which took place twenty-five years ago, not least because they have been extended to farmers in the new member states which never experienced those price reductions and where prices generally rose on accession to the EU" (Matthews 2017). Direct payments have become capitalized in European land prices, which resulted in higher costs for new entrants purchasing land and higher rents for tenant farmers, and there has been a high leakage of benefits to non-farm groups that has increased over time. Eventually, a system of direct payments will need to be reformed, although care must be taken in doing so to avoid undue disruptions. "The next CAP [Common Agricultural Policy] must begin the process of phasing out direct payments, instead introducing and building on a more targeted set of policies designed to better equip farmers to face the changes of the future" (Matthews 2017). Likewise, compensatory payments made to quota holders should be limited to a specific period of time, as was the case in the peanut and tobacco buyout programs.

4. ECONOMICS OF REFORMING DAIRY SUPPLY MANAGEMENT IN CANADA

In Europe, each EU member state determined its own quota based on its domestic demand and history of exports to other countries. Canada did something similar in that provincial quota was determined on the basis of the industrial (butter fat) quota allocated to it by the Canadian Milk Supply Management Committee (CMSMC) 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 et al. 2016b). This is evident from the disparity in quota values across provinces, which, as indicated at the end of section 2, ranged from $19,900/kg bf to $38,500/kg bf in January 2018.

The main difference between the EU's dairy SM situation and that of Canada relates to the export market. The EU was a net exporter of dairy products before, during and after SM, while Canada is an 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 (see section 7). To examine reform of the

Canadian SM in dairy, a stylized compensation mechanism is developed that is similar to the one presented in Figure 7, except modified for the case of imports as opposed to exports. The model is presented in Figure 8.

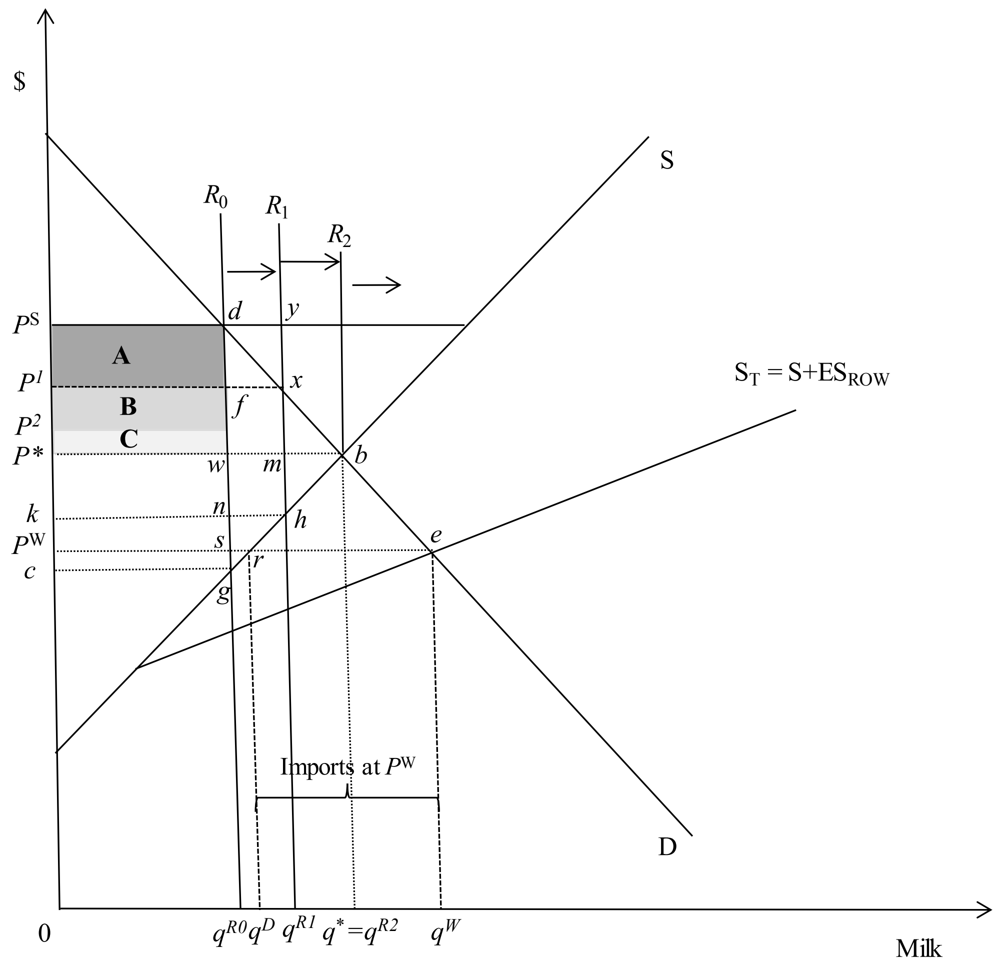


Figure 8: Reforming Canada's Dairy Supply Management Sector

In Figure 8, S and D are the domestic supply and demand functions, respectively; with trade, total supply is S_T, which consists of the horizontal sum of domestic supply S and the excess supply from the rest of the world (ES_{ROW}). Under autarky, price and quantity are given by (P^*, q^*), but under free trade Canadians would consume q^W at price P^W. The dairy marketing board imposed a supply restriction (quota) at R_0 ($=q^{R0}$) at the support price P^S; to maintain this price, however, imports need to be restricted. To keep the analysis simple, I assume that the tariff (some 270%) is sufficient to block all imports. The (annual) quota rent is given by the area ($P^S dgc$), where c is the marginal cost of production. The total value of the quota asset then equals the capitalized value of the the quota rent (as discussed in section 2).

Suppose the authority wishes to reform or eliminate the quota regime while providing dairy producers with compensation. A stylized description of how this might be done begins by increasing the quota beyond that needed to maintain price at P^S. Suppose the quota is initially increased to R_1 from R_0, which causes the domestic price to fall to P^1. Denoting the original quota amount as the reference quantity, the authority compensates producers for the price reduction up to the reference quantity. That is, producers receive $(P^S - P^1) \times q^{R0}$ as compensation, which is equivalent to the dark shaded area denoted **A**. Not only do producers receive **A** as compensation, they also gain area (*ghn*) as quasi-rent (also referred to as producer surplus); that is, dairy producers are overcompensated for their loss in quota value. Overcompensation can be dealt with by reducing the difference $(P^S - P^1)$, or can be dealt with in the next step.

In the second step, the dairy quota is increased to q^{R2} ($=R_2$), which also happens (for convenience) to equal q^* as drawn here. This time the dairy producers are not compensated the full amount of the price decline from P^1 to P^*, but rather only for part of the difference, namely, $(P^1 - P^2)$. The total compensation for this increase in quota would amount to only the medium shaded area denoted **B**, but farmers would gain (*hmb*) as quasi-rent. Whether they are over or under compensated will depend whether the lightest shaded area, denoted **C**, is smaller (overcompensation) or larger (undercompensation) than area (*hmb*).

Any number of further steps are required to reduce the price to the world level P^W. Each step consists of some compensation at the discretion of the policymaker. That is, the policy maker must determine how much of the drop in price to compensate at each step – the price premium to be provided (using an EU term), if any. However, when a free market equilibrium is reached and given that the underlying fundamentals of the market structure in Figure 8 remain unchanged, Canadian producers will only increase output from q^{R0} to q^D (where *D* refers to domestic), with an amount $q^W - q^D$ imported from other countries. Producers gain (*gsr*) but lose ($P^S P^W sd$).

Notice the caveat in the above paragraph, namely, that the fundamentals of the market structure in Figure 8 are unchanged. This is highly unlikely to be the case. Rather, the supply curve is likely to shift downwards as some dairy producers increase their cow herds to achieve economies of scale, while others will leave the industry (which is why some level of compensation is required from a political perspective). That this is the case is seen in Figures 3 and 4: Canada's cows are just as productive as those in exporting nations, but its cow herds are much smaller. In general, dairy farms in Canada have too few milk cows to compete with those in other countries – economies of scale require expansion of its dairy herds. Unless this occurs, Canada will be unable to compete internationally and require continued tariff protection. Milk prices will remain higher than those in other countries with the least well off citizens bearing the burden of SM.

5. REFORMING SUPPLY MANAGEMENT IN CANADA'S DAIRY SECTOR: NUANCES AND PRACTICAL ISSUES

Before proposing methods of reforming Canada's dairy SM sector, it is helpful to consider some further issues that relate more to practice than stylized models, although such models are helpful as a guidepost. I address a few of these nuances and issues in this section.

5.1 High- versus Low-Cost Producers

One issue to consider when reforming a SM regime relates to differences among producers. To analyze outcomes at the farm level, consider Figure 9 where three farm types are modeled according to differences in their marginal costs of producing milk. The farms represent low, medium and high cost producers of milk as represented by the supply functions in panels (a), (b) and (c), respectively. For convenience, the same or similar notation is used in each panel. Each producer has her own unique quota, but the sum of the individual quota equals the Canada-wide quota, with Canada employing a TRQ to prevent imports and keep price above the world price p^w, and perhaps above the autarkic price. (Prices are assumed to be at the farm gate.) With quotas assigned to each producer, and permitting imports as determined by the TRQ, the Canadian price of milk is given by p^q (the target or support price). For convenience, it is assumed each producer faces the same price (except for location-specific differences due to transport costs). Thus, milk producers only sell milk at $p^q > p^w$, up to their individual quota.

Consider first the low-cost producer in Figure 9(c). For this producer, the world price (p^w) is higher than the marginal cost of production (or supply price), c_L, evaluated at the producer's quota level $\bar{q}$ (=Q^L). The low-cost producer has an incentive to produce more than her quota would have allowed; it is clearly profitable to do so as $q_0 > \bar{q}$. In this case, the world price is also the price determining the farmer's marginal cost of production. In contrast, the high-cost producer in Figure 9(a) will not fill his quota ($q_0 < \bar{q}$), because $c_H > p^q$ at the quota limit Q^H. The low-cost producer receives a quota rent equal to r_L as indicated in panel (c), while the high-cost producer in panel (a) receives no quota rent. Finally, the medium-cost producer is defined here as one who wants to produce the allocated quota amount, Q^M ($=q_0$) even in the absence of SM. This milk producer is in a situation where $c_M = p^q$ precisely at her available quota, so no quota rent is earned, although there is a quasi-rent. Of course, each producer earns quasi-rent (producer surplus) over and above any quota rent.

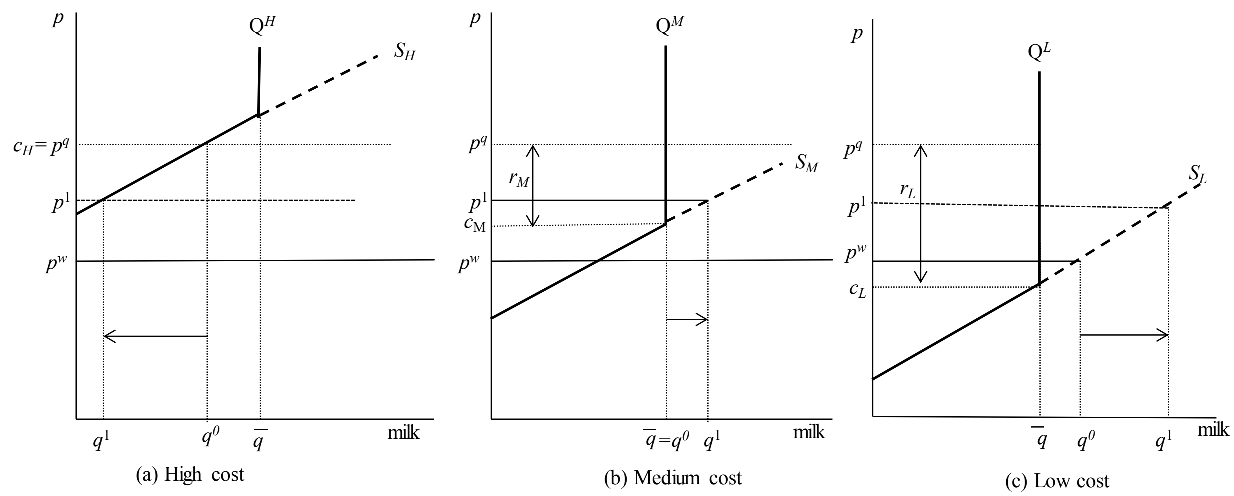


Figure 9: Quota, Rental Values and Supply Response to Reform, Three Farm Types

Now suppose the quota is removed but imports are still restricted so that the Canada-wide price faced by each farmer drops to p^1. A new equilibrium is established in Figure 9 where demand equals supply (see the allocations in each panel denoted by p^1, q^1). As shown by the arrows in panels (b) and (c), the lower price leads to an increase in milk output for the low- and medium-cost producers. Indeed, as long as $p^1 > c_k$, $k \in \{c_L, c_M, c_H\}$, there is an increase in output despite a fall in price because producers are no longer constrained by a quota and, thus, will increase output until the marginal cost of production c_k rises to p^1. For individual producers, one expects that, the larger the initial quota rent (due to low costs of production or competitiveness), the greater the expected expansion in production when the quota is abolished (e.g., difference $q^1 - \bar{q}$). However, for the high-cost producer in panel (a), $p^1 < c_k$ and therefore the farmer must reduce output (as indicated by the arrow) to avoid losses.

Finally, if imports were no longer restricted and the price were to fall to the world price p^w, both the high and medium-cost producers would exit the market, while the low-cost producer would reduce production from q_1 to q_0, where the latter is still greater than what would be produced under a quota regime. Thus, it would appear that Canada might well be a net importer of dairy products if trade is liberalized, as is often assumed. To determine if this is the case, it is necessary to compare the ratio of the autarkic price to the world price, and compare these across countries. The problem is that SM obscures the autarkic price in Canada. However, using economic theory, available data and assumptions on supply and demand elasticities, Carter and Mérel (2016) make the case that Canadian dairy producers may actually have a comparative advantage over countries that currently dominate dairy export markets; this is supported by evidence of per cow productivity (see Figure 4). Thus, by liberalizing trade, Canadian dairy producers would benefit, although there would likely be a shakeup in the sector that would lead to the exit of high- and medium-cost producers.

In an earlier study, Vercammen and Schmitz (1992) demonstrated that,

> *"if producers under SM were forced to choose between offering import concessions and abandoning SM, they will, in specific circumstances [e.g., very inelastic demand], choose the former. The main reason for this is that SM may result in relatively large rent transfers from consumers to producers, implying that considerable import concessions could occur before the 'excessive' producer rents are eroded away" (p.969).*

If this is the case in dairy SM, and the authors do not identify this as a possibility in the dairy sector while it could be in chicken, then policymakers might wish to begin any dairy reform by providing greater import concessions (higher import quotas) during trade negotiations.

5.2 Value of Quota: Empirical Data

Some economists have argued that, to increase the efficiency in Canada's dairy sector while retaining supply management, the authority should permit industrial milk quota to be freely traded across regions, without any restrictions as to how much quota a particular producer can purchase at any given time. That is, Canada should begin reform of its dairy programs by permitting trade in quota across provincial boundaries, which is currently not the case (e.g., Meilke 2017). This will ensure that quota goes to the most efficient producers while compensating small producers, and reduce the disparity in quota values across provinces. As indicated in Figure 10, quota values at the beginning of 2018 ranged from $19,900 per kg of butter fat (bf) per day in New Brunswick to $38,500/kg bf per day in British Columbia (Canadian Dairy Information Centre, hereafter CDIC, 2018). Dairy quota could be purchased in Ontario, Quebec and Nova Scotia for $24,000, although these provinces cap the value at which quota can trade and, in some cases (Quebec), the amount of quota that a single farmer can purchase in a given year. The problem with a price cap is that farmers are reluctant to sell quota that is more valuable than the capped price. This in turn prevents potential buyers from expanding their operations to take advantage of economies of scale.

Even so, it is unlikely that country-wide free trade in quota could be a first step towards major reform or eventual elimination of SM for several reasons. First, if producers who intend to buy quota recognize this as a first step to further reform, they will delay purchasing quota or offer much less for it (perhaps providing too little compensation to sellers). Second, the question of compensation (or buyout) shifts from those who have long owned quota to new quota holders who purchased quota in a country-wide market and may require a higher level of compensation as they have not yet paid off the quota asset.

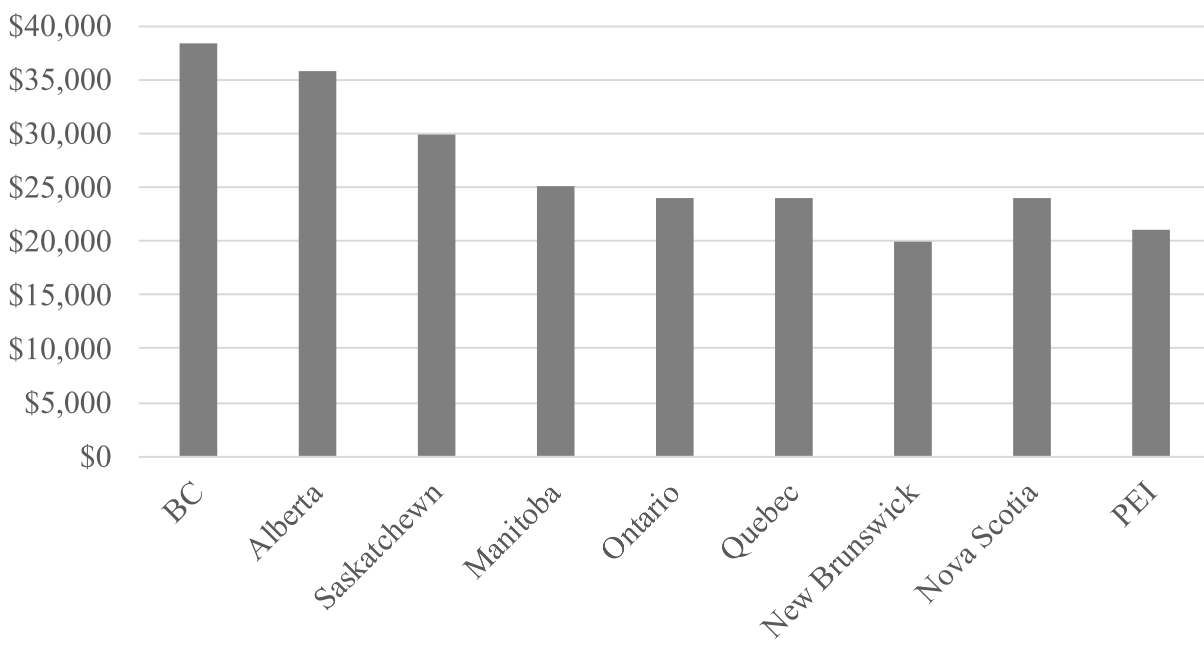


Figure 10: Quota Value by Province, January 2018 ($ per kg butter fat per day)

The prices at which quota trade in a free market are a factor in determining the compensation that might have to be paid to dairy producers to have them acquiesce to sectoral reform. The monthly milk quota traded in Canada for the 15 years (181 months) from January 2003 through January 2018 is plotted in Figure 11, as is the weighted average of the provincial prices for each of those months. Between the beginning of the series and the end of 2009, the price of quota exceeded $1,000 per kg bf per day only nine times and only once did it spike above $20,000 (July 2005). In 2010, the quota traded above $20,000 and continued to do so until the present with the exception of two months (May and June 2010), averaging $27,016 per kg bf per day for the period 2010 through the first month of 2018. I do not know what caused the price to spike in 2010 and remain high thereafter. In the meantime, trade averaged 106,400 kg bf per month for the first 84 months of data (for the period 2003-2009) but only 1950 kg bf per month thereafter – the sharp break in Figure 11 is indicative of this. This information could have important implications for compensation policy.

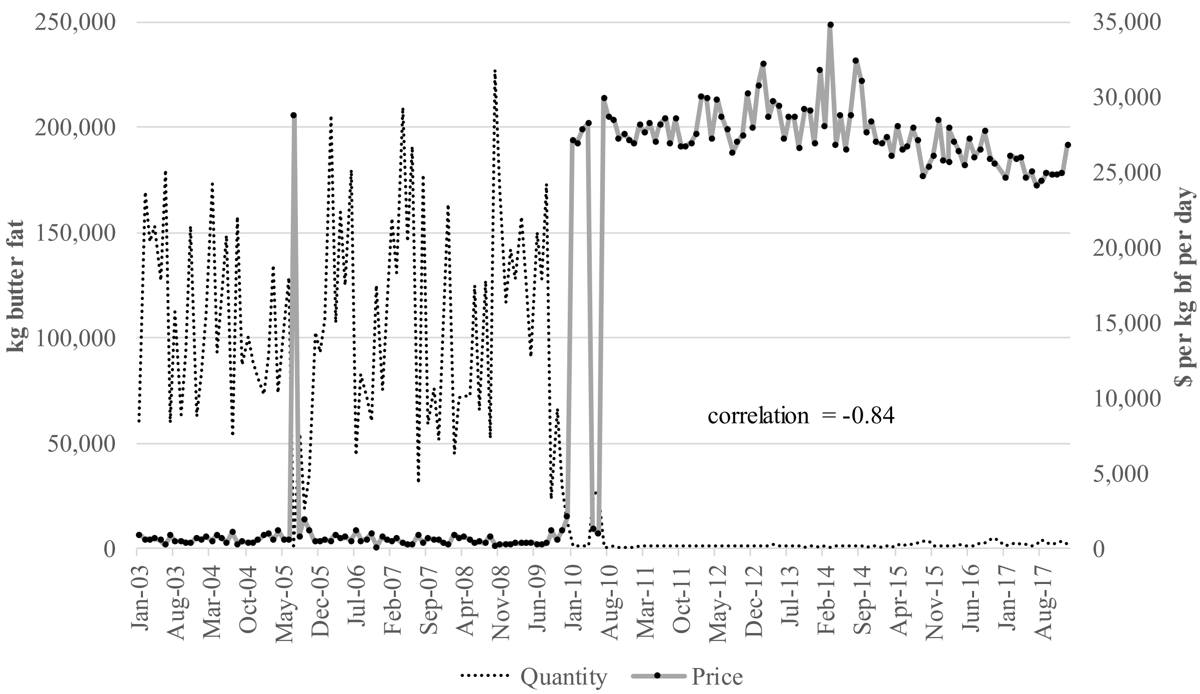


Figure 11: Markets for Dairy Quota: Monthly Canada-wide Average Quota Purchased (kg bf per day) and Prices ($/kg bf), January 2003 to January 2018
Source: CDIC (2018)

A closer look at the provincial level indicates the reason for the break in 2010. Prior to 2010, prices at which quota traded in the western provinces exceeded those in the rest of Canada by a factor of 100. Then, for some inexplicable reason other than lobbying by western owners of quota, the prices in the western provinces spiked. This is seen in Figure 12 where graphs of quota trading are presented for Canada's four major provinces – Ontario, Quebec, British Columbia and Alberta. Prior to September 2009, unfettered trade dominated in Alberta with milk quota trading at an average weighted monthly price of $68.18 per kg bf with monthly trading (purchases) equalling 49,346.98 kg bf; the price in Alberta jumped from from $89 to over $33,215 per kg bf between August and September 2009, with purchases falling from over 127,000 kg bf to only 68 kg bf. In British Columbia, quota traded at a weighted average price of $88.27/kg bf prior to July 2010, with 50,131.2 kg bf traded monthly; then, over the period July 2010 through January 2018, quota traded at an average price of $42,111.77/kg bf with only 124.40 kg bf traded monthly. Prior to about 2010 the markets in BC and Alberta were rather robust, but after 2010 little quota was traded in these provinces.

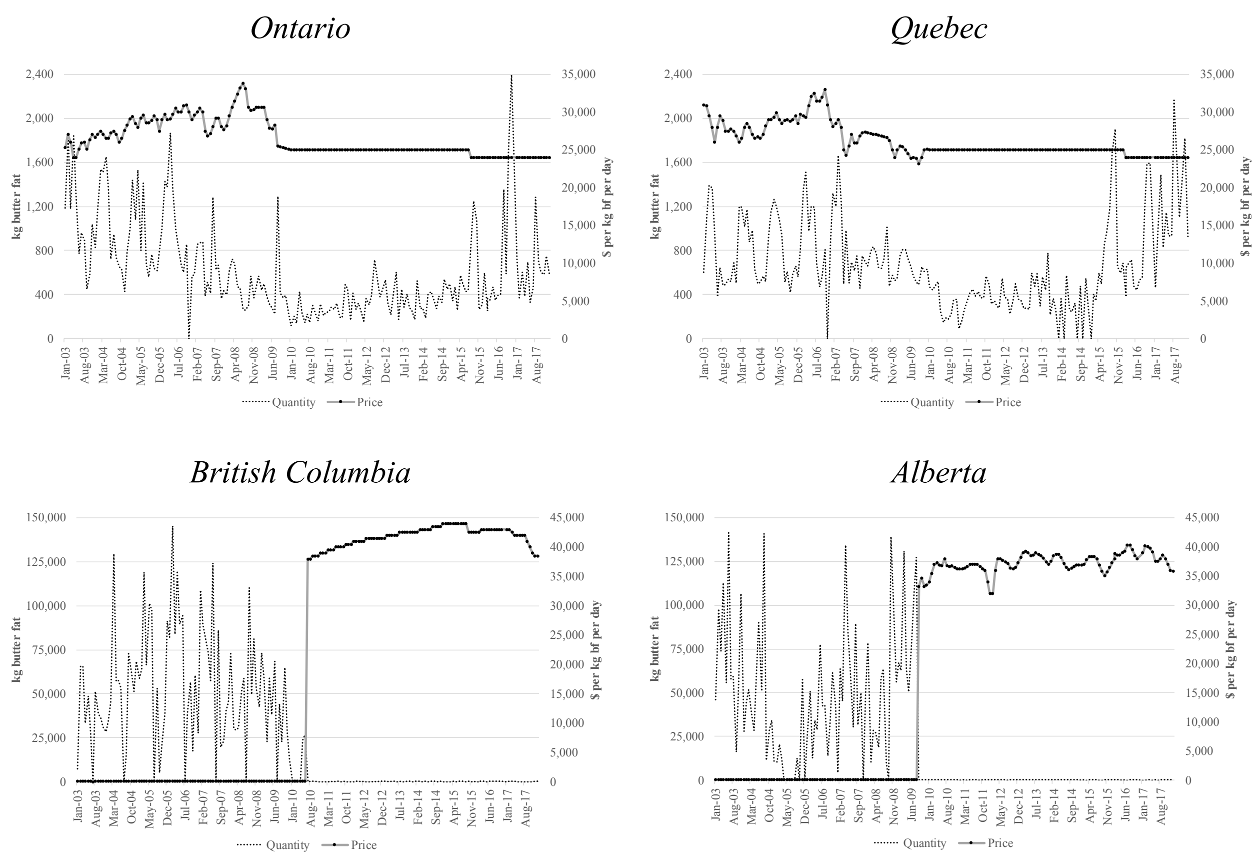


Figure 12: Markets for Dairy Quota: Monthly Average Quota Purchased (kg bf per day) and Prices ($/kg bf), January 2003 to January 2018, Selected Provinces
Source: CDIC (2018)

From the raw data, it appears that prices for quota in Ontario and Quebec were set or manipulated by the authority since 2003, but that during 2009 the Ontario and Quebec marketing boards sought to coordinate prices, which occurred beginning in 2010 (Figure 12). Meanwhile, the Alberta marketing board also sought to fall in line as prices rose in late 2009 (as discussed above), while BC prices falling in line mid 2010. Afterwards, prices in BC and Alberta have tracked each other and have also remained relatively close to those in Ontario and Quebec. One can only speculate, but the data strongly suggest that quota prices throughout Canada are tightly controlled by the marketing authorities.

Finally, jumps aside, what can explain the high volatility? The profit margin on producing milk should be reasonably constant over time and across regions and so one would expect fairly stable quota prices. This certainly warrants further investigation.

6. REFORMING SUPPLY MANAGEMENT IN CANADA'S DAIRY SECTOR: THE COST OF POTENTIAL COMPENSATION

To provide some context, Figure 13 provides some indication regarding total milk production in Canada and its growth from mid-August 2008 to January 2018. Monthly milk quota is plotted (although actual quota is measured in terms of butter fat (with 3.6 kg bf per 100 litres of milk); milk quota rose from about 650 million litres to around 850 million litres during this period. Although there is a decline in milk quota at the beginning of each year, the drop in quota is quite pronounced in 2018 compared to previous years. However, data for the remainder of 2018 are needed to determine if milk production is expected to continue its upward trend.

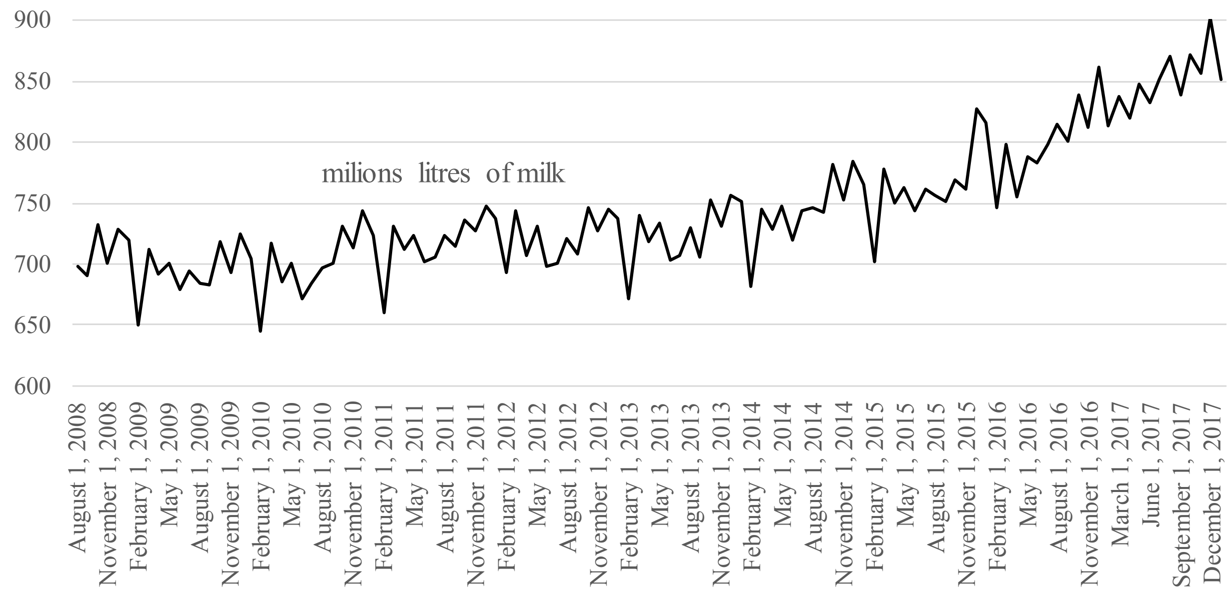


Figure 13: Monthly Dairy Quota Measured in Fluid Milk, 2008-2018
Source: CDC(2018) http://www.cdc-ccl.gc.ca/CDC/index-eng.php?id=3810

In this section, I use two methods to calculate potential amount the authority might have to pay to buyout dairy producers. The objective is to derive values that are reasonable, rooted in economic analysis, and do not overestimate the amount that producers should receive, which was a particular problem with the Ontario tobacco buyout program (Schmitz et al. 2016b). In the next subsection, I employ data on quota trade to develop estimates of the costs of a potential compensation program to eliminate SM in dairy. Then, I calculate levels of compensation based on the theory in section 4.

6.1 Calculating Compensation using Data on Quota Trades

From the value of quota data in Figures 11 and 12, I can calculate a crude estimate of the potential cost of a quota buyout in the dairy sector. Assume that farmers know there is a risk to buying quota and, therefore, they discount future quota rents at a high rate. For example, Chen and Meilke (1998) estimated that, in the early 1990s, producers used a discount rate of between 20 and 49 percent in valuing future quota rents. If we assume a discount rate of 22%, then $1 received 15 years hence is worth about $0.05. Therefore, looking back at the past 15 years, the total quota purchased by producers during the period 2003 through 2017 turns out to be $8.4 billion. Therefore, this would represent an upper limit on the compensation that should be paid to dairy producers for loss of their quota benefits. Those who purchased quota prior to 2003 would have received a quota rent each year, thereby having recovered their quota cost. Farmers who purchased milk quota early in 2003 would not have benefitted from some 15 years of quota rents, compared to a quota buyer in 2016 who might have received quota rent for less than two years. Further, since it likely takes several years before any changes to dairy SM are realized, producers are able to collect quota rents during this period. Therefore, the use of 15 years of quota sales data for calculating a potential buyout seems reasonable.

To take into account the number of periods that a farmer could collect quota rent before SM in dairy was reformed, I first converted the nominal payments for quota into real $2018. Then, I determined the number of months that a purchaser of quota would be able to collect quota rent, and subtracted the potential quota benefits from the original purchase price. In doing so, a discount rate of 22% was employed to reflect the risk that dairy producers face when they buy quota. The results are provided in Table 2. The total compensation package for eliminating the SM regime in dairy would amount to about $2.6 billion, representing an estimate that takes into account the risk that supply management regime may face major reform in the not-too-distant future; this is a risk that farmers knowingly undertake. Compensation is greatest for Quebec dairy producers ($1.0 billion), followed by those in Ontario ($0.8 billion), with other Canadian producers receiving about the same as the Ontario dairy farmers.

Table 2: Estimates of Annual and Total Compensation Required to Buyback Dairy Quota in Canada and Four Provinces, Based on Risk Discount Rate of 22% ($2018 millions)

Year	Canada	Ontario	Quebec	BC	Alberta	ROC[a]
2003	**39.419**	17.645	14.016	1.595	2.655	3.507
2004	**45.780**	21.276	17.193	3.330	2.489	1.493
2005	**56.786**	25.915	22.854	5.132	0.637	2.249
2006	**79.390**	32.998	31.132	7.305	3.288	4.667
2007	**76.109**	26.978	33.962	7.638	4.847	2.684
2008	**75.678**	24.906	32.046	8.349	5.783	4.595
2009	**88.564**	26.418	34.253	8.897	13.740	5.256
2010	**68.193**	14.583	19.804	3.462	14.938	15.406
2011	**93.236**	23.199	30.578	7.313	10.300	21.846
2012	**129.525**	38.779	34.502	15.446	20.502	20.297
2013	**162.341**	40.955	51.338	17.626	30.861	21.561
2014	**178.677**	54.351	38.081	36.117	25.571	24.556
2015	**342.702**	100.979	149.020	31.092	25.988	35.622
2016	**489.690**	169.130	171.145	47.685	47.634	54.095
2017	**609.053**	163.094	327.194	22.133	36.257	60.375
2018	**62.315**	13.944	22.073	12.485	4.588	9.225
Total	**2,597.459**	**795.151**	**1,029.191**	**235.607**	**250.079**	**287.432**

[a] Rest of Canada
Source: Author's calculations.

6.2 Calculating Compensation Based on Support Prices and Marginal Costs of Production

An alternative theoretical estimate of potential compensation levels is based on Figure 1. Information on supply and demand functions is used to calculate the annual quota rent as a loss that is set against the gain in producer surplus; in essence, the net loss to producers is measured by the lost rent (area *a* in Figure 1) minus the gain in producer surplus or quasi-rent (area *e*). The data required to calculate the welfare areas are found in Table 3. The table provides the support prices, supply prices (marginal costs of production), and the levels of milk output for the years 2010 through 2016. The quota rent is calculated simply as the difference between the support price and the marginal cost of production.

Table 3: Estimated Support Prices, Marginal Costs of Production, Quota Rent and Milk Production, 2010 through 2016

Year	Support price	Marginal cost	Quota rent	Production
		$/litre		*million litres*
2010	0.80665	0.52900	0.27765	7,652.49
2011	0.81825	0.54670	0.27155	7,754.69
2012	0.86866	0.57070	0.29796	7,957.57
2013	0.87636	0.63320	0.24316	7,797.67
2014	0.88850	0.64060	0.24790	7,802.88
2015	0.87574	0.62950	0.24624	8,155.38
2016	0.72817	0.62100	0.10717	8,448.85

Source: Author's calculations using data from CDC; support prices are found at http://www.cdc-ccl.gc.ca/CDC/index-eng.php?id=3809 [accessed 20 February 2018] and marginal cost data, plus information on butter fat and solid non-fat (SNF) component, from annual Cost of Production surveys at http://www.cdc-ccl.gc.ca/CDC/index-eng.php?link=209 [accessed 20 February 2018]. Production data are from http://aimis-simia-cdic-ccil.agr.gc.ca/rp/index-eng.cfm?action=pR&pdctc=&r=235 [accessed 23 February 2018]. No data are available for other years.

To determine the potential levels of compensation, we further require information about the elasticities of supply and demand. In this regard, we use data from Carter and Mérel (2016). These authors use a derived demand elasticity for milk of –0.47 and an elasticity of supply of 1.0, although they also consider supply elasticities of 5 and 10 (p.574). We construct a Monte Carlo simulation model written in R (R Core Team 2017); the model randomly selects elasticity values for derived demand from a uniform distribution between –0.4 and –0.6, and elasticity of supply values from a triangular distribution with minimum value of 0.8, mode of 1.0 and maximum value of 10. For each year (scenario), we employ 10,000 iterations and, for each, estimate the quota rents, lost rent, gain in consumer surplus and net loss in moving from the quota regime to free trade. These values are upper bounds on the compensation that might be paid to dairy producers. The results are provided in Tables 4 and 5, where monetary values have been adjusted for inflation; that is, all values in these tables are real 2018 Canadian dollars.

Table 4: Annual Quota Rent and Losses, Gains and Net Loss with Elimination of Quota Regime, Various Scenarios ($2018 millions)[a]

Year	Quota rent	Rent lost	Surplus gain	Net loss
2010	2,414.70	372.47	18.48	353.99
2011	2,325.32	345.09	17.53	327.56
2012	2,579.50	396.13	19.61	376.52
2013	2,044.31	251.79	13.52	238.27
2014	2,045.57	253.52	13.66	239.86
2015	2,100.18	262.18	14.17	248.01
2016	933.67	59.71	3.72	55.99
Average	**2,063.32**	**277.27**	**14.39**	**262.89**

[a] Author's calculations based on Monte Carlo simulation with 10,000 iterations for each year.

Table 5: Quota Value, and Discounted Total Losses, Gains and Net Losses with Elimination of Quota Regime, Risk Discount Rate of 22%, Various Scenarios ($2018 millions)[a]

Year	Quota value	Rent lost	Surplus gain	Net loss
2010	10,975.89	1,693.04	84.01	1,609.03
2011	10,569.64	1,568.58	79.66	1,488.92
2012	11,725.01	1,800.61	89.15	1,711.46
2013	9,292.31	1,144.52	61.46	1,083.05
2014	9,298.06	1,152.36	62.09	1,090.27
2015	9,546.29	1,191.73	64.43	1,127.30
2016	4,243.96	271.42	16.92	254.50
Average	**9,378.74**	**1,260.32**	**65.39**	**1,194.93**

[a] Author's calculations based on Monte Carlo simulation with 10,000 iterations for each year. The annual values in Table 4 are converted to total discounted values by dividing by the discount rate, 0.22 in this case.

The columns in Table 4 represent the annual quota rent (essentially area *a*+*b* in Figure 1) and, when eliminating dairy quota in favour of free trade, the annual quota rent that producers lose, the producer quasi-rent gained (area *e*) and the net loss (area *a*–*e*), respectively. The discounted values of the infinite future stream of quota rents, lost quota rents, quasi-rents (producer surpluses), and net losses are then provided in Table 5, using a discount rate of 22%. It is the net loss that is of most interest because this is the theoretically correct measure of the loss to producers in moving from a quota regime to free trade. The net loss in surplus ranges from $255 million to $1.7 billion, and averages $1.2 billion (last column). This contrasts with quota values that range between $4.2 billion and $11.7 billion (first column).

The annual quota rents vary between $2.0 and $2.6 billion over the period 2010 through

2015, but, for some reason, fall to \$0.9 billion for 2016. The annual quota rent averages \$2.1 billion, which translates into a quota value of \$9.4 billion. However, as noted in the discussion concerning Figure 1, dairy producers would recover a large portion of the quota rent as quasi-rent (or producer surplus) when output expands and prices fall. Indeed, based on our simulations, on average 86.5% of the quota rent is recovered through increased producer surplus. In terms of Figure 1, this implies that area *a* is quite a bit smaller than area *b*. Further, producers would gain area *e*, which not surprisingly is quite small in comparison to the other areas, averaging only \$65.4 million. While estimates of compensation using this approach are sensitive to supply and demand elasticities, especially the latter, the range of elasticities employed are based on best available data.

The conclusion from this analysis is that, if the authority wishes to compensate dairy producers for potentially reforming the dairy SM system, compensation should be based on the net loss in Table 5. If the situation representing 2012 is expected to continue in the future, the level of compensation should be around \$1.7 billion, but, based on average conditions over the period 2010-2016, the level of compensation should be \$1.2 billion.

Notice that the level of compensation found in Table 5 is approximately half of that found in Table 2 (\$2.6 billion), where a different method of determining compensation was employed. In calculating the values in Table 2, no account was taken of the gain in producer surplus or quasi-rent – the recovery of area *b* in Figure 1. However, the calculations in Table 2 do not consider compensation for those who purchased quota prior to 2003, thereby assuming that these producers have recovered the cost of purchasing the dairy quota asset. In the final analysis, the awarding of compensation is a political decision, but, based on the analysis in this study, it should be limited to about \$1.2 billion, with maximum compensation of \$2.6 billion.

There is a caveat. The calculations in Table 5 ignore the impact of trade – the potential of Canadian producers losing market share to foreign competitors. This was illustrated in Figure 8 where it is assumed that, after removal of supply management, the world price would be much lower than the Canadian domestic autarkic price. If this is true, then the gain in producer surplus (quasi-rent) is given by area (*gsr*) and not the larger area (*gwb*), and the measures of compensation in Table 5 are too low. However, as argued by Carter and Mérel (2016), there is no reason why Canada could not be a net exporter of dairy products once SM is eliminated. There is no reason Canadian dairy farmers would be less efficient than those in the U.S., New Zealand or Europe. To investigate this issue further, I look at developments in agricultural trade negotiations and construct a small dairy trade model to consider some potential outcomes.

7. BACKGROUND TO AGRICULTURAL TRADE

The Uruguay Round of the General Agreement on Tariffs and Trade (1986-1994) concluded with an agreement signed April 1994, and came into effect January 1, 1995. It created the World Trade Organization (WTO) to replace the GATT and, for the current purposes, resulted in an Agreement on Agriculture (AA). Establishment of the WTO included an agreement to continue negotiating on agricultural policy reform beginning in 2000. The reductions in agricultural subsidies and protection undertaken as a result of the conclusion of the Uruguay Round are provided in Table 6, although only figures for cutting export subsidies appear in the agreement.

Table 6: Agricultural Policy Reform as a Result of the Conclusion of the Uruguay Round of the GATT in 1994: Percent Reductions in Support Payments by Developed and Developing Countries and Time Frame for Implementation[a]

Item	Developed 1995-2000 (6 years)	Developing 1995-2004 (10 years)
Tariffs[b]		
Average cut for all agricultural products	-36%	-24%
Minimum cut per product	-15%	-10%
Domestic support[c]		
Total AMS cuts for sector (base period: 1986-88)	-20%	-13%
Exports		
Value of subsidies	-36%	-24%
Subsidized quantities (base period: 1986-90)	-21%	-14%

[a] Least developed countries do not have to make commitments to reduce tariffs or subsidies.
[b] The base level for tariff cuts was the agreed to (or bound) rate before 1 January 1995; or, for unbound tariffs, the actual rate charged in September 1986 when the Uruguay Round began.
[c] The other figures were targets used to calculate countries' legally-binding "schedules" of commitments.
Source: WTO (no date); Hanrahan and Schnepf (2007)

The Doha Round of the WTO, known as the Doha Development Agenda (DDA) because it emphasized integration of the developing nations into the world trade system, was launched at the Fourth Ministerial Conference of the WTO held in Doha, Qatar in November 2001. Agricultural negotiations emphasize market access, particularly for developing countries and the least developed nations. In addition to market access, the focus on agricultural negotiations would be on domestic support and export subsidies – together these three issues are known as the three pillars of the agricultural negotiations. Finally, agricultural negotiations are of great importance to the DDA because policies that distort agricultural trade account for two-thirds of all trade-distorting policies (Hanrahan and Schnepf 2007).

Based on WTO notification data for the period 1995-2001, 24 of 36 countries (or trading blocs) that were eligible to use export subsidies actually used them, with the EU accounting for nearly 90% of the total; for the same period, the EU, the U.S. and Japan accounted for 91% of domestic support (35 out of 149 countries reported using domestic support payments) (Hanrahan and Schnepf 2007). However, all countries have implemented barriers to market access, making this a complex issue to deal with in trade negotiations. Indeed, tariffs and tariff rate quotas (defined below) account for some 80% to 90% of the total cost of trade-distorting agricultural policies, with domestic support and export subsidies accounting for the remainder (Hanrahan and Schnepf 2007).

The EU and the U.S. had agreed to a framework for negotiating agricultural trade liberalization by 2003. However, a group of developing countries known as the G-20, which included Brazil, China, India and South Africa, made a counter proposal for developed countries to reduce significantly domestic subsidies and agricultural tariffs. At a meeting in Cancun, Mexico in September 2003, parties failed to reach an agreement reconciling the two positions. A framework agreement was subsequently agreed to in July 2004, but negotiators could not complete a draft of the agricultural 'modalities' (the ways or methods of doing something) by a July 2005 deadline. The framework agreement 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 subsidy ceiling of 5% of product TVPs in the Blue Box category where none existed. An overall limit on total domestic subsidies (Amber Box plus Blue Box plus *de minimis*) was also proposed where none previously existed. Other details of the agreement are found in Hanrahan and Schnepf (2007).

Subsequently, a Hong Kong (HK) Declaration on Agriculture adopted December 18, 2005 included the following key resolutions:

- Elimination of export subsidies by 2013. The EU met this target but other countries did not.
- Reduction in domestic support levels. The HK Declaration placed developed countries in three bands according to the extent of needed cuts. The EU was placed in the highest band, thus having to reduce its support levels by the greatest percentage. The U.S. and Japan followed in the middle band, with remaining countries in the lowest band. The extent of the required reductions would be decided during the negotiations concerning modalities.
- Improvement in market access. Countries are to replace non-tariff barriers on sensitive products with quotas that are dubbed tariff rate quotas (TRQs). The process of substituting non-tariff barriers with a combination of quotas and discriminating tariff levels is known as 'tariffication', with the tariff rates to be negotiated as part of the 'modalities'. However, developing countries are to be given preference in accessing developed markets. For example, the EU abolished its supply management regime in sugar at the end of September 2017, replacing it with a TRQ that provides certain developing countries priority access to its sugar market.
- Immediate elimination of export subsidies on cotton.
- Development access. Developed and, to the extent possible, developing countries are to provide better access (e.g., specific quotas) for agricultural products from the least developed countries (LDCs).

Doha negotiations were suspended indefinitely on July 24, 2006 because a core group of countries – the United States, European Union, Brazil, India, Australia and Japan, known as the G-6 – could not resolve issues related to agricultural trade. The main sticking points concerned the three agricultural pillars: (1) trade-distorting domestic supports, (2) the potential elimination of export subsidies, and (3) increased market access for agricultural products (e.g., some countries' protected import-sensitive products). In addition to agricultural reform, main issues at stake during DDA negotiations related to developing countries – to ensure sustainable economic growth within a liberalizing world economy and increase developing countries' access to markets in developed countries. Indeed, developing countries play a much larger role in the Doha negotiations than they ever did in the Uruguay Round (EU 2016).

At a December 2015 meeting of WTO ministers, 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 2017, 2014b). It included a proposal by the EU, Brazil, Uruguay, Paraguay, Argentina, Peru, New Zealand and Moldova to reform agriculture (WTO 2015). A main item was the elimination of export subsidies by the end of 2018 and limits on the activities of state trading enterprises (that might be construed as providing an export subsidy) by 2020.

WTO members also agreed that negotiations would continue on exempting from legal challenges trade-distorting public storage programs in developing countries that use storage to enhance food security. Storage is incentivized with support payments that constitute a trade distortion. Attempts to have this activity included in the Green Box have been rebuffed because only non-distorting policies are considered in the Green Box. To get around the issue, the Bali position remains in place – a peace clause whereby countries agree not to challenge public storage policies in developing countries (WTO 2014a). Further, developing countries may also raise tariffs temporarily to address import surges or price declines – known as the Special Safeguard Mechanism (SSM). Unfortunately, the suspension of formal negotiations under the Doha Development Agenda was not lifted in 2015 "due to differences among WTO members regarding the value of the previously made attempts to reach consensus" (EU 2016). Nonetheless, a Trade Facilitation Agreement, which included the aforementioned agricultural reforms, came into effect February 23, 2017 when two-thirds of the WTO membership had ratified it.

In the meantime, the suspension of DDA negotiations opened the door for countries to pursue bilateral and regional free trade agreements (FTAs). This led to the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) signed on January 23, 2018 by 11 countries (but not the U.S. or China), the Comprehensive and Economic Trade Agreement (CETA) between Canada and the EU, the U.S.-EU Transatlantic Trade and Investment Partnership (TTIP) talks (not concluded as a result of President Trump's election), and other regional trade initiatives (e.g., Pacific Alliance in Latin America with Mexico, Peru, Chile and Columbia). Although unrelated to renewed efforts to conclude regional trade agreements, but in contradistinction to them, the U.S., Canada and Mexico are renegotiating the North American Free Trade Agreement (NAFTA) because the U.S. feels NAFTA disadvantages that country.

What are the implications for Canada and dairy trade? First, the U.S., Australia and New Zealand have targeted Canada's SM sectors at the WTO. Second, as noted above, agricultural policy distortions account for nearly 65% of all policy-induced trade distortions, and some 80-90% of these are tariffs and TRQs. Thus, ongoing WTO negotiations will inevitably seek to eliminate TRQs by increasing quota levels and reduce tariffs on imports above the quota. Third, NAFTA negotiations will target supply management, as will any other trade agreements Canada will enter into. 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 4), perhaps lack of economies of scale (Figure 3) 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 that is constructed in the next section.

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

In this section, we construct a spatial price equilibrium (SPE), 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 (2018, Chapter 5). The SPE modeling approach has been used since at least the 1960s, and the approach is more commonly known as the Samuelson-Takayama-Judge (STJ) model (Samuelson 1952; Takayama and Judge 1971).

The objective in the STJ 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:

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

Subject to: Dual Variable

$$x_d^D \le \sum_{s=1}^{N} x_{sd} \qquad P_d^D \tag{2}$$

$$x_s^S \ge \sum_{s=1}^{M} x_{sd} \qquad P_s^S \tag{3}$$

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 $P_d^D = a_s + b_s x_s^S$, respectively. Coefficients α_d, β_d, a_s and b_s are known scalars, while demand and supply quantities, $x_d^D = \sum_{d=1}^{M} x_{sd}$ and $x_s^S = \sum_{s=1}^{N} x_{sd}$, 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, it is assumed that we have knowledge of the S&H costs for moving a unit of *x* from *s* to *d*, denoted t_{sd}. The model used in the current analysis is described in more detail in what follows. We then discuss our data, followed by some results from a simplified version of a dairy trade model, focusing on how Canada might be impacted.[14]

8.1 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*:

$$P_d^k = \alpha_d^k - \beta_d^k q_d^k,\ \alpha_d^k, \beta_d^k \geq 0,\ \forall d = 1, \ldots, M,\ \forall k, \text{ and} \quad (4)$$

$$P_s^k = a_s^k + b_s^k q_s^k,\ a_s^k, b_s^k \geq 0,\ \forall s = 1, \ldots, N,\ \forall k, \quad (5)$$

where $k \in$ {raw milk, butter, cheese, milk powder, fluid milk products, 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*.[15] There are *M* demand (import) regions and *N* supply (export) regions and, for convenience, it is assumed that each region is a potential importer and exporter. 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 (4) and

[14] It is important to note that time constraints prevented the construction of a more detailed model with TRQ and appropriate calibration of, for example, the shipping and handling costs (see Paris et al. 2011). Therefore, the results are best considered to be preliminary.

[15] 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.

subtracting the sum of the areas under the N supply schedules (5). These respective areas are given by:

$$B_d^k = \int_0^{q_d^k} \left(\alpha_d^k - \beta_d^k x\right) dx = \alpha_d^k q_d^k - \frac{1}{2}\beta_d^k q_d^{k^2}, \text{ and} \tag{6}$$

$$C_s^k = \int_0^{q_s^k} \left(a_s^k + b_s^k x\right) dx = a_s^k q_s^k + \frac{1}{2} b_s^k q_s^{k^2}, \tag{7}$$

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.[16] 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 butter, cheese, milk powder, fluid milk and other dairy products. For each product k ($\neq$ 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: $P^k \times MP_{milk \rightarrow k}$, where P^k is the price of k. The total derived demand for 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 2018, section 5.3). Now, if all raw milk was allocated to the various k–1 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.

In the current analysis, however, raw (fresh) milk is distinguished from fluid milk products (see Appendix Table A1), which includes cream, reconstituted milk, evaporated milk and condensed milk. Raw milk is traded as both an input into the production of other dairy products

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

and as a final consumption good. To address this, the objective function includes the consumer and producer surpluses in the raw milk markets, with a constraint that the proportion of raw milk allocated to the production of various non-fresh-milk dairy components not exceed half of the total raw milk available. Of the raw milk produced by various jurisdictions, the proportion of raw milk allocated to the fresh milk market ranges from 49.9% (Canada) to 91.1% (other Asia), with an average allocation of 71.8%. Nonetheless, the inclusion in the objective function of consumer surplus in the raw milk market does result in some double counting that only future research can resolve as this would require separate raw milk into an input and output component.

The overall objective in the dairy trade model is then to maximize the sum of the necessary producer and consumer surpluses provided above, while subtracting the S&H costs and associated taxes. The objective function to be maximized can be written as:

$$W = \sum_{k=1}^{K} \left[\sum_{d=1}^{M} B_d^k - \sum_{s=1}^{N} C_s^k - \sum_{d=1}^{M} \sum_{s=1}^{N} \left(t_{s,d}^k + \tau_{s,d}^k \right) q_{s,d}^k \right], \tag{8}$$

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 (8) 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 (4) and (5), 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:

$$\sum_{d=1}^{M} q_{s,d}^k \leq q_s^k, \forall\ s, k, \tag{9}$$

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*:

$$\sum_{s=1}^{N} q_{s,d}^{k} \geq q_{d}^{k},\ \forall\ d, k. \tag{10}$$

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

$$\sum_{k=1}^{K} \rho_{s}^{k} = 1,\ \forall\ s, \tag{11}$$

where ρ_s^k is the proportion of raw milk in region *s* that is used to produce downstream dairy product *k*. As noted above, since raw milk is both an input into the production of other dairy products and a final consumer good itself, and because the proportions vary from one jurisdiction to another, we employ a simpler constraint, namely, that half of the raw milk be consumed as fresh milk. To give some notion of the limits that are constraining in the real world, outside of water, Table 7 provides some of the components (measured in kg) available from litres (hl) of raw milk. Since the production and trade data available are all measured in kilograms and not litres, it is not possible to apply the values in the table without more information, something which is left to future research.

Table 7: Components of Raw Milk

Item	kg/hl	Proportion
Butter fat (BF)	3.6000	0.2876
Protein (PT)	3.2326	0.2583
Other solids (OS)	5.6851	0.4541

Data Sources

The data used to construct the dairy products trade model come from three sources: the Comtrade website of the United Nations (2018), the Food and Agricultural Organization of the United Nations (FAO 2018), and the Foreign Agricultural Service of the U.S. Department of Agriculture (USDA 2017). Quantities are in kilograms and values in US dollars. The model is based on 2014 data because this was the latest year for which all the needed data were available.

The data are grouped into six product categories and ten regions. The data categories are: raw (fluid) milk, butter, cheese, powdered milk, fluid milk and other dairy products according to HS codes, as described in Appendix Table A1. The ten regions used in the model, and the production and consumption of dairy products by region, are provided in Table A2. An example of the bilateral trade flow matrices used in the development of the SPE trade model is provided in Table A3 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 (2018a) and Canadian Dairy Commission (2018) is used to infer Canadian supply and demand prices, as discussed in section 6.2. 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). Demand elasticities were discussed in section 6.2; demand elasticities varied from one product category to another, ranging from -0.49 (raw milk) through -1.01 (other products), with the same elasticity of demand used in each region.

8.2 Results

Three scenarios are examined. The baseline scenario assumes supply management in the Canadian dairy sector prevents the import or export of any dairy products – Canada is essentially isolated from the rest of the world. The high-cost scenario assumes the removal on SM in Canada, but that the high domestic cost structure remains in the dairy sector. Finally, the low-cost scenario also assumes elimination of SM but further assumes, arbitrarily, that the slope of the dairy product milk supply functions in Canada is 1.2 times greater than that of the comparable U.S. supply functions. This latter case is extreme in that it assumes Canada can be a low-cost producers and thus a global exporter of dairy products. Both alternatives are extreme assumptions but illustrate the range of possible outcomes for the Canadian dairy sector. The model outcomes for each of the three scenarios are provided in Tables 8 and 9, and Appendix Tables A4 through A10.

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 (see Table A4).[17] Clearly, Canadian consumers are worse off than consumers elsewhere, while Canadian dairy farmers gain because of 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 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).

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 as Canada imports dairy products mainly from the U.S. but also from Europe (Tables A6 and A9). 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 (Table A10). Production of milk would increase nine fold, while consumption would rise by more than 20% (compare Tables A5 and A7). Prices globally would fall (Table A4). The low-cost scenario is clearly unrealistic as Canada would export raw milk to all but the U.S. and China, although it would export significant amounts of butter and cheese to the U.S. and cheese to the EU. Nonetheless, 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, I now turn to the insights one can draw from the trade

[17] It is assumed that dairy markets elsewhere are not distorted so that supply and demand prices are equal in other countries.

modeling results in compensatory terms. Table 8 provides estimates of the welfare measures under the current SM system. Producer surplus is estimated to be $9.2 million annually, with this amount required to cover investments in land and capital associated with machinery, buildings, equipment, land and animals – the annual payment needed to cover investments in these assets. In addition, farmers receive quota rents of $5.3 million annually. When consumer surplus is included, the total surplus (welfare) from the dairy sector is estimated to be $34.9 million annually. Under free trade with high production costs, total social welfare increases to $36.1 million (Table 9), but producers only receive a producer surplus of $7.1 million; consumers gain at the expense of producers, as expected.

Table 8: Quasi-rent, Quota Rent and Total Welfare, with SM in Dairy (‘000s $2014)

Country/Region	Quasi-rent	Quota rent	Total welfare
Australia	7,843.0	-	44,129.4
Canada	9,208.2	5,314.2	34,861.7
New Zealand	19,195.7	-	85,787.5
USA	103,640.2	-	191,956.9
EU28	160,844.1	-	453,118.7
Other Europe	65,653.4	-	215,111.0
China	29,468.4	-	85,203.7
Other Asia	66,561.7	-	307,251.5
Latin America	51,151.0	-	213,733.3
Rest of World	38,928.3	-	138,524.7
Objective value[a]	901,260.9		

[a] This is the value of total global net welfare – the sum of producer and consumer surpluses and quota rents.
Source: Author’s calculations

Table 9: Quasi-rent and Total Welfare, without SM in Dairy, High Cost and Low Cost Scenarios ('000s $2014)

	Free Trade: High Cost		Free Trade: Low Cost	
Country/Region	Quasi-rent	Total Welfare	Quasi-rent	Total Welfare
Australia	7,904.0	44,122.7	6,803.9	44,390.5
Canada	7,149.9	36,083.2	40,576.2	75,915.5
New Zealand	19,372.8	85,819.8	16,538.0	85,840.7
USA	104,554.5	192,291.7	87,993.1	186,888.2
EU28	161,698.8	453,134.9	145,483.7	453,309.6
Other Europe	66,112.3	215,051.4	57,071.6	216,370.8
China	29,508.4	85,198.3	25,747.4	85,031.1
Other Asia	66,924.2	307,087.3	57,574.1	311,161.2
Latin America	51,424.1	213,652.3	44,070.1	216,045.8
Rest of World	39,025.4	138,481.4	33,979.6	139,743.3
Objective value[a]	935,465.3		973,939.0	

[a] This is the value of total global net welfare – the sum of producer and consumer surpluses and quota rents.

Source: Author's calculations

It is possible to calculate the potential compensation that might be required in these circumstances. In each case, I discount the annual producer surplus at 10% as I assume this constitutes a reasonable return on investment. In that case, the difference in quasi-rent between the SM scenario and the scenario where SM is eliminated in the dairy sector but production costs are not lowered, amounts to a loss of $2.1 billion. To this must be added the lost quota rent, which I discount at 22% (for reasons discussed earlier); it amounts to a loss of $2.4 billion. The total loss would then amount to $4.5 billion. Offsetting this would be an annual gain in consumer surplus of $1.2 million, or discounted gain of $1.2 billion. Canada would lose some $3.3 billion in social welfare but the gain in welfare globally would amount to more than $30 billion. Of course, this scenario assumes that Canada's dairy producers would not be able to purchase more cows and reduce costs – that neither dairy farmers nor downstream processors could gain from economies of scale.

On the other hand, 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 producer surplus from $9.2 million to $40.6 million, or gain of $31.4 million. There would also be a loss of $5.3 million annually associated with the elimination of the quota rent. Using the same discount factors as above, the net discounted gain to Canadian producers would amount to more than $300 billion! In addition, consumers would gain more than $400 billion over an infinite time horizon.

In summary, the trade modeling exercise confirms some of the results of section 6. In section 6, the potential level of compensation required to eliminate SM in Canada's dairy sector was estimated to be between $1.2 and $2.6 billion. The results in this section suggest that, if major reform of the dairy sector does not lead to lower costs, compensation could amount to some $4.5 billion, but, if there is a supply response, compensation might be lower. This is not to suggest that compensation is not warranted in the latter circumstance. Rather, it indicates that the matter relates as much to institutional factors than to economic measurement of welfare and income redistribution.

9. DISCUSSION

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 because 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. Given how entrenched a supply managed regime can become, a major problem is devising an acceptable means of compensating dairy producers and dismantling the system. In this paper, I provided an underlying theoretical framework for reforming supply management and estimates of the potential levels of compensation that might be required. The advantage is that this framework and related estimates makes explicit the political decisions that need to be made.

As Schmitz and his colleagues have warned (Schmitz and Schmitz 2010; Schmitz et al. 2016a, 2016b), evidence from quota buyback programs in tobacco and peanuts indicates that such programs have tended to overcompensate producers by a substantial amount. The results of the current analysis suggest that, if supply management should be eliminated in Canada's dairy sector, one must be careful to avoid overcompensating producers. Doing so could result in undue burden on the Treasury and thus might be an unnecessary obstacle to political appetite for reform.

Some economists have recommended that, as a first step towards reforming Canada's supply managed agricultural sectors, particularly dairy, quota should be freely traded across provincial borders. While I have argued that doing so might increase the costs of a future buyout (section 5.2), I also discovered that the current situation militates against interprovincial free trade in quota. Not only is there no intra-provincial trading of dairy quota, provincial dairy marketing boards have colluded to keep quota prices beyond the reach of all but a few buyers (as is evident from Figures 11 and 12). However, this is good news because few have purchased quota as a result and, based on sales over the past decade and a half, the compensation required would amount to no more than about $2.6 billion and might be even less in the future (see section 6.1). The reason is that those who purchased quota in the more distant past have already earned sufficient rent and have thereby earned enough to pay off their investment in the quota asset.

While the compensation figure of $2.6 billion is based on actual sales of quota, theory clearly indicates that compensation based only on such quota value is misleading, because it does not take into account the producer surplus (quasi-rent) that is captured as prices fall as production increases (as explained in section 4). In section 6.2, the theoretically correct measure of compensation takes this adjustment into account – the revised measure of compensation based on the theoretically appropriate measure of compensation is $1.2 billion. Yet, this latter measure does not take into account the impact of global trade. Using the trade model constructed in section 8.1, potential compensation was estimated at no more than $4.5 billion. I would consider this to be a maximum measure because it assumes the costs of production remain the same under free trade as they would with SM (e.g., farmers fail to expand their herds and dairy processors do not take advantage of economies of scale as they are free to produce as much as they like). If production costs are lowered, Canada could become a net exporter of dairy products, in which case the gain in producer surplus might well exceed the loss in quota rents. Would compensation still be warranted in this case?

In my view compensation would still be warranted. How much would depend on how the transition from SM to free trade occurs – one needs to know how the reform actually occurs. For example, it would be beneficial to know which farmers stay in the sector and how those that do transition to take advantage of economies of scale. Compensation could come in the form of payments to incentivize dairy producers (and perhaps even certain processors) to leave the sector; this would lead high-cost producers to abandon dairying while others expand their operations. While such rationalization of the sector will be opposed, it has happened and continues in other agricultural sectors, and is necessary if farmers are to compete globally.

Many factors suggest that it may finally be necessary for Canada to abandon its supply management regime in dairy. SM is clearly an obstacle in Canada's ability to conclude free trade negotiations, and reform of SM could be used as a bargaining 'chip' to obtain better access for other commodities in foreign markets (viz., softwood lumber, steel and aluminum). Evidence of very high quota prices (section 5.2) suggests that it will not be possible under SM for dairy farmers to lower costs in the future, with adverse consequences for prices of dairy products. This is particularly disconcerting for the poorest in society, because cheese, yoghurt, pizza and many other products that rely on dairy are a greater proportion of the budgets of the poor than of the more well to do. Finally, by not competing in global markets, dairy producers and processors fail to capture potentially large surpluses from the sale of dairy products to foreign buyers.

Supply management has been the norm in Canada's dairy sector for some 35 years. As an agricultural support mechanism, SM has been successful in stabilizing prices and maintaining incomes at little cost to the Treasury. It has been less successful in providing low-cost food to citizens, earning foreign exchange and/or economic surplus, or driving economic growth, innovation and employment. It has also 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 abandoned in the future, dairy producers would then likely 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. Based on the research in this study, compensation of between $1.2 and a maximum of $4.5 billion.

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11. APPENDIX TABLES

Table A1: Source of Dairy Sector Production and Trade Data[a]

Products	FAOSTAT Code	Comtrade HS07 Code	FAOSTAT Item Descriptions
Fresh cow milk	0882	0401.20	Fresh cow whole milk
Butter	0886	0405.10	Butter of cow milk
		0405.20	
Fluid	0885	0401.30	Fresh cream
	0888	0401.10	Skim milk of cows
	0908		Reconstituted milk
	0889	0402.99	Condensed whole milk
	0896		Condensed skim milk
	0894	0402.91	Evaporated whole milk
	0895		Evaporated skim milk
Powdered Milk	0897	0402.21	Dry whole cow milk
		0402.29	
	0898	0402.10	Dry skim cow milk
Cheese	0901	0406	Cheese from whole cow milk
	0904		Cheese from skimmed cow milk
	0905		Whey cheese
	0907		Processed cheese
Others	0890	0404	Condensed whey
	0900		Dry whey
	0903		Fresh whey
	0909		Products of natural milk constitue, nes
	0891	0403.10	Yoghurt
	0892		Yoghurt, concentrated or unconcentrated

[a] Source: United Nations (2018); FAO (2018).

Table A2: Production and Consumption, Trade Model Inputs ('000s tonnes)

Region	Raw milk	Butter	Cheese	Milk powder	Fluid product	Other dairy
			Production			
Australia	9,542	116	311	343	2,577	98
Canada	8,400	87	382	81	3,592	67
New Zealand	21,320	331	325	1,875	6,340	96
USA	93,465	842	5,222	1,003	16,422	1,435
EU28	156,894	1,901	8,434	1,909	56,374	2,121
Other Europe	79,552	784	1,828	479	19,125	320
China	37,247	88	1	1,475	2,199	22
Other Asia	117,186	238	43	433	9,658	18
Latin America	81,111	276	1,340	1,367	6,907	117
Rest of World	51,498	369	850	62	10,066	139
			Consumption			
Australia	9,417	99	238	108	2,529	79
Canada	8,426	96	404	72	3,594	70
New Zealand	21,225	22	42	45	6,303	38
USA	93,377	796	5,016	406	16,421	968
EU28	157,138	1,788	7,747	908	55,907	1,678
Other Europe	78,943	912	2,015	441	19,110	191
China	37,530	148	83	2,387	2,353	407
Other Asia	117,326	346	552	1,572	9,716	550
Latin America	81,135	257	1,472	1,661	6,886	188
Rest of World	51,695	567	1,167	1,425	10,440	263

Source: Author's calculations

Table A3: 2014 Bilateral Trade Flows for Butter, based on FAO Production and UN Comtrade Data (kt)

	AUS	CAN	NZL	USA	EU28	OthEur	China	OthAsia	LatinAm	ROW	**Production**
AUS	79,741	21	322	754	2	10,670	4,129	12,613	20	7,852	**116,124**
CAN	41	86,749	-	404	1	-	1	7	19	8	**87,230**
NZL	17,910	5,751	22,000	3,560	22,819	50,812	50,173	49,654	8,284	99,906	**330,870**
USA	557	2,579	39	780,897	1,796	4,280	518	4,505	3,934	42,459	**841,565**
EU28	952	705	17	9,471	1,756,399	53,948	4,597	28,686	2,589	43,186	**1,900,548**
OthEur	0	195	-	27	5,952	766,115	0	9,217	4	2,709	**784,220**
China	0	-	-	-	-	299	86,405	814	0	482	**88,000**
OthAsia	97	2	5	184	266	275	137	234,255	61	2,749	**238,031**
LatinAm	-	-	-	1,087	219	25,160	395	370	241,754	6,583	**275,569**
ROW	21	0	0	7	650	3	1,194	5,512	10	361,372	**368,771**
Consumption	*99,319*	*96,001*	*22,382*	*796,390*	*1,788,105*	*911,564*	*147,549*	*345,634*	*256,676*	*567,307*	**5,030,928**

Source: FAO (2018), United Nations (2018) and author's calculations.

Table A4: Prices of Dairy Products with and without SM, High- and Low-Cost Scenarios, 2014 ($/kg)

Region	Raw milk	Butter	Cheese	Milk powder	Fluid product	Other dairy
			With SM in Dairy			
Australia	1.13	3.73	4.08	0.73	1.52	2.39
Canada						
- Demand	1.41	8.16	5.70	5.63	2.30	4.16
- Supply	1.15	4.88	4.88	2.45	1.69	3.00
New Zealand	1.12	3.29	3.78	0.51	1.40	2.22
USA	1.06	3.72	4.03	0.74	1.37	2.33
EU28	1.20	3.70	4.06	0.81	1.52	2.23
Other Europe	1.24	3.82	4.15	1.02	1.52	2.24
China	1.20	3.90	4.82	1.17	1.47	2.90
Other Asia	1.24	3.94	4.72	1.39	1.52	3.02
Latin America	1.24	3.82	4.22	1.15	1.52	2.54
Rest of World	1.23	3.95	4.26	1.56	1.53	2.56
			No SM in Dairy: High Cost Scenario			
Australia	1.13	3.76	4.08	0.74	1.53	2.40
Canada	1.09	3.81	4.13	0.75	1.35	2.36
New Zealand	1.12	3.32	3.83	0.52	1.41	2.23
USA	1.07	3.73	4.07	0.75	1.38	2.34
EU28	1.20	3.73	4.06	0.82	1.53	2.25
Other Europe	1.24	3.85	4.16	1.03	1.53	2.25
China	1.20	3.93	4.86	1.17	1.47	2.91
Other Asia	1.24	3.97	4.76	1.39	1.54	3.03
Latin America	1.24	3.82	4.23	1.16	1.53	2.55
Rest of World	1.23	3.99	4.27	1.57	1.54	2.57
			No SM in Dairy: Low Cost Scenario			
Australia	1.05	3.57	3.57	0.69	1.44	2.24
Canada	0.70	3.03	3.18	0.45	0.96	1.72
New Zealand	1.03	3.04	3.24	0.50	1.35	1.99
USA	0.97	3.46	3.63	0.73	1.32	2.20
EU28	1.15	3.51	3.64	0.80	1.47	2.11
Other Europe	1.15	3.63	3.68	1.01	1.47	2.03
China	1.12	3.61	4.28	1.11	1.35	2.76
Other Asia	1.15	3.69	4.17	1.37	1.46	2.79
Latin America	1.15	3.56	3.65	1.12	1.44	2.38
Rest of World	1.15	3.71	3.73	1.55	1.48	2.43

Source: Author’s calculations

Table A5: Model-Generated Consumption and Production under Supply Management, 2014 ('000s tonnes)

Region	Raw milk	Butter	Cheese	Milk powder	Fluid product	Other dairy
			Consumption			
Australia	8,950.6	103.9	259.8	238.2	2,506.6	77.8
Canada	8,399.7	87.2	382.1	81.1	3,591.9	66.7
New Zealand	23,315.0	315.2	307.5	1,062.1	6,671.0	88.9
USA	137,005.7	1,003.0	5,390.0	1,165.4	23,875.9	1,043.4
EU28	157,059.7	2,099.8	8,596.3	1,476.2	54,933.1	2,535.5
Other Europe	75,671.0	757.6	1,793.2	428.5	17,223.2	335.6
China	43,886.5	82.8	0.8	1,925.9	2,430.7	18.9
Other Asia	96,757.6	223.3	47.5	456.7	7,546.4	17.6
Latin America	69,269.4	265.2	1,255.7	1,235.7	5,575.1	123.4
Rest of World	47,784.5	373.9	770.9	83.1	8,914.4	134.0
			Production			
Australia	11,504.9	99.5	259.8	140.2	2,580.9	95.4
Canada	8,399.7	87.2	382.1	81.1	3,591.9	66.7
New Zealand	25,324.6	31.0	43.3	64.6	6,052.8	41.2
USA	79,745.2	1,007.1	5,066.6	341.7	10,756.9	1,235.4
EU28	157,059.7	1,765.8	7,663.4	1,110.2	56,992.8	1,347.5
Other Europe	80,753.3	967.8	2,036.8	486.8	20,553.9	181.8
China	38,223.6	163.2	82.4	1,672.3	2,164.9	459.6
Other Asia	126,939.0	364.7	517.8	1,488.9	11,331.0	564.1
Latin America	86,702.3	265.2	1,523.7	1,817.5	7,895.3	177.3
Rest of World	53,447.3	560.3	1,227.9	949.6	11,347.7	272.7

Source: Author's calculations

Table A6: Model-Generated Consumption and Production, No Supply Management, High-Cost Scenario, 2014 ('000s tonnes)

Region	Raw milk	Butter	Cheese	Milk powder	Fluid product	Other dairy
			Consumption			
Australia	11,499	99	260	139	2,566	95
Canada	9,302	137	451	134	4,722	98
New Zealand	25,311	31	43	64	6,009	41
USA	79,602	1,006	5,038	337	10,595	1,232
EU28	157,060	1,751	7,655	1,103	56,659	1,336
Other Europe	80,678	961	2,035	484	20,449	181
China	38,213	162	82	1,672	2,163	458
Other Asia	126,842	362	515	1,479	11,285	562
Latin America	86,633	265	1,522	1,807	7,861	176
Rest of World	53,460	556	1,227	940	11,292	271
			Production			
Australia	8,972	105	260	241	2,527	78
Canada	7,964	68	323	25	2,872	53
New Zealand	23,370	318	311	1,079	6,729	89
USA	137,346	1,006	5,446	1,178	24,089	1,049
EU28	157,060	2,119	8,612	1,491	55,376	2,549
Other Europe	75,833	764	1,797	432	17,362	337
China	43,915	83	1	1,926	2,433	19
Other Asia	96,964	225	48	459	7,607	18
Latin America	69,417	265	1,258	1,244	5,620	124
Rest of World	47,757	377	772	84	8,986	135

Source: Author's calculations

Table A7: Model-Generated Consumption and Production, No Supply Management, Low-Cost Scenario, 2014 ('000s tonnes)

Region	Raw milk	Butter	Cheese	Milk powder	Fluid product	Other dairy
			Consumption			
Australia	11,670	103	274	145	2,676	99
Canada	10,398	146	492	137	5,183	110
New Zealand	25,804	32	46	65	6,246	45
USA	84,687	1,041	5,335	349	11,469	1,275
EU28	160,390	1,847	8,123	1,120	58,459	1,464
Other Europe	83,363	1,005	2,163	491	21,016	201
China	39,326	172	88	1,817	2,321	477
Other Asia	130,264	383	557	1,507	11,570	605
Latin America	89,012	280	1,628	1,858	8,113	189
Rest of World	55,027	592	1,302	964	11,595	286
			Production			
Australia	8,317	99	227	224	2,379	73
Canada	75,396	681	3,552	594	13,953	642
New Zealand	21,411	292	264	1,038	6,415	80
USA	125,235	934	4,866	1,147	22,939	986
EU28	149,986	1,994	7,704	1,455	52,988	2,389
Other Europe	70,076	720	1,590	424	16,614	304
China	41,031	77	1	1,835	2,239	18
Other Asia	89,692	209	42	452	7,234	16
Latin America	64,357	247	1,087	1,202	5,288	116
Rest of World	44,437	351	675	82	8,601	127

Source: Author's calculations

Table A8: Trade Flows with Supply Management in Dairy in Place ('000s tonnes)

Exporter	Importer	Raw milk	Butter	Cheese	Milk powder	Fluid product	Other dairy
AUS	AUS	8,950.6	99.5	259.8	140.2	2,506.6	77.8
AUS	USA		4.1				
AUS	EU28		0.3		98.0		
CAN	CAN	8,399.7	87.2	382.1	81.1	3,591.9	66.7
NZL	NZL	23,315.0	31.0	43.3	64.6	6,052.8	41.2
NZL	China		142.8			618.2	
NZL	OthAsia		141.3	264.2	997.5		47.7
USA	AUS	2,554.3				74.4	
USA	NZL	2,009.6					
USA	USA	79,745.2	1,003.0	5,066.6	341.7	10,756.9	1,043.4
USA	EU28					2,059.7	
USA	OthEur	5,082.3				3,330.7	
USA	China			81.6		1,546.7	
USA	OthAsia	30,181.4		206.0	34.7	3,784.6	
USA	LatinAm	17,432.9		35.7	581.9	2,320.3	
USA	ROW				207.2	2.6	
EU28	AUS						17.6
EU28	USA						192.0
EU28	EU28	157,059.7	1,765.6	7,663.4	1,012.2	54,933.1	1,347.5
EU28	OthEur		210.2	243.6	58.3		181.8
EU28	China						459.6
EU28	LatinAm			232.3			177.3
EU28	ROW		123.9	457.0	405.6		159.7
OthEur	OthEur	75,671.0	757.6	1,793.2	428.5	17,223.2	
OthEur	OthAsia						335.6
China	China	38,223.6	20.4	0.8	1,672.3		
China	OthAsia						18.9
China	ROW	5,662.8	62.4		253.6	2,430.7	
OthAsia	OthAsia	96,757.6	223.3	47.5	456.7	7,546.4	17.6
LatinAm	OthAsia						123.4
LatinAm	LatinAm	69,269.4	265.2	1,255.7	1,235.7	5,575.1	
ROW	OthAsia						21.0
ROW	ROW	47,784.5	373.9	770.9	83.1	8,914.4	113.0

Source: Author's calculations

Table A9: Trade Flows with NO SM in Dairy, High-Cost Scenario ('000s tonnes)

Exporter	Importer	Raw milk	Butter	Cheese	Milk powder	Fluid product	Other dairy
AUS	AUS	8,971.6	98.7	259.8	139.4	2,526.8	78.2
AUS	EU28		6.1		101.4		
CAN	CAN	7,963.8	68.2	323.3	24.8	2,871.6	52.6
NZL	NZL	23,370.0	30.9	43.1	64.2	6,008.7	41.0
NZL	China		150.5	81.2			
NZL	OthAsia		137.0	186.6	1,014.8	720.6	48.4
USA	AUS	2,527.8				39.0	
USA	CAN	1,337.9		127.3	109.3	1,850.0	
USA	NZL	1,940.6					
USA	USA	79,602.3	1,005.7	5,038.1	336.6	10,594.9	1,048.9
USA	EU28					1,283.3	
USA	OthEur	4,844.9				3,086.8	
USA	China					0.0	
USA	OthAsia	29,877.5		280.2	5.2	2,957.0	
USA	LatinAm	17,215.3			562.8	2,241.4	
USA	ROW				164.4	2,036.6	
EU28	AUS						16.8
EU28	CAN		69.2				45.7
EU28	USA						182.8
EU28	EU28	157,059.7	1,745.1	7,655.1	1,001.9	55,375.8	1,336.4
EU28	OthEur		197.0	238.3	51.9		180.7
EU28	China						458.2
EU28	LatinAm			264.4			176.3
EU28	ROW		107.5	454.6	437.1		152.4
OthEur	OthEur	75,832.9	764.2	1,796.5	431.9	17,361.9	
OthEur	OthAsia						337.4
China	China	38,212.5	12.0	0.8	1,671.5	2,163.4	
China	OthAsia						19.0
China	ROW	5,702.6	71.3		254.8	269.1	
OthAsia	OthAsia	96,964.3	225.2	47.9	459.4	7,607.0	17.7
LatinAm	OthAsia						124.0
LatinAm	LatinAm	69,417.4	265.2	1,257.9	1,244.4	5,620.0	
ROW	OthAsia						15.5
ROW	ROW	47,757.5	377.1	772.2	83.6	8,985.7	119.1

Source: Author's calculations

Table A10: Trade Flows with NO SM in Dairy, Low-Cost Scenario ('000s tonnes)

Exporter	Importer	Raw milk	Butter	Cheese	Milk powder	Fluid product	Other dairy
AUS	AUS	8,317.2	99.4	227.2	144.6		72.9
AUS	EU28				79.6	2,378.7	
CAN	AUS	3,353.1	3.9	46.6			
CAN	CAN	10,397.9	146.5	491.6	137.4	5,183.4	109.6
CAN	NZL	4,392.9					
CAN	USA		107.8	468.5			
CAN	EU28	10,404.1		418.9		3,091.9	
CAN	OthEur	13,286.6	137.8	573.0		1,340.7	
CAN	China				373.5		
CAN	OthAsia	22.6	86.6	385.9	82.6	4,336.7	532.2
CAN	LatinAm	24,654.1	33.2	541.1			
CAN	ROW	8,885.1	165.1	626.3			
NZL	NZL	21,411.4	31.9	46.5	65.2	6,246.5	44.9
NZL	China		171.9	87.6		168.2	
NZL	OthAsia		87.8	129.4	972.5		34.8
USA	AUS					2,676.3	
USA	USA	84,686.8	933.7	4,866.1	349.0	11,468.6	985.6
USA	OthEur					3,061.6	
USA	OthAsia	40,548.5					
USA	LatinAm				655.8	2,825.0	
USA	ROW				142.3	2,907.9	
EU28	AUS						26.5
EU28	USA						208.5
EU28	EU28	149,985.6	1,847.3	7,703.7	1,040.5	52,988.1	1,464.2
EU28	OthEur		146.5		67.7		
EU28	China						458.6
EU28	LatinAm						73.1
EU28	ROW				346.8		158.4
OthEur	USA						80.6
OthEur	OthEur	70,076.2	720.5	1,589.6	423.6	16,614.1	201.0
OthEur	OthAsia						21.9
China	China	39,326.4			1,443.0	2,152.9	18.0
China	ROW	1,704.1	76.6	0.7	391.9	85.8	
OthAsia	OthAsia	89,692.5	208.9	42.0	451.7	7,233.5	16.2
LatinAm	LatinAm	64,357.5	247.1	1,086.6	1,201.9	5,287.9	116.1
ROW	ROW	44,437.3	350.6	674.8	82.5	8,601.1	127.2

Source: Author's calculations