Endogenous Market Structure and Trade

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Abstract:

Many agricultural products are exported from a small number countries and few export traders are typically involved. This is the case for maple syrup whose production takes place in eastern Canada and in the northeastern part of the United States. Corner solutions in oligopoly models usually arise because of asymmetries in trade and procurement costs. Such asymmetries can be ruled out in the case of Canadian and US maple syrup exports, yet many importing countries purchase only either from Canada or from the US. A theory of endogenous market structures based on duopoly competition with fixed costs is developed. It explains many stylized facts including that large markets have a higher probability of accommodating duopoly competition while smaller markets are more likely to "naturally" attract a single entrant or no entrant at all. A random parameter multinomial logit model is used to explain market structure and probability estimates are used to correct for potential selection biases in market-structure-specific gravity equations.

Acknowledegment: We would like to thank Gilbert Lavoie for sharing his knowledge about the marketing of maple syrup and the Fédération des Producteurs Ascéricoles du Québec for answering questions and sharing documents about the maple syrup industry.

JEL Codes: Q17, L13

#2452

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1. Introduction

Gravity models can be rationalized from different micro foundations. Eaton and Kortum (2002 derived a gravity equation from their probabilistic Ricardian model which assumes perfect competition between firms. More often, gravity equations are based on monopolistic competition with symmetric (i.e., Krugman, 1980) or heterogeneous firms (Melitz, 2003), iceberg trade costs and consumers with CES preferences. In models with heterogeneous firms, firms behave non-strategically even though there are some very large ones when productivity is Pareto distributed.[1] Empirical evidence indicates that there are industries for which industry concentration is very high, with a few firms exporting a significant share of the world's exports. Freund and Pierola (2015) contend that export superstars have a dramatic influence on trade and sectoral trade patterns. In such industries, one would expect large firms to have strategic interactions (Neary, 2016) and this has important implications for gravity models. Many agricultural sectors fit this description and this is why trade is often modeled as a game between oligopolists (e.g., Tamini, Gervais and Larue, 2010; Lavoie, 2005; Hamilton and Stiegert, 2002). While there are many agricultural commodity producers, there are often just a few large traders handling the bulk of commodity exports. This is the case for the maple syrup industry.

Production of maple syrup is geographically concentrated in the extreme with 72% of the world's production produced in the Canadian province of Quebec. The rest of the world's production takes place in other Canadian provinces and in US northeastern states. Barring a little re-exportation, there are only two exporting countries. In Quebec, a marketing agency buys from

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[1] A common critique about models with a continuum of firms is that firm-level shocks cannot have aggregate effects. This goes against the empirical evidence about granular effects (Eaton, Kortum and Sotelo, 2012; Gabaix, 2011).

producers and sells maple syrup only to "authorized" trading firms. A cooperative with over 2000 members is the most important authorized trader in Quebec and since it also operates in New Brunswick, it exports a considerable share of Canada's maple syrup exports. Similarly, a few traders handle most of the US maple syrup exports.[2]

Other elements make maple syrup an interesting commodity to analyze. First, both exporting countries are geographically close and one cannot have a large transport cost advantage over the other in all markets, including their own. Indeed, there is much reciprocal dumping with Canada exporting to the US and the US exporting to Canada. Second, export prices vary a lot, but prices paid to maple syrup producers by Canadian and US traders are close year after year. According to FPAQ (2016), the Canada-US farm price differential was -US$0.18/ lb in 2016, -US$0.02/lb in 2015 and US$0.12/lb in 2014. There are also quality premia, but they are relatively small. Quebec maple syrup producers who delivered bulk syrup graded AA or A, received Can$2.95/lb in 2016 from the FPAQ while maple syrup graded B and C fetched Can$2.93/lb and Can$2.82/lb.[3] These two elements combined imply that unit variables costs of Canadian and US maple syrup traders are roughly the same. In standard Bertrand and Cournot oligopoly models, corner solutions emerge when unit costs are highly asymmetric. When costs are symmetric, the prediction about trade flows is that Canadian and US traders should operate concurrently in the same markets. This is not the case. In our sample, conditional on trade being observed, a monopoly equilibrium is observed as frequently as a duopoly equilibrium.

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[2] Less is known about US trading firms, but anecdotal evidence from industry sources indicates that the 20-80 rule applies : 20% of the trading firms account for 80% of the exports.

[3] The low degree of vertical differentiation is the reason why many agricultural commodities are reference-priced and traded on an organized exchange like the Chicago Mercantile Exchange (Rauch, 1999).

In this paper, we develop duopoly models to provide an explanation for the high frequency of monopoly outcomes. We show that the introduction of fixed export costs can induce equilibria in mixed and correlated strategies supporting monopoly outcomes. This explanation for zeros is new and contrasts with previous analyses of trade at the extensive margin which focussed on tariffs and non-tariff barriers (e.g., Debaere and Mostashari, 2010; Ghazalian, Larue and Gervais, 2010), GATT/WTO and trade agreements (e.g., Buono and Lalane, 2012, Dutt, Mihov and Van Zandt, 2013), and trade policy uncertainty (Handley, 2014). We then used data about maple syrup exports to validate some of the insights from our theoretical analysis. As such, we contribute to the literature about the implications of different microfoundations for the analysis of trade flows at the extensive and intensive margins. A pioneering study on this issue is that of Feenstra, Markusen and Rose (2001). They showed that the gravity equation can arise from monopolistic models, reciprocal dumping models, and Armington/national product differentiation models. Because some theoretical models are consistent with home market effects while others are consistent with reverse home market effects, they can infer from observed trade flows which theoretical foundation is more plausible. Our theoretical framework is different as it endogenizes market structure (duopoly, monopoly, no trade) which gives rise to conditional structure-specific gravity equations.

2. Bertrand competition and gravity without fixed export costs

From the above discussion, we posit that trade is conducted by oligopolistic trading firms. To keep the modeling simple, we will assume a Canada-US duopoly. Consumers in market *k* have quasi-linear preferences with a quadratic sub-utility function:

$$U^k = \gamma_c^k A^k Q_c^k - 0.5\beta\left(Q_c^k\right)^2 + A^k Q_u^k - 0.5\beta\left(Q_u^k\right)^2 - \alpha Q_c^k Q_u^k, \qquad (1)$$

where Q_c^k is the quantity of Canadian maple syrup consumed and Q_u^k is the quantity of US maple syrup consumed and $\gamma_c^k \geq 1$ is a quality parameter (weakly) favoring Canadian maple syrup. Parameter $\alpha < \beta / \gamma_c^k$ governs the degree of substitution between Canadian and US maple syrup. Inverse import demands in country *k* for Canadian and US maple syrup are :

$$p_c^k = \gamma_c^k A^k - \beta Q_c^k - \alpha Q_u^k \text{ and } p_u^k = A^k - \beta Q_u^k - \alpha Q_c^k . \qquad (2)$$

These can be inverted to obtain direct demand functions:

$$Q_c^k = \delta_c^k a^k - b p_c^k + e p_u^k \text{ and } Q_u^k = a^k - b p_u^k + e p_c^k , \qquad (3)$$

where $\delta_c^k \equiv \dfrac{\beta\gamma_c^k - \alpha}{\beta - \alpha\gamma_c^k} \geq 1$, $a^k \equiv \dfrac{A^k\left(\beta - \alpha\gamma_c^k\right)}{\beta^2 - \alpha^2}$, $b \equiv \dfrac{\beta}{\beta^2 - \alpha^2} > e \equiv \dfrac{\alpha}{\beta^2 - \alpha^2} > 0$.

The trading firms buy maple syrup in their respective country at a fixed price. In Quebec, the price is negotiated between the FPAQ and authorized buyers. The price is negotiated in the Fall before Quebec maple syrup producers make their decision about the number of trees to tap. Statistics about bulk prices in Quebec and in the US suggest that average prices paid to producers are quite close, even though there is price dispersion across states in the United States. Accordingly, we define as r_c and r_u the prices paid by the Canadian and US trading firms to maple syrup producers in their respective country. For simplicity, we assume that traders face no other variable production costs. Traders face iceberg transport costs and tariffs. They must ship $D_x^k Q_x^k$ to get paid for Q_x^k units, where $x = \{c, u\}, D_x^k > 1$. Tariffs $t_x^k \equiv \left(1 + \tau_x^k\right) \geq 1$ are of the ad valorem kind and add to the overall per unit variable cost of traders: $T_x^k \equiv r_x D_x^k t_x^k$.

We assume that traders maximize profit and compete à la Bertrand. The profit of the Canadian and US traders are: $\pi_x^{B,k} = \left(\frac{p_x^{B,k} - T_x^k}{t_x^k} \right) Q_x^{B,k}$, $x = \{c, u\}$ and superscripts *B* and *k* stands for the Bertrand duopoly solution and the destination. An interior solution is characterized by the following export values:[4]

$$\frac{p_c^{B,k}}{t_c^k} Q_c^{B,k} = \frac{b\left(-2b^2 T_c^k + e\left(a^k + eT_c^k + bT_u^k\right) + 2a^k b\delta_c^k\right)\left(b\left(2bT_c^K + eT_u^k\right) + a^k\left(e + 2b\delta_c^k\right)\right)}{\left(4b^2 - e^2\right)^2 t_c^k} \quad (4),$$

$$\frac{p_u^{B,k}}{t_u^k} Q_u^{B,k} = \frac{b\left(-2b^2 T_u^k + a^k e\delta_c^k + e^2 T_u^k + beT_c^k + 2a^k b\right)\left(b\left(2bT_u^k + eT_c^k + 2a^k\right) + a^k e\delta_c^k\right)}{\left(4b^2 - e^2\right)^2 t_u^k} \quad (5)$$

Focussing on Canadian exports, we can see that the expression is a polynomial in unit variable costs T_c^k and T_u^k. The first derivative with respect to procurement cost is:

$$\frac{\partial p_c^{B,k} Q_c^{B,k} / t_c^k}{\partial r_c} = \frac{\left(b^2 D_c^k\left(-8b^3 T_c^k + 4be^2 T_c^k + e^3 T_u^k\right) + a^k be^2 D_c^k\left(e + 2b\delta_c^k\right)\right)}{\left(4b^2 - e^2\right)^2} \underset{<}{\geq} 0 \quad (6)$$

The derivative of Canadian export sales with respect to D_c^k is the same up to a multiple $\frac{r_c}{D_c^k}$. For American export sales, an increase in the Canadian syrup price increases export sales.

$$\frac{\partial p_u^{B,k} Q_u^{B,k} / t_u^k}{\partial r_c} = \frac{b\left(2a^k b + bT_c^k e + 2b^2 T_u^k + ae\delta\right)\left(2a^k b + bT_c^k e - 2b^2 T_u^k + e^2 T_u^k + ae\delta\right)}{\left(4b^2 - e^2\right)^2} > 0$$

(7)

[4] It should be pointed out that because consumers have quasi-linear preferences, tariff revenue is spent entirely on the aggregate good.

The last two equations imply the following result:

RESULT 1: *For $i = \{c, u\}$ an increase in procurement price r_i or in transport cost D_i^k when T_i^k is low relative to T_j^k with $j \neq i$, can induce an increase in firm i's exports. Beyond a certain threshold, additional increases in r_i reduce the value of firm i's exports.*

The possibility of a positive effect in (6) hinges on the positive price effect dominating the negative quantity effect. The equilibrium quantity Q_c^{Bk} is decreasing in T_c^k and increasing in T_u^k while the equilibrium price p_c^{Bk} is increasing in both T_c^k and T_u^k. Figure 1 illustrates the non-monotone effect of transport costs/procurement price on the value of exports. As in Eaton and Grossman (1985), prices are strategic complements and an increase in T_c^k makes the Canadian firm's reaction function shifts to the right, inducing higher prices for both exporters. Export sales can increase with T_c^k when such increases occur at low values of T_c^k because the effect of price on sales dominates the quantity effect. In contrast, the effect of a tariff increase on export sales is always negative because it combines the effect of T_c^k in the numerator and the effect of t_c^k in the denominator of (4).

When $r_c \approx r_u, D_c^k \approx D_u^k, t_c^k \approx t_u^k \approx t$, then $T_c^k \approx T_u^k \approx T$, as for maple syrup exported by Canada and the US, then (4) and (5) reduces to:

$$\frac{p_c^{B,k}}{t} Q_c^{B,k} = \frac{b\left(2a^k b\delta_c^k + ea^k - T\left(2b^2 - e^2 - eb\right)\right)\left(a^k\left(e + 2b\delta_c^k\right) + T\left(2b^2 + eb\right)\right)}{\left(4b^2 - e^2\right)^2 t} \qquad (8)$$

$$\frac{p_u^{B,k}}{t} Q_u^{B,k} = \frac{b\left(2a^k b + a^k e\delta_c^k - T\left(2b^2 - e^2 - eb\right)\right)\left(2a^k b + a^k e\delta_c^k + T\left(2b^2 + eb\right)\right)}{\left(4b^2 - e^2\right)^2 t} \qquad (9)$$

Even though these export expressions are conditioned by a single distance measure, and a single tariff rate, they remain asymmetric as long as $\delta_c^k > 1$.

RESULT 2: *An increase in Canadian maple syrup quality* δ_c^k *increases Canadian exports and US exports. This is so because a higher* δ_c^k *enlarges the demand for Canadian maple syrup allowing the Canadian oligopolist to increase its price. Under Bertrand competition, maple syrup prices are strategic complements and both the Canadian and US oligopolists end up setting higher prices.*

The Bertrand interior solution is conditioned by the duopolists'unit variable costs not being too high and not too different from one another.[5] Accordingly, corner solutions with a market supplied by a single firm occur when variable unit costs differ enough across firms. Such asymmetries arise when firms face much different transport costs and/or trade taxes. As shown by Clarke and Collie (2003), the reaction function of a Bertrand duopolist is made up of 4 segments. The first one is defined by the zero-profit condition preventing the duopolist's price from falling below the duopolist's unit variable cost. In figure 2, this is depicted by the segment $T_c^k - B$. The second segment, B-B', is defined by the duopolist's first order condition. Along the third segment, B'-M, the duopolist sets its price to pre-empt entry by the other duopolist $Q_u^k\left[p_u^k, p_c^{p,k}\right] = 0$. Finally, there is a threshold price set by the duopolist's rival above which the

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[5] The price-marginal cost differentials and the quantities must be weakly positive. When $T_c^k = T_u^k = T$, then $p_c^{B,k} = \dfrac{a^k e + 2a^k b\delta_c^k}{4b^2 - e^2} + \dfrac{bT}{2b-e}$ and the level condition is: $T \le \dfrac{ae + 2ab\delta}{2b^2 - e(b+e)}$. More generally, $Q_c^{B,k} = \dfrac{b\left(a^k\left(e + 2b\delta_c^k\right) - \left(2b^2 - e^2\right)T_c^k + beT_u^k\right)}{4b^2 - e^2} \ge 0$ if $T_c^k \le \dfrac{a^k\left(e + 2b\delta_c^k\right)}{\left(2b^2 - e^2\right)} + \dfrac{be}{\left(2b^2 - e^2\right)}T_u^k$. If $b = 2e$ and $\delta_c^k = 1$, then $Q_c^{B,k} \ge 0$ as long as $T_c^k - T_u^k \le \dfrac{5}{7}\left(\dfrac{a}{e} - T_u^k\right)$.

duopolist can act as an unconstrained monopolist by setting price $p_c^{m,k}$. Intuitively, if the duopolist's rival calls an infinite price, the duopolist maximizes its profit by setting its unconstrained monopoly price. Keeping in mind that superscripts *B*, *p* and *m* stands for Bertrand, pre-emption and unconstrained monopoly, the Canadian trader's reaction function is as follows:

$$p_c^k = T_c^k \; if \; p_u^k \le \frac{bT_c^k - a^k\delta_c^k}{e}$$

$$p_c^k = p_c^{B,k} = \frac{ep_u^k + bT_c^k + a^k\delta_c^k}{2b} \; if \; \frac{bT_c^k - a^k\delta_c^k}{e} < p_u^k < \frac{\left(2b + e\delta_c^k\right)a^k + ebT_c^k}{2b^2 - e^2}$$

$$p_c^k = p_c^{p,k} = \frac{bp_u^k - a^k}{e} \; if \; \frac{\left(2b + e\delta_c^k\right)a^k + ebT_c^k}{2b^2 - e^2} \le p_u^k < \frac{a^k + a^k b\left(b - e\gamma_c^k\right) + eT_c^k}{2b}$$

$$p_c^k = p_c^{m,k} = \frac{\gamma_c^k A^k + T_c^k}{2} \; if \; p_u^k \ge \frac{a^k + a^k b\left(b - e\gamma_c^k\right) + eT_c^k}{2b}$$

The US firm's reaction function is also made up of four segments as shown in Figure 2. The Bertrand equilibrium is depicted by the intersection of the two reaction functions. However, one can see that corner solutions would arise if unit variable costs T_c^k and T_u^k were sufficiently different. In such instances, the price chosen by the high-cost duopolist prompts the low-cost duopolist to set its pre-emption price or its unconstrained monopoly price. For example, if the Canadian firm was subject to a much higher tariff than its US rival, its reaction function would then be depicted by the dotted lines in Figure 2 and would intersect the US firm's reaction function to the right of point E. The US firm would set a pre-emptive price and would then be the sole supplier in the market.

As indicated above, procurement costs (i.e., farm prices) and transport costs for traders located in eastern Canadian provinces and in US northeastern states are very close. Furthermore, Canada and the United States are both WTO members and hence face the same Most Favored Nations tariffs and benefit from similar preferential access because they have many common partners in regional trade agreements (RTAs).[6] Under these conditions, the Bertrand model predicts that importing countries will buy from both sources or from none. This prediction is inconsistent with the empirical evidence about the high frequency of US and Canadian monopolies.

2.1 Bertrand competition with fixed export costs

Fixed export costs are at the heart of monopolistic models with heterogeneous firms as they play a key role in explaining the extensive margin of trade (Helpman, Melitz and Rubinstein, 2008). Fixed export costs are not considered in Clarke and Collie (2003) nor in Neary (2016), possibly because in many markets traders are not located side by side and asymmetric trade costs offer a plausible explanation for corner solutions. The addition of fixed export costs f_x^k makes entry harder, as traders must have larger volumes and markups to be profitable. This implies that at least the first segment and part of the second segment of a trader's reaction function vanish because such prices entail losses. In figure 2, the Canadian trader's reaction function could begin at point D for example, increasing the minimum price justifying entry well above T_c^k. If the US trader's reaction function is truncated from T_u^k to C, then a Bertrand equilibrium in pure strategies no longer exists because the reaction functions no longer intersect. In such a case, the market is too small for two traders to operate profitably.[7] Like Champagne, maple syrup is a luxury

[6] Canada and the United States have RTAs with Chile, Columbia, Costa Rica, Honduras, Israel, Jordan, the Republic of Korea, Panama and Peru.

[7] Even though the duopolists have Bertrand conjectures, the problem is different from Kreps and Sheinkman (1983) that considered capacity choices in a first stage followed by Bertrand price competition in a second stage. In our case, the export fixed cost does not constrain the quantity that each duopolist can produce.

product, but unlike Champagne, it is not universally known.[8] Thus, one might expect some markets to have no demand for maple syrup, others with a small enough demand to warrant imports from only one firm, and finally large import markets where Canadian and US maple syrup compete.

Result 3: *If fixed exporting costs in market k,* f_c^k *and* f_u^k *are such that* $\pi_c^{B,k} > 0, \pi_u^{B,k} > 0$*, then both firms enter market k and compete à la Bertrand. If* f_c^k *and* f_u^k *are such that* $\pi_c^{B,k} > 0 > \pi_u^{B,k}$ or $\pi_c^{B,k} < 0 < \pi_u^{B,k}$ or $\pi_c^{m,k} > 0 > \pi_c^{B,k}, \pi_u^{m,k} < 0$ or $\pi_c^{m,k} < 0$, $\pi_u^{m,k} > 0 > \pi_u^{B,k}$ *then a single firm enters and a monopoly equilibrium ensues. If* f_c^k *and* f_u^k *are such that* $\pi_c^{B,k} < 0, \pi_u^{B,k} < 0$ and $\pi_c^{m,k} > 0, \pi_u^{m,k} > 0$*, then the discontinuity in payoffs induces an equilibrium in mixed strategies, with ex post duopoly,monopoly and no entry equilibria being observed with strictly positive probabilities. Finally fixed export costs prevent entry when* $\pi_c^{m,k} < 0, \pi_u^{m,k} < 0$.

Let us focus on the case with $\pi_i^{B,k} < 0, \pi_i^{m,k} > 0, i = \{c, u\}$. The two traders must decide to enter or not. Each trader has a payoff of zero from not entering. If they both enter, they incur losses and if one enters and the other does not, the one that enters enjoy monopoly profit. The Canadian trader chooses its probability of entering market *k*, ψ_c^k, to make the US trader indifferent between its two pure strategies and the US trader chooses ψ_u^k to make the Canadian trader indifferent between entering and not entering. It follows that the equilibrium probabilities are:

$$\psi_c^k = \frac{\pi_u^{m,k}}{\pi_u^{m,k} - \pi_u^{B,k}}, \ \psi_u^k = \frac{\pi_c^{m,k}}{\pi_c^{m,k} - \pi_c^{B,k}}. \qquad (10)$$

[8] There are 300 Champagne houses that exported for roughly US$3 billions in 2016 which is almost ten times maple syrup export sales. The largest importers of Champagne are also amongst the largest importers of maple syrup. For more details see https://www.champagne.fr/en/champagne-economy/key-market-statistics .

The duopolists' profits are given by:

$$\pi_c^{B,k} = \frac{\left(a^k\left(e+2b\delta_c^k\right)+beT_u^k-\left(2b^2-e^2\right)T_c^k\right)^2}{\left(4b^2-e^2\right)^2 t_c^k} - f_c^k \tag{11}$$

$$\pi_u^{B,k} = \frac{\left(a^k\left(e\delta_c^k+2b\right)+beT_c^k-\left(2b^2-e^2\right)T_u^k\right)^2}{\left(4b^2-e^2\right)^2 t_u^k} - f_u^k \tag{12}$$

while monopoly profits are:

$$\pi_c^{m,k} = \frac{\left(A^k\gamma_c^k - T_c^k\right)^2}{4\beta t_c^k} - f_c^k \tag{13}$$

$$\pi_u^{m,k} = \frac{\left(A^k - T_u^k\right)^2}{4\beta t_u^k} - f_u^k \tag{14}$$

When the firms are mixing, there is a probability $\psi_c^k\psi_u^k$ that both firms will enter and experience a loss. There is a probability $\psi_c^k+\psi_u^k-2\psi_c^k\psi_u^k$ of a monopoly and a probability $1-\psi_c^k-\psi_u^k+\psi_c^k\psi_u^k$ that the market will not be supplied at all. Expected profit is zero since this is the profit from not entering.

Result 4: *In the mixed-strategies equilibrium, the higher the fixed costs, the lower the probability of entry. Also,* $\psi_c^k \underset{<}{\overset{>}{-}} \psi_u^k$ *as* $\frac{\pi_u^{m,k}}{\pi_c^{m,k}} \underset{<}{\overset{>}{-}} \frac{\pi_u^{B,k}}{\pi_c^{B,k}}$. *Accordingly, if the duopolists are symmetric in every way except for fixed costs, then* $\psi_c^k \underset{<}{\overset{>}{-}} \psi_u^k$ *if* $f_u^k \underset{>}{\overset{<}{-}} f_c^k$ *. If the duopolists are symmetric in every way except for the tariffs they face, then* $\psi_c^k \underset{<}{\overset{>}{-}} \psi_u^k$ *if* $t_u^k \underset{>}{\overset{<}{-}} t_c^k$ *. Finally, if the duopolists are symmetric in everyway except for* $\gamma_c^k > 1$, *then* $\psi_c^k < \psi_u^k$.

The first part of the above result is quite intuitive. A higher fixed cost reduces monopoly profit and increases the magnitude of duopoly losses. The remaining parts of the above result state that a firm with a cost or quality disadvantage must enter more often to keep its rival indifferent between entering and not entering. Finally, if firms are symmetric in every way, then they enter with the same probability and the observed frequencies of Canadian and US monopolies should be the same.

3. Cournot and gravity

We begin by ignoring fixed export costs and corner solutions to focus on the Cournot duopoly equilibrium. Using (2), we can solve the profit maximization problem of the duopolists and using superscript C to write exports as:

$$\frac{p_c^{C,k}}{t_c^k} Q_c^{C,k} = \frac{\left(T_u^k \alpha - 2T_c^k \beta + A^k\left(2\beta\gamma_c^k - \alpha\right)\right)\left(T_c^k\left(2\beta^2 - \alpha^2\right) + \beta\left(T_u^k \alpha + A\left(2\beta\gamma_c^k - \alpha\right)\right)\right)}{t_c^k\left(4\beta^2 - \alpha^2\right)^2} \tag{15}$$

$$\frac{p_u^{C,k}}{t_u^k} Q_u^{C,k} = \frac{\left(T_c^k \alpha - 2T_u^k \beta + A^k\left(2\beta - \alpha\gamma_c^k\right)\right)\left(T_u^k\left(2\beta^2 - \alpha^2\right) + \beta\left(T_c^k \alpha + A^k\left(2\beta - \alpha\gamma_c^k\right)\right)\right)}{t_u^k\left(4\beta^2 - \alpha^2\right)^2} \tag{16}$$

As for the Bertrand case, unit variable costs (i.e., procurement prices and transportation costs) influence export sales in a nonlinear fashion. The derivative with respect to transport cost is as follows:

$$\frac{\partial p_c^{C,k} Q_c^{C,k} / t_c^k}{\partial D_c^k} = \frac{r_c^k \left(-T_u^k \alpha^3 - 4T_c^k \beta \left(2\beta^2 - \alpha^2\right) - A^k \alpha^2 \left(2\beta\gamma_c^k - \alpha\right)\right)}{\left(4\beta^2 - \alpha^2\right)^2} < 0 \tag{17}$$

The result displayed above contrasts with the ambiguity in Result 1 specific to duopolists with Bertrand conjectures. Given our assumptions about the parameters, quantities are strategic substitutes. Corner solutions arise when transport costs, tariffs and procurement costs are different enough across exporters. More specifically, the US firm enjoys a monopoly when $2\beta T_c^k - \alpha T_u^k \geq \left(2\beta\gamma_c^k - \alpha\right) A^k$ while the Canadian firm is a monopolist when $2T_u^k \beta - \alpha T_c^k \geq \left(2\beta - \alpha\gamma_c^k\right) A^k$. As for the Bertrand case, symmetric procurement costs, tariffs and distances support only duopoly and no-trade equilibria. Fixed costs are required to support monopoly equilibria.

Adding fixed costs truncates the reaction functions. Low profit points along the reaction functions in the absence of fixed costs become unprofitable once fixed costs are factored in and this raises the possibility that there might not be an equilibrium in pure strategies. For a mixed strategies equilibrium, fixed export costs are such that Cournot equilibrium profits are negative and monopoly profits are positive. The monopoly profits are the same as the ones depicted in (13) and (14) and we assume that the fixed costs do not drive them to zero. On the other hand, we assume that fixed costs are large enough to induce the following Cournot losses:

$$\pi_c^{C,k} = \frac{\beta\left(\alpha T_u^k - 2\beta T_c^k + A^k \left(2\beta\gamma_c^k - \alpha\right)\right)^2}{t_c^k \left(4\beta^2 - \alpha^2\right)^2} - f_c^k \tag{18}$$

$$\pi_u^{C,k} = \frac{\beta\left(\alpha T_c^k - 2\beta T_u^k + A^k \left(2\beta - \alpha\gamma_c^k\right)\right)^2}{t_u^k \left(4\beta^2 - \alpha^2\right)^2} - f_u^k \tag{19}$$

The mixing probabilities of entry by the firms are:

$$\omega_c^k = \frac{\pi_u^{m,k}}{\pi_u^{m,k} - \pi_u^{C,k}} \text{ and } \omega_u^k = \frac{\pi_c^{m,k}}{\pi_c^{m,k} - \pi_c^{C,k}} \tag{20}$$

As is well known, Cournot profits are higher than Bertrand profits and this implies that Cournot losses are shallower than their Bertrand counterparts. Accordingly:

Result 5: *The probabilities of entry in the Cournot mixed strategies equilibrium are higher than in the Bertrand mixed strategies equilibrium.*

The payoffs structure giving rise to mixed strategy equilibria is that of the chicken game. In the context of maple syrup exports, one could see that this game is played in several markets year after year. The mixed strategy equilibrium is not only a Nash equilibrium, but it is also an evolutionary stable one.

4. Correlated strategies

Mixed strategies equilibria are often criticized on the ground that players would find a mechanism to avoid painful ex post outcomes like joint entry in our duopoly games or a collision in the famous chicken game. Such bad outcomes can be avoided if players use correlated strategies (Myerson, 1991). In the duopoly game there are four pairs of strategies $S_{ji} = \left(S_{c,j}, S_{u,i}\right)_{i,j=entry,no\ entry}$ yielding the following payoffs where the index *d* designates either *C* (Cournot) or *B* (Bertrand):

		US: Entry	US: No Entry
Can	Entry	$\pi_c^{d,k} < 0, \pi_u^{d,k} < 0$	$\pi_c^{m,k} > 0, 0$
	No Entry	$0, \pi_u^{m,k} > 0$	$0, 0$

A correlated equilibrium assigns a probability $\mu_{j,i} \equiv \mu\left(S_{ji}\right) \geq 0$ to each of the four pairs of pure strategies. Thus, $1 = \mu_{e,e} + \mu_{e,ne} + \mu_{ne,e} + \mu_{ne,ne}$. Since joint entry entails a loss for both firms, let us first consider correlated equilibria consistent with $\mu_{e,e} = 0$, $\mu_{e,ne}, \mu_{ne,e}, \mu_{ne,ne} > 0$. This implies that $1 = \mu_{e,ne} + \mu_{ne,e} + \mu_{ne,ne}$. In a correlated equilibrium, the Canadian and US firms observe a separate signal from which they infer a strategy to play without knowing what strategy their rival is assigned. Because they know the probabilities of each payoff allocation, they can verify that it is in their best interest to follow the strategy assigned to them. Accordingly, the probabilities are set so that each firm has no incentive to deviate provided the other player follows the pure strategy associated with the signal they observed. Thus, the following constraints must be satisfied:

$$\mu_{e,ne}\left(\pi_c^{m,k} - 0\right) \geq 0 \tag{21}$$

$$\mu_{ne,e}\left(0 - \pi_c^{d,k}\right) + \mu_{ne,ne}\left(0 - \pi_c^{m,k}\right) \geq 0 \tag{22}$$

$$\mu_{ne,e}\left(\pi_u^{m,k} - 0\right) \geq 0 \tag{23}$$

$$\mu_{e,ne}\left(0-\pi_u^{d,k}\right)+\mu_{ne,ne}\left(0-\pi_u^{m,k}\right)\geq 0 \qquad (24)$$

Equations (21) and (23) simply say that strategy pairs with one firm entering should have weakly positive probabilities and hence are redundant. Treating the other two equations as identities and accounting for the adding-up constraint restricts the set of potential equilibria. Under symmetric monopoly gains and duopoly losses, $\pi_c^{m,k} = -\pi_c^{d,k}$ and $\pi_u^{m,k} = -\pi_u^{d,k}$, then it can be shown that $\mu_{e,ne} = \mu_{ne,e} = \mu_{ne,ne} = 1/3$.[9] With these probabilities, the Canadian firm receiving the signal to enter does so knowing that it will be the only one entering. The US firm knows that it is in its interest to follow the proposed strategy because by (24) it would not gain from deviating. In this symmetric correlated equilibrium, the exporters' payoff are $\left(\frac{\pi_c^{m,k}}{3},\frac{\pi_u^{m,k}}{3}\right)$ and they exceed the zero payoffs of the mixed strategies equilibrium.

Let us now introduce some asymmetries in the payoffs. If the Canadian firm is the most profitable one and duopoly losses are shallow relative to monopoly profits such that $\frac{\pi_c^{m,k}}{-\pi_c^{d,k}} > \frac{\pi_u^{m,k}}{-\pi_u^{d,k}}$ >1, then $\mu_{ne,e} > \mu_{e,ne} > \mu_{ne,ne}$. On the other hand, if the US firm is the most profitable firm and duopoly losses are shallow, $\frac{\pi_u^{m,k}}{-\pi_u^{d,k}} > \frac{\pi_c^{m,k}}{-\pi_c^{d,k}}$ >1, then $\mu_{e,ne} > \mu_{ne,e} > \mu_{ne,ne}$. If the Canadian

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[9] The resulting correlated equilibrium is the same as in Myerson (1991, p. 254) even though the payoff matrices are different. The games are "Chicken" games, but with different payoff structures. In Myerson (1991), there is a best payoff allocation, but it can be secured only through a binding contract. In our case, the firms'payoffs are zero when both firms do not enter and do not constitute a best payoff allocation. The correlated equilibrium in Myerson (1991, p.254) can then be thought as a second best outcome even though it maximizes joint payoffs amongst possible correlated equilibria. Our correlated equilibrium is not a first best outcome either. A (fair) coin toss to decide who should enter (i.e., setting $\mu_{ne,ne} = \mu_{e,e} = 0$) would provide higher expected payoffs. However, our proposed correlated equilibrium can be seen as one for which the mediator sending the signals is concerned only with loss aversion. Still, both firms have higher expected payoffs than when they play mixed strategies.

firm is the most profitable firm and duopoly losses are deep, $1>\frac{\pi_c^{m,k}}{-\pi_c^{d,k}}>\frac{\pi_u^{m,k}}{-\pi_u^{d,k}}>0$, then

$\mu_{ne,ne}>\mu_{ne,e}>\mu_{e,ne}$.

Result 6: *If firms adopt correlated strategies that assign a zero probability only on joint losses, then the most profitable firm (with the highest monopoly profit and lowest duopoly loss) has a lower probability of entry than its rival.*

Thus, if the US firm has higher fixed export cost than its Canadian counterpart, all else equal, then it should enjoy a monopoly in more destinations than its Canadian rival. The same conclusion would apply if the only source of firm asymmetry was due to Canadian maple syrup benefiting from a quality premium over US maple syrup.

There are many possible correlated equilibria. The ones discussed above that only restrict joint entry do not maximize joint profit because there is "money left on the table" when no one enters. Setting $\mu'_{ne,ne}=\mu'_{e,e}=0$ implies that entry is randomized between the two firms the above incentive conditions reduce to $\mu'_{e,ne},\mu'_{ne,e}>0$ and expected payoffs for the Canadian and US firms are respectively $\mu'_{e,ne}\pi_c^{m,k}$ and $\mu'_{ne,e}\pi_u^{m,k}$. All entry-randomizing equilibria satisfying $\mu'_{e,ne}>\mu_{e,ne}$ and $\mu'_{ne,e}>\mu_{ne,e}$, including a fair coin toss, generate higher payoffs than the correlated equilibria allowing for no entry among ex post outcomes.

From an empirical perspective cost differences giving rise to monopolies in oligopoly models can be downplayed in the maple syrup case. This is so because of the geographical proximity of maple syrup production in Canada and in the United States, the mature nature of the technology and the fact that Canada and the United States face similar tariffs in almost all markets as they are both WTO members and have regional trade agreements with common partners.

Furthermore, while non-tariff barriers can severely impede trade for some agricultural products, they are not important in maple syrup trade. Thus, in the absence of fixed export costs, the data on maple syrup trade should be characterized by very few destinations supplied by a single exporting country.

Since many monopolies are observed in the data, a more likely explanation is the presence of large fixed export costs relative to the size of the export market. The demand for maple syrup is likely to be small in poorer countries and this should increase the likelihood of monopolies. Equilibria in mixed and correlated strategies provide some insights about which of Canada or the United States is more likely to be a monopolist. The next section documents the frequency of monopolies and the relative frequency of Canadian and US monopolies. Estimates from a two-stage empirical trade model are also presented. The first stage is meant to explain the probabilities of no trade, of a Canadian monopoly, of a US monopoly and of a Canada-US duopoly. As per our theoretical framework, three distinct gravity equations must be estimated, each adjusted for the probability of its given market structure.

5. **An empirical gravity model with endogenous market structures**

5.1 Patterns in maple syrup trade

Our data features maple syrup exports from Canada and the United States. Canada is the largest exporter of maple syrup with sales of US$292 millions in 2015 compared to US exports sales of US$22 millions. The United States is by far the largest importing country with imports amounting to US$179 millions in 2015. Japan, Germany, the UK and Australia are the next largest importers. Canada, with imports of over US$10.3 millions, was the 6th largest importer in 2015, just ahead of France. In all, 160 countries/territories imported maple syrup at least once between 1996 and

2015 from either or both Canada and the United States. Botswana, Gabon, Iran, Macao, Mali, Suriname, Uruguay, Zambia and Afghanistan bought maple syrup from a single exporter only once over the 20 years spanned by our sample. 24 countries have bought Canadian maple syrup every year while 16 countries have done the same for US maple syrup. From these countries, 10 have bought every year from both sources. Some flows are tiny, as they possibly are imports by Canadian and US citizens living abroad in need of sweets or restaurant owners trying to cater to Canadian and US tourists.[10]

Conditional on export sales, Canada has a monopoly with probability of 0.109/(0.109+0.281) or 28%. For the US the probability of being a monopolist, conditional on export sales, is higher at 41%. Table 1 reports statistics about averages sales, average tariffs and average distances across destinations supplied only by Canada, only by the US or from both exporters. Looking first at trade impediments, the average tariff faced by Canada when it has a monopoly is 13.9%. This is not very different from the average tariff of 10.1% it faces when importers buy Canadian and US maple syrup. The US faces an average tariff of 15.9% in export markets where Canada is not present and 10.2% when Canada is present. Likewise, average distances are very similar between exporting countries whether they are alone in the market or competing with each other.

In spite of the similarities in average tariff protection and distances hindering Canadian and US exports of maple syrup, there are large differences in sales across market structures for both Canada and the US and in sales between Canada and the US for both types of market structures. As expected, monopoly sales are much smaller. Average export sales of Canadian maple syrup when importers buy only from Canada average only $42330/year while Canadian

[10] Countries like Jamaica, Thailand, Saint Kitts and Nevis, Seychelles and Cuba attract their fair share of Canadian and US tourists.

exports average $3872430/year in markets where US maple syrup is also purchased. Canadian exports to the US are huge and this might bias average Canadian exports when Canada and US are competing with each other. Excluding the US as one of the markets where Canada is competing with the US, the average importer that buys from both Canada and the US spends $1387570 on Canadian maple syrup annually. The same sales pattern is observed for the US. Table 1 shows that US sales average only $27140/year in markets where Canadian maple syrup is not imported, as opposed to $219650/year in markets where maple syrup from Canada is also purchased. Maple syrup is a luxury product and one would expect that large importers tend to have higher gross domestic product (GDP) per capita. The average GDP per capita for importing countries buying from both Canada and the US is $25269. The same statistic for importing countries buying only from Canada is $13753. The average GDP per capita of countries buying maple syrup only from the US is only $6764.[11]

As per the theoretical results derived previously, the empirical evidence reported above about monopoly sales is consistent with large fixed export costs and small markets that give rise to random natural monopolies. From Results 4 and 6, we can infer from the US being a more frequent monopolist than Canada that is suffer a competitive disadvantage vis-à-vis Canada.

Table 1 reports also on unit values or the ratio of imports and quantities. Some quantity entries were missing and the average unit values are computed on fewer observations. The average Canadian unit value, is $11.54 when Canada has a monopoly as opposed to $8.40 ($8.48) when it is a duopolist (excluding the US market). Similarly, the exclusion of Canadian imports from the computation of US maple syrup unit values in a duopoly setting has a small inflationary

[11] The average GDP per capita of importers vary over years, but the ranking is always the same. In 2015, the average GDP per capita of countries buying from Canada and the US, from Canada only and from the US only were $24954, $13764 and $5529 respectively.

effect as the unit value increases from $7.70 to $7.79. The US average unit value is noticeably lower in markets where Canada is absent ($4.42).[12] A higher unit value on smaller volumes is to be expected as a larger margin is needed to cover fixed export costs. Differences in unit values can be influenced by changes in product composition within the 6-digit category. It could be that Canada's monopoly exports have a higher percentage of further processed products (i.e., maple sugar) and/or that Canadian maple syrup is more likely to be exported in fancy glass bottles than in large barrels or tin cans. Furthermore, the distribution of monopoly markets over the years can also play a role in explaining the difference in average unit values in markets-years for which Canada and the US have monopolies. Figure 3 shows that Canada tends to have more monopolies near the end of the sample while the US has most monopolies in the middle of the sample.

Importing countries that import from only one source in a given year do not always import from the same source. In fact, 36 countries have bought some years only from Canada and in other years only from the US. For example, the US was the sole exporter in Turkey in 1997 and 2000, shared the market with Canada in 1999, 2002-03, 2006-07, while Canada was the only exporter in 1996, 1998, 2001, 2004-05, 2008-15. Production can vary much from one year to the next due to weather conditions, but weather shocks across exporting countries are likely to be highly correlated due to the geographical concentration of the production. In years with good weather, we would expect unit values for Canada and the US to be lower than in years of low production. To control for that, we computed annual unit value averages for Canada and the US when they are monopolists and duopolists. Since we have 20 years of data, we have 20 yearly

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[12] To ascertain the robustness of this low US unit value, the statistic was recomputed by excluding sales of less than $2000 and by keeping only the last ten years. This generated an average unit value of $4.43. Restricting the range of unit values between $2 and $20 produced an average unit value of $5.53 which is still quite low compared to the Canadian monopoly unit value. Similar checks on the Canadian monopoly unit values generated some variations ($9.79-$12.04) that were not large enough to make a qualitative change in interpretation.

average unit values for monopoly and duopoly markets. The yearly average unit values when Canadian and US compete as duopolists are highly correlated (0.83), as one would expect. When Canada and the US are monopolists, the correlation coefficient between the yearly average unit values for Canadian and US exports fall to 0.36. Table 2 reports matched pair t-tests about differences in yearly average unit values and the results adds evidence that Canada's exports embody more value added. The difference between Canada and the US is particularly large when comparing their average unit values for markets where they have a monopoly.

The descriptive statistics reported above confirm that import markets supplied by both Canada and the US are quite different from markets supplied by only one supplier. The sub-section develops an empirical gravity framework that accounts for this and the fact that several import countries do not import every year.

5.2 An econometric approach to endogenous market structures and exports

In monopolistic trade models, domestic firms may face competition from foreign firms depending on fixed export costs and variable trade costs. In these models, there is either a single monopolistic market structure or no trade. The "zeros" are handled through a Poisson-Pseudo Maximum Likelihood (PPML) estimator or through a two-step estimation (e.g., Helpman, Melitz and Rubinstein, 2008; Egger et al. 2011) involving a first-stage probit or logit model to explain the probability of a positive trade flow. A second-stage corrected gravity equation is then estimated on a truncated sample of strictly positive flows. The correction in the second-stage model is based on non-linear functions of the estimated parameters of the first-stage binary model. Helpman, Melitz and Rubinstein (2008, p.456) use the inverse Mills ratio and a function involving the inverse Mills ratio or the linear prediction of the first-stage latent variable to address the biases due to sample selection and unobserved firm-level heterogeneity. Their exact second-stage equation is estimated by non-linear least squares, but they also propose a linear specification involving a polynomial of the first-stage predictions of the latent variable. Egger et al. (2011) dismiss the inverse Mills ratio, relying only on the polynomial of the linear first-stage extensive margin predictions to correct their conditional gravity model. They also use Santos Silva and Tenreyro's (2006) PPML estimator because it is robust to various forms of heteroskedasticity. The estimation strategies for monopolistic trade models provide valuable insights, but they must be modified in important ways to account for the particularities of maple syrup exports.

Denoting y_j the value of trade for market structure j, our model takes the following form:

$$E\left[y\right]=\Pr\left[z=j\right]*E\left[y\mid z=j\right] \tag{25}$$

There are four market structures that can be observed: a Canada-US duopoly, a Canadian monopoly, a US monopoly and no trade. Naturally, markets that are large enough to support a duopoly have different (conditional) expected trade levels than smaller markets supplied by a single exporting country. Selection models dealing with more than two alternatives often rely on a first-stage multinomial logit model. This is the case for Lee (1983), Dubin and McFadden (1984) and Dahl (2002) who propose different ways of "correcting" alternative-specific second-stage OLS regressions. These models, extensively used in energy economics (e.g., Mansur, Mendelsohn and Morrison, 2008), also provide valuable insights, but they must be modified to addresses specific issues pertaining to endogenous market structures and trade data.

In a multinomial logit model, the probability of a given market structure *j* is:

$$\theta_j \equiv \Pr\left[z_i=j\right]=\frac{\exp\left(\alpha_j\,'w\right)}{1+\sum_{j=1}^{J}\exp\left(\alpha_j\,'w\right)} \tag{26}$$

for *j*=no trade, Canadian monopoly, US monopoly and Canada-US duopoly, were α_j is a vector of parameters specific to alternative j and w is a matrix of regressors. A base case (e.g., no trade) with zero coefficients must be selected for identification purposes. Accordingly, the probability of the base case is $\Pr\left[z_j = 1\right] = \frac{1}{1+\sum_{j=1}^{J}\exp\left(\alpha_j ' w\right)}$. The probability of alternative *k* relative to the base case is simply $\exp\left(\alpha_k ' w\right)$. This relative probability depends only on parameters specific to outcome *k*. By the same token, the ratio of probabilities for two non-base alternatives are not affected by parameters specific to other alternatives. This property, known as the independence of irrelevant alternatives (IIA) assumption, is inconsistent with our theoretical model. The number of firms in a given market is conditioned by the size of the market and fixed export costs for this market. If a market is large enough to support one entrant but is too small for two, the choice between a Canadian monopolist or a US monopolist is due to a randomization process possibly stemming from mixed or correlated strategies.[13] Thus the two monopoly alternatives are very much like the “reb bus/blue bus” alternatives in the transport mode example used in many econometric textbooks to illustrate IIA failure. Different estimators can be used to relax the IIA assumption. We rely on the random parameter logit estimator because it offers much flexibility and parsimony in modeling unobserved heterogeneity while allowing for correlation between alternative choices.

Rather than relying on OLS for the estimation of each second-stage market structure specific trade equation, we follow Egger et al. (2011) in relying on the PPML estimator. Simulations showed that PPML is robust to various types of heteroscedasticity common in international trade

[13] We use the Hausman-McFadden (1984) test to confirm the rejection of the IIA assumption. The test compares common estimated parameters of models with J and J-1 alternatives to ascertain the sensitivity of parameters to the drop of one alternative.

data (Santos Silva and Tenreyro, 2006). Second stage corrections typically entails non-linear functions of the first stage predictions. In Lee (1983), the correction in each equation is the alternative-specific inverse Mills ratio $\lambda_k = \frac{\phi(\alpha_k ' w)}{\Phi(\alpha_k ' w)}$, where ϕ and Φ are the normal density and cumulative functions. In Dubin and McFadden (1984), second-stage for alternative *k* must be augmented with the following terms: $\sigma_k \sum_{j \neq k}^{J} r_j \left(\frac{\theta_j \ln[\theta_j]}{1-\theta_j} + \ln[\theta_k] \right)$, where r_j represents the correlation between the first-stage residuals and the residuals of alternative *j*'s second-stage equation. Dahl's (2002) semi-parametric correction revolves around a series expansion of θ_k, the predicted probability of alternative *k*. Egger et al. (2011) also used a polynomial function to address the selection issue in their model, but their function was about $\alpha_j ' w$, not $\theta_j(\alpha_j ' w)$. Bourguignon, Fournier and Gurgand (2007, 174) compared the performance of these selection-bias corrections and concluded that the Dubin and McFadden (1984) and Dahl (2002) were the preferred approaches. We implemented Dahl's approach.

As for the choice of explanatory variables for our model, the above theoretical section, and more specifically Results 3-6, point out that the probability of a given market structure (i.e., no trade, Canadian monopoly, US monopoly and Canada-US duopoly) is determined by a measure of effective market size. This index determines whether the market is large enough to support two entrants, a Canadian entrant, a US entrant or no entrant at all and it is conditioned by variables affecting the profits of firms: tariff, distance, procurement cost, fixed export cost for both export sources and potential market size (*A*, β in our theoretical models) that we approximate with GDP. Since sales are non-linear with respect to most variables (see (4), (5), (15) , (16)), we must allow for linear, interaction and quadratic effects.

Canadian and US exports of maple syrup are available from the COMTRADE database. Data about maple syrup tariffs is available from the TRAINS database which, like COMTRADE, can be accessed from the World Integrated Trade Solution website. Distances between exporting and importing countries are available from the CEPII's website. Market size potential can be proxied by real GDP, which can be downloaded from the World Bank economic indicators database. Procurement costs depend on the current year production as well as stocks on hand. We use exporter-year fixed effects as proxies. As one would expect, production is heavily influenced by weather and hence it quite variable from one year to the next. Exporter-year fixed effects also capture potential regulatory changes in Canada and in the US.

In our framework, fixed export costs play a critical identification role because they explain market structure while not affecting the volume traded for any given market structure (conditional on positive trade flows in standard gravity models) while GDP and trade costs operate at both margins. Fixed export costs can be proxied in various ways. The World Bank has an attractive "lead time to import" indicator, but data is available for only a subset of countries and two years, 2007 and 2016, the latter being out of our sample (1996-2015). Helpman, Melitz and Rubinstein (2008) use religion as an identifying variable while Egger et al. (2011) needing identifying instrument to address the endogeneity of trade agreements as well as the selection issue used colonial linkages indicators. Johnson (2012) used lagged participation as a proxy. It is expected that once an exporting firm has invested resources to find a distributor for its product in a given importing country that it could more easily recontact this distributor in subsequent years to discuss terms and get updated information about regulations in the importing country. However, lagged participation must go back enough in time to be independent of current trade volumes. Our indicator is a binary variable equal to one if the exporter had been present in a given destination four years before. Our specification posits that the parameters for fixed export costs are random, that the incidence of fixed export cost on the market structure probabilities vary from one exporter-importer pair to another. The estimated coefficients of multinomial models are of little interest by themselves, especially since variables interact with one another. This is why marginal effects are typically reported to facilitate the interpretation of the results. The marginal effect of variable w_i (tariff, distance, gdp) on the probability of market structure *k* that account for interactions between variable *i* and variables *n* is given by:

$$\frac{\partial \theta_k}{\partial w_i} = \theta_k \left(\alpha_{ki} + 2\alpha_{ki2} w_i + \sum_{n \neq i}^{N} \alpha_{kn} w_n - \sum_{j=1}^{J} \theta_j \left(\alpha_{ji} + 2\alpha_{ji2} w_i + \sum_{n \neq i}^{N} \alpha_{jn} w_n \right) \right) \qquad (27)$$

The above equation tells us about a unit change in variable i on the probability of market structure *k*. It is computed at the average values of the variables. Another interpretation of first-stage results is in terms of the extensive margin of trade. Since (25) is made up of two components, the quasi-elasticity about the unconditional level of trade is simply the sum of the quasi-elasticities for the two right-hand side components: $\varepsilon_{y_k w_i} \equiv \varepsilon_{\theta_k w_i} + \varepsilon^c_{y_k w_i}$, where $\varepsilon_{\theta_k w_i} = \frac{\partial \theta_k}{\partial w_i} \frac{1}{\theta_k}$ and $\varepsilon^c_{y_k w_i} = \frac{\partial y^c_k}{\partial w_i} \frac{1}{y^c_k}$, $y^c_k \equiv E\left[y \mid z = k \right]$. Comparing these two components tells us whether the impact of a unit increase in a given variable is stronger at the extensive or at the intensive margin of trade.

The second stage specifications reflect the structure of the theoretical export equation derived in the previous section. Generally, a firm's conditional exports in a monopoly (duopoly) market depend on its own (and its rival's) trade and procurement costs. When such costs are symmetric (or almost symmetric as in our case), theory imposes common specifications, but the parameters are expected to be different and this warrants the estimation of market-structure specific gravity models corrected for the market structure selection. More specifically, in the conditional trade equation for market structure *j*, we used a polynomial of degree 3 about the predicted probability of market structure *j* to correct for selection. A test about the joint significance of the coefficients of the correction terms allows us to validate that a correction is needed. PPML coefficients for continuous variables expressed in levels can be interpreted as quasi-elasticities. Therefore, the conditional trade or intensive margin quasi-elasticity with respect to variable *i* , assumed to be interacting with variables *n* and to have a quadratic effect, is computed as:[14]

$$\varepsilon^{c}_{y_k w_i} = \beta_{w_i} + 2\beta_{w_i w_i} w_i + \sum_{n \neq i}^{N} \beta_{w_i w_n} w_n \tag{28}$$

5.3 Empirical results

The results of the random parameter logit model are reported in Table 3. Most of the coefficients are statistically significant. Lagged participation coefficients are random and are allowed to be correlated. Lagged participation has on average a positive influence on the probability of a US monopoly and a Canada-US duopoly and a negative mean effect on the probability of a Canadian monopoly. The negative effect of lagged participation on the probability of a Canadian monopoly suggests that Canada gives up on small stagnant or declining markets and/or that market development efforts induce a US entry giving rise four years later to a US monopoly or a Canada-US duopoly. With normally distributed random parameters, the parameters span positive and negative values across import markets, reflecting heterogeneity induced by unobservable factors.

[14] Note that for tariff, our variable is defined as $t = 1 + \tau$ and $\varepsilon^{c}_{y_k \tau} = \varepsilon^{c}_{y_k t} / 100$.

The coefficients of the L matrix can be used to construct the covariance matrix of random parameters as *V=LL'*. The variance of the lagged participation parameter for a Canadian monopoly is particularly large in magnitude. Subtracting and adding two standard deviations to the random coefficient make it span negative and positive values. Thus, past Canadian sales increase (decrease) the likelihood of a Canadian monopoly for a few (many) markets. The covariance terms involving the Canadian monopoly coefficient are fairly large and negative as unobservable factors decreasing the likelihood of a Canadian monopoly will tend to increase the probabilities of US monopolies and Canada-US duopolies.

The marginal effects about a 1% tariff increase on the probability of a Canada monopoly, a US monopoly or a Canada-US duopoly are 0.008 (p-value=0.000), -0.0002 (p-value=0.868) and -0.012 (p-value=0.000). These marginal effects are small, and in the case of the US monopoly not statistically significant. It can be concluded that a tariff increase decrease the probability that the market will be large enough for a duopoly, thus increasing the likelihood of no trade and of a Canadian monopoly. The marginal effects about a 1 billion dollars increase in GDP are -0.00013 (p-value=0.027), -0.00006 (p-value=0.409), and 0.00144 (p-value=0.000). An increase in GDP has a positive effect on the probability of observing a Canada-US duopoly, no effect on the probability of observing a US monopoly and a negative effect on the probability of observing a Canadian monopoly. Since the marginal effect on the probability of a duopoly is much larger in magnitude than the negative marginal effect for a Canadian monopoly, we can infer that an increase in GDP in any given importing country reduces the probability of no trade. The marginal effects about a 1000km increase in distance are: -0.00056 (p-value=0.000), 0.00022 (p-value=0.000) and -0.00004 (0.682). Thus, an increase in distance decrease the probability of a Canadian monopoly, increase the probability of a US monopoly, has no effect on the probability of a duopoly and increases the probability of no trade.

The results for the conditional trade regressions are reported in Table 4. Most coefficients are statistically significant. The duopoly equation has a very high R2 of 0.98, while the monopoly equations for Canada and the US, which potentially reflect a randomization process, have lower R2s (0.85 and 0.47) respectively. The correction terms are jointly highly significant for the duopoly case. The corresponding p-values about joint significance of the correction terms are 0.54 and 0.11 for the Canadian and US monopoly cases. The quasi-elasticities give us the percentage changes in the value of exports in response to unit changes in explanatory variables. For example, if the tariff rate increases by 1% (i.e., the tariff increases from say 20% to 21% as opposed to 0.01X20%=0.2%), the conditional value of exports decreases by 2.2% for a duopolist, by 6.5% for a Canadian monopolist and by 9.9% for a US monopolist. The tariff increase has a more potent effect under a monopoly because it impacts only the firm's sales, while in a duopoly setting the tariff has negative effect on the firm's cost, but a positive effect through the rival's cost. The effect of a one billion dollars increase in GDP increases trade by 0.15% and 0.3% in the cases involving Canadian and US monopolies. For the duopoly case, the effect is 0.04%. The quasi-elasticities for an increase of 1000km in distance are -17.7% in the duopoly case and -8% and -2.33% for the Canadian and US monopoly cases.

6. Conclusion

For many primary commodities (e.g., maple syrup, vanilla and cocoa), the number of potential sourcing countries is small because production requires specific soil and climate. Furthermore, the small number of export traders, because of marketing boards directly involved in export marketing or indirectly through authorized intermediaries, gives rise to destinations served by a monopoly and an oligopoly. In this paper, we use maple syrup exports to motivate the modeling of endogenous market structures. World production is concentrated in eastern Canada and in the northeastern part of the United States. The procurement price announced by a marketing board in Quebec acts as a reference price outside Quebec. As a result, procurement costs for Canadian and US exporting firms are quite similar. The same can be said about their trade costs for most destinations because of the geographical proximity between Quebec and northeastern states and because Canada and the US essentially face the same tariffs in every market. This symmetry in costs favors the existence of duopolies in foreign markets yet empirical evidence shows a large number of monopolies.

We developed theoretical and empirical frameworks to explain market structure and trade flows (conditional on market structure) when two exporting firms from different countries compete against each other in foreign markets. The main prediction is that large import markets are more likely to support duopoly equilibria while small import markets should be catered by a single firm or not catered at all. As for monopolistic competition models, fixed export costs play a critical role in defining the probabilities of Canada-US duopoly, a Canada monopoly, a US monopoly or absence of trade. A pure strategy monopoly assignation occurs when joint entry is unprofitable for both firms and only one firm is profitable as a monopolist. When joint entry is unprofitable and a monopoly is profitable for both firms, mixed-strategy and correlated equilibria suggest that the least competitive firm is the most frequent monopolist.

Descriptive statistics about maple syrup exports indicate that Canadian and US export sales are much higher in duopoly markets than in markets where maple syrup comes from a single country. The empirical framework revolves around a random parameter multinomial logit, to generate probabilities for the four possible market outcomes, and market structure specific second-stage gravity models. Polynomials of first-stage probabilities are used to correct the conditional second-stage trade equations. As expected, GDP has a strong positive effect on the probability of a duopoly, no effect on the probability of a US monopoly and negative effect on the probabilities of a Canadian monopoly and no trade. Because of symmetries in trade and procurement costs, conditional trade equations have similar specifications, but theory predicts lower trade costs impacts in duopoly than in monopoly cases. Our results respect this pattern.

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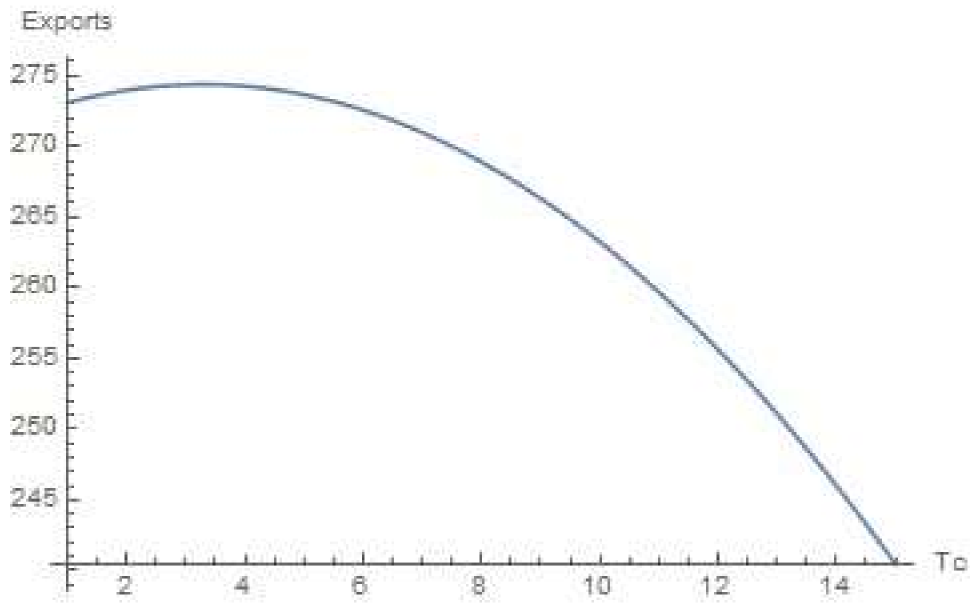

Figure 1. Unit variable cost and exports given parameters $a = 15,\ b = 1,\ e = 0.6$, $T_u^k = 10$, $\delta = 1.5$.

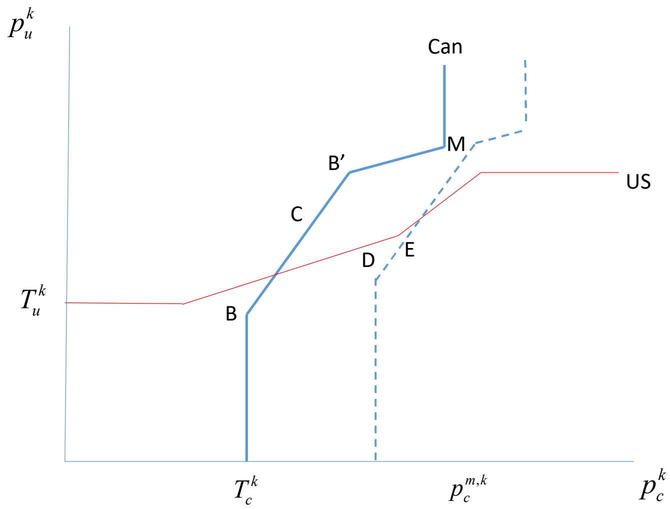

Figure 2. Bertrand reaction functions

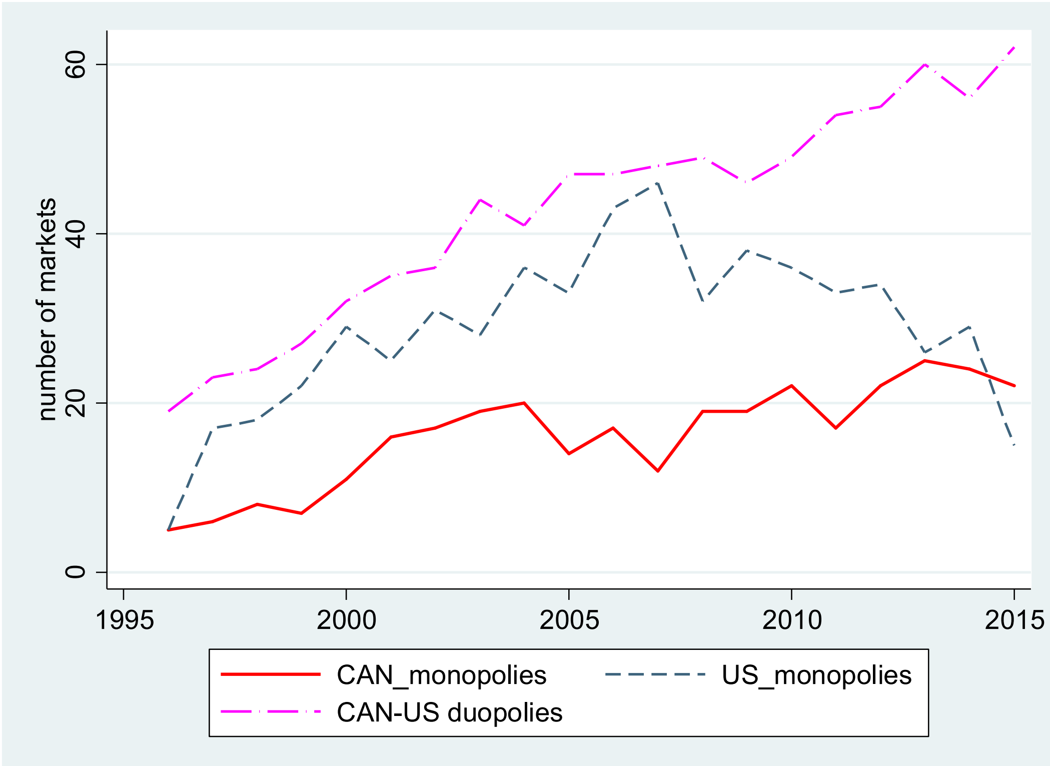

Figure 3. Number of Canadian monopolies, US monopolies and Canada-US duopolies, 1996-2015

Table 1. Average Imports, tariffs, distances under different market structures

	Canada				United States			
	Average Exports ($1000)	Average Tariff (%)	Average Distance (km)	Average Unit Value ($/kg)	Average Exports ($1000)	Average Tariff (%)	Average Distance (km)	Average Unit Value ($/kg)
Monopoly	42.33	13.9	7775	11.54	27.14	15.9	7639	4.42
Duopoly	3872.43	10.1	7986	8.40	219.65	10.2	7939	7.70
	1387.57 (excl.USA)			8.48	109.82 (excl.CAN)			7.79

Table 2. Matched pairs t-tests about differences in yearly average unit values

Exporter/market structure	N	Mean (95% C.I.)	Standard error	Standard deviation	t-stat (p-value)
Canada-monopoly	20	10.01	0.86	3.83	
US-monopoly	20	4.07	0.44	1.95	
Difference	20	5.94 (4.25-7.64)	0.81	3.62	7.33 (0.0000)
Canada-duopoly	20	7.46	0.52	2.33	
US-duopoly	20	6.03	0.39	1.73	
Difference	20	1.43	0.30	1.33	4.80 (0.0000)

Table 3. Market Structure Probabilities (base case=no trade)

	Canada Monopoly	US Monopoly	Canada-US Duopoly
	Fixed parameters		
Gdp	-0.0311***	0.00440	0.0329***
	(-5.46)	(0.98)	(7.43)
Tariff	2.576*	4.364***	-1.323
	(1.99)	(5.22)	(-1.40)
Distance	0.134	-0.943***	-0.477***
	(0.60)	(-7.75)	(-3.33)
Tariff**2	-3.377***	-2.281***	1.374*
	(-3.39)	(-3.89)	(2.09)
Tariff*distance	-0.0351	0.132	-0.157
	(-0.20)	(1.63)	(-1.66)
Tariff*gdp	0.0406***	-0.00455	-0.0198***
	(7.67)	(-1.26)	(-5.50)
Distance**2	-0.0157**	0.0404***	0.0352***
	(-2.74)	(10.89)	(7.92)
Distance*gdp	-0.00161***	0.000432*	-0.000253
	(-6.35)	(2.35)	(-1.43)
	Random parameters		
Participation (t-4)	-8.8084***	1.4079***	3.0405***
	(-4.90)	(3.49)	(7.36)
	L matrix		
Canada monop.	-9.7711***		
	(-5.56)		
US monop.	1.8723	1.1130	
	(1.75)	(1.10)	
Can-US duop.	1.6731	0.9995	0.0185
	(1.68)	(1.01)	(0.09)

t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, *LL'*=covariance of random parameters
Exporter-year fixed effects included but not reported.

Table 4. Market structure specific gravity equations (selection corrected PPML)

	Canadian monopoly	US monopoly	Canada-US duopoly
Gdp	0.00648**	0.0146*	0.000125
	(2.90)	(2.06)	(0.22)
Distance	-0.0838	-2.629***	-0.815*
	(-0.09)	(-3.76)	(-2.47)
Tariff	-24.43*	14.23	230.3***
	(-2.22)	(0.87)	(5.03)
Tariff**2	8.100**	-9.053	-105.3***
	(2.93)	(-1.44)	(-4.88)
Distance**2	-0.00251	0.0576***	0.0474***
	(-0.13)	(4.47)	(12.24)
Tariff*gdp	-0.00269	-0.00720	-0.0000589
	(-1.55)	(-1.68)	(-0.10)
Tariff*distance	-0.0135	1.514**	-0.118
	(-0.02)	(3.11)	(-0.40)
Distance*gdp	-0.000253	-0.000468*	0.0000453***
	(-1.00)	(-2.34)	(6.42)
Prob[j]	-7.192	-20.11*	22.82***
	(-0.66)	(-2.33)	(3.61)
Prob[j]**2	12.17	63.05*	-36.99***
	(0.41)	(2.42)	(-3.57)
Prob[j]**3	-8.207	-58.20*	20.94***
	(-0.41)	(-2.35)	(3.94)
$\chi^2(3)$	2.14	5.88	396.81***

t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Exporter-year fixed effects included but not reported.