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Trade and Investment Liberalization in the Processed Food Market under the Comprehensive Economic and Trade Agreement

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We investigate the impacts of Comprehensive Economic and Trade Agreement (CETA) liberalizations of trade and investment barriers on processed food markets. Using a four-region monopolistic competition model with heterogeneous food-processing firms that incorporates domestically operating, exporting, and multinational enterprise (MNE) firms, we quantify the effects of tariff elimination, fixed trade cost reduction, and foreign direct investment (FDI) cost reduction under CETA on prices, domestic sales, bilateral trade flows, affiliate sales, productivity, number of firms, and aggregate output. Our results highlight that trade liberalization promotes bilateral exports but reduces foreign affiliate sales, and, in contrast, lower FDI costs expand MNE affiliate sales but curtail bilateral exports.

Key words: Canada, CETA, European Union

Introduction

The recently completed Comprehensive Economic and Trade Agreement (CETA) between Canada and the European Union provides sweeping cuts to trade and investment restrictions.[1] This study extends Luckstead and Devadoss (2016) by introducing horizontal multinational enterprises (MNEs) as modeled by Helpman, Melitz, and Yeaple (2004) to investigate the impacts of CETA liberalizations of trade and investment barriers on processed food markets, not only in the European Union and Canada but also in the United States (a key trading and investment partner of both regions) and the rest of the world (ROW).

After 8 years of negotiation, CETA, with its primary objective of liberalizing trade and investment barriers, was ratified by Canada and the European Union in early 2017 and enacted in September 2017 (International Center for Trade and Sustainable Development, 2017b). CETA lowers variable trade costs by removing 98% of bilateral tariffs between Canada and the European Union (International Center for Trade and Sustainable Development, 2017a; European Commission, 2017b). CETA also reduces fixed trade cost by providing conformity assessment certificates, which simplify and streamline the process for (i) verifying the conformity of the products to technical rules and regulations, (ii) health, safety, and consumer protections, and (iii) environmental standards (European Commission, 2017a). CETA also facilitates foreign direct investment (FDI) between Canada and the European Union by lowering investment barriers with nondiscrimination clauses

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[1] This agreement was enacted in September 2017 (International Center for Trade and Sustainable Development, 2017b) and touted as a "new global standard of progressive trade agreements" (European Commission, 2016).

for domestic and foreign investors, reducing restrictions on foreign shareholdings, establishing investment protection measures, and strengthening copyright protections. This comprehensive trade liberalization enhances trade and FDI in the processed food industry by providing greater market access to exporting and MNE firms. Consequently, this trade agreement can impact firms' decisions to sell domestically, export, or establish MNEs.

The trade and investment liberalizations under CETA can have opposing effects. Elimination of trade barriers lowers trade costs and expands exports, which can adversely affect the sales and profitability of foreign affiliates. Conversely, lower FDI fixed costs makes it easier for parent companies to establish affiliates and increase sales, which can negatively impact the sales and profitability of exporting firms. Helpman, Melitz, and Yeaple (2004) term the trade-off between variable trade cost versus FDI fixed cost in deciding between exports versus affiliate sales as the proximity–concentration trade-off. Therefore, it is important to investigate the impacts of reducing trade costs and fixed investment costs separately and to examine the net effect of both cost reductions for a complete assessment of CETA on the processed food market. Furthermore, since the United States is not a signatory of CETA and Canada and the European Union are maintaining their tariffs on U.S. products, this trade agreement may work against the United States as Canada (the European Union) diverts imports from the United States to the European Union (Canada).

Processed food is a key segment of the food supply chain as international sales through both exports and MNE operations have steadily risen over the last 2 decades, with MNE sales expanding at a faster rate than exports. Processed food and beverage sales of U.S. affiliates of have grown by 267%, from \$51.1 billion in 1995 to \$187.7 billion in 2015 (U.S. Bureau of Economic Analysis, 2017a), while exports increased by only 160%, from \$19.5 billion in 1995 to \$50.7 billion in 2015 (United Nations, 2017).[2] These data highlight that MNE sales have been 3.5 times higher on average than exports in recent years. MNEs avoid trade costs (transport costs and tariffs) and escalating nontariff barriers by setting up affiliates abroad to access cheaper and/or higher quality intermediate inputs in the host countries, creating sharp growth in FDI in the food processing sector in recent decades. Global processed food and beverage FDI outflows increased from \$16 billion in 2003 to \$22 billion in 2015, a 37.5% increase (Fiedler and Iafrate, 2017).

Firms with affiliates represent a small percentage of total firms. In the European Union, the total number of food and beverage firms averaged 245,205 between 2010 and 2014, with only 2,050 affiliates (0.9% of total firms) operating outside the EU (Organisation for Economic Co-Operation and Development, 2017a). In the United States, there were an average of 25,256 domestic food and beverage firms between 2010 and 2014, with only 778 affiliates (3.1% of total firms) abroad. While the European Union has about 2.6 times more MNEs than the United States, the latter has a larger percentage of firms with affiliates abroad.

Canadian exports are larger in volume and have grown faster than FDI. For instance, Canadian exports for processed food and beverage products increased by 112.44%, from \$13.89 billion in 1999 to \$29.50 billion in 2015, whereas Canadian FDI stocks in other countries increased only by 79.67% over the same period, from \$8.40 billion in 1999 to \$15.08 billion in 2015 (Statistics Canada, 2017a).[3]

The processed food and beverage segment of the food supply chain is characterized by product differentiation, monopolistic competition, economies of scale, and heterogeneity in firm size and productivity (Berden et al., 2009; Luckstead and Devadoss, 2016). In the United States and the European Union, 89.5% and 92.9% of food and beverage manufacturing firms are small with 1–49 employees, 7.7% and 5.8% are midsize with 50–249 employees, and 2.7% and 1.3% are

[2] As FDI outflows grow, the rise in MNE sales can largely be attributed to the increase in the number of MNEs. For example, over the 2010–2014 period, the number of affiliates with parent companies located in the United States increased by 15.2%, from 736 to 848 MNEs. Similarly, the number of EU companies with affiliates operating outside the European Union rose by 14.4%, from 1,850 to 2,117 MNEs.

[3] The reason Canada exports more than it spends on FDI outflows is likely that Canada has relatively large land resources (474,681 square kilometers of cultivable land), produces agricultural commodities that are primary inputs in processed food manufacturing, and has a small population (35.9 million people).

large with more than 250 employees, respectively (Organisation for Economic Co-Operation and Development, 2017c). In Canada, 93.6% of firms are small with 1–99 employees, 5.6% are midsize with 100–500 employees, and 0.8% are large with more than 500 employees (Government of Canada, 2017).[4] Small and midsize companies generally sell in the domestic market, but larger companies take advantage of their economies of scale and sell in both domestic and international markets. The largest and most productive firms further exploit their economies of scale to sell in the domestic market and serve foreign markets through affiliates. According to Handy et al. (1996), food processing companies largely engage in horizontal FDI (affiliate firms replicate the production process in a host country to cater to consumers in that market) because MNEs utilize raw agricultural commodities in the host countries to produce and sell the processed foods in these countries. Modeling the market structure, productivity, firm size, and firm composition of the processed food industry is essential to accurately capturing the impact of multilateral trade and investment agreements.

Theoretical studies have incorporated FDI and MNEs in firm-level heterogeneity models.[5] Helpman, Melitz, and Yeaple (2004) extend Melitz (2003) with firms exporting or selling in a foreign market through affiliates via horizontal FDI. They observe that establishing affiliates in foreign markets requires a considerable investment, and only the largest and most productive firms find affiliate operations to be more profitable than exporting. Grossman, Helpman, and Szeidl (2006) build on the three-region, two-stage production framework of Ekholm, Forslid, and Markusen (2007) and firm heterogeneity of Helpman, Melitz, and Yeaple (2004) to comprehensively model all options for international operations facing firms. They find that, depending on fixed costs and relative wage rates, an internationally oriented firm will export or undertake vertical FDI, export-platform FDI, or horizontal FDI. Chor (2009) finds a small subsidy to attract MNE investment improves the host country's welfare because the efficiency of productive firms and gains to consumers outweigh the cost of the subsidy. For the current study, because most FDI in food and beverage processing is horizontal, we adapt the horizontal MNE model of Helpman, Melitz, and Yeaple (2004) to the characteristics of the food and beverage processing industry.

Several studies examine the effects of free trade using a computable general equilibrium (CGE) framework without incorporating MNEs (see Beckman, Arita, and Mitchell, 2015; Disdier, Emlinger, and Fouré, 2015; Zhai, 2008; Akgul, Villoria, and Hertel, 2006). Devadoss and Luckstead (2017) develop a partial-equilibrium monopolistic competition trade model with firm heterogeneity to analyze the effect of eliminating tariffs under CETA on processed food markets and trade. Our study differs from earlier work by incorporating MNEs into the analysis and comprehensively examining CETA liberalization policies: tariff elimination and fixed trade and affiliate cost reductions. A few studies have modeled both firm-level heterogeneity and FDI to quantify the impacts of a reduction in trade and investment cost in a general equilibrium setting but do not analyze CETA (see Latorre, 2013; Arita and Tanaka, 2014; Tanaka and Arita, 2016; Eaton, Kortum, and Kramarz, 2011; Li, Scollay, and Gilbert, 2017; Petri, Plummer, and Zhai, 2012). We build on this literature by developing a transparent model tailored to the specific characteristics of the food and beverage processing industry to quantify the impacts of CETA liberalization of both trade and investment costs.

The objectives of this study are fourfold: First, we develop a model of multi-regional, monopolistic competition with heterogeneous food processing firms by incorporating domestic

[4] Organisation for Economic Co-Operation and Development (2017c) and Government of Canada (2017) differ in employment bin classifications.

[5] The theoretical literature on MNEs sans firm-level heterogeneity is extensive. In seminal studies, Helpman (1984) analyzes vertical MNEs under monopolistic competition and Markusen (1984) examines horizontal MNEs with one factor and firm-level economies of scale. Other important theoretical work includes Markusen (1997) (both horizontal and vertical FDI, known as the "knowledge capital model"), Zhang and Markusen (1999) (vertical MNEs that supply intermediate inputs to a final production plant in a host country), Yeaple (2003) (three-country model to analyze strategic simultaneous vertical and horizontal integration), and Ekholm, Forslid, and Markusen (2007) (three-region framework that also includes export-platform FDI).

sales, exports, and horizontal FDI. Second, we calibrate the model to the EU, Canadian, U.S., and ROW processed food and beverage markets. Third, we quantify the impacts of trade liberalization and reduction in FDI costs under CETA on prices, domestic sales, bilateral trade flows, MNE sales, productivity, number of firms, input prices, and aggregate output. Fourth, we draw policy implications from the impacts of comprehensive regional trade agreements for both member and nonmember countries.

With a model that allows consumers and producers to differ across markets, the impacts of trade and investment liberalization—particularly the indirect effects for nonmember countries—on trade flows, MNE sales, number of operating firms are ambiguous *ex ante*. This work contributes to the literature by providing a detailed analysis, based on plausible modeling assumptions, of CETA on not only domestic sales and exports but also MNE sales for processed food manufacturing. In doing so, this analysis highlights the implications of (i) trade liberalization in promoting bilateral exports but reducing foreign affiliate sales and (ii) lower FDI cost on expanding foreign affiliate sales but curtailing bilateral exports.

Model

We develop a four-region (European Union, Canada, United States, and ROW) model for the food manufacturing industry by extending the monopolistic competition and firm heterogeneity framework of Luckstead and Devadoss (2016) to incorporate horizontal MNEs à la Helpman, Melitz, and Yeaple (2004). All trade and investment policy changes under CETA will have general-equilibrium cross-sectoral impacts. However, the processed food industry generally accounts for only about 2% of total GDP,[6] and the magnitudes of the effects of CETA processed food free trade policies on other sectors are likely to be small. Consequently, for the analysis we consider a partial-equilibrium model in which income spent on processed food is exogenous because profits and tariff revenues are not rebated back to consumers,[7] fixed operating costs are exogenous, and the input supply is a positively sloped function. Next, we present the consumer's problem, producer's problem, market-clearing conditions, productivity distribution, model summary, and aggregate output for each region.

Consumer's Problem

A representative consumer in region j derives utility from consumption of differentiated processed food items—defined over a continuum θ—produced domestically $(c_{jj}(\theta))$, imported from region i $(c_{ij}(\theta))$, and produced by an affiliate located in j with a parent company in i and sold in j $(c^S_{ij}(\theta))$. Preferences for differentiated products are represented by the Dixit–Stiglitz utility function:

$$(1) \qquad U_j = \left(\sum_i \int_{\theta \in \Theta_{ij}} c_{ij}(\theta)^{\rho_j} d\theta + \sum_{i \neq j} \int_{\theta \in \Theta^S_{ij}} c^S_{ij}(\theta)^{\rho_j} d\theta \right)^{\frac{1}{\rho_j}} \quad \forall\, j,$$

where Θ_{ij} is the set of food items produced in region i and sold in j, Θ^S_{ij} is the set of food items produced by affiliates in region j with the parent company headquartered in i, and $\rho_j \in (0,1)$ is the CES parameter. The consumer optimally chooses c_{ij} and c^S_{ij} by maximizing U_j subject to the budget

[6] The data from Commission (2017), U.S. Bureau of Economic Analysis (2017b), and Statistics Canada (2017b), respectively, show that processed food contributes about 2% to the total GDP of the European Union, the United States, and Canada.

[7] Income spent on processed food is exogenous for two reasons: First, the change in income in the European Union, Canada, or the United States due to a change in processed food policies under CETA is likely very small. Second, the income elasticities for food, beverages, and tobacco are very low—0.332 for France, 0.284 for Canada, and 0.103 for the United States (Seale, Regmi, and Bernstein, 2003)—implying that the impact of any income changes due to these policies on food expenditures is particularly small.

constraint

$$\sum_i \int_{\theta \in \Theta_{ij}} p_{ij}(\theta) c_{ij}(\theta) d\theta + \sum_{i \neq j} \int_{\theta \in \Theta^S_{ij}} p^S_{ij}(\theta) c^S_{ij}(\theta) d\theta \leq I_j \; \forall \, j, \tag{2}$$

where $p_{ij}(\theta)$ and $p^S_{ij}(\theta)$ are the prices of $c_{ij}(\theta)$ and $c^S_{ij}(\theta)$, respectively, and I_j is income spent on processed food. This maximization yields the demand functions

$$c_{ij}(\theta) = \frac{I_j}{P_j} \left(\frac{p_{ij}(\theta)}{P_j} \right)^{-\sigma_j} \; \forall \, i, j, \tag{3a}$$

$$c^S_{ij}(\theta) = \frac{I_j}{P_j} \left(\frac{p^S_{ij}(\theta)}{P_j} \right)^{-\sigma_j} \; \forall \, i \neq j, \tag{3b}$$

where $P_j = \left(\sum_i \int_{\theta \in \Theta_{ij}} (p_{ij}(\theta))^{-\frac{\rho_j}{1-\rho_j}} d\theta + \sum_{i \neq j} \int_{\theta \in \Theta^S_{ij}} \left(p^S_{ij}(\theta) \right)^{-\frac{\rho_j}{1-\rho_j}} d\theta \right)^{-\frac{1-\rho_j}{\rho_j}}$ is the composite price index and $\sigma_j = \dfrac{1}{1-\rho_j}$ is the elasticity of substitution.

Producer's Problem

Heterogeneous firms, indexed by productivity level z, engage in monopolistic competition. Thus, each firm is a monopolist in its unique and differentiated product, implying a one-to-one correspondence between the firm index z and the product index θ. As a result, in all subsequent equations, θ is replaced with z. Furthermore, firms draw productivity level z from the cumulative distribution function $G(z)$. Then, given the level of z, the firm endogenously determines whether it operates only in the domestic market, domestically and in the export market, or domestically and abroad through affiliates. Therefore, a firm can earn profits from selling in the domestic market, and it can also augment its profits by selling in foreign markets through exports or establishing a foreign affiliate.

A firm operating in the domestic market with productivity z uses the composite input $l_{ii}(z)$ (consisting of primary intermediate agricultural products and other inputs) to produce a processed food item using production technology $y_{ii}(z) = z l_{ii}(z)$. This firm also pays a fixed operating cost f_{ii} to establish and maintain domestic production plants. The profits are

$$\pi_{ii}(z) = p_{ii}(z) y_{ii}(z) - w_i l_{ii}(z) - f_{ii} \; \forall \, i, \tag{4}$$

where w_i is the price of the composite input. After substituting the demand function for domestically produced product z ($c_{ii}(z)$ from equation 3a) into the profit function (4), maximization yields the pricing rule

$$p_{ii}(z) = \frac{w_i}{z \rho_i} \; \forall \, i, \tag{5}$$

where $\frac{w_i}{z}$ is the marginal cost and $\frac{1}{\rho_i}$ is the markup in region i. A higher productivity level (i.e., a larger value of z) implies lower marginal cost. The operating decision of the marginal firm is given by the cutoff productivity level ($\bar{z}_{ii}$) at which profit from the domestic market is 0:

$$\pi_{ii}(\bar{z}_{ii}) = 0 \; \forall \, i. \tag{6}$$

A firm with productivity z in region i utilizes inputs $l_{ij}(z)$ and production technology $y_{ij}(z) = z l_{ij}(z)$ to produce a processed food item that is exported to region j. To export, a firm incurs variable trade costs, consisting of transport cost ($t_{ij} > 0$) and tariff ($\tau_{ij} > 0$), and fixed export cost f_{ij} to establish an international marketing channel, networking, and product distribution in region j. Profits from exports from i to j are

$$\pi_{ij}(z) = \frac{p_{ij}(z)}{1 + t_{ij} + \tau_{ij}} y_{ij}(z) - w_i l_{ij}(z) - f_{ij} \; \forall \; j \neq i. \tag{7}$$

Plugging the demand function for exports ($c_{ij}(z)$ from equation 3a) into the profit function (7) and maximizing yields the pricing rule

$$p_{ij}(z) = \frac{w_i(1 + t_{ij} + \tau_{ij})}{z\rho_j} \; \forall \; j \neq i, \tag{8}$$

where $\frac{w_i(1+t_{ij}+\tau_{ij})}{z}$ is the marginal export cost and $\frac{1}{\rho_j}$ is the markup for exports to region j. Because the fixed cost of exporting and variable trade costs are in addition to the fixed operating cost, a firm that chooses to export has to be more productive than firms operating only domestically and will necessarily sell in the domestic market. Given the production technology, domestic and export profits are separable (and the total profit for the firm is the sum of these two profits). The separable domestic and export profits coupled with the fixed and variable trade costs imply the operating decisions can be considered independently. A firm will export only if it earns nonnegative export profits; thus, the operating decision identifies the cutoff productivity level, $\bar{z}_{ij}$, at which profits from exporting are 0:

$$\pi_{ij}(\bar{z}_{ij}) = 0 \; \forall \; j \neq i. \tag{9}$$

Because marginal costs are higher for exports than for domestic sales (compare equation 8 to 5) and the additional fixed export cost, $\bar{z}_{ij} > \bar{z}_{ii}$.

A parent company with productivity z located in i with an affiliate in j employs inputs $l^S_{ij}(z)$ from j, produces using technology $y^S_{ij}(z) = zl^S_{ij}(z)$, and sells in j. With the affiliate located in j, the parent company avoids the variable trade costs but incurs a fixed operating cost, f^S_{ij}, to establish and maintain production plants in j and research international marketing channels, networking, and product distribution in region j. Profits for a parent company in i that establishes an affiliate in j are

$$\pi^S_{ij}(z) = p^S_{ij}(z) y^S_{ij}(z) - w_j l^S_{ij}(z) - f^S_{ij} \; \forall \; j \neq i. \tag{10}$$

After substituting demand for an affiliate-produced product z ($c^S_{ij}(z)$ from 3b) into the profit function (10), maximization yields the pricing rule

$$p^S_{ij}(z) = \frac{w_j}{z\rho_j} \; \forall \; j \neq i, \tag{11}$$

where marginal cost is $\frac{w_j}{z}$ and markup is $\frac{1}{\rho_j}$. A parent company that chooses to establish an affiliate has to be highly productive to cover the large fixed FDI cost, and thus it will necessarily sell in the domestic market. Given the production technology, domestic and affiliate profits are separable, and the presence of fixed FDI cost makes the operating decisions of domestic sales and affiliate sales independent. A firm deciding to establish an affiliate over exporting will compare the affiliate fixed cost versus the variable and fixed trade costs and will sell through affiliate only if profits exceed those from exporting (i.e., the proximity–concentration tradeoff of Helpman, Melitz, and Yeaple, 2004). Thus, cutoff productivity ($\bar{z}^S_{ij}$) for a firm with an affiliate is such that affiliate and export profits are equal:

$$\pi^S_{ij}(\bar{z}^S_{ij}) - \pi_{ij}(\bar{z}^S_{ij}) = 0 \; \forall \; j \neq i. \tag{12}$$

Table 1. Operating Decision and Profits

z	Operating Decision	Profits
$z < \bar{z}_{ii}$	Exit	0
$z = \bar{z}_{ii}$	Domestic market	0
$\bar{z}_{ii} < z < \bar{z}_{ij}$	Domestic market	$\pi_{ii}(z) > 0$
$\bar{z}_{ij} \leq z < \bar{z}^S_{ij}$	Domestic and export markets	$\pi_{ii}(z) + \pi_{ij}(z) > 0$
$z \geq \bar{z}^S_{ij}$	Domestic market and foreign affiliate	$\pi_{ii}(z) + \pi^S_{ij}(z) > 0$

Hence, a firm can sell to consumers in j through either exports or an affiliate, but not both. Cutoff productivity, $\bar{z}^S_{ij}$, will exist as long as profits of MNEs exceed those of exporting. In addition, to ensure the model is consistent with the observed data that MNEs are larger and more productive than firms that export ($\bar{z}^S_{ij} > \bar{z}_{ij}$), the fixed costs of establishing an affiliate must be sufficiently larger than fixed export costs: $f^S_{ij} > (1 + t_{ij} + \tau_{ij})^{\sigma_j - 1} f_{ij}$. A firm can export to one region and sell in another region through its foreign affiliate. Specifically, if MNE cutoff productivities are such that $\bar{z}^S_{ij} > \bar{z}^S_{ik}$, then a firm with a productivity draw $\bar{z}^S_{ij} > z > \bar{z}^S_{ik}$ would choose to serve the kth market by setting up an MNE but would find it optimal to export to the jth market.

Based on the cutoff-productivity conditions given by equations (6), (9), and (12), the operating decisions and corresponding profits for various levels of productivities are summarized in Table 1. A firm with $z < \bar{z}_{ii}$ exits without producing and does not earn profits, a firm with $z = \bar{z}_{ii}$ earns 0 profits from domestic operations, a firm with $\bar{z}_{ii} < z < \bar{z}_{ij}$ obtains positive profits $\pi_{ii}(z)$ from domestic sales only, a firm with $\bar{z}_{ij} \leq z < \bar{z}^S_{ij}$ secures total profits $\pi_{ii}(z) + \pi_{ij}(z)$ from domestic and export sales, and a firm with $z \geq \bar{z}^S_{ij}$ generates total profits $\pi_{ii}(z) + \pi^S_{ij}(z)$ from domestic and affiliate sales.

Each region i has an exogenous mass of firms n_i that will operate only if profits are nonnegative (Chaney, 2008).[8] However, given f_{ii}, f_{ij}, and f^S_{ij}, the total mass of n_i firms is segmented into those that operate domestically (n_{ii}), domestically and in the export market (n_{ij}), and domestically and in the foreign market through an affiliate (n^S_{ij}) after they realize their productivity z. Using the cutoff-productivity levels and $G(z)$, these firm segments are given by

(13a) $$n_{ii} = n_i(1 - G(\bar{z}_{ii}))\ \forall\, i, j,$$

(13b) $$n_{ij} = n_i(G(\bar{z}^S_{ij}) - G(\bar{z}_{ii}))\ \forall\, i, j,$$

(13c) $$n^S_{ij} = n_i(1 - G(\bar{z}^S_{ij}))\ \forall\, j \neq i.$$

Market Equilibrium

Final goods and input market clearing conditions close the model and endogenously determine commodity prices and input prices. With monopolistic competition and product differentiation, total supply equals total demand for each good z:

(14a) $$y_{ij}(z) = c_{ij}(z)\ \forall\, i, j,$$

(14b) $$y^S_{ij}(z) = c^S_{ij}(z)\ \forall\, j \neq i.$$

Total supply of raw agricultural commodities equals total input demand in region i:

(15) $$\delta_i w_i^{\zeta_i} = \sum_j n_i \int_{\bar{z}_{ij}} l_{ij}(z) dG_i(z) + \sum_{j \neq i} n_j \int_{\bar{z}^S_{ji}} l^S_{ji}(z) dG_j(z)\ \forall\, i.$$

The left side consists of a well-behaved input supply function. The first term on the right side indicates the demand for inputs for all processed food production by domestic firms in region i,[9]

[8] Because this model has a continuum of firms, we employ the term "mass" for n_i (as in Melitz, 2003) as it can take any positive real number. For practical purposes, mass can be thought of as the "number" of firms.

[9] Input demand is computed as the average input use by all domestic firms multiplied by the total mass of firms.

which is sold domestically and exported. The second term on the right side captures input demand for production by all foreign affiliates located and selling in i.[10]

Productivity Distribution

As highlighted in the introduction, data on firm size and productivity show that manufacturing firms in all industries and countries have numerous small firms, some midsize firms, and a few large firms (also see Axtell, 2001; Luttmer, 2007). Based on these observations, we follow the trade literature (Kortum, 1997; Helpman, Melitz, and Yeaple, 2004) to characterize firm-level productivity differences with the Pareto distribution that exhibits a heavy left tail. Furthermore, the Pareto distribution lends itself to simplify the model in a tractable way, which we exploit below to reduce the number of equations. The Pareto cumulative distribution function for random variable z is

$$G_i(z) = 1 - \left(\frac{\mu_i}{z}\right)^{\alpha_i} \quad z > \mu_i,\ \forall\, i, \tag{16}$$

where $\mu_i > 0$ is the scale parameter and $\alpha_i > 1$ is the shape parameter.

Model Summary

For the four-region model, consumer demand functions, profit functions, pricing rules, operating decisions, and market clearing conditions (equations 3–15), as well with the production technologies, define a system of 200 equations in 200 variables: $c_{ij}(z)$, $c^S_{ij}(z)$, $p_{ij}(z)$, $p^S_{ij}(z)$, $\pi_{ij}(z)$, $\pi^S_{ij}(z)$, $\bar{z}_{ij}$, $\bar{z}^S_{ij}$, $y_{ij}(z)$, $y^S_{ij}(z)$, $l_{ij}(z)$, $l^S_{ij}(z)$, n_{ij}, n^S_{ij}, and w_i.[11] Given the large system, we combine these equations and use the Pareto distribution (equation 16) to condense the number of equations and obtain the operating decisions

$$\frac{1}{\sigma_j - 1}\frac{I_j(1+t_{ij}+\tau_{ij})^{-\sigma_j}}{\rho_j^{-\sigma_j}}\left(\frac{w_i}{\bar{z}_{ij}P_j}\right)^{1-\sigma_j} = f_{ij}\ \forall\, i,j, \tag{17a}$$

$$\frac{1}{\sigma_j - 1}\frac{I_j\left(w_j^{1-\sigma_j} - w_i^{1-\sigma_j}(1+t_{ij}+\tau_{ij})^{-\sigma_j}\right)}{\left(P_j\bar{z}^S_{ij}\right)^{1-\sigma_j}\rho_j^{-\sigma_j}} = f^S_{ij} - f_{ij}\ \forall\, i \neq j \tag{17b}$$

and input market-clearing condition

$$\delta_i w_i^{\zeta_i} = \sum_j n_i I_j \left(\frac{w_i(1+t_{ij}+\tau_{ij})}{\rho_j}\right)^{-\sigma_j}\left(\frac{1}{P_j}\right)^{1-\sigma_j}\frac{\bar{z}_{ij}^{\sigma_j-1-\alpha_i}\alpha_i\mu_i^{\alpha_i}}{1+\alpha_i-\sigma_j} + \sum_{j\neq i} n_j I_i\left(\frac{w_i}{\rho_i}\right)^{-\sigma_i}\left(\frac{1}{P_i}\right)^{1-\sigma_i}\frac{\left(\bar{z}^S_{ji}\right)^{\sigma_i-1-\alpha_j}\alpha_j\mu_j^{\alpha_j}}{1+\alpha_j-\sigma_i}\ \forall\, i, \tag{17c}$$

where $P_j = \left(\sum_i n_i\left(\frac{w_i(1+t_{ij}+\tau_{ij})}{\rho_j}\right)^{\frac{-\rho_j}{1-\rho_j}}\frac{\frac{\alpha_i\mu_i^{\alpha_i}(\rho_j-1)}{\alpha_i(\rho_j-1)+\rho_j}}{(\bar{z}_{ij})^{1+\alpha_i+\frac{1}{\rho_j-1}}} + \sum_{i\neq j} n_i\left(\frac{w_j}{\rho_j}\right)^{\frac{-\rho_j}{1-\rho_j}}\frac{\frac{\alpha_i\mu_i^{\alpha_i}(\rho_j-1)}{\alpha_i(\rho_j-1)+\rho_j}}{(\bar{z}^S_{ij})^{1+\alpha_i+\frac{1}{\rho_j-1}}}\right)^{-\frac{1-\rho_j}{\rho_j}}$.

As a result, we have reduced the system of 200 equations in 200 endogenous variables to a system

[10] This input demand is calculated as the average input use by all affiliate firms located in i multiplied by the total mass of affiliate firms from all $j \neq i$.

[11] For this four-region model, there are 16 variables with subscripts ij (no superscript), 12 with subscript ij and superscript S, and 4 with subscript i.

of 32 equations (17a–17c) in 32 endogenous variables ($\bar{z}_{ij}$, $\bar{z}^S_{ij}$, and w_i). This system of 32 equations needs to be solved simultaneously for the 32 endogenous variables, which can then be used to obtain the solutions for the other endogenous variables using the rest of the equations in the model. Given the complexity and regional asymmetry of this system of equations, the model cannot be solved analytically for the endogenous variables. Therefore, we numerically simulate the model to quantify the impact of CETA on all endogenous variables in the model.

Aggregate Output

The total production for each region (Y_i) is obtained by summing over all bilateral trade sales and affiliate sales:

(18a) $$Y_i = \sum_j Y_{ij} + \sum_{j \neq i} Y^S_{ij},$$

where Y_{ij} is the total sales from i to j and Y^S_{ij} is total sales of affiliates located in j with parent company headquartered in i, which are defined, respectively, as

(18b) $$Y_{ij} = n_i \alpha_i \mu_i^{\alpha_i} \frac{I_j}{P_j^{1-\sigma_j}} \left(\frac{w_i \tau_{ij}}{\rho_j} \right)^{-\sigma_j} \frac{\bar{z}_{ij}^{\sigma_j - \alpha_i}}{\alpha_i - \sigma_j} \; \forall\, i, j,$$

(18c) $$Y^S_{ij} = n_i \alpha_i \mu_i^{\alpha_i} \frac{I_j}{P_j^{1-\sigma_j}} \left(\frac{w_j}{\rho_j} \right)^{-\sigma_j} \frac{\left(\bar{z}^S_{ij}\right)^{\sigma_j - \alpha_i}}{\alpha_i - \sigma_j} \; \forall\, j \neq i.$$

Y_{ij} and Y^S_{ij} are calculated as the mass of firms multiplied by the average output of all operating firms.

Data and Calibration

The model consists of 68 exogenous variables (I_i, t_{ij}, τ_{ij}, n_i, f_{ij}, and f^S_{ij}) and 20 parameters (σ_i, α_i, ζ_i, μ_i, and δ_i). Of these exogenous variables, we collect data for I_i, t_{ij}, and τ_{ij}. Total expenditures on processed food (I_j) are calculated as the sum of the value of domestic sales, imports, and foreign affiliate sales for each region using the GTAP 9 database and Foreign Affiliate Sales database (Fukui and Lakatos, 2012). We obtain transport cost, t_{ij}, and tariff, τ_{ij}, data from the GTAP 9 database.[12] We normalize the mass of firms n_i to one in all four regions. The 16 fixed domestic and export operating costs, f_{ij}, and 12 affiliate fixed costs, f^S_{ij} are calibrated as discussed in detail below.

Of the 20 parameters, σ_i, α_i, and ζ_i come from the literature. We use the trade value-weighted elasticity of substitution for processed food, $\sigma_i = 3.38$ (Devadoss and Luckstead, 2017), Pareto shape parameter, $\alpha_i = 3.99$ (Rau and van Tongeren, 2009), and assume an input supply elasticity of $\zeta_i = 0.1$.[13] The remaining eight parameters, μ_i and δ_i, are calibrated.

The exogenous variables f_{ij} and f^S_{ij} and the parameters μ_i and δ_i do not come from data or the literature and thus must be calibrated based on the model structure; values of other exogenous variables, parameters, and endogenous variables (Y_{ij}, Y^S_{ij}, and w_i); and the data for the probability of firms operating domestically $1 - G(\bar{z}_{ii})$, operating domestically and exporting $1 - G(\bar{z}_{ij})$ for $i \neq j$, or operating domestically and abroad through affiliates $1 - G(\bar{z}^S_{ij})$ for $i \neq j$.

We collect data for the value of domestic production and bilateral trade from the GTAP 9 database and the value of foreign affiliate sales from Foreign Affiliate Sales database (Fukui and

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[12] See Hummels and Lugovskyy (2006) for issues related to the use of CIF-FOB prices to compute transport costs.

[13] Raw agricultural commodities are primary inputs for processed food. However, the supply elasticity for a composite raw agricultural input is not found in the literature. We consider an elasticity of 0.1 since the supply elasticity for most agricultural goods is inelastic. We conduct sensitivity analysis for different values of these parameters.

Lakatos, 2012). Since these databases have only value data, we calculate quantities (Y_{ij} and Y_{ij}^S) by dividing the values by prices. Following the trade literature (Anderson and van Wincoop, 2003; Kehoe and Ruhl, 2009), we normalize domestic price indices, p_{ii}, to 1 and calculate bilateral prices, p_{ij}, using the transport cost and tariff data.

We calculate an input price index, w, for the United States, Canada, and European Union by collecting total value and quantity in millions of metric tons for 2003–2014 from Food and of the United Nations (2017) for key raw agricultural commodities (barley, maize, cattle, chicken, milk, sunflower seed, and wheat). For each commodity, we take the average value and quantity over 2003–2014 to ensure an abnormal year does not dominate the data. To obtain unit prices, we divide values by quantities. We then calculate the value-weighted average input price for all commodities for each region.

We present data and sources for the percentage of firms that operate in various markets. According to Bernard et al. (2007), 12% of food manufacturing (NAICS code 311) firms and 23% of beverage and tobacco processing (NAICS code 312) firms export. Consequently, assuming that 90% of operating firms sell in the domestic market and 16% export, 17.8% ($= 100 \times \frac{16}{90}$) of operating firms sell in both the domestic and export markets. Thus, $1 - G(\bar{z}_{ii})$ is 90% and $1 - G(\bar{z}_{ij})$ is 17.8%. To obtain the percentage of firms that have affiliates, $1 - G(\bar{z}_{ij}^S)$, we collect data on the total number of enterprises from the "Structural and Demographic Business Statistics" and the number of affiliate enterprises operating abroad from the "FDI statistics according to Benchmark Definition 4th Edition" databases from the Organisation for Economic Co-Operation and Development (2017b). Assuming a one-to-one correspondence between a parent company and a foreign affiliate, 1.63% of EU firms have foreign affiliates outside the European Union and 3.1% of U.S. firms have foreign affiliates. Similar data are not available for Canadian and ROW firms; consequently, we assume 1% of Canadian firms and 0.8% of ROW firms to have foreign affiliates. Since a parent company will likely have multiple affiliates, we reduce these percentages by one-half.[14] This leads to 0.815% of EU firms, 1.55% of U.S. firms, 0.5% of Canadian firms, and 0.4% of ROW firms with foreign affiliates.

Next, we discuss the calibration process to pin down the fixed operating costs f_{ij}, affiliate fixed costs f_{ij}^S, Pareto scale parameters μ_i, and input supply scale parameters δ_i. The system of equations for the calibration is as follows: Substitution of (18b) and (18c) into (18a) yields four equations. In these equations, the left side contains Y_is, which are data on total sales, and the right side includes the μ_i parameters. Note that the right side of this and the other equations used to calibrate (discussed below) depends on the 28 endogenous cutoff productivities ($\bar{z}_{ij}$ and $\bar{z}_{ij}^S$). Since the values for these variables do not come from data or literature, the baseline values of these variables are simultaneously determined in the calibration. Plugging the cutoff productivities $\bar{z}_{ij}$ and $\bar{z}_{ij}^S$ into the Pareto distribution and rearranging yields 28 equations:

(19a) $$1 - G_i(\bar{z}_{ij}) = \left(\frac{\mu_i}{\bar{z}_{ij}}\right)^{\alpha_i},$$

(19b) $$1 - G_i(\bar{z}_{ij}^S) = \left(\frac{\mu_i}{\bar{z}_{ij}^S}\right)^{\alpha_i},$$

where $1 - G_i(\bar{z}_{ij})$ and $1 - G_i(\bar{z}_{ij}^S)$ are data for the percentage of operating firms, as discussed previously. The input market-clearing conditions in (17c) give four equations. The left side of these equations consists of δ_i. The operating decisions, (17a) and (17b), give 28 equations, wherein f_{ij} and f_{ij}^S enter. Thus, this calibration routine contains 64 equations in 64 unknown variables (36 unknown exogenous variables and parameters f_{ij}, f_{ij}^S, μ_i, and δ_i and 28 unknown endogenous variables $\bar{z}_{ij}$ and $\bar{z}_{ij}^S$). Using the data and the values of the other parameters (discussed in the preceding paragraphs),

[14] Below, we conduct a sensitivity analysis on this assumption.

we solve this system of equations simultaneously to calibrate the values for f_{ij}, f_{ij}^S, μ_i, and δ_i and baseline values for $\bar{z}_{ij}$ and $\bar{z}_{ij}^S$.

Simulation Analysis

We numerically simulate the model using equations (17a)–(17c) to quantify the impacts of CETA trade and investment liberalization by running a pre-CETA baseline scenario and four post-CETA alternate scenarios: (i) elimination of tariffs, (ii) 20% reduction in fixed trade costs, (iii) 50% reduction in fixed affiliate costs, and (iv) simultaneous implementation of all three policies. Since the exact amount by which fixed trade and investment costs are reduced is unknown, we consider a 20% reduction in fixed trade costs and a 50% reduction in fixed FDI costs.[15] Given the calibration, the baseline scenario replicates the data. Comparing each of the alternate scenarios 1), 2), and 3) to the baseline indicates the impacts attributable to each of these scenarios. Comparing alternate scenario 4) to the baseline provides the total impacts of CETA. We provide sensitivity analyses below to understand how changes in the parameters impact the magnitude and direction of the results.

Tables 2–7 report the bilateral results of CETA policies. In Tables 2, 4, and 6, the first column identifies the location of the exporting regions where production occurs, and the second column lists the importing regions where exporting firms sell. In Tables 3, 5, and 7, the first column indicates the location of the parent company, and the second column identifies the regions where affiliates produce and sell. In these tables, columns 3–6 present the effects of alternate scenarios 1–4, respectively.[16]

EU and Canadian Exporting Firm Bilateral Results

Eliminating tariffs and reducing fixed trade costs under CETA lower trade barriers for EU and Canadian firms exporting to each other's market, which positively impact exporting firms, while the cut in affiliate fixed costs lowers the cost of MNEs operating in each other's market, which negatively impacts exporting firms. Trade barrier liberalization enhances the profitability of existing exporting firms, which attracts some of the higher-productivity firms that had been catering only to the domestic market to also enter the export market, causing cutoff productivity, $\bar{z}_{ij}$, for EU (Canadian) firms exporting to Canada (the European Union) to fall by 12.473% (16.433%) (column 3 in Table 2). While exporting is relatively more profitable than FDI sales, some lower-productivity MNEs transition to exporting, the cutoff productivities for EU (Canadian) affiliate firms $\bar{z}_{ij}^S$ rise by 8.857% (5.169%) (column 3 in Table 3). The fall in the cutoff productivity of exporting firms and the rise in the cutoff productivity of MNEs lead to a substantial rise in the number of firms operating in the export market, as evidenced by the increase in the mass of EU (Canadian) exporting firms by 75.709% (109.030%) (column 3 in Table 4). As a result, EU exports to Canada increase by 83.920% (column 3 in Table 6) because the rise in exports at the extensive margin (due to the increase in the mass of operating firms) reinforces the rise in exports at the intensive margin (due to an increase in $\frac{P_{Ca}^{\sigma_{Ca}-1}}{((1+t_{EU,Ca})w_{EU})^{\sigma_{Ca}}}$ as tariffs are eliminated).[17]

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[15] The larger reduction in FDI costs is due to the emphasis of CETA in lowering fixed investment costs as opposed to reducing fixed trade cost.

[16] Though we report the results up to three decimals because some of the impacts are very small, the focus of the interpretation should not be on the three-decimal precision because the quantitative results hinge upon assumptions, data, model, and parameters.

[17] This change in exports at the intensive margin can be seen by examining bilateral trade flows from i to j using equations (3a), (8), and (14a), which result in $y_{ij}(z) = \frac{P_j^{\sigma_j-1}}{((1+t_{ij}+\tau_{ij})w_i)^{\sigma_j}} I_j(z\rho_j)^{\sigma_j}$. For a firm z that exports before and after CETA, the change in exports under the intensive margin depends on $\frac{P_j^{\sigma_j-1}}{((1+t_{ij}+\tau_{ij})w_i)^{\sigma_j}}$. If this ratio rises (falls), then this firm will export more (less) because the relative return for exports increases (decreases).

Table 2. Impact of CETA on Cutoff Productivities $\bar{z}_{ij}$ (% Change)

		Alternate Scenario			
Production in Region *i*	**Sales in Region *j***	**Tariff Removal**	**20% Decrease in Fixed Trade Cost**	**50% Decrease in Fixed Affiliate Cost**	**Combined Effects**
EU	EU	0.398	0.084	0.041	0.540
EU	CA	−12.473	−7.840	−0.955	−19.794
EU	U.S.	−0.015	0.004	0.226	0.222
EU	ROW	−0.027	0.000	0.309	0.281
CA	EU	−16.433	−8.672	1.893	−22.555
CA	CA	2.622	0.535	0.879	4.035
CA	U.S.	−0.566	−0.224	2.081	0.849
CA	ROW	−0.578	−0.228	2.166	0.908
U.S.	EU	0.435	0.085	−0.245	0.290
U.S.	CA	3.228	0.766	−1.238	3.131
U.S.	U.S.	0.022	0.006	−0.061	−0.027
U.S.	ROW	0.009	0.002	0.022	0.031
ROW	EU	0.431	0.085	−0.297	0.240
ROW	CA	3.225	0.767	−1.289	3.079
ROW	U.S.	0.018	0.006	−0.113	−0.077
ROW	ROW	0.006	0.002	−0.030	−0.019

Table 3. Impact of CETA on Cutoff Productivities for Affiliate $\bar{z}^S_{ij}$ (% Change)

		Alternate Scenario			
Parent Company in *i*	**Sales in Region *j***	**Tariff Removal**	**20% Decrease in Fixed Trade Cost**	**50% Decrease in Fixed Affiliate Cost**	**Combined Effects**
EU	CA	8.857	0.820	−24.502	−16.766
EU	U.S.	0.036	0.006	−0.176	−0.128
EU	ROW	0.01	0.002	−0.069	−0.053
CA	EU	5.169	0.299	−25.094	−20.905
CA	U.S.	0.180	0.067	−0.605	−0.256
CA	ROW	0.063	0.024	−0.234	−0.106
U.S.	EU	0.389	0.083	0.112	0.602
U.S.	CA	2.480	0.480	1.403	4.253
U.S.	ROW	0.006	0.002	−0.035	−0.023
ROW	EU	0.373	0.082	0.295	0.766
ROW	CA	2.360	0.433	1.890	4.466
ROW	U.S.	0.025	0.005	−0.010	0.022

Similarly, Canadian exports to the European Union increase by 107.507%.[18]

The effects of a reduction in fixed trade costs reinforce the results of tariff elimination because both increase the profitability of exporting firms. However, unlike the effects of variable trade costs reduction, a cut in fixed trade cost does not directly impact sales at the intensive margin for a given firm (refer to the equations in footnote 17). The cutoff productivity for EU and Canadian firms exporting to each other's market fall by 7.840% and 8.672% (column 4 in Table 2), and the cutoff productivity for EU and Canadian affiliates operating in each other's market rise by 0.820% and

[18] Under the tariff elimination scenario, the percentage change of the volume of cross-hauling between Canada and the European Union under CETA is predicted to be much higher in the current study than in Devadoss and Luckstead (2017): 83.920% versus 49.859% for EU exports to Canada and 107.507% versus 55.975% for Canadian exports to the European Union. The percentage change is smaller in Devadoss and Luckstead (2017) because the mass of exporting firms is greater as the productivity of these firms ranges from $\bar{z}_{ij}$ to ∞, and, consequently, the denominator of the percentage change is larger. In contrast, in the current study, the productivity of exporting firms ranges from $\bar{z}_{ij}$ to $\bar{z}^S_{ij}$ and the denominator of the percentage change is smaller, indicating large percentage changes even when the change in trade volume is fairly modest.

Table 4. Impact of CETA on Mass of Operating Firms n_{ij} (% Change)

Production in Region i	Sales in Region j	Alternate Scenario: Tariff Removal	20% Decrease in Fixed Trade Cost	50% Decrease in Fixed Affiliate Cost	Combined Effects
EU	EU	−1.576	−0.333	−0.164	−2.133
EU	CA	75.709	40.864	−7.031	143.425
EU	U.S.	0.071	−0.017	−0.984	−0.959
EU	ROW	0.117	0.000	−1.305	−1.188
CA	EU	109.030	45.189	−14.482	178.711
CA	CA	−9.834	−2.110	−3.441	−14.634
CA	U.S.	2.395	0.938	−8.244	−3.466
CA	ROW	2.431	0.950	−8.509	−3.680
U.S.	EU	−1.739	−0.340	1.139	−1.021
U.S.	CA	−12.212	−3.125	6.230	−11.202
U.S.	U.S.	−0.086	−0.024	0.245	0.110
U.S.	ROW	−0.039	−0.006	−0.111	−0.148
ROW	EU	−1.819	−0.363	1.335	−0.958
ROW	CA	−12.702	−3.229	6.011	−11.969
ROW	U.S.	−0.077	−0.027	0.492	0.339
ROW	ROW	−0.027	−0.009	0.128	0.079

Table 5. Impact of CETA on Mass of Affiliate Firms n^S_{ij} (% Change)

Parent Company in i	Sales in Region j	Alternate Scenario: Tariff Removal	20% Decrease in Fixed Trade Cost	50% Decrease in Fixed Affiliate Cost	Combined Effects
EU	CA	−28.786	−3.216	207.786	108.350
EU	U.S.	−0.145	−0.026	0.708	0.513
EU	ROW	−0.040	−0.009	0.275	0.211
CA	EU	−18.256	−1.188	217.638	155.502
CA	U.S.	−0.716	−0.269	2.457	1.031
CA	ROW	−0.252	−0.097	0.940	0.427
U.S.	EU	−1.540	−0.332	−0.447	−2.374
U.S.	CA	−9.335	−1.898	−5.421	−15.345
U.S.	ROW	−0.024	−0.009	0.141	0.093
ROW	EU	−1.569	−0.348	−1.245	−3.191
ROW	CA	−9.437	−1.820	−7.649	−16.947
ROW	U.S.	−0.105	−0.023	0.041	−0.094

0.299% (column 4 in Table 3). Consequently, the masses of EU and Canadian exporting firms expand by 40.864% and 45.189% (column 4 in Table 4). As a result, EU exports to Canada rise by 12.239% (column 4 in Table 6) because gains at the extensive margin offset the decline at the intensive margin.[19] Canadian exports to the European Union expand by 14.230%, with the gains at the extensive margin and intensive margin reinforcing each other. This occurs because Canada is a small country, with both incumbent and new Canadian exporting firms benefiting from access to the EU processed food market, which is the largest in the world.

However, lower affiliate fixed costs under CETA boost Canadian and EU MNE profits and sales in each other's market (discussed in detail below), paving the way for more exporting firms to

[19] The intensive margin declines because tariffs are not cut in the fixed trade cost scenario, leading to a relatively larger denominator in the intensive margin term $\frac{P_{Ca}^{\sigma_{Ca}-1}}{((1+t_{EU,Ca}+\tau_{EU,Ca})w_{EU})^{\sigma_{Ca}}}$ when fixed trade cost is reduced compared to tariff elimination.

Table 6. Impact of CETA on Bilateral Sales y_{ij} (% Change)

Production in Region i	Sales in Region j	Alternate Scenario: Tariff Removal	20% Decrease in Fixed Trade Cost	50% Decrease in Fixed Affiliate Cost	Combined Effects
EU	EU	−0.854	−0.176	−0.781	−1.799
EU	CA	83.920	12.239	−30.727	61.040
EU	U.S.	0.437	0.063	−1.768	−1.246
EU	ROW	0.454	0.076	−1.945	−1.367
CA	EU	107.507	14.230	−36.081	74.123
CA	CA	−6.647	−1.289	−4.992	−11.917
CA	U.S.	3.330	1.251	−10.579	−4.288
CA	ROW	3.201	1.202	−10.334	−4.275
U.S.	EU	−1.065	−0.184	0.890	−0.361
U.S.	CA	−9.799	−2.601	7.409	−7.339
U.S.	U.S.	0.233	0.055	−0.190	0.133
U.S.	ROW	0.264	0.069	−0.515	−0.117
ROW	EU	−1.140	−0.208	1.132	−0.252
ROW	CA	−10.156	−2.646	6.634	−8.309
ROW	U.S.	0.246	0.051	0.129	0.434
ROW	ROW	0.280	0.066	−0.224	0.161

Table 7. Impact of CETA on Bilateral Sales y^S_{ij} (% Change)

Parent Company in i	Sales in Region j	Alternate Scenario: Tariff Removal	20% Decrease in Fixed Trade Cost	50% Decrease in Fixed Affiliate Cost	Combined Effects
EU	CA	−9.360	−1.429	9.822	−1.524
EU	U.S.	0.225	0.055	−0.133	0.184
EU	ROW	0.279	0.066	−0.203	0.182
CA	EU	−3.129	−0.283	14.664	10.716
CA	U.S.	0.153	0.025	0.082	0.248
CA	ROW	0.239	0.049	−0.079	0.223
U.S.	EU	−0.849	−0.176	−0.816	−1.829
U.S.	CA	−6.582	−1.262	−5.238	−12.009
U.S.	ROW	0.282	0.066	−0.228	0.160
ROW	EU	−0.934	−0.196	−0.980	−2.096
ROW	CA	−7.071	−1.345	−5.906	−13.054
ROW	U.S.	0.225	0.054	−0.214	0.103

become MNEs. Consequently, the most productive EU (Canadian) firms that had been exporting switch to MNEs by establishing affiliates to serve the Canadian (EU) market, as evident from a 24.502% (25.094%) decrease in the EU (Canadian) affiliate cutoff productivity, $\bar{z}^S_{ij}$ (column 5 in Table 3). Consequently, the number of high-productivity exporting firms dwindles, putting downward pressure on bilateral exports in each other's market. To determine the total mass of exporting firms, we also need to ascertain changes in $\bar{z}_{ij}$, which can be examined using equation (17a); as f_{ij} on the right side remains fixed, $\bar{z}_{ij}$ depends on changes in $\frac{w_i}{P_j}$. For EU firms exporting to Canada, $\frac{w_{EU}}{P_{Ca}}$ falls, causing the cutoff productivity to decline slightly, by 0.955% (column 5 in Table 2), which leads to more lower-productivity EU firms exporting to Canada. Conversely, for Canadian firms exporting to the European Union, $\frac{w_{Ca}}{P_{EU}}$ rises, causing the cutoff productivity to increase slightly, by 1.893%, which results in fewer lower-productivity Canadian exporting firms selling in the European Union.[20] The total mass of EU firms exporting to Canada (equation 13b) falls by 7.031% because the number of highly productive exporting firms shifting to MNEs outweighs the number of lower-productivity firms entering the export market. The total mass of Canadian firms exporting to the European Union also falls by 14.482% as the mass of higher-productivity exporting firms switching to MNEs reinforces the decline in the mass of low-productivity exporting firms. EU exports to Canada falls by 30.727% because the decline in exports at the extensive margin (due to the decline in the mass of operating firms) offsets the rise in exports at the intensive margin (due to an increase in $P_{Ca}^{\sigma_{Ca}-1}/w_{EU}^{\sigma_{Ca}}$). Canadian exports to the European Union falls by 36.081% as the decrease in exports at the extensive margin is further intensified by the decline in exports at the intensive margin (due to a fall in $P_{EU}^{\sigma_{EU}-1}/w_{Ca}^{\sigma_{EU}}$).

Though affiliate fixed cost reduction has fairly large adverse effects on Canadian–EU bilateral exports, the combined effects of all three scenarios are dominated by tariff elimination and fixed trade cost reduction. The total effect of the three scenarios on EU firms exporting to Canada is to reduce the cutoff productivity by 19.794%, increase the mass of firms by 143.425%, and expand exports by 61.040%. The corresponding results for Canadian firms exporting to the European Union are −22.555%, 178.711%, and 74.123%.[21]

EU and Canadian MNE Bilateral Results

In contrast to bilateral exports, tariff elimination and lower fixed trade costs negatively impact and lower affiliate fixed costs positively impact MNE affiliates. As discussed previously, trade barrier liberalization enhances the profitability of exporting relative to affiliate operation, which causes EU and Canadian firms selling in each other's market to redirect their production and sales from foreign affiliates to exports. The resulting decline in MNE profits makes it possible for only more-productive MNEs to continue to operate, as revealed by the increase in the cutoff productivity for EU (Canadian) foreign affiliate firms operating in Canada (the European Union) by 8.857% (5.169%) (column 3 in Table 3). This causes the mass of EU (Canadian) MNE affiliates to fall by 28.786% (18.256%) (column 3 in Table 5). With the MNE sales at the extensive margin and intensive margin declining,[22] sales of EU and Canadian MNEs in each other's market fall by 9.360% (3.129%) (column 3 in Table 7). The qualitative results of fixed trade cost reduction on affiliate sales are similar to tariff elimination impacts, though the quantitative impacts are smaller.

Lower affiliate fixed costs enhance the profitability of MNE operations relative to exporting, providing more incentive for Canadian and EU firms to focus their operations through affiliates than through exporting. As a result, the cutoff productivities of EU and Canadian affiliates operating in each other's market fall by 24.502% and 25.094% (column 5 in Table 3), which causes the masses of

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[20] Lowering the fixed affiliate cost boosts Canadian and EU affiliate sales in each other's market. However, because the European Union is the largest producer and market for processed food, the increased demand for inputs and sales by Canadian affiliates (with a relatively small market share) in the European Union has a relatively small impact on the input market and processed food sales. Conversely, because the Canadian processed food market is relatively small, the increased demand for inputs and processed food sales by EU affiliates (with a relatively large market share) in Canada has a relatively large impact on the input market and sales. Consequently, the decline in the ratio of EU input price and output price index is relatively small compared to those in Canada; thus, $\frac{w_{EU}}{P_{Ca}}$ falls while $\frac{w_{Ca}}{P_{EU}}$ rises.

[21] Since the current paper deals with a more comprehensive liberalization of barriers, the combined effects of CETA on the volume of cross-hauling between Canada and the European Union is considerably more pronounced than in Devadoss and Luckstead (2017): 61.040% versus 49.859% for EU exports to Canada and 74.123% versus 55.975% for Canadian exports to the European Union.

[22] This change in affiliate sales at the intensive margin can be seen by combining equations (3b), (11), and (14b): $y_{ij}^S(z) = \frac{P_j^{\sigma_j-1}}{w_j^{\sigma_j}} I_j (\frac{1}{z\rho_j})^{-\sigma_j}$. For a firm with a z that sells through affiliates before and after CETA, the change in volume of sales depends on $\frac{P_j^{\sigma_j-1}}{w_j^{\sigma_j}}$. The results indicate that $\frac{P_j^{\sigma_j-1}}{w_j^{\sigma_j}}$ $(j = EU, CA)$ falls for tariff elimination, leading to lower affiliate sales at the intensive margin.

these firms to rise by 207.786% and 217.638% (column 5 in Table 5). In response to larger masses, EU and Canadian affiliate sales expand by 9.822% and 14.664% (column 5 in Table 7), though sales under the intensive margin exhibit small decline because $P_j^{\sigma_j-1}/w_j^{\sigma_j}$ $(j = EU, CA)$ falls.

Implications of CETA for the United States and ROW

Because CETA excludes the United States and ROW, U.S. and ROW firms are impacted as they continue to face pre-CETA trade and investment barriers in Canada and the European Union. This subsection presents the results of EU and Canadian exports to the United States, EU and Canadian MNE sales in United States, and U.S. exports and MNE sales in the European Union and Canada under CETA.[23]

First, we discuss the impacts of CETA on EU and Canadian exports to the United States. Lowering bilateral tariff and fixed trade cost intensifies competition for EU and Canadian domestic firms; consequently, EU and Canadian firms with productivities just low enough to be unprofitable in the U.S. market before CETA now find it profitable to export to the United States. This is borne out by the small decreases in the cutoff productivities of EU and Canadian firms exporting to the United States (column 3 in Table 2). Furthermore, as input prices fall relatively more in the European Union and Canada (lower trade barriers cause input demand to fall as inefficient domestic firms exit from fierce competition due to cross-hauling and fewer foreign affiliates operate, which dominates the rise in input demand as exports expand) than in the United States, EU and Canadian firms shift from foreign affiliates to exports to serve the U.S. market. Consequently, the cutoff productivities of EU and Canadian affiliates operating in the United States increase, albeit minimally (column 3 in Table 3). The export cutoff productivity decreases and MNE cutoff productivity increases leading to an increase in the mass of firms exporting to, and hence their sales in, the United States. However, these increases are relatively small for EU exports (0.437%) but modest for Canadian exports (3.330%) to the United States.[24,25]

As the European Union and Canada reduce fixed FDI cost, their MNEs find it more profitable to sell in each other's market through affiliates. Because of this greater profitability, EU and Canadian exporting firms will divert their operations from exporting to the United States to MNE affiliates to sell in each other's market. As a result, the input demand by the exporting firms and affiliates will expand, causing EU and Canadian input price to rise, particularly relative to aggregate prices in the United States. This has important implications for the cutoff productivities of exporting and MNE firms, which impact the mass of exporting firms. For example, the rise in the input price leads to an increase in the variable cost of exports to the United States. Consequently, only higher-productivity firms export to the United States, as revealed by the rise in the cutoff productivities of EU and Canadian firms' exporting to the United States (0.226% and 2.081%) (column 5 in Table 2). However, the greater rise in input demand in the European Union and Canada than in the United States causes the relative input price differences (e.g., $\frac{w_{US}}{P_{US}} - \frac{w_{EU}}{P_{US}}$) to fall. As a result of the lower production cost ($\frac{w_{US}}{P_{US}}$) in the United States compared to the variable export cost ($\frac{w_{EU}}{P_{US}}$), EU and Canadian MNEs find it more attractive to operate in the U.S. market, as evidenced by the decline in the cutoff productivities of these firms by 0.176% and 0.605%, respectively (column 5 in Table 3). With the cutoff productivities of exporting firms increasing and MNE affiliates falling, the mass of

[23] Since the results for ROW are qualitatively and quantitatively similar to those for the United States, we focus only on the results for the United States in the remainder of this subsection.

[24] It is worth noting, as highlighted previously, the effects for Canada are amplified relative to those for the European Union because Canada is a small country.

[25] Another notable difference between Devadoss and Luckstead (2017) and the current study is that tariff elimination causes Canadian exports to the United States to *fall* by 6.394% in the former study, whereas they *rise* by 3.330% in the current study. This reversal occurs because, in the current study, tariff elimination under CETA adversely impacts Canadian affiliates in the European Union. Consequently, these affiliates switch to exporting and focus their sales on the United States. In contrast, Devadoss and Luckstead (2017) does not take account for the role of MNEs. In the following sensitivity analysis section, we examine the role of MNE affiliates in the sign reversal of Canadian exports to the United States.

EU and Canadian exporting firms to the United States shrinks by 0.984% and 8.244% (column 5 in Table 4) and exports fall by 1.768% and 10.579% (column 5 in Table 5), respectively.

The larger decline of EU and Canadian exports to the United States under the fixed FDI cost reduction scenario dominates the rise in exports under the trade liberalization scenarios. Consequently, the total impact of all three policies on EU exports to the United States is small, but Canadian exports to the United States decrease by 4.288% (column 6 in Table 6).

Second, we discuss changes in EU and Canadian affiliate sales in the United States under CETA. For tariff elimination and fixed trade cost reduction, bilateral exports expand but MNEs and domestic firms exit in the European Union and Canada, causing the input demand and input prices in these CETA regions to fall relative to the U.S. input price. Consequently, the relative U.S.–European and U.S.–Canadian input price differences rise, leading to higher costs for EU and Canadian MNE operations in the United States relative to exporting to the United States. The results show a small rise in the MNE cutoff productivities and fall in the masses of EU and Canadian MNEs in the United States. Interestingly, the decline of these masses results in a fall in the sales at the extensive margin, which is dominated by the gains at the intensive margin of the affiliates that continue to operate in the United States,[26] leading to an increase, albeit minimal, in EU and Canadian sales in the United States.

As discussed previously, the fall in EU and Canadian bilateral fixed FDI costs increases MNE operation in these two regions, which raises input demand and input prices in Canada and the European Union relatively more than in the United States. The low input price in the United States attracts MNE affiliates from Canada and the European Union, as seen by a small decline in EU and Canadian affiliate cutoff productivities for U.S. operations (0.176% and 0.605%) and the increase in the corresponding affiliate masses (0.708% and 2.457%). For the European Union, the decrease in sales at the intensive margin for existing affiliates in the United States (i.e., decline in $w_{US}^{-\sigma_{US}}/P_{US}^{1-\sigma_{US}}$) dominates the small rise in the sales at the extensive margin (due to an increase in the masses), and affiliate sales decline slightly, by 0.133%. However, for Canada, the increase in the sales at the extensive margin is larger than that for the European Union, which offsets the fall in sales at the intensive margin, leading to a small rise in Canadian affiliate sales in the United States.

Third, we focus on changes in U.S. exports and affiliate sales to the European Union and Canada. Tariff elimination and fixed trade cost reduction under CETA generate tougher competition for U.S. firms selling in the EU and Canadian markets, leading to a decline of these firms' exports and affiliate sales in these markets. Under the fixed FDI cost reduction scenario, while cutoff productivities of U.S. exporting firms decline, those of U.S. affiliates' rise in the European Union and Canada because only more-productive affiliates can operate in the tougher competitive environment, and the less-productive MNEs now shift to exporting. Consequently, the mass of U.S. exporting firms rises and their exports also increase, while the mass and sales of MNEs fall. The expansion in U.S. exports under fixed FDI cost reduction is smaller than the decline under tariff elimination and fixed trade cost reduction, and thus exports under the combined policies decline. For affiliates, total sales under the complete CETA scenario also decline because the reduction in both trade costs and fixed FDI costs lead to a decline in sales. These results underscore the negative consequences to U.S. firms when the United States does not participate in free trade agreements.

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[26] Combining equations (3b), (11), and (14b) yields $y_{ij}^{S}(\theta) = \frac{I_j}{(z\rho_j)^{-\sigma_j}} \frac{w_j^{-\sigma_j}}{P_j^{1-\sigma_j}}$; then for a given affiliate with productivity z operating in the United States, the intensive margin is determined by $\frac{w_{US}^{-\sigma_{US}}}{P_{US}^{1-\sigma_{US}}}$. If this wage-to-price-index ratio rises, then production and sales of the affiliate z will expand at the intensive margin.

Table 8. Impact of CETA on Input Prices, Aggregate Production, and Price Index (% Change)

Production in Region i	Tariff Removal	20% Decrease in Fixed Trade Cost	50% Decrease in Fixed Affiliate Cost	Combined Effects
		Alternate Scenario		
		Input Price, w_i		
EU	−0.333	−0.074	0.663	0.199
CA	−0.882	−0.302	2.526	0.825
U.S.	−0.296	−0.073	0.375	−0.051
ROW	−0.300	−0.072	0.323	−0.101
		Aggregate Output, Y_i		
EU	−0.230	−0.046	−0.119	−0.427
CA	0.844	0.137	1.924	2.732
U.S.	−0.482	−0.090	−0.617	−1.105
ROW	−0.308	−0.060	−0.293	−0.621
		Price Index, P_i		
EU	−0.728	−0.158	0.621	−0.340
CA	−3.415	−0.833	1.633	−3.085
U.S.	−0.318	−0.079	0.436	−0.023
ROW	−0.306	−0.074	0.353	−0.082

Domestically Operating Firms' Results

Because of freer markets under CETA, EU and Canadian firms operating in their domestic markets face heightened competition. Consequently, low-productivity firms find it unprofitable and stop producing processed food. These results are supported by the higher cutoff productivities, decrease in mass, and lower domestic sales, which results in a reallocation of resources from low-productivity firms to high-productivity firms.

Since the United States and ROW are not CETA signatories, these regions' firms are disadvantaged in accessing EU and Canadian markets. As a result, U.S. and ROW firms' exports and affiliate sales to the European Union and Canada decline, which causes them to marginally increase their sales domestically (Tables 6 and 7).

Aggregates

In this section, we present the results of input price, aggregate production, and price index (Table 8). With the input supply functions unchanged, input price changes are driven by demand-side effects. For instance, a rightward shift in the demand function increases input use and input prices. Thus, changes in the input price in region i depend on changes in input demand by the ith region's firms selling domestically and exporting and by other regions' affiliates operating and selling in the ith region. The directional change in input demand is positively related to the volume of production by firms selling in region i and exporting to other regions. For the European Union, the demand for EU inputs falls under the tariff elimination and fixed trade cost reduction, which is dominated by the rise in input demand under the FDI fixed cost reduction scenario, leading to an increase in the total input demand and input price under all three policies combined. Similar results are also observed for the input demand and input prices in Canada. The overall input use, and thus input prices, fall in the United States and ROW under the combined scenario because production in these regions is adversely impacted by CETA. Since labor is a major input in food processing, the loss in employment and fall in the wage rate hurt workers when countries such as the United States pursue protective trade policies.

Aggregate output for region i is the sum of output of the ith region firms' domestic sales, exports, and affiliate sales in foreign regions. For the European Union, under the tariff elimination and fixed trade cost scenarios, aggregate output declines because inefficient domestic firms stop producing processed food due to the competition and large increase in exports from Canadian firms. However, this decline in output is mitigated by the reduced sales of Canadian MNE affiliates operating in the European Union because tariff elimination and fixed trade cost reductions are not favorable for these affiliates. Under the fixed FDI cost reduction scenario, EU aggregate output falls because the fall in domestic sales and exports dominates the rise in EU affiliate sales in Canada. Thus, EU aggregate output under all three policies combined declines.[27] In contrast, Canadian aggregate output increases under all three scenarios, largely due to Canadian firms' access to the larger EU market. U.S. and ROW aggregate outputs decline because the variable and fixed trade costs and fixed FDI cost for these regions' firms remain high, at their pre-CETA level, which is not a conducive business climate for U.S. and ROW firms. This result also underscores the loss in production when countries do not participate in free trade and investment agreements.

The aggregate price index depends on changes in prices of processed food sold in region i by firms operating domestically, foreign exporting firms, and foreign affiliates. The price index (P_i) is inversely related to real income (U_i), which can be also seen from the identity that the price index multiplied by real income is equal to exogenous nominal income ($P_i U_i = I_i$). Thus, when more goods are sold, prices decline, leading to higher consumption and real income. For tariff elimination and fixed trade cost reduction, the price index falls in all four regions, with Canada experiencing the largest decline, followed by the European Union, the United States, and ROW. The decline in the price index and the accompanying rise in real income in Canada and the European Union are due to increased cross-hauling resulting from trade and investment liberalization between these two regions, even though MNE affiliate sales decline. The lower price index and higher real income in the United States and ROW arise from (i) EU and Canadian firms exporting more to these two regions by expanding their sales at the intensive margin, (ii) more EU and Canadian firms operating in the U.S. and ROW export markets, as evidenced from the increase in the masses of firms, and (iii) U.S. and ROW firms being less competitive in EU and Canadian markets and, consequently, selling more within their domestic markets. Under the fixed FDI cost reduction scenario, price indices rise minimally in all four regions. In the European Union and Canada, even through affiliate sales rise, exports sales decline considerably more, leading to higher price indices. The net effect of all three scenarios is to lower the aggregate price indices, with Canada exhibiting the largest decline (3.085%) in prices and gain in real income. These results again highlight the greater benefits of free trade to consumers in a small country.

Sensitivity Analyses

We present results of changes in parameter values to provide further insights into the behavior of the model. Toward this goal, we carried out sensitivity analyses for the percentage of foreign affiliates $1 - G(\bar{z}_{ij}^S)$ and policy variables (fixed trade cost f_{ij} and fixed affiliate cost f_{ij}^S) and key parameters (input supply elasticity ε, the elasticity of substitution σ, and Pareto shape parameter α). In the Online Supplement, we report tables of the results of these analyses, which need to be compared to the main results reported in Tables 6–8. Here, we summarize key findings.

[27] We analyze the sensitivity of this result under different parameter values in the next subsection.

Foreign Affiliates and Policy Variables

For the sensitivity analysis of foreign affiliates, $1 - G(\bar{z}_{ij}^S)$, note that a lower value for $1 - G(\bar{z}_{ij}^S)$ lessens the role of MNE affiliates. As discussed previously, we considered for the main analysis that 0.815% of EU firms, 0.5% of Canadian firms, 1.55% of U.S. firms, and 0.4% of ROW firms have foreign affiliates. Under the tariff scenario, when we lower the percentage of foreign affiliates by about 75%, Canadian exports to the United States and ROW fall (Table S1), rather than rise as discussed previously. This occurs because, as the role of MNE affiliates diminishes, the role of exporting firms strengthens, causing the increase in input demand resulting from the expansion of EU and Canadian bilateral exports to dominate the decline in input demand as MNEs and domestic firms exit. Consequently, input prices in these CETA regions increase relative to the U.S. input price, leading to a rise in the relative cost for Canadian (as well as for EU) exporting firms to the United States and exports decline.

In our main analysis, we assumed 20% and 50% reductions in fixed trade cost and fixed affiliate cost, respectively, because CETA does not specify the exact reduction of these policy variables. Here, we investigate the sensitivity of the results for a larger decrease in the fixed trade cost (30%) and fixed FDI cost (60%). Since a 20% reduction in fixed trade costs had only modest effects, an additional 10% decrease in these costs has only small effects on key endogenous variables (Table S2). For instance, EU and Canadian bilateral exports expand by an additional 5.093% and 2.156%. EU exports to the United States exhibit only marginal changes, but Canadian exports to the United States decline by an additional 2.770%. Since a lower fixed trade cost has adverse consequences for MNE affiliates, a 30% reduction in fixed trade cost decreases EU MNE sales in Canada by an additional 5.600%, while Canadian affiliate sales in the European Union fall only marginally.

Affiliate fixed cost reduction generally has large negative impacts on export firms, as the main results show. For a 60% decrease in fixed FDI costs, EU and Canadian bilateral exports are dampened further, by −9.589% and −17.489% (Table S3). In contrast, EU and Canadian affiliate sales rise by an additional 5.858% and 5.205% in each other's market.

Parameters

Here, we examine the sensitivity of key results to a 10% increase and a 10% decrease in input supply elasticity, elasticity of substitution, and the Pareto shape parameters. The impacts of the input supply elasticity parameter on key variables are small (Table S4), indicating that it does not play a significant role in influencing the magnitude and direction of the variables.

The elasticity of substitution parameter, σ, plays an important role in the simulation analysis because it captures the degree of product differentiation. A large value of σ indicates that consumers have greater substitutability among goods, which reduces the markup and market power of firms. This causes lower-productivity firms to become unprofitable and exit, while sales of remaining firms expand. The sensitivity results generally show only modest impacts for bilateral trade flows, MNE sales, aggregate output, and price index (Table S5). The largest changes are Canadian exports to the European Union, which increase (decrease) from 107.507% in the main results to 111.964% (99.999%) for a 10% increase (decrease) in σ. However, the results for three bilateral trade flows change from positive to negative. These include Canadian exports to the United States and ROW under the tariff removal scenario for a 10% decrease in σ and ROW exports to the United States under fixed affiliate cost reduction scenario for a 10% increase in σ. For easy identification, we have included an asterisk (*) next to these results in the Table S5. The magnitude of these directional changes is very small because the results of these bilateral trade flows in the main results are modest or close to 0. The impacts of changes in σ on MNE sales exhibit only three directional changes: EU MNE sales in Canada and Canadian MNE sales to the United States under the fixed FDI cost reduction scenario for the increase in σ and Canadian MNE sales to ROW under fixed FDI cost reduction for the decrease in σ. These directional changes occur when the impacts are small in the main result. The effects of the changes in σ on the aggregate output and price index are only modest, with directional changes occurring only for the EU output, which goes from -0.119% in the main results to 0.035% under fixed FDI cost reduction scenario for the decrease in σ.

The Pareto shape parameter, α, captures the distribution of small and large firms: A large α implies a heavier left tail, indicating a higher probability that firms receive a low productivity draw and a lower chance that firms secure a high productivity draw. Consequently, the baseline mass of firms operating only domestically increases and the mass of firms exporting and establishing affiliates falls; with baseline output levels unchanged, output per firm for domestic operations falls, while output per export and affiliate operation rises. A 10% increase (decrease) in α causes variables that exhibited positive changes in the main results to become slightly more (less) positive and variables that exhibited negative changes in the main results to become less (more) negative (Table S6). For the bilateral results, ROW exports to the United States and Canadian MNE sales in the United States go from small positive changes in the main results to small negative changes for the decrease in α. In terms of aggregates, EU output reverses signs and is now slightly positive for the increase in α, and Canadian output reverses signs and is now slightly negative for the decrease in α.

Conclusions and Policy Implications

In the wake of the active protectionism pursued by the United States, the European Union and Canada created positive impetus for free trade by completing a comprehensive trade agreement that liberalizes not only trade barriers but also investment barriers. In light of these bilateral developments, this study examines the potential impacts of CETA policies on the EU, Canadian, U.S., and ROW processed food industries by applying firm-level trade theory and incorporating MNE affiliates.

Large fixed costs and heterogeneity in productivity in the processed food industry play a crucial role in determining the percentage of firms that operate only in the domestic market, operate in both domestic and export markets, or operate in both domestic market and foreign market affiliates. Because of the large fixed costs involved in exporting and FDI investment, it is worth noting that (i) only a small percentage of firms participate in international commerce and (ii) to compete effectively in the world market, these exporting and FDI firms have to be highly productive to earn nonnegative profits. Furthermore, the higher fixed FDI cost compared to fixed export costs implies that firms that establish foreign affiliates are even larger and more productive than firms that export. Therefore, modeling the firms with different productivities and MNEs is crucial to accurately assess the CETA effects on the processed food industry, as these firms play a large role in this industry.

Incorporating firm-level trade theory allows us to study the impacts of CETA on the reallocation of resources among heterogeneous firms as firms (i) exit the domestic market, (ii) enter and exit export markets, and (iii) switch between exporting and MNE operations. In particular, modeling intra-industry firm heterogeneity helps us assess the change in the volume of exports versus MNE affiliate sales and examine the changes in the mass of firms operating domestically, exporting, and setting up affiliates abroad in response to trade and investment liberalization.

The findings of this study highlight the complex interactions of comprehensive trade and investment agreements, which have important policy implications. Lowering bilateral variable and fixed trade costs provides incentives for firms that export to remain in the home country and not establish production facilities in foreign countries. In doing so, these firms can generate more employment within the home country. However, under these policies, foreign affiliates may not find it conducive to operate in this country, which can reduce employment levels. Thus, modeling MNE affiliate operations allows us to capture the trade-off between the expansion of exporting firms and the contraction of foreign affiliates under bilateral trade liberalization. Our results show that the decline in employment as domestically operating firms and foreign affiliates exit dominates the increase in employment as exporting firms enter. The sensitivity analysis shows that the net decline in employment could be reversed if the role of affiliates were smaller.

By contrast, lowering fixed FDI costs has opposite results in that MNEs bring more employment, but firms selling domestically and exporting produce less and hire fewer workers. Thus, lowering FDI barriers also leads to a trade-off between greater foreign MNE affiliate operations versus fewer domestically operating and exporting firms. Our results show that the increase in employment due to more foreign affiliates dominates the decline in employment by the exit of firms operating domestically and exporting firms. The sensitivity results show that employment in the home country can expand only when more foreign affiliates operate in this country.

The results highlight the conflicting effects of trade liberalization, which works against affiliates, and investment liberalization, which negatively impacts exporting firms. The net effect of the three combined CETA policies is to *increase* overall input use for the signatory regions—an important result because countries, such as the United States, are implementing trade barriers to protect workers and other input supply industries. Our results show that liberalization of investment barriers is particularly important to augment input demand, contradicting the U.S. position. The sensitivity analysis suggests that this result is accentuated (attenuated) when more (fewer) MNEs are operating.

The results of this paper are insightful for negotiators of bilateral and multilateral agreements to seek trade and investment liberalization and to motivate the larger food processing firms to persuade their governments to pursue free trade agreements.

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Jeff Luckstead and Stephen Devadoss

Foreign Affiliates and Policy Variables

Table S1. Sensitivity Analysis for Percent of Foreign Affiliates: $1 - G(\bar{z}_{ij}^{S})$ (% Change)

Prod. Reg. *i*	Sales Reg. *j*	Alternate Scenario: Tariff Rem.	20% Dec FTC	50% Dec FAC
		Bilateral Trade, y_{ij}		
EU	EU	−0.891	−0.180	−0.739
EU	CA	81.469	11.448	−28.018
EU	U.S.	0.365	0.055	−1.633
EU	ROW	0.376	0.067	−1.806
CA	EU	103.389	13.374	−33.385
CA	CA	−7.139	−1.369	−4.707
CA	U.S.	2.444	1.065	−9.765
CA	ROW	2.353	1.026	−9.559
U.S.	EU	−1.023	−0.179	0.788
U.S.	CA	−9.358	−2.462	6.504
U.S.	U.S.	0.237	0.056	−0.179
U.S.	ROW	0.256	0.068	−0.481
ROW	EU	−1.101	−0.203	1.036
ROW	CA	−9.836	−2.541	5.968
ROW	U.S.	0.253	0.051	0.123
ROW	ROW	0.274	0.064	−0.208
		Bilateral MNE Sales, y_{ij}^{S}		
EU	CA	−9.870	−1.491	10.042
EU	U.S.	0.232	0.056	−0.125
EU	ROW	0.273	0.064	−0.188
CA	EU	−3.141	−0.273	14.634
CA	U.S.	0.179	0.030	0.077
CA	ROW	0.244	0.050	−0.072
U.S.	EU	−0.888	−0.180	−0.772
U.S.	CA	−7.092	−1.346	−4.937
U.S.	ROW	0.275	0.064	−0.211
ROW	EU	−0.979	−0.200	−0.927
ROW	CA	−7.636	−1.440	−5.565
ROW	U.S.	0.230	0.055	−0.202
		Aggregate Output, Y_i		
EU		−0.253	−0.051	−0.094
CA		0.826	0.128	1.928
U.S.		−0.514	−0.095	−0.573
ROW		−0.313	−0.060	−0.262
		Price Index, P_i		
EU		−0.707	−0.154	0.585
CA		−3.362	−0.814	1.518
U.S.		−0.300	−0.075	0.411
ROW		−0.292	−0.072	0.333

Table S2. Sensitivity Analysis for Fixed Trade Cost: f_{ij} (% Change)

Prod. Reg. *i*	Sales Reg. *j*	Alternate Scenario: Tariff Rem.	20% Dec FTC	50% Dec FAC
		Bilateral Trade, y_{ij}		
EU	EU	−1.086	−0.328	−0.508
EU	CA	71.652	13.280	−17.642
EU	U.S.	0.052	0.048	−1.018
EU	ROW	0.020	0.056	−1.153
CA	EU	84.953	15.690	−21.787
CA	CA	−9.888	−2.999	−3.149
CA	U.S.	−2.007	0.297	−6.003
CA	ROW	−1.958	0.293	−5.941
U.S.	EU	−0.874	−0.274	0.408
U.S.	CA	−7.687	−3.198	3.238
U.S.	U.S.	0.264	0.102	−0.119
U.S.	ROW	0.218	0.107	−0.314
ROW	EU	−0.951	−0.320	0.615
ROW	CA	−8.452	−3.466	3.264
ROW	U.S.	0.291	0.089	0.086
ROW	ROW	0.241	0.094	−0.132
		Bilateral MNE Sales, y^S_{ij}		
EU	CA	−12.722	−3.085	11.436
EU	U.S.	0.273	0.104	−0.082
EU	ROW	0.243	0.095	−0.118
CA	EU	−3.198	−0.380	14.585
CA	U.S.	0.329	0.097	0.048
CA	ROW	0.275	0.091	−0.043
U.S.	EU	−1.092	−0.329	−0.530
U.S.	CA	−9.940	−2.994	−3.299
U.S.	ROW	0.240	0.094	−0.134
ROW	EU	−1.217	−0.367	−0.638
ROW	CA	−10.792	−3.242	−3.716
ROW	U.S.	0.265	0.104	−0.137
		Aggregate Output, Y_i		
EU		−0.361	−0.133	0.044
CA		0.634	0.081	2.000
U.S.		−0.673	−0.193	−0.353
ROW		−0.318	−0.095	−0.128
		Price Index, P_i		
EU		−0.590	−0.225	0.400
CA		−3.060	−1.193	0.978
U.S.		−0.197	−0.096	0.284
ROW		−0.211	−0.095	0.228

Table S3. Sensitivity Analysis for Fixed Affiliate Cost: f^S_{ij} (% Change)

Prod. Reg. *i*	Sales Reg. *j*	Alternate Scenario		
		Tariff Rem.	20% Dec FTC	50% Dec FAC
			Bilateral Trade, y_{ij}	
EU	EU	−1.086	−0.199	−0.722
EU	CA	71.652	8.345	−23.879
EU	U.S.	0.052	0.024	−1.444
EU	ROW	0.020	0.029	−1.633
CA	EU	84.953	9.727	−29.395
CA	CA	−9.888	−1.807	−4.440
CA	U.S.	−2.007	0.208	−8.410
CA	ROW	−1.958	0.204	−8.323
U.S.	EU	−0.874	−0.161	0.579
U.S.	CA	−7.687	−1.958	4.615
U.S.	U.S.	0.264	0.062	−0.169
U.S.	ROW	0.218	0.065	−0.445
ROW	EU	−0.951	−0.190	0.872
ROW	CA	−8.452	−2.121	4.653
ROW	U.S.	0.291	0.054	0.120
ROW	ROW	0.241	0.057	−0.187
			Bilateral MNE Sales, y^S_{ij}	
EU	CA	−12.722	−1.865	15.078
EU	U.S.	0.273	0.063	−0.117
EU	ROW	0.243	0.058	−0.168
CA	EU	−3.198	−0.235	19.701
CA	U.S.	0.329	0.058	0.066
CA	ROW	0.275	0.055	−0.062
U.S.	EU	−1.092	−0.200	−0.755
U.S.	CA	−9.940	−1.804	−4.652
U.S.	ROW	0.240	0.057	−0.191
ROW	EU	−1.217	−0.224	−0.908
ROW	CA	−10.792	−1.953	−5.240
ROW	U.S.	0.265	0.063	−0.194
			Aggregate Output, Y_i	
EU		−0.361	−0.078	0.018
CA		0.634	0.057	2.658
U.S.		−0.673	−0.117	−0.500
ROW		−0.318	−0.057	−0.182
			Price Index, P_i	
EU		−0.59	−0.135	0.567
CA		−3.06	−0.726	1.387
U.S.		−0.197	−0.058	0.402
ROW		−0.211	−0.058	0.323

Sensitivity for Parameters

Table S4. Sensitivity Analysis for Elasticity of Input Supply ε_i (% Change)

		10% Increase in ε_i			10% Decrease in ε_i		
			Alternate Scenario			Alternate Scenario	
Prod. Reg. i	Sales Reg. j	Tariff Rem.	20% Dec FTC	50% Dec FAC	Tariff Rem.	20% Dec FTC	50% Dec FAC
				Bilateral Trade, y_{ij}			
EU	EU	−0.857	−0.177	−0.775	−0.851	−0.175	−0.786
EU	CA	83.917	12.239	−30.729	83.923	12.239	−30.725
EU	U.S.	0.433	0.063	−1.761	0.440	0.064	−1.775
EU	ROW	0.450	0.075	−1.937	0.457	0.077	−1.953
CA	EU	107.490	14.227	−36.065	107.523	14.233	−36.097
CA	CA	−6.653	−1.291	−4.975	−6.640	−1.286	−5.010
CA	U.S.	3.321	1.248	−10.557	3.338	1.254	−10.601
CA	ROW	3.192	1.199	−10.312	3.209	1.205	−10.356
U.S.	EU	−1.068	−0.185	0.891	−1.063	−0.184	0.888
U.S.	CA	−9.799	−2.601	7.404	−9.798	−2.602	7.414
U.S.	U.S.	0.230	0.055	−0.187	0.235	0.056	−0.194
U.S.	ROW	0.262	0.068	−0.510	0.267	0.070	−0.519
ROW	EU	−1.143	−0.208	1.132	−1.138	−0.207	1.131
ROW	CA	−10.156	−2.646	6.630	−10.155	−2.646	6.638
ROW	U.S.	0.243	0.050	0.131	0.248	0.052	0.127
ROW	ROW	0.277	0.065	−0.220	0.283	0.066	−0.227
				Bilateral MNE Sales, y_{ij}^S			
EU	CA	−9.366	−1.431	9.843	−9.353	−1.426	9.802
EU	U.S.	0.222	0.054	−0.130	0.228	0.056	−0.136
EU	ROW	0.276	0.065	−0.199	0.282	0.067	−0.206
CA	EU	−3.132	−0.284	14.670	−3.126	−0.283	14.658
CA	U.S.	0.151	0.024	0.085	0.156	0.025	0.079
CA	ROW	0.236	0.049	−0.076	0.242	0.050	−0.082
U.S.	EU	−0.852	−0.176	−0.81	−0.846	−0.175	−0.822
U.S.	CA	−6.589	−1.264	−5.220	−6.576	−1.260	−5.256
U.S.	ROW	0.279	0.065	−0.224	0.285	0.067	−0.231
ROW	EU	−0.937	−0.196	−0.973	−0.931	−0.195	−0.986
ROW	CA	−7.077	−1.348	−5.887	−7.064	−1.343	−5.926
ROW	U.S.	0.222	0.053	−0.210	0.228	0.055	−0.218
				Aggregate Output, Y_i			
EU		−0.233	−0.047	−0.113	−0.227	−0.045	−0.124
CA		0.841	0.136	1.931	0.848	0.138	1.918
U.S.		−0.485	−0.091	−0.612	−0.479	−0.089	−0.622
ROW		−0.311	−0.061	−0.289	−0.305	−0.059	−0.297
				Price Index, P_i			
EU		−0.725	−0.157	0.617	−0.731	−0.158	0.625
CA		−3.412	−0.832	1.628	−3.417	−0.833	1.637
U.S.		−0.315	−0.078	0.432	−0.321	−0.079	0.440
ROW		−0.303	−0.074	0.349	−0.309	−0.075	0.357

Table S5. Sensitivity Analysis for Elasticity of Substitution σ_i (% Change)

		10% Increase in ε_i Alternate Scenario			10% Decrease in ε_i Alternate Scenario		
Prod. Reg. i	Sales Reg. j	Tariff Rem.	20% Dec FTC	50% Dec FAC	Tariff Rem.	20% Dec FTC	50% Dec FAC
				Bilateral Trade, y_{ij}			
EU	EU	−0.559	−0.090	−0.537	−1.108	−0.292	−0.996
EU	CA	88.303	9.825	−30.024	85.052	16.402	−34.324
EU	U.S.	0.179	0.013	−1.145	0.844	0.209	−2.341
EU	ROW	0.164	0.013	−1.169	0.848	0.231	−2.651
CA	EU	111.964	10.737	−32.606	99.999	18.243	−39.358
CA	CA	−3.035	−0.452	−3.729	−10.509	−2.683	−5.011
CA	U.S.	4.754	1.002	−7.305	−0.599*	0.758	−11.923
CA	ROW	4.486	0.947	−7.022	−0.514*	0.754	−11.795
U.S.	EU	−0.610	−0.079	0.575	−1.651	−0.406	1.187
U.S.	CA	−7.828	−1.532	4.655	−9.573	−3.402	9.132
U.S.	U.S.	0.130	0.023	−0.087	0.319	0.100	−0.296
U.S.	ROW	0.111	0.021	−0.202	0.367	0.133	−0.804
ROW	EU	−0.551	−0.070	0.606	−1.815	−0.473	1.612
ROW	CA	−7.750	−1.503	4.018*	−10.537	−3.621	8.402
ROW	U.S.	0.251	0.043	−0.014	0.256	0.061	0.248
ROW	ROW	0.229	0.040	−0.140	0.307	0.096	−0.298
				Bilateral MNE Sales, y_{ij}^S			
EU	CA	−3.716	−0.475	−0.046*	−16.272	−3.174	27.699
EU	U.S.	0.129	0.023	−0.077	0.279	0.092	−0.141
EU	ROW	0.230	0.040	−0.135	0.290	0.093	−0.235
CA	EU	−1.114	−0.107	3.256	−5.764	−0.603	32.704
CA	U.S.	0.101	0.017	−0.042*	0.369	0.064	0.362
CA	ROW	0.204	0.035	−0.100	0.332	0.078	0.038*
U.S.	EU	−0.558	−0.090	−0.542	−1.083	−0.287	−1.094
U.S.	CA	−3.011	−0.447	−3.770	−10.549	−2.652	−5.604
U.S.	ROW	0.230	0.040	−0.142	0.306	0.096	−0.300
ROW	EU	−0.627	−0.102	−0.604	−1.139	−0.303	−1.424
ROW	CA	−3.245	−0.480	−4.127	−11.427	−2.850	−6.540
ROW	U.S.	0.114	0.020	−0.083	0.331	0.107	−0.379
				Aggregate Output, Y_i			
EU		−0.298	−0.045	−0.364	−0.151	−0.046	0.035*
CA		0.087	0.002	0.494	1.351	0.308	3.259
U.S.		−0.396	−0.059	−0.588	−0.558	−0.135	−0.598
ROW		−0.284	−0.043	−0.370	−0.288	−0.072	−0.208
				Price Index, P_i			
EU		−0.487	−0.079	0.310	−0.931	−0.275	0.957
CA		−2.420	−0.446	0.854	−3.818	−1.224	2.362
U.S.		−0.246	−0.044	0.211	−0.329	−0.118	0.681
ROW		−0.241	−0.043	0.179	−0.318	−0.110	0.552

Table S6. Sensitivity Analysis for Pareto Shape Parameter α_i (% Change)

		10% Increase in ε_i			10% Decrease in ε_i		
			Alternate Scenario			Alternate Scenario	
Prod. Reg. i	**Sales Reg. j**	**Tariff Rem.**	**20% Dec FTC**	**50% Dec FAC**	**Tariff Rem.**	**20% Dec FTC**	**50% Dec FAC**
				Bilateral Trade, y_{ij}			
EU	EU	−1.087	−0.239	−0.941	−0.529	−0.099	−0.546
EU	CA	90.771	15.106	−31.027	81.557	10.070	−31.774
EU	U.S.	0.663	0.110	−2.188	0.227	0.032	−1.149
EU	ROW	0.702	0.135	−2.503	0.200	0.029	−1.160
CA	EU	116.089	17.683	−37.869	97.297	10.622	−33.458
CA	CA	−9.287	−1.950	−5.693	−3.512	−0.606	−3.472
CA	U.S.	2.170	1.279	−12.462	2.874	0.816	−6.890
CA	ROW	2.149	1.251	−12.334	2.690	0.767	−6.589
U.S.	EU	−1.477	−0.278	1.132	−0.623	−0.103	0.556
U.S.	CA	−11.175	−3.267	9.104	−6.392	−1.477	4.416
U.S.	U.S.	0.287	0.074	−0.243	0.136	0.028	−0.098
U.S.	ROW	0.356	0.103	−0.735	0.109	0.025	−0.208
ROW	EU	−1.633	−0.329	1.528	−0.562	−0.092	0.587
ROW	CA	−11.836	−3.378	8.294	−6.451	−1.470	3.808
ROW	U.S.	0.229	0.046	0.261	0.260	0.051	−0.026*
ROW	ROW	0.303	0.077	−0.266	0.227	0.047	−0.146
				Bilateral MNE Sales, y^S_{ij}			
EU	CA	−14.082	−2.260	22.720	−4.081	−0.630	−0.650*
EU	U.S.	0.264	0.072	−0.123	0.135	0.028	−0.090
EU	ROW	0.295	0.077	−0.224	0.228	0.047	−0.140
CA	EU	−5.055	−0.463	28.790	−0.989	−0.116	2.344
CA	U.S.	0.205	0.022	0.302	0.121	0.024	−0.061*
CA	ROW	0.266	0.054	−0.015	0.210	0.042	−0.101
U.S.	EU	−1.073	−0.238	−1.014	−0.528	−0.099	−0.551
U.S.	CA	−9.222	−1.904	−6.183	−3.500	−0.603	−3.506
U.S.	ROW	0.304	0.078	−0.269	0.228	0.047	−0.149
ROW	EU	−1.144	−0.258	−1.308	−0.595	−0.113	−0.611
ROW	CA	−9.888	−2.018	−7.158	−3.802	−0.654	−3.837
ROW	U.S.	0.293	0.077	−0.314	0.122	0.026	−0.094
				Aggregate Output, Y_i			
EU		−0.158	−0.036	0.055*	−0.372	−0.066	−0.425
CA		1.484	0.277	3.055	−0.075*	−0.022*	0.275
U.S.		−0.539	−0.108	−0.617	−0.449	−0.078	−0.588
ROW		−0.286	−0.060	−0.217	−0.310	−0.054	−0.374
				Price Index, P_i			
EU		−0.834	−0.197	0.797	−0.518	−0.100	0.334
CA		−3.669	−0.975	1.997	−2.407	−0.518	0.915
U.S.		−0.349	−0.097	0.571	−0.238	−0.050	0.227
ROW		−0.333	−0.091	0.459	−0.236	−0.049	0.191