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Trade liberalization and inter-provincial dumping in a spatial equilibrium model: the case of the Canadian dairy industry

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Abstract: The paper introduces imperfect competition in a spatial equilibrium model of provincial dairy markets to analyze the welfare impacts of trade liberalization. Our model accounts for output restrictions at the farm level and the potential presence of market power at the processing level. Our model builds on the reciprocal dumping model of Brander and Krugman (1983) because processing firms from different provinces compete with one another in several provinces. Simulations reveal that welfare in the Canadian dairy sector could increase by as much as $1 billion per year if aggressive tariff cuts were made while moderate liberalization plans would yield annual gains of $234.5 million. Even large producing provinces like Quebec and Ontario gain from trade liberalization. In comparison, a perfect competition model yields more modest welfare gains in the range of $15.6 million and $34.5 million. Finally, we show that the switch in the sign of the transport cost-welfare relation identified by Brander and Krugman (1983) occurs at transport costs that are too high to be policy-relevant.

JEL Codes: Q17; F12; L13

Keywords: Supply management, Canadian dairy sector, imperfect competition, bilateral dumping

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Introduction

The current of round of multilateral trade negotiations at the World Trade Organization (WTO) is stalled. While a host of new trade issues have emerged since the conclusion of the Uruguay Round in 1994, the negotiations in agriculture still mostly rest on three pillars: 1) export competition; 2) domestic support; and 3) market access. With regards to market access, the most contentious subject is arguably the notion of sensitive products. The 2004 July Framework (WTO, 2010) called for the introduction of flexibility in lowering tariffs of products deemed sensitive mostly on the basis of non-trade concerns. In return for this flexibility, WTO members are to offer increased duty-free market access mostly through increases in minimum access granted under Tariff-Rate Quotas (TRQs). The July 2008 draft modalities for agriculture propose that a maximum of 4% of tariff lines be allowed for sensitive products. Canada and Japan have requested a higher ceiling and it remains to be seen whether other WTO members will agree and what will the compensation be in terms of minimum access (WTO, 2010).

The issue of sensitive products is particularly important for Canada's supply managed dairy sector. The dairy supply management policy is implemented by a national agency and provincial organizations. The Canadian Milk Supply Management Committee (CMSMC) is responsible for administering the national production system for industrial milk. It is responsible to allocate industrial milk among provinces while the amount of fluid milk to be produced in each province is determined by milk marketing pools. There are two such pools in Canada. Provincial producer boards then allocate total milk production to dairy quota holders. Milk prices vary with the end-use of the milk. Milk used to make fluid milk and cream is sold at a premium compared to industrial milk. All revenues in a province are shared with the pool, and the milk price at the farm level is a weighted average of the different milk class prices. The Canadian Dairy Commission (CDC) buys and sells butter and skimmed milk powder at fixed support prices to deal with demand and supply shocks that could prevent the achievement of a target return at the farm level once the national quota has been determined.

The effectiveness of supply management in supporting high domestic prices paid to Canadian producers rests on the ability to control domestic production and imports of foreign products. Not surprisingly, trade liberalization is strongly opposed by producer organizations. Barichello and Zhang (2008) found that the over-quota tariffs of the TRQs shielding Canadian dairy products are set so high that even large tariff reductions would not be effective. Clearly the use of watery tariffs was to mimic the import quotas that were replaced by the TRQs (Larue, Gervais and Pouliot, 2007). Huff, Meilke and Amedei, (2000) and Rude and Gervais (2006) computed tariff equivalent measures of the TRQ in the Canadian poultry sector and estimated the welfare impacts of liberalizing trade. In all cases, the results critically hinge on the output adjustment chosen in response to increased market access. Meilke, Sarker and LeRoy (1998) analyzed the potential increase in U.S.-Canada bilateral dairy trade flows following liberalization using a non-spatial synthetic model. Larivière and Meilke (1999) addressed a more global issue as they looked at dairy product trade for OECD countries. More recently, Abbassi, Bonroy and Gervais (2008) departed from the synthetic non-spatial framework of the previous studies and proposed a spatial equilibrium model of the Canadian dairy industry to investigate the impacts of trade liberalization.

While the aforementioned studies rely on different underlying assumptions, they also have many similarities. Most studies investigate the behavior of producers at the farm level, but ignore vertical and horizontal interactions between firms in downstream markets. For example, it is generally assumed that retail and/or processing margins are constant or are a linear function of industry output. Yet, there is evidence of increased concentration in dairy markets. Concentration in the European dairy industry varies across countries and products, with higher industry concentration observed in France and in the United Kingdom (Bouamra and al., 2005). In the United States, the market shares of the four largest processors of fluid milk, cheese and dry, condensed and evaporated milk are 43%, 35% and 47%, respectively (GAO, 2009). In Canada, 14% of Canadian plants are owned by the three largest processors in the country, Saputo, Agropur and Parmalat which process approximately 75% of the milk produced by Canadian farms.[1] Naturally, concentration at one level of the market is not *de facto* detrimental to the other agents in the supply chain as economies of scale and other efficiencies can be passed on to upstream and downstream firms. However, the rigid control of upstream production, which does not encourage economies of scale, and the high degree of concentration in processing and retail have institutionalized a multiple marginalization problem.[2] The purpose of this paper is to measure the impacts of trade liberalization scenarios on the Canadian dairy sector through a spatial model of the Canadian dairy industry and to assess the incidence of imperfect competition in processing activities on the magnitude of the gains from trade.

[1] See www.dairyinfo.gc.ca/index_e.php?s1=cdi-ilc for more details.

[2] Dairy Farmers of Canada argues the opposite when it states on its website that: "Canada's supply management system provides balance in the concentrated dairy sector" (www.dairyfarmers.ca/what-we-do/supply-management). We argue that supply management exacerbates social losses arising from concentration in processing activities by institutionalizing a multiple-marginalization problem. The volume of milk marketed is controlled by producers because they control the Canadian Milk Supply Management Committee (CMSMC), which determines the volume of milk to be allocated to the provinces, and the provincial marketing boards which control milk production within provinces and negotiate prices with processors. In some provinces, retail prices are constrained by minimum prices. The system is designed to allow all of the agents along the marketing chain to take a profit margin. Because producers control the regulatory institutions, it would be difficult for processors to exploit oligopsony power.

The literature on spatial equilibrium models applied to the dairy sector is dominated by analyzes based on perfectly competitive markets.[3] Kawaguchi *et al*. (1997) were the first to introduce market power in a dairy spatial equilibrium model. They developed a generalized dual-structure spatial equilibrium model which allows for any degree of competition, from perfect competition to monopoly. Cox and Chavas (2001) introduced imperfect competition in both the input and final good markets. In their application, U.S. producers capture all gains associated with price discrimination in the downstream market. In other words, processors simply act as pass-through agents of producers. Abbassi, Bonroy and Gervais (2008) applied these insights to model dairy trade liberalization in the Canadian dairy industry.

In this paper, we rely on a different approach to introduce imperfect competition in the dairy market. The model links five Canadian regions (Atlantic, Quebec, Ontario, Prairies and British Columbia) spatially. In each region, dairy producers act as a price discriminating monopolist in that they sell milk to processors in their own region at different prices according to the end-usage of the milk. Dairy processors purchase the input from producers and sell to buyers located in different regions. A few simplifying assumptions are made regarding the firms' strategy space. While there are several processed products in the model, we assume that processing firms are specialized in the production of a single output. This is necessary to calibrate output decisions given the data available. Processing firms consider the Canadian regions as segmented markets and compete *à la* Cournot in these markets.

Our model is similar to the reciprocal dumping model of Brander and Krugman (1983). In our case, the assumption about the input market leads to a double marginalization problem and

[3] Spatial equilibrium models were first proposed by Samuelson (1952) and Takayama and Judge (1964). Takayama and Judge (1971) relaxed the perfect competition assumption in their analysis of a price discriminating monopolist. Hashimoto (1984) generalized the previous approach by having firms located in different markets compete using Cournot conjectures. Nelson and McCarl (1984) used a conjectural variation approach to analyze departures from standard oligopoly models.

the reciprocal dumping is done across provinces as processors engage in interprovincial trade to maximize profit when processing and transport costs are low enough while imports of foreign products are restricted by TRQs. As argued by Brander and Krugman (1983), reciprocal dumping is the outcome of a non-cooperative game that on one hand enhances competition while on the other hand creates sourcing inefficiencies because increases in consumption are supported by purchases subject to transport costs. The effects of trade liberalization in our model are different because the dumping is interprovincial and because of the supply management policy that induces a double marginalization problem.[4] Finally, we abstract from modeling the support price administered by the CDC because it is essentially a dynamic tool to balance unexpected seasonal variations in supply and demand. Our assumptions allow us to treat our optimization problem as a linear complementarity problem which is solved following the procedure described in Yang *et al* (2002).

The remainder of the paper is structured as follows. The next section develops a theoretical model of the Canadian dairy sector under imperfect competition that accounts for: 1) the existence of a production quota at the farm level in each region; 2) no interregional trade in farm output; 3) interregional trade in processed products; and 4) the existence of TRQs in dairy product trade. Section 3 describes the dataset and presents the calibration exercise. Section 4 introduces two trade liberalization scenarios and reports the impacts of lowering tariffs and expanding market access on welfare, farm prices and quota values under imperfect at the processing level. We also analyze the same scenarios under perfect competition to ascertain the degree of magnification of the gains from trade due to imperfect competition. The final section

[4] A significant literature emerged following Brander and Krugman (1983)'s introduction of dumping. Baldwin and Krugman (1988) were first to present an empirical application of reciprocal dumping. Feenstra *et al* (2001) consider bilateral dumping as a foundation for the standard gravity equation in applied trade. Friberg and Ganslandt (2008) generalized Brander and Krugman (1983)'s model by introducing product differentiation.

summarizes the impacts of trade liberalization and their implication for Canada's position on agricultural issues in the Doha Round of multilateral negotiations.

The theoretical model

Let $K = 8$ be the number of processed dairy products in the model (fluid milk, ice cream, yogurt, cheese, butter, skim milk powder, concentrated milk and buttermilk powder) and $J = 5$ represent the number of Canadian regions in the model (Atlantic, Quebec, Ontario, Prairies and British Columbia). The variables Q_i and MSQ_i represent, respectively, farm output and the market sharing quota (production quota) in region i. The constraint $Q_i \leq MSQ_i$ assures that aggregate farm output is lower or at most equal to the production quota. Marginal production cost in region i is defined by $p_i^s\left(Q_i\right)$ and is assumed to be linear in output. Total variable cost of producers in region i is $C_i\left(Q_i\right) = \int_0^{Q_i} p_i^s(q)\, dq$.

We assume that there exists a single representative processing firm in each region that sells an output k produced with a fixed proportion technology such that production of product k in region i is represented by $y_{ik} = \min\left\{x_{ik}/\alpha_k, f\left(\Theta_{ik}\right)\right\}$, where y_{ik} and x_{ik} represent output of processed product k and milk going into the production of output k used in region i. The parameter α_k determines the technological relationship between raw milk and product k while Θ_{ik} is a vector of variable inputs other than raw milk. In what follows, we assume that $f\left(\Theta_{ik}\right)$ is a sub-production function characterized by constant returns to scale. Under these assumptions, the cost function of a firm selling product k in region i is $G\left(y_{ik}\right) = \left(\alpha_k p_{ik}^l + g_{ik}\right) y_{ik}$, where g_{ik} and p_{ik}^l are, respectively, the marginal cost of processing and the farm gate price of milk used in the production of product k.

The demand for product k in region i is measured by z_{ik}. The inverse demand function of buyers, $p_{ik}^{d}\left(z_{ik}\right)$, is derived from linear preferences of the form: $U_i(z_{i1},...,z_{iK}) = \int_0^{z_{iK}} \sum_{k=1}^{K} p_{ik}^{d}\left(q_k\right) dq_k$.[5] Let t_{ijk} measure sales of product k by a firm located in region i to buyers located in region j. Transportation costs for product k between two regions is denoted by c_{ijk}. The constraint $y_{ik} \geq \sum_j t_{ijk}$ guarantees that total shipments of a product from a given region will be no higher than its output.

Imports of dairy products into region i above the minimum access commitment are denoted OM_{Wik}^{OQ} and are taxed at an ad-valorem rate of τ_k^{OQ}. Imports in region i under the minimum access commitment (i.e. in-quota imports) are denoted by $TMAC_{ik}$ and are taxed at an ad-valorem rate of τ_k^{IQ}. The constraint $\sum_j t_{jik} + TMAC_{ik} + OM_{Wik}^{OQ} \geq z_{ik}$, guarantees that total domestic sales in a region plus total imports are weakly higher than total consumption in that same region. MAC_k denotes the minimum market access under the Canadian TRQ for product k. Let the parameter ρ_{ik} be the proportion of import licenses held by firms in region i, such that $MAC_{ik} \equiv \rho_{ik} MAC_k$. The constraint $\rho_{ik} MAC_k \geq TMAC_{ik}$ guarantees that imports of product k in a given region that fall within the minimum market access commitment are no higher than the minimum access level implied by the licenses allocated to this region. Finally, define the world price of product k by p_{Wk} and let c_{Wik} measure the transportation cost between region i and the rest of the world.

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[5] We refer to buyers instead of consumers and retailers because no distinction is made in our model between the two groups. Introducing strategic interactions between retailers would be appealing, but difficult to implement without data on purchases by individual retailers.

Imperfect competition in the Canadian dairy industry is introduced at the farm and processing levels. At the farm level, producers in each region collectively behave as a price discriminating monopolist, selling milk at different prices according to the end-usage of processors. Processors compete *à la* Cournot by determining their sales in a given region. The inverse demand that processors face in a given region is $p\left(\sum_{i=1}^{J} t_{ijk}\right)$.[6] The strategic game can be solved in two stages. First, the output of producers and the assumptions about technology determine the processors' output in each region. In the second stage, processors simultaneously allocate their output across regions.

Using backward induction, we first investigate the buyers' behaviour in a given region. We need to solve the optimization problem:

$$\max_{z_{jk}, t_{ijk}, TMAC_{jk}, OM_{jW}^{OQ}} U_j\left(z_{jK}\right) - \sum_{i=1}^{J} p_{jk}^{d} t_{jik} - (p_{Wk} + c_{Wjk} + \tau_k^{IQ}) TMAC_{jk} - (p_{Wk} + c_{Wjk} + \tau_k^{OQ}) OM_{Wjk}^{OQ}$$

such that: $\chi_{jk}: \quad \sum_{i=1}^{J} t_{ijk} + TMAC_{jk} + OM_{Wjk}^{OC} \geq z_{jk}$

$\eta_{jk}: \quad \rho_{jk} MAC_k \geq TMAC_{jk}$

The Kuhn-Tucker first-order conditions are:

$$\frac{\partial L}{\partial z_{jk}} = \frac{\partial U_j}{\partial z_{jk}} - \chi_{jk} \leq 0 \text{ for } z_{jk} \geq 0 \tag{1}$$

$$\frac{\partial L}{\partial t_{jik}} = \chi_{jk} - p_{jk}^{d} \leq 0 \text{ for } t_{jik} \geq 0 \tag{2}$$

[6] We assume that processors do not market imports. In this sense, the demand that they face is a residual demand once imports have been accounted for and imports and domestic products are perfect substitute. However, there are no substitution possibilities across products (*e.g.,* cheese vs. ice cream). This assumption is made because it is not possible to obtain reliable cross-price elasticities to calibrate the demand functions at the application stage. Evidence from recent studies (e.g., Chouinard et al., 2010 and Bouamra-Merchemache et al. (2008) confirms that many cross-price effects are indeed zero and that significant cross-price effects vary across countries. This suggests that there might be significant cross-price effects that need not be the same from one province to another. The fact that we could not identify and internalize them is a limitation of our study.

$$\frac{\partial L}{\partial TMAC_{jk}} = -p_{Wk} - c_{Wjk} - \tau_k^{IQ} + \chi_{jk} - \eta_{jk} \leq 0 \text{ for } TMAC_{jk} \geq 0 \tag{3}$$

$$\frac{\partial L}{\partial OM_{Wjk}^{OQ}} = -p_{Wk} - c_{Wjk} - \tau_k^{OQ} + \chi_{jk} \leq 0 \text{ for } OM_{Wjk}^{OQ} \geq 0 \tag{4}$$

$$\frac{\partial L}{\partial \chi_{jk}} = \sum\nolimits_{i=1}^{J} t_{ijk} + TMAC_{jk} + OM_{Wjk}^{OQ} - z_{jk} \geq 0 \text{ for } \chi_{jk} \geq 0 \tag{5}$$

$$\frac{\partial L}{\partial \eta_{jk}} = \rho_{jk} MAC_k - TMAC_{jk} \geq 0 \text{ for } \eta_{jk} \geq 0 \tag{6}$$

Eq. (1) implies that the buyer's price is equal to its marginal utility while eq. (2) states that the buyer's price is equal to the price paid to processors. Equation (3) defines the maximum price paid by buyers (χ_{jk}) as the sum of the world price, transportation cost in the world market, the in-quota import tariff and the TRQ import rent (η_{jk}). When imports exceed the minimum access commitment $(t_{Wjk}^{OQ} \geq 0)$, eq. (4) implies that the buyer's price is equal to the world price plus transportation cost and the over-quota import tariff.

The next step is to maximize processors' profits:

$$\max_{t_{ijk}} \sum\nolimits_{j=1}^{J} p_{jk}\left(\sum\nolimits_{i=1}^{J} t_{ijk}\right) t_{ijk} - \left(g_{ik} + \alpha_k p_{ik}^{l}\right) \sum\nolimits_{j=1}^{J} t_{ijk} - \sum\nolimits_{j=1}^{J} c_{ijk} t_{ijk}$$

The first-order condition (or the firm's reaction function) is:

$$\frac{\partial L}{\partial t_{ijk}} = p_{jk} + t_{ijk} p'_{jk} - \left(g_{ik} + \alpha_k p_{ik}^{l} + c_{ijk}\right) \leq 0 \text{ for } t_{ijk} \geq 0 \tag{7}$$

Each processing firm considers a region as a segmented market and marginal revenue must equal marginal cost in each market: $p_{jk} = \left(g_{ik} + \alpha_k p_{ik}^{l} + c_{ijk}\right) + t_{ijk}\left|p'_{jk}\right|$ (for an interior solution). Processor *i*'s price of good k for sales in region j is the sum of marginal processing cost (g_{ik}), marginal cost of the milk input $\left(\alpha_k p_{ik}^l\right)$, transportation cost between the source and destination regions $\left(c_{ijk}\right)$ and a profit margin which is denoted by: $MK_{ijk} \equiv t_{ijk}\left|p'_{jk}\right|$. With identical demand functions across regions and no transportation costs, prices across regions would be identical $p_{jk} = p_{mk}$ and so would sales $t_{ijk} = t_{imk}, \forall m \in J$. Under perfect competition, $MK_{ijk} = 0$, implying $p_{jk} = g_{ik} + \alpha_k p_{ik}^l + c_{ijk}$.

The solutions to the processors' optimization determine the inverse demands for milk of each processing firm. According to eq.(7), we have $p_{jk} + t_{ijk} p'_{jk} - \left(g_{ik} + \alpha_k p_{ik}^l + c_{ijk}\right) = 0$. As mentioned before, the buyers' demand for product k $\left(p\left(\sum_{i=1}^J t_{ijk}\right)\right)$ is a linear function : $p_{jk} = \varphi_{jk} - b_{jk}\left(t_{ijk} + \sum_{m\neq i}^J t_{mjk}\right)$, with $\varphi_{jk} > 0$ and $p'_{jk} = -b_{jk} < 0$. Substituting $p\left(\sum_{i=1}^J t_{ijk}\right)$ into (7), the reaction function of processor k in region j is: $t_{ijk} = \dfrac{\varphi_{jk} - \left(g_{ik} + \alpha_k p_{ik}^l + c_{ijk}\right) + b_{jk}\sum_{m\neq i}^J t_{mjk}}{2b_{jk}}$. Solving the set of reaction functions defined by the first-order condition in (7) yields optimal sales: $t_{ijk} = \dfrac{\varphi_{jk} - J\left(g_{ik} + \alpha_k p_{ik}^l + c_{ijk}\right) + \sum_{m\neq i}^J \left(g_{mk} + \alpha_k p_{mk}^l + c_{mjk}\right)}{(J+1)b_{jk}}$.

Sales in each region are aggregated to determine the demand of milk by processors of a given region. Using the above solution for t_{ijk} and constraints $y_{ik} = \sum_{j=1}^J t_{ijk}$ and $\alpha_k y_{ik} = x_{ik}$, the farm-level demand for milk by processor k in region i is: $x_{ik} = A_{ik} - JB_k p_{ik}^l + B_k \sum_{m\neq i}^J p_{mk}^l$ such that $A_{ik} \equiv \alpha_k \sum_j^J \dfrac{\varphi_{jk} - J(c_{ijk} + g_{ik}) + \sum_{m\neq i}^J \left(g_{mk} + c_{mjk}\right)}{(J+1)b_{jk}}$ and $B_k \equiv \dfrac{\sum_j^J b_{jk}^{-1}\alpha_k^2}{(J+1)}$.

The farm-level demand for milk is negatively correlated with p_{ik}^{l} $\left(\frac{\partial x_{ik}}{\partial p_{ik}^{l}}=-JB_k<0\right)$ and positively correlated with p_{mk}^{l} $\left(\frac{\partial x_{ik}}{\partial p_{mk}^{l}}=B_k>0\right)$. An increase in the price of milk at the farm level in region m increases the marginal cost of processors located in that region, leading to a decrease in their sales, but an increase in the sales of processors located in other regions. Hence, the farm-level demand for milk in regions other than *m* would increase.

The inverse demand of milk at the farm level $p_{ik}^{l}=F\left(x_{ik},...,x_{Jk}\right)$ is determined by solving simultaneously the demand of processor *k* in all regions:

$$\begin{pmatrix} x_{1k} \\ x_{2k} \\ . \\ . \\ x_{Jk} \end{pmatrix}=\begin{pmatrix} A_{1k} \\ A_{2k} \\ . \\ . \\ A_{Jk} \end{pmatrix}+\begin{pmatrix} -JB_k & B_k & . & . & B_k \\ B_k & -JB_k & . & . & B_k \\ . & . & . & . & . \\ . & . & . & . & . \\ B_k & B_k & . & . & -JB_k \end{pmatrix}\begin{pmatrix} p_{1k}^{l} \\ p_{2k}^{l} \\ . \\ . \\ p_{Jk}^{l} \end{pmatrix}$$

Applying Cramer's rule to the above system yields: $p_{ik}^{l*}=\frac{2A_{ik}+\sum_{m\neq i}^{J}A_{mk}}{\left(1+J\right)B_k}-\frac{2x_{ik}+\sum_{m\neq i}^{J}x_{mk}}{\left(1+J\right)B_k}$.

In the first stage, dairy producers are assumed to maximize profits: $\max_{x_{ik},Q_i}\ \sum_{k=1}^{K}p_{ik}^{l*}\left(x_{ik}\right)x_{ik}-C\left(Q_i\right)$

subject to $\sigma_i:\ \sum_{k=1}^{K}x_{ik}\leq Q_i$

$\delta_i:\ Q_i\leq MSQ_i$

Kuhn-Tucker first-order conditions are:

$$\frac{\partial L}{\partial Q_i}=-\frac{\partial C_i}{\partial Q_i}-\delta_i+\sigma_i\leq 0 \quad \text{for} \quad Q_i\geq 0 \tag{8}$$

$$\frac{\partial L}{\partial x_{ik}} = p_{ik}^{l} - \frac{2x_{ik}}{\alpha_k^2 \sum_{j=1}^{J} b_{jk}^{-1}} - \sigma_i \leq 0 \ \text{ for } \ x_{ik} \geq 0 \tag{9}$$

$$\frac{\partial L}{\partial \sigma_i} = Q_i - \sum_{k=1}^{K} x_{ik} \geq 0 \ \text{ for } \ \sigma_i \geq 0 \tag{10}$$

$$\frac{\partial L}{\partial \delta_i} = QM_i - Q_i \geq 0 \ \text{ pour } \ \delta_i \geq 0 \tag{11}$$

Equation (8) implies that $\sigma_i = \partial C_i / \partial Q_i + \delta_i$ which states that in each region i, σ_i is equal to marginal cost $(\partial C_i / \partial Q_i)$ plus the quota unit rent (δ_i). According to (9), the farm-level price in region i for milk sold to processor k equals the farm marginal cost plus the unit rent of the production quota and the mark-up due to the ability of producers to practice monopoly pricing. This mark-up is $PC_{ik} \equiv 2x_{ik} / \alpha_k^2 \sum_{j=1}^{J} b_{jk}^{-1}$. To close the model, we must introduce a condition that sets milk sold to a processor in a given region (x_{ik}) equal to the quantity of raw milk implied by the production of the processed product $\left(\alpha_k \sum_{j=1}^{J} t_{ijk}\right)$. In all, the model includes 12 equations and 12 endogenous variables. Under perfect competition, processors simply act as pass-through agents of producers and do not act strategically. Thus, instead of solving the first order conditions of Cournot oliogopolists, we have zero profit conditions for each product.

As argued by Melvin and Warne (1973, p.133), trade liberalization gains are larger when a domestic sector is imperfectly competitive provided that the rest of the world is perfectly competitive because the gains arising from a more efficient resource allocation are magnified in a general equilibrium setting. In our partial equilibrium model, trade liberalization can help mitigate oligopoly distortions from processors and monopoly pricing of raw milk that leads to a multiple-marginalization problem. Thus, we would expect trade liberalization gains to be substantial. To find out exactly how large the gains are in absolute terms, we rely on simulations.

To size up the importance of imperfect competition in processing activities on our results, we also perform calibrations and simulations under the assumption of perfect competition in processing. Before discussing the simulations scenarios and results, we describe the manner with which we calibrated our model and the data we use for this purpose.

Data and Calibration

We must calibrate the cost and demand functions using publicly available data in order to implement our framework. Consider first the processing sector. Under the assumption of constant returns to scale, the cost function associated with production of good *k* in region *i* is: $G_{ik}(y_{ik}) = g_{ik} y_{ik}$; where g_{ik} is marginal cost. Ideally, marginal cost would be calibrated using the first-order conditions of profit maximization along with observable output and sales. However, sales between regions at the processing level are not available. Hence, we use marginal cost reported in Abbassi, Bonroy and Gervais (2008) and update the value using the consumer price index. Data on the technical relationship between raw milk and the processed product are taken from Meyer and Duteurtre (1998). Farm-level milk prices for 2006 were obtained from the Canadian Dairy Information Center (CDIC).

Buyers demand schedules are calibrated using 2006 consumption data and demand elasticities reported in Veeman and Peng (1995) for yogurt (-0.81), cheese (-1.22) and ice cream (-0.68). Own-price demand elasticities for fluid milk (-0.34), butter (-0.92) and other dairy products are taken from (-1.02) Moschini and Moro (1993). Retail prices were obtained from CDIC and from the 2001 household expenditure survey of Statistics Canada. The latter prices were updated using the retail dairy price index. Dairy wholesale prices are only available for the province of Quebec. Regional variations in wholesale prices were built into the model by using a regional price index computed by the CDIC. In instances when it was not possible to obtain either the retail or wholesale price of a commodity, a cost-plus approach was implemented to infer the missing price using the average retail to processing margin of the dairy industry.

Given the existence of supply controls at the farm level, it is not possible to directly observe the supply response of dairy producers and compute a marginal cost function. The own-price elasticity of supply is set at 0.5 as in Abbassi, Bonroy and Gervais (2008). CDIC data on dairy production in each region, quota prices and farm gate prices can be used to construct the marginal cost function of producers that also hinges on a discount rate to internalize the benefits from holding production quotas. Following Brodeur, Doyon and Gervais (2006), we set the discount rate at 10%. The aforementioned assumptions yield a marginal cost estimate of $33.4 per hl for Quebec, $33.5 in Ontario and slightly higher cost estimates in other regions (e.g., Prairies producers' marginal cost is $38.2 per hl). These estimates are in line with previously reported estimates of marginal costs (e.g., Abbassi et al. 2008).

Dairy product consumption on a per capita basis was obtained from Statistics Canada. World prices were obtained from the CDIC database. Table 1 presents information about world prices for each product. For butter, cheese and skim milk powder, we rely on the 2006 average Oceanic export prices. World prices for yogurt, ice cream, dry whey and concentrated milk were obtained by dividing the value of imports for each product by the volume imported minus a margin to account for unit transportation costs. The world price of fluid milk is proxied by the US price.

Transportation costs between Canada and the rest of the world are estimated using the differences between export prices and import unit values. Transportation costs for yogurt, ice cream, dry whey and concentrated milk are proxied by the unit transportation cost for butter. Unit transportation cost between provinces are based on Chavas and Cox (2001) and set equal to

Can$0.35 per 100 lbs per 100 miles. This value was updated using the average exchange rate and the price index for transportation services of Statistics Canada. Distances between regions are taken from Furtan and van Melle (2004) and are equal to a weighted average of the latitude and longitude of the most important three cities in each region.

Table 2 presents information about the TRQ for each product. All over-quota tariffs are the Most Favoured Nation (MFN) tariffs found in Canada's tariff schedule at the WTO. We also report the in-quota tariff applied to imports within the minimum access commitment of the TRQ. Tariff preferences for within quota imports exist for New Zealand, Australia, the USA and other countries, but given the relatively low in-quota tariffs, these preferences are likely to have little or no impact. Ad valorem tariffs were converted into specific-equivalents using the relevant world price. Import licenses allocations were made on the most recent year of available data (2003).

The purpose of the calibration exercise is to replicate the 2005/2006 market outcomes in the Canadian dairy sector. The solution of the model provides a baseline to which simulations will be subsequently measured against. Predicted prices and quantities for the baseline solution are in each case less than 10 percent away from the observed values used in the calibration. The conditions for market segmentation are also respected because wholesale price differences across markets are larger than transportation costs. Finally, the 2005/2006 wholesale butter price in the baseline solution is higher than the support price and thus support is non-binding in the baseline solution.

Simulations

Simulations are carried out to estimate the impacts of trade liberalization in the Canadian dairy sector. Reductions in import tariffs are based on the latest revised draft modalities (a sort of blueprint for the final deal) made in December of 2008 and involve multiple tier reductions (WTO, 2008). Developed countries may be able in a future agreement to identify between 4 or 6 percent of their tariff lines as sensitive. Tariff cuts for sensitive products could be one-third, one-half or two-thirds of the “normal” tier cuts. Under this proposal, the minimum reduction applied to over-quota tariffs of dairy TRQs would be 22 percent while the maximal cut applied could be 49%. In return for the ability to implement less aggressive tariff cuts, developed countries would be asked to expand the minimum access commitment of the TRQ to around 5 to 6 percent of domestic consumption, depending on the extent of the tariff exemption allowed.

We consider two liberalization scenarios. In both scenarios, we assume that dairy products are identified as sensitive. The scenarios are labeled “aggressive” (A) and “moderate” (M):

Scenario A: Over-quota tariffs are cut by 49 percent and in-quota tariffs are eliminated. The minimum access commitment is set at 5 percent of domestic consumption.

Scenario M : Over-quota tariffs are cut by 22 percent and in-quota tariffs are reduced to zero. Given the less ambitious cuts to over-quota tariffs, it is assumed that minimum access commitment is increased to 6 percent of domestic consumption.

Table 3 presents the impact of the two liberalization scenarios on prices and quantities. In scenario A, tariff cuts trigger imports of cheese and butter over the minimum access commitment. These impacts as well as the increase in the minimum access commitment lower the residual demand faced by domestic firms in all sectors, especially for cheese and butter. Cheese and butter prices decrease on average by 14.4 and 32.1%, respectively, while total output in Canada decreases by 25.5% for cheese and 56.9% for butter.

The lower output of processed products implies a decrease in the demand for milk at the farm level. Table 4 reports the impacts of trade liberalization on quota values[7] and farm prices. We do so by province and nationally because the dairy industry is relatively more important for Quebec and Ontario than for the Prairies. Opposition to trade liberalization for dairy products is also strongest in Quebec and Ontario. The farm price decreases by 17.8% in the Prairies and by 16.4% in Quebec and Ontario. Because the lower farm price decreases the marginal cost of processors, increases in production are observed for some sectors in spite of the enlargement of the minimum access commitments. For skim milk powder, output increases by 21.1% and the average wholesale price is reduced by 7.0%. In the fluid milk and yogurt markets, output increases by 6.6 and 2.4%, respectively, while average wholesale prices decrease by 5.3 and 2.9%.

Table 5 presents the impacts of liberalization on producers, processors and buyers surplus.[8] Under scenario *A*, buyers' surplus increases by 42.8% in Canada due to lower wholesale prices. In Ontario, Quebec and the Prairies, buyers' surplus increases, respectively, by 43.1%, 39.0% and 46.4%. At the wholesale level, the decrease in wholesale prices and the overall impact on output triggers an average decrease of 64.6% in processors' surplus. Quebec and Ontario processors are impacted the most as their surplus falls by 73.0% and 73.6%, respectively. The surplus of Canadian dairy producers falls by 21.2% and the magnitude of the impact is similar across regions. Overall, scenario *A* increases welfare by 12.5 %, which translates into a gain of $1.078 billion per year for the Canadian dairy sector.

Under scenario *M*, duty-free market access is larger and over-quota tariffs are lowered by 22 percent. In this case, only butter imports occur at the over-quota tariff. The reduction in over-

[7] Dairy quota values are equal to the production quota rent plus the benefits linked to the price discrimination policy.

[8] Producers' surplus includes the quota value.

quota tariff is not large enough to trigger imports above the minimum access as in scenario *A* for all other commodities. The increase in minimum access has a significant impact in all sectors except for cheese and skimmed milk powder for which current minimum access is already quite high. At the national level, the production of outputs of yogurt, fluid milk and butter fall by 2.8%, 0.5% and 21.7%, respectively.

At the farm level, the milk price and the quota value fall due to the lower demand by domestic processors. In comparison to the more aggressive scenario, the impacts are small. Milk prices decrease by 4.9% in the Prairies, 4.0% in Quebec and 4.1% in Ontario. The lower farm prices reduce processors' marginal cost and increase output of cheese and skim milk powder by 1.2% and 6.0%, respectively. Table 4 reports that the surplus of buyers increases by 9.4 percent for Canada and the distribution of gains is fairly even across regions. The surplus of Canadian dairy processors would fall by 9.4% under scenario *M*. Processors located in Quebec and Ontario are the most affected by this liberalization plan as their surplus falls by 16.4% and 15.5%, respectively. Canadian dairy producers see their surplus fall by 5.3%. The net impact of liberalization under scenario *M* is an increase in surplus of 2.7 percent for the Canadian dairy sector, which amounts to a gain of $234.5 million per year.

We now wish to compare the above trade liberalization outcomes derived under the assumption of imperfect competition to outcomes for similar scenarios, but obtained under perfect competition.[9]. Table 6 presents the effects of the trade liberalization scenarios on the surpluses of the various agents and on aggregate welfare. At the aggregate level, trade liberalization increases consumer surplus and welfare. Regardless of the trade scenario considered, imports do not increase beyond the minimum access commitment threshold. As a

[9] Under perfect competition, processors simply act as pass-through agents of producers. They do not behave strategically and their surplus is equal to zero because of the assumption of constant returns to scale in processing activities.

result, increases in imports can only be brought about by changes in minimum access commitments and this explains why variations in surpluses and in welfare are larger under scenario M. Our simulation results indicate that trade liberalization would increase aggregate welfare by $34.5 million under scenario M and by $15.6 million under scenario A. As per our theoretical prior, trade liberalization produces much larger gains under the assumption of an imperfectly competitive processing sector than under the perfect competition assumption. This is primarily due to the double marginalization problem when processing firms have strategic interactions. Our results under perfect competition are lower from the ones reported in Abbassi, Bonroy and Gervais (2008) which vary between $48 million and $64 million per year. Both sets of results are not directly comparable because of differences in the calibrating year, in the trade liberalization scenarios investigated and in the manner with which price discrimination mark-ups in the pricing of milk are modeled.

Table 7 presents the impacts of liberalization on the interregional deadweight losses arising because of transport costs of dairy products. Under scenario *A*, decreases in domestic output for products like butter and cheese would tend to decrease the volume of « interprovincial dumping », but output increases in other dairy products would have the opposite effect. The net effect of aggressive international trade liberalization is an increase in interprovincial trade. This gives rise to an increase of 2.5 percent in transportation costs between regions. In Brander and Krugman (1983), reciprocal dumping increases competition, but transportation costs increase sourcing inefficiencies which give rise to a non-monotonic relation between welfare and per unit transportation cost. Under scenario *M*, there is less interprovincial trade than in the baseline situation because decreases in the production of fluid milk, butter and yogurt more than offset increases in the production of cheese and skim milk powder. As a result, interprovincial transportation cost decreases by 0.9 percent.

Transportation costs being fairly low, it should come as no surprise that small increases in per unit transportation cost reduce welfare. The theoretical results of Brander and Krugman (1983) showed that increases in per unit transportation cost can actually increase welfare once a certain threshold is reached, corresponding to a minimum welfare level. This occurs because firms with a higher per unit cost (production and transport) are disadvantaged but not necessarily driven out of a market in which firms have Cournot conjectures. In our model, the threshold occurs at a level of per unit transportation cost that is 10.6 times the benchmark level. Additional increases in per unit transportation cost increase welfare until all interprovincial dumping ceases. This occurs at a per unit transportation cost that is 75.7 times the benchmark level. When this occurs, there is no interprovincial dumping and hence no sourcing waste , but the lack of competition is such that welfare under the benchmark per unit transport cost is much higher. While the non-monotonic relation between transportation cost and welfare is interesting from a theoretical standpoint, it does not have important implications in the case of interprovincial dumping of dairy products.

Conclusion

This paper measures the impacts of trade liberalization on the supply-managed Canadian dairy industry under an imperfectly competitive market structure. Our spatial equilibrium framework accounts for production limits at the farm level and other important features of the supply management policy. More specifically, it allows producers to practice price discrimination. Dairy processing firms compete with one another using Cournot conjectures and engage in interprovincial dumping as in Brander and Krugman's (1983) reciprocal dumping model.

International trade is hindered by restrictive Tariff Rate Quotas (TRQs). The model features 5 regions and 8 different products.

Two liberalization scenarios were investigated. In the more aggressive (A) scenario, welfare gains are estimated to be $1078 million whereas in the moderate (M) scenario, welfare gains were estimated at $ 234.5 million. The differences between the two scenarios stem from the differences in tariff reductions. In the more conservative liberalization scenario, increases in duty-free market access are not large enough to compensate the relatively timid reductions in tariffs. We also simulated the same scenarios when processing firms behave as perfectly competitive firms and found much smaller gains from trade.

The regional distribution of milk and dairy products production is mainly concentrated in the provinces of Quebec and Ontario. However, because these provinces have relatively large populations, they both stand to gain from trade liberalization even though milk producers and dairy processors stand to lose. Given that it is easier to mobilize smaller groups, opposition to trade liberalization has been and is expected to remain strong in spite of the sizeable gains that could be achieved for specific provinces and for Canada as a whole. Canada's efforts on slowing down the pace of trade liberalization on its supply-managed sectors in the Uruguay and Doha Rounds of multilateral trade negotiations are misplaced.

As in the Brander and Krugman (1983) model, we found a non-monotonic relationship between welfare and per unit transportation cost. However, the threshold at which an increase in transportation costs increases welfare is very large, making this result more of a theoretical curioso than a policy relevant feature, in the case of the supply-managed Canadian dairy industry.

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Table 1. World prices

Product	World prices ($/kg)
Fluid milk	0.7
Yogurt	2.8
Powdered buttermilk	2.7
Butter	2.0
Cheese	3.3
Ice Cream	3.2
Concentrated milk	1.5
Skim milk powder	2.5

Source: CDIC database, 2006
Notes: the 2006 world prices were converted in Canadian dollars using an average exchange rate of Can$1.134/US$.

Table 2. In-quota and over-quota tariffs and minimum access commitments of Canadian dairy TRQs

Product	MAC (MT)	In-quota tariff (%)	Over-quota tariff (%)
Fluid milk	64,500	7.5	241.0
Yogurt	332	6.5	237.5
Powdered buttermilk	908	1.2[1]	208.0
Butter	3,274	5.7[2]	298.5
Cheese	20,412	1.0[3]	245.5
Ice Cream	347	6.5	277.1
Concentrated milk	12	2.2[4]	243.0
Skim milk powder	4,345	6.5	270.1

Source: AMAD Tariff database (www.amad.org)
Notes: Some in-quota tariffs are specific tariffs and were converted in ad-valorem terms using the world price. [1]The specific tariff for powdered buttermilk is 3.32 ckg (cents per kg). [2]The specific tariff for butter is 11.38 ckg. [3]The specific tariff for cheese is 3.32 ckg. [4]The specific tariff for concentrated milk is 2.84 ckg.

Table 3. Trade liberalization impacts on output and average prices of processed products in Canada

	Fluid milk	Butter	Cheese	Skim milk powder	Yogurt
Production (Baseline - 000 MT)	2403.2	74.5	386.6	60.6	160.8
Scenario *A* (% change)	6.6	-56.9	-25.5	21.1	2.4
Scenario *M*	-0.5	-21.7	1.2	6.0	-2.8
Average Price (baseline - $ / kg)	1.5	7.8	9.1	6.3	4.1
Scenario *A* (% change)	-5.3	-32.1	-14.4	-7.0	-2.9
Scenario *M*	-2.4	-11.5	-1.3	-2.2	-1.6

Table 4. Trade liberalization impacts at the farm level

	Prairies	Ontario	Quebec
Farm price (Baseline - $ / hl)	83.3	82.3	82.9
Scenario *A* (% change)	-17.8	-16.4	-16.4
Scenario *M*	-4.9	-4.1	-4.0
Quota value (baseline - $ / hl)	45,1	48,8	49,5
Scenario *A* (% change)	-19.0	-13.1	-13.0
Scenario *M*	-9.1	-3,7	-3.2
Farm output (baseline - 000 MT)	1273,8	1554,9	1575,7
Scenario *A* (% change)	-8,2	-10,6	-10,7
Scenario *M*	0,0	-2.4	-2.6

Table 5. Trade liberalization impacts on welfare

	Prairies	Ontario	Quebec	Canada
Welfare				
(Baseline - $million)	1730,2	2750,0	2534,9	8615,4
Scenario *A* (% change)	9.6	13.5	11.2	12.5
Scenario *M*	2.1	2.8	2.7	2.7
Buyer surplus				
(baseline - $million)	376.7	988.2	759.1	2643
Scenario *A* (% change)	46.4	43.1	39.0	42.8
Scenario *M*	10.2	9.4	8.6	9.4
Processor surplus				
(Baseline - $million)	277.2	391.1	406.2	1238.1
Scenario *A* (%change)	-68.9	-73.6	-73.0	-64.6
Scenario *M*	-0.3	-15.5	-16.4	-9.4
Producer surplus				
(Baseline - $million)	1061.4	1279.3	1306.2	4545.6
Scenario *A* (% change)	-21.1	-21.4	-21.5	-21.2
Scenario *M*	-4.9	-5.5	-5.5	-5.3

Table 6. Trade liberalization impacts on welfare under perfect competition in processing

	Prairies	Ontario	Quebec	Canada
Welfare				
(Baseline - $million)	2089,2	3793,9	3167,7	11148,7
Scenario *A* (% change)	0.06	0.12	0.16	0.14
Scenario *M*	0.12	0.35	0.37	0.31
Buyer surplus				
(baseline - $million)	900,4	2244,5	1559,4	5865,9
Scenario *A* (% change)	1.43	1.45	1.57	1.52
Scenario *M*	2.00	2.14	2.29	2.18
Producer surplus				
(Baseline - $million)	1182,1	1505,3	1576,7	5192,3
Scenario *A* (% change)	-1.91	-1.96	-1.93	-1.94
Scenario *M*	-2.90	-2.96	-2.91	-2.96

Table 7. Trade liberalization impacts on the cost of interregional trade

	Interregional trade cost
Baseline ($million)	263.3
Scenario A (% change)	2.5
Scenario M	-0.9