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Abstract

We investigate two puzzles in the export duration literature. The first puzzle has to do with the frequent entries and exits of firms in export markets, which are at odds with the large fixed export costs in such markets. We introduce convex production technologies in a trade model to show how variable marginal costs create direct linkages between export markets. As fixed export costs vary across destinations, more productive firms need not necessarily export to more destinations. Cost convexity implies that the probability of supplying a given export market is adversely affected by positive export shocks in other markets. This is supported by our empirical analysis of bilateral flows for over 200 agri-food products to 176 destinations originating from six large exporting countries. The second puzzle has to do with the paradoxical effect of tariffs reported in empirical export duration studies. When endogeneity is addressed, tariffs increase the probability of an export failure.

Keywords: Cost convexity, export failure, gravity.

JEL Classification: F12, F14, Q17.

Les énigmes de la durée des exportations

Résumé

Dans cet article, nous tentons de réconcilier deux constats empiriques en lien avec la durée des exportations et les théories du commerce international. Tout d'abord, les entrées et sorties fréquentes observées des entreprises sur les marchés d'exportation sont en contradiction avec les théories modernes pour lesquelles les coûts d'exportation fixes ont un rôle central dans les décisions d'exportation. Nous introduisons des couts marginaux de production non constants dans un modèle de commerce international et montrons comment les coûts marginaux variables créent des liens directs entre les différents marchés d'exportation. La convexité des coûts implique que la probabilité de maintenir son activité d'exportation vers un pays dépend négativement des chocs positifs d'exportation vers d'autres marchés. Notre analyse empirique des flux bilatéraux de plus de 200 produits agroalimentaires vers 176 destinations, provenant de six grands pays, confirme cette hypothèse. Ensuite, on questionne l'effet positif paradoxal des tarifs douaniers dans les études empiriques sur la durée des exportations. Lorsque l'endogénéité des tarifs est prise en compte, l'effet devient négatif en accord avec la théorie.

Mots-clés: Gravité, durée d'exportation, convexité des couts, tarifs douaniers.

Classification JEL: F12, F14, Q17.

On Export Duration Puzzles

1. Introduction

The size, composition, and duration of trade flows are the main issues studied in trade research. The gravity model has had much success in explaining agricultural trade flows (*e.g.,* Sun and Reed, 2010 and Winchester *et al.*, 2012). When considering firm heterogeneity and fixed export costs, new trade models also explain why so few food firms export (Gaigné and Larue, 2016 and Gaigné *et al.*, 2017 and Luckstead and Devadoss, 2016). However, the duration of trade relationships in agricultural products has received less attention (Peterson *et al.*, 2017), and the existing literature on export duration suffers from at least two limitations.

First, trade models based on monopolistic competition with symmetric or heterogeneous firms cannot explain why entries and exits are frequent and export spells have a short duration. According to the new trade theory, the presence of fixed export costs favors highly productive firms with a higher probability of export survival (Melitz and Redding, 2015). Even though exporters face negative transitory shocks, they may prefer to maintain their export activities to avoid paying fixed re-entry costs. However, empirical evidence shows that the rate of exit is high in the first few years of export activities. Sabuhoro *et al.* (2006) report a median survival time of only 20 months for exports by Canadian plants, while Besedeš and Prusa (2006a) find a median duration of 2 years for United States imports of reference-priced and homogenous products.

To account for frequent entries and exits, short export duration, and fixed export costs, we develop a new multi-country trade model with *variable* marginal costs. In our case, allowing for convex variable costs has important implications for export duration because the export volume of a firm in one market impacts its marginal cost and survival in all markets, while under constant marginal costs, markets are completely segmented and independent of each other from each firm's standpoint. In standard trade models, a shock in a foreign market has only an indirect impact on the export sales of firms in other markets through changes in price indices and national income, which are treated as given in the optimization of monopolistic firms.[1] If marginal costs increase with output, a higher demand in one country implies higher prices in all destinations and, in turn, a rise in exports to that first country at the expense of other destinations. Cost convexity is particularly pertinent in agricultural trade because many primary agricultural goods take a long time to produce and are perishable. In addition, processing plants may also

[1]Trade models allowing for heterogeneous firms provide valuable insights about how *changes* in trade costs can bring about the creation of new trade flows and the disappearance of old ones. In Helpman *et al.* (2008), a country's exports cease when increases in export costs are such that they prompt the country's most productive firm to exit. However, a trade cost reduction in one market does not directly impact the firm's sales in other markets. Markets are linked through price indices and total expenditures, which are treated as given in the optimization of monopolistic firms.

face capacity constraints due to investment lags, which are an extreme form of convexity. Cost convexity also implies that the number of destinations served by a firm is not perfectly correlated with the firm's productivity. Intuitively, firms must commit to selling large quantities in markets with large fixed export costs and try to minimize the accumulation of fixed export costs. This favors exports to one or more large markets over exports to several small markets. Thus, firms experiencing a positive productivity shock may choose to replace several smaller destinations with one or more larger markets. The policy implication of this is that, all else being equal, a country with relatively less geographically diversified exports may not have a productivity deficit.

The second export duration puzzle has to do with empirical results suggesting that higher tariffs decrease or have an effect on the probability of an export failure (*e.g.,* Besedeš and Prusa, 2006b; Hess and Persson, 2012; Peterson *et al.*, 2017). This contrasts with the unambiguous theoretical negative effect of tariffs on export survival. In trade models with heterogeneous firms, higher tariffs impact firms' intensive margin and the fraction of firms that export. Higher tariffs induce firms to reduce their sales (see equation 6 in Helpman *et al.*, 2008), but higher tariffs impact some firms at the extensive margin, prompting firms to exit when their profits fall below the zero threshold (as shown by equation 10 in Helpman *et al.*, 2008).[2] Thus, the reduction in sales makes it more difficult for firms to cover their fixed export costs. In the probabilistic Ricardian model of Eaton and Kortum (2002), perfectly competitive suppliers from a given country make a sale in a third country only if their price is the lowest and the probability of being the lowest cost supplier decreases with the tariff. Generally, export sales decrease with tariffs up to the point when tariffs become prohibitive and force an export failure. A potential reason why empirical studies about export duration have failed to find a positive relationship between tariffs and the probability of an export failure might be due to an endogeneity bias. There could be unobserved foreign productivity shocks that reduce the probability of an export failure. These shocks may increase imports enough to prompt the governments of importing countries to increase their tariffs. Thus, the true effect of tariffs on export failure may be biased by the confounding effect of productivity shocks. Tariff endogeneity has been addressed in studies about trade liberalization, including Trefler (1993), Goldberg and Pavcnik (2005) and Buono and Lalanne (2012), but not in export and import duration studies.

In this paper, we address the effect of variable marginal costs and of tariff endogeneity on the duration of trade with a rich dataset covering 176 destinations and 235 agri-food products shipped by six large exporting countries (Australia, Brazil, Canada, France, Germany and the United States). As such, our analysis contrasts with most trade duration studies, which concentrate on one importing country purchasing from several sources, or on one exporting

[2] The intensive margin in this case refers to the entry and exit of firms producing different varieties of product k, as in Helpman *et al.* (2008) and Eaton *et al.* (2011). As pointed out by a referee, the extensive margin often refers to exports of new product categories, as in Foellmi *et al.* (2018).

country's sales to many destinations. We also shed new light on factors impacting export duration by addressing tariff endogeneity and market linkages. As such, our focus is quite different from that in recent studies about the duration of agricultural exports, such as Bojnec and Fertő (2012), which found that improved access to the EU market extended the duration of agri-food exports of new EU members like Poland, Hungary and Romania, and Peterson *et al.* (2017), which focused on the role of price changes and sanitary and phytosanitary regulations in determining the duration of fresh fruit and vegetable exports from the United States. Our findings confirm that foregone sales from terminated trade flows (*i.e.*, the sum of sales at $t-1$ that vanish at t) decrease the probability of export failure. This is consistent with technology-induced market linkages that rationalize frequent entries and exits and short export spells. Like several other studies, we find that higher tariffs appear to decrease the probability of an export failure when tariffs are treated as exogenous. However, tariffs have an expected positive and highly significant effect on export failure once the endogeneity bias is addressed with a two-stage residual inclusion estimator.

The rest of the paper is structured as follows. The next section discusses the determinants of export duration and previous studies questioning the constant returns to scale assumption in trade models. This is followed by the development of a multi-destination trade model to derive new insights about cost convexity and export duration. The empirical part begins in Section 4 with a description of the empirical strategy and employed data, and of the nonparametric Kaplan-Meier statistics comparing the probability of survival across exporting countries. Section 5 presents the estimation results from discrete-time multivariate models, and Section 6 concludes the paper.

2. Related literature

The concept of export duration is closely related to the extensive margin of trade, which reflects the probability of observing a trade flow. Fixed export costs impact the extensive margin of trade and play a crucial identification role. Fixed export costs can take different forms, such as warehouse space rentals, standards compliance costs (Ferro *et al.*, 2015), and search costs to find foreign partners that will distribute and market goods abroad. Many export duration studies use search cost theory as a microfoundation. According to Rauch and Watson (2003), export flows are larger and more likely to cover fixed export costs when exporters and importers are properly matched. Lower search costs increase the probability of entries and exits. Search costs are sunk costs, regardless of whether the search is successful, but contacts established during a first export spell can be approached when the exporting firm is ready to begin a second export spell. Thus, fixed export costs should be lower in subsequent spells. The probability and length of a second spell may also be higher if there are X-efficiency gains (*e.g.*, Sjöström and Weitzman, 1996)[3] from operating in highly competitive export markets or from learning through export activities (*e.g.*, De Loecker, 2013). This is why several empirical studies, such as Brenton *et al.* (2009), use a past-spell indicator as an explanatory variable. The interplay between sunk and fixed export costs is investigated in Albornoz *et al.* (2016), who demonstrate that the probability of export survival upon entry increases as the ratio of sunk to fixed costs increases.

The decision to continue to export is also influenced by the cost of serving foreign markets through foreign direct investment. Helpman *et al.* (2004) show that foreign direct investment becomes more attractive as exporting firms become more productive. In Vernon (1966)'s product cycle model, the introduction phase takes place in industrialized countries. Once the product is mature, it is exported. Then, when the product has become standardized, production moves to countries with low labor costs. Innovations create new cycles of export entries and exits. This theory predicts that spells of exports from rich countries will be followed by spells of exports from countries with low wages, but it does not explain frequent entries and exits by firms manufacturing the same product(s).

The validity of the assumption of a constant marginal cost has been questioned recently (Vannoorenberghe, 2012; Blum *et al.*, 2013; Soderbery, 2014; Karasik, 2014; Antras *et al.*, 2017). This assumption is quite practical because it allows firms to make decisions about trade at the extensive and intensive margins for a given destination independently from its decisions about other destinations. The firm's optimization is much more complicated under variable marginal costs, as all markets must be simultaneously considered. With a two-country model, Krugman (1984) showed that strategic import restrictions can be used as export promotion policies when oligopolistic firms enjoy economies of size.[4] Keeping the 2-country setup, a positive demand shock on the domestic market may induce a reduction or even the termination of export sales in the presence of diseconomies of size (Vannoorenberghe, 2012). Unlike the 2-country models featured in Blum *et al.* (2013) and Vannoorenberghe (2012), the model we develop to explore the implications of cost convexity on export duration is a *multi*-country trade model. An advantage of our multi-country theoretical framework is that it shows that the monotone relationship between productivity and the number of destinations can be broken down even further.

[3] X-efficiency was first described by Leibenstein (1966), and focuses on intrafirm organizational change in response to profit declines (Borenstein and Farrell, 2000), as when a firm is exposed to stiffer competition.

[4] Economies of size and economies of scale can be used interchangeably when technologies are homogeneous. When input shares change with the level of output to produce, all else constant, economies of scale are no longer economically meaningful.

3. A trade model with variable marginal cost

Consumers in country j derive utility from a nested Cobb-Douglas CES utility function. The top tier expresses how consumers in country j aggregate the consumption of product k (C_j^k) with $U_j = \prod_k (C_j^k)^{\beta^k}$, where $\beta^k \in (0,1)$. The second tier describes the consumption of variety ω of product k. Consumers have identical CES subutility functions, such that $C_j^k = \left[\int_{\omega\in\Omega_j^k} [q(\omega)]^{\frac{\varepsilon^k-1}{\varepsilon^k}} \mathrm{d}\omega\right]^{\frac{\varepsilon^k}{\varepsilon^k-1}}$, where Ω_j^k represents the set of available varieties within product class k in country j, and $q(\omega)$ is the consumption of variety ω in country j. The elasticity of substitution across varieties of product k is defined by $\varepsilon^k > 1$ and is the same in every country. Expenditure on product k in country j is defined as $E_j^k = \int_{\Omega_j^k} p(\omega)q(\omega)\mathrm{d}\omega$, where $p(\omega)$ is the price of variety ω. Consumers in country j have the following demand for variety ω exported by country i:

$$q_{ij}^k(\omega) = A_j^k \left[p_{ij}^k(\omega)\right]^{-\varepsilon^k}, \tag{1}$$

where $p_{ij}(\omega)$ is the price of variety ω produced in country i and delivered to destination j and $A_j^k \equiv E_j^k (P_j^k)^{1-\varepsilon^k}$ with $P_j^k = \left[\int_{\omega\in\Omega_j^k} p(\omega)^{1-\varepsilon^k}\right]^{\frac{1}{1-\varepsilon^k}}$ a price index that aggregates the prices of all available varieties in country j.

Each firm produces a different variety $\omega \in \Omega^k$. We assume that the variable cost function is:

$$VC(y_i^k) = \frac{1}{\varphi}(y_i^k)^{\gamma^k}, \tag{2}$$

where φ is a productivity parameter that varies across firms and y_i^k is the production of a firm located in country i selling product k. Cost convexity is governed by the extent to which γ^k exceeds 1. We fall back on standard trade models when $\gamma^k = 1$. The average variable cost of a firm located in country i supplying market j is defined as $AVC(y_i^k) = \frac{1}{\varphi}(y_i^k)^{\gamma^k-1}$. The average variable production cost is the same across destinations. Since all firms with the same productivity within a given product behave symmetrically, we index firms producing a variety of product k from now onwards by φ alone. The firm's profit associated with a destination market can be depicted as:

$$\pi_{ij}^k(\varphi) = \frac{p_{ij}^k(\varphi)q_{ij}^k(\varphi)}{T_{ij}^k} - AVC^k(y_i^k)\tau_{ij}^k q_{ij}^k(\varphi) - f_{ij}^k, \tag{3}$$

where τ_{ij}^k represents iceberg trade costs and T_{ij}^k is the gross tariff rate. All firms share the same fixed export cost f_{ij}^k and cost convexity parameter γ_k, but have different productivity levels φ. The price in country j for product k imported from a firm in country i that maximizes its total profit ($\pi_i^k = \sum_j \pi_{ij}^k$) is given by

$$p_{ij}^k(\varphi) = p_i^k(\varphi)\tau_{ij}^k T_{ij}^k \quad \text{with} \quad p_i^k(\varphi) = \frac{\varepsilon^k \gamma^k}{(\varepsilon^k - 1)\varphi}(y_i^k)^{\gamma^k - 1}. \tag{4}$$

It follows that p_{ij}^k exceeds factory gate price p_i^k by the iceberg trade costs and the tariff, while factory-gate price p_i^k equals marginal production cost, $\frac{\gamma^k}{\varphi}(y_i^k)^{\gamma^k-1}$, times a markup $\frac{\varepsilon^k}{\varepsilon^k-1}$, which increases with the degree of product differentiation (1/ε^k).

Iceberg trade costs imply that total production is given by $y_i^k = \sum_j \tau_{ij}^k q_{ij}^k$ with $q_{ij}^k = A_j^k (p_i^k)^{-\varepsilon^k} (\tau_{ij}^k)^{-\varepsilon^k} (T_{ij}^k)^{-\varepsilon^k}$ (see (1) and (4)). As a result, factory-gate price p_i^k is implicitly defined. Using Brouwer's fixed point theorem and assuming convex costs, the system of equations has a unique solution $p_i^{k\star}$. Prices paid by consumers increase with the convexity parameter, trade costs and tariffs, and decrease with productivity. Export sales to a given destination, $p_{ij}^k q_{ij}^k = A_j^k (p_i^k)^{1-\varepsilon^k} (\tau_{ij}^k)^{1-\varepsilon^k} (T_{ij}^k)^{1-\varepsilon^k}$, decrease with the tariff. Under cost convexity, the reduction in the export quantity lowers the average production cost and the factory-gate price, which partially offset the inflationary effect of the tariff on the price paid by consumers. The reduced price stemming from the reduction in the marginal cost and the lower quantity reduce the profit from serving destination j. Therefore, a sufficiently large tariff can turn a once profitable destination into an unprofitable destination. Accordingly, higher tariffs unambiguously reduce export duration.

Inserting (1), (2), and (4) in (3), the profit π_i^k of a firm producing a variety of product k in country i over all of the n_i^k destinations that it can supply, given its productivity φ, can be rewritten as:

$$\pi_i^k = \frac{(\mu^k - 1)(y_i^k)^{\gamma^k}}{\varphi} - \sum_{j=1}^{n_i^k(\varphi)} f_{ij}^k \quad \text{with} \quad y_i^k = \left[\left(\frac{\varphi}{\mu^k}\right)^{\varepsilon^k} \sum_{j=1}^{n_i^k(\varphi)} A_j^k (\tau_{ij}^k)^{1-\varepsilon^k} (T_{ij}^k)^{-\varepsilon^k} \right]^{\rho^k} \tag{5}$$

where $\mu^k \equiv \varepsilon^k\gamma^k/(\varepsilon^k - 1)$ and $\rho^k \equiv 1/[1 + (\gamma^k - 1)\varepsilon^k]$. It is straightforward to check whether profit increases with firm productivity as $\varepsilon^k > 1$. Furthermore, the price must exceed marginal cost for fixed costs to be covered, which requires that $\gamma^k > 1 - 1/\varepsilon^k$. The inequality implies that economies of size ($\gamma < 1$) can be introduced in models of monopolistic competition with CES preferences as long as they are not too strong.[5] There is no theoretical restriction on the degree of decreasing returns, as γ^k is allowed to take arbitrarily high values. In addition, if two firms have the same set of destinations, the more productive firm produces and exports larger quantities at a lower price.

[5]The concepts of economies of size and economies of scale are equivalent in our setting. Increasing (unit) costs and decreasing returns can then be used interchangeably.

It is also worth stressing that the relationship between productivity and the number of destinations is complex under variable marginal costs. Remember that under constant marginal costs and heterogeneous firms, the trade literature finds that (i) the number of destinations served by a firm increases with productivity, (ii) the set of destinations served by a firm is a subset of destinations served by firms with higher productivity, and (iii) the number of destinations chosen by the most productive firm is the number of destinations served by the country hosting the firm (Helpman *et al.*, 2008). Under variable marginal cost, the relationship between productivity and the number of destinations may be nonmonotonic. To illustrate this finding, consider a firm from country i with a set of three potential destinations $j = a, b, c$. The firm is indifferent between exporting to one or two destinations if $\tau_{ia}^k q_{ia}^k + \tau_{ib}^k q_{ib}^k = \tau_{ic}^k q_{ic}^k = y_i^k$ and $f_{ia}^k + f_{ib}^k = f_{ic}^k$. The larger market has a higher fixed export cost, perhaps because of its standards. According to (5), the firm may elect to serve either only destination c or only destinations a and b. In addition, if multiple firms in this situation have the same productivity, some may serve destinations a and b, while others may elect to serve destination c. Accordingly, the equilibrium number of destinations served by country i can vary from 1 to 3 with symmetric firms. Now let us consider the case with $f_{ic}^k > f_{ia}^k + f_{ib}^k$, $\tau_{ic}^k q_{ic}^k > \tau_{ia}^k q_{ia}^k + \tau_{ib}^k q_{ib}^k$ and allow one firm to be more productive than others in the initial equilibrium. Depending on how much more productive that firm is, it could stop selling to markets a and b and begin selling only to market c, a drop from 2 destination markets to 1. With less productive firms selling to markets a and b, the number of flows emanating from the exporting country would nevertheless increase from 2 to 3. Then, if the less productive firms experienced a jump in productivity to restore symmetry between firms, the exporting country would export only to destination c, a drop from 3 destinations to 1.

As a result, the correspondence between a country's set of destinations and that of one or more of its firms is more complicated under convex costs because of the tradeoff between variable profit and fixed export costs. When costs are convex, the most productive firm is the one producing the largest output, but it is not necessarily the firm exporting to the most destinations, as in Helpman *et al.* (2008). In addition, unlike Helpman *et al.* (2008), even if the most productive firm is the firm with the largest set of destinations, that set may not include all destinations served by domestic rivals. Firms experiencing productivity shocks are likely to add and drop destinations. Thus, a subset of profitable destinations may be dropped if new destinations are more profitable. Whether a destination remains in the destination set of an exporting firm still depends on the trade costs for that market, but under increasing marginal costs, it also depends on the firm's trade costs for other destinations. Even if firms end up exporting to fewer but larger markets after a productivity shock, the destination set of the firms' country as a whole may undergo a net expansion if the new, larger markets were not in the country's initial set of destinations and if the destinations dropped by one or more firms nevertheless remain in the sets of other firms.

The following proposition summarizes our discussion:

Proposition 1 *When marginal costs vary with output size and fixed export costs vary across destinations, high-productivity firms need not export to more destinations than exporters with a lower productivity, and the number of destinations served by an exporting country is higher or equal to the number of destinations served by most productive firms.*

Proof. In a multi-country world, consider two sets of destinations $\Gamma^+ \subset \mathbb{R}^N$ and $\Gamma^- \subset \mathbb{R}^N$, where the number of destinations in the former set is equal or greater than in the latter set ($|\Gamma^+| \geq |\Gamma^-|$) and the two sets have at least one destination in common ($\Gamma^+ \cap \Gamma^- \neq \varnothing$).[6] Define $F^k_{i,\Gamma^+} \equiv \sum_{j\in\Gamma^+} f^k_{ij}$ and $F^k_{i,\Gamma^-} \equiv \sum_{j\in\Gamma^-} f^k_{ij}$ as well as $y^k_{i,\Gamma^+} \equiv \sum_{j\in\Gamma^+} \tau^k_{ij} q^k_{ij}$ and $y^k_{i,\Gamma^-} \equiv \sum_{j\in\Gamma^-} \tau^k_{ij} q^k_{ij}$. It follows that the selection of the best set of destinations for an exporting firm from country i is reduced to a sequence of binary comparisons. Hence, using (5), we have $\Gamma^+ \succ (\prec)\, \Gamma^-$ iff $\left(\frac{\mu^k-1}{\varphi}\right)\left[\left(y^k_{i\Gamma^+}\right)^{\gamma^k} - \left(y^k_{i\Gamma^-}\right)^{\gamma^k}\right] > (<)\, F^k_{i\Gamma^+} - F^k_{i\Gamma^-}$.

If $y^k_{i,\Gamma^+} = y^k_{i,\Gamma^-}$ and $f^k_{i,j\in\Gamma^+} = f^k_{i,j\in\Gamma^-}$ regardless of destination j, then the firm prefers to select the set with the lower number of destinations $\Gamma^- \succ \Gamma^+$ to avoid the unnecessary accumulation of fixed export costs. In this case, the choice of destinations must start with larger markets. If all firms in the exporting country are symmetric and there are $\mathcal{N}_i \geq 2$ profit-maximizing sets of destinations, ordered from the largest to the smallest number of destinations, $\Gamma^+ \sim ... \sim \Gamma^-$, the number of export flows from country i is simply $|\Gamma^- \cup ... \cup \Gamma^+| = \Gamma^i$. Note that $\Gamma^i = |\Gamma^-|$ if all symmetric firms choose the smallest set and that $|\Gamma^i| > |\Gamma^+|$ if, for at least two profit-maximizing sets (say, Γ' and Γ''), the following condition $|\Gamma' \cap \Gamma''| < \min\left[|\Gamma'|, |\Gamma''|\right]$ holds.[7] In contrast, under constant (unit) costs, all firms located in country i choose the same set of destinations when they are at the same level of productivity as in Krugman (1980), and the number of destinations at the country level is identical to the number of destinations of any firm. In addition, under constant (unit) costs and heterogeneous firms, the number of destinations for exports from country i is $|\Gamma^i| = |\Gamma^+|$, where Γ^+ is the set chosen by the most productive firm, and the destination set of a firm is a subset of destinations served by a firm with a higher productivity ($\Gamma^+ \cap \Gamma' = \Gamma' \;\forall \Gamma' \neq \Gamma^+$ because $\Gamma' \subset \Gamma^+$), as in Helpman *et al.* (2008). With asymmetric firms and convex costs, a positive productivity shock implies $\left.\frac{\partial \pi^k_i}{\partial \varphi}\frac{\varphi}{\pi^k_i}\right|_{\Gamma} = -1 + \gamma^k \frac{\partial y^k_i}{\partial \varphi}\frac{\varphi}{y^k_i} = \frac{\varepsilon^k - 1}{1+(\gamma^k-1)\varepsilon^k} > 0$ so that $\pi^k_i(\varphi', \Gamma) > \pi^k_i(\varphi, \Gamma)$ when $\varphi' > \varphi$. The elasticity being constant, more productive firms experience larger absolute profit increases than firms with slightly lower productivity with the same set of destinations Γ. Let us assume that the most productive firm is the only firm experiencing a productivity shock. The increase in variable profit prompts the firm to make changes at the extensive margin if $\Gamma' \succ \Gamma$, with

[6]For Canadian firms, competing sets would include at least the United States. For Canadian firms belonging to industries exhibiting high productivity, several sets could include destinations such as Mexico, EU countries, Japan and China.

[7]For example, if some firms select $\Gamma^- = \{\text{United States}, \text{Mexico}\}$ while the other firms choose $\Gamma^+ = \{\text{United States}, \text{France}, \text{Chili}\}$, then $\left|\Gamma^i\right| = 4 > |\Gamma^+| = 3$.

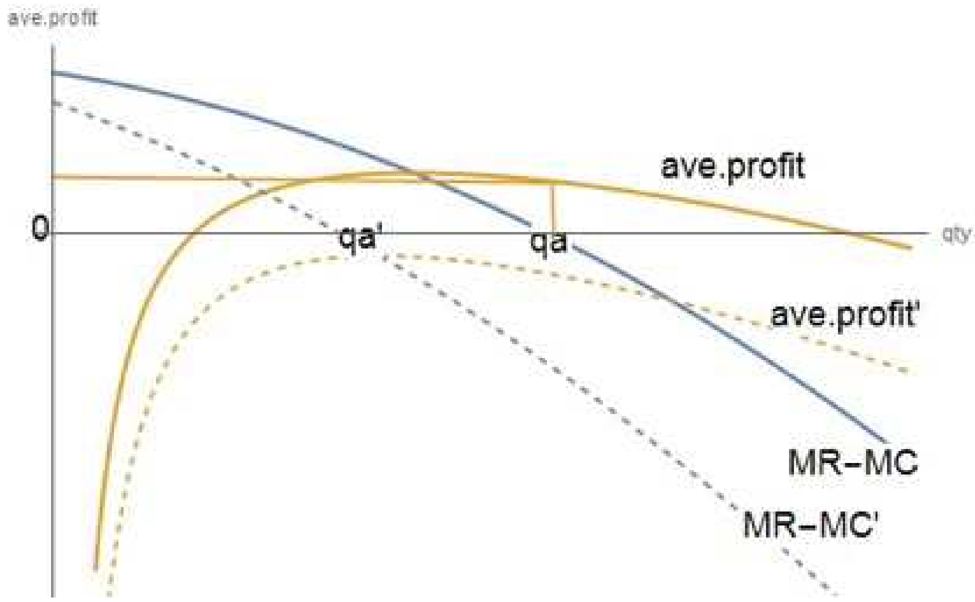

Figure 1: Cost linkages, entries and exits

$|\Gamma'| \lesseqgtr |\Gamma|$. Destinations can be dropped by a firm experiencing an increase in productivity even if these destinations generate more profit. This is especially plausible when large destinations enter the new set. Consider the case of $|\Gamma'| < |\Gamma|$ with $|\Gamma' \cap \Gamma| < |\Gamma'|$. The most productive firm loses more destinations than it gains, but some of the new and lost destinations may not be included in the sets of other firms. Hence, at the country level, the number of destinations may either increase or decrease. ■

Figure 1 illustrates the equilibrium conditions for operating profitably in a market and the notion of technology-induced market linkages. The firm's first-order condition for profit maximization in this market entails choosing a quantity for which marginal revenue equals marginal cost: $MR - MC = 0$. At the proposed quantity, q_a, the firm must make a positive profit. The variable profit, the difference between revenue and variable cost, is the area under the $MR - MC$ line between zero and q_a, while the profit is the rectangle connecting q_a and the average profit line. The difference between the two areas is the fixed cost. If a second market exists, say, market b, the firm's destination set may include only market a, ($\Gamma^a = \{a\}$), only market b, ($\Gamma^b = \{b\}$), or both markets, ($\Gamma^{a,b} = \{a, b\}$). $\Gamma^{a,b}$ would entail increasing production and higher marginal and average costs in both markets. In market a, this shifts downward the $MR - MC$ and the average profit lines, as shown by the dashed lines. The new potential equilibrium quantity in market a would fall to $q_{a'}$, but the firm would lose money at this quantity, which means that $\Gamma^a \succ \Gamma^{ab}$. Then, either $\Gamma^a \succ \Gamma^b$ or $\Gamma^b \succ \Gamma^a$ or $\Gamma^a \sim \Gamma^b$.

Figure 1 also reveals insights about the effect of tariffs on export duration. A tariff increase shifts down the $MR - MC$ and the average profit lines, but unlike what is seen in the parallel shifts in Figure 1, the spreads between the tariff-distorted and nondistorted lines decrease as the quantity sold increases and the border price decreases. A tariff minimally triggers a reduction in the quantity sold in the destination imposing the tariff, but it can also trigger the exit of the firm from that market. The reduction in sales in the destination imposing the tariff decreases output and hence marginal production cost, which has intensive and extensive margin effects in other markets. Thus, the $MR - MC$ and the average profit lines in other markets would shift up, and it follows that a tariff-induced exit might induce entries elsewhere. The incidence of a tariff is conditioned by the elasticity of substitution, as foreign consumers will reduce their consumption of taxed varieties by a greater extent in response to a tariff hike when taxed and untaxed varieties are close substitutes. Accordingly, the lowest tariff that induces the exit of an exporting firm is lower when the elasticity of substitution is high. By the same token, the probability of tariff-induced entry is higher when varieties are more homogeneous.

Therefore, a large market with a small fixed export cost generating a large profit is more likely to be chosen when comparing potential export configurations. In the presence of an adverse demand shock reducing A_j^k (or a tariff increase) in market j, the exporting firm will maintain the same set of destinations if the shock is small, and make only intensive margin adjustments, by reducing sales to market j and increasing sales on other markets. Because other incumbent markets become more profitable, they increase *de facto* their resilience to their own adverse shocks. This occurs because the shock brings about a drop in production y_i^k. If the adverse shock in market j is large enough to prompt the firm to drop market j, markets where sales increase, including new markets, are *de facto* more resilient. If the exporting firm has large markets in its set of destinations, dropping a marginal market j will not bring about a large change in the marginal cost. This limits the possibility of entering new markets and tends to increase export duration for incumbent markets. If a few marginal markets are dropped, they can be replaced by one or more new destinations with fixed costs low enough to support small exports. This is consistent with the Costa Rican import pattern described by Arkolakis *et al.* (2012), who argued that marginal varieties contributed little to the gains from trade because of the small imported volumes. Small markets tend to be more interchangeable. If a large adverse shock hits a large export market, the cumulative effect of fixed export costs to new alternative markets makes it unlikely that production will remain the same and that foregone export sales will be completely offset by new sales. In such cases, incumbent destinations become more profitable and hence less likely to be dropped if adverse shocks were to hit them. The following proposition summarizes our discussion:

Proposition 2 *When variable cost increases with output size, foregone sales from terminated trade flows reduce marginal costs and make incumbent destinations more profitable, all else being equal. Export duration in incumbent destinations increases (decreases) when exports to third countries fall (increase), implying a fall (rise) in total production.*

Proof. Using (4), the export values to destination j of product k supplied by a producer located in i, $x^k_{ij} \equiv p^k_{ij} q^k_{ij}$, can be rewritten as:

$$x^k_{ij}(\varphi) = A^k_j(\mu^k - 1)^{-\theta^k} \varphi^{\theta^k} [y^k_i(\varphi)]^{-(\gamma^k - 1)\theta^k} \left(\tau^k_{ij}\right)^{-\theta^k} \left(T^k_{ij}\right)^{-\theta^k} \quad (6)$$

where $\theta^k \equiv \varepsilon^k - 1$ (the *trade elasticity*). The distinguishing feature of equation (6) is the inclusion of the component that aggregates the size of individual markets chosen by the firm. This term disappears under constant returns when $\gamma^k = 1$. We study shocks prevailing in third countries on the above bilateral export equation. Consider that $y^k_i = \tau^k_{ij} q^k_{ij} + Q^k_{ij'}$, where $Q^k_{ij'} = \sum_{j' \neq j} \tau^k_{ij'} q^k_{ij'}$, and $q^k_{ij} = A^k_j (p^k_i)^{-\varepsilon^k} (\tau^k_{ij})^{-\varepsilon^k} (T^k_{ij})^{-\varepsilon^k}$. Applying the composite function rule, the *partial* impact of shocks in third countries $\mathrm{d}Q^k_{ij'}$ (holding price indexes and expenditures in other countries, captured by the term A^k_j, constant) can be decomposed as follows:

$$\frac{\mathrm{d}x^k_{ij}}{\mathrm{d}Q^k_{ij'}} = \frac{\partial x^k_{ij}}{\partial p^k_i} \left(\frac{\partial p^k_i}{\partial Q^k_{ij'}} + \frac{\partial p^k_i}{\partial q^k_{ij}} \times \frac{\partial q^k_{ij}}{\partial Q^k_{ij'}} \right). \quad (7)$$

The first effect corresponds to the direct impact of the change in total production on price and, subsequently on sales. The second effect captures the indirect impact through a change in demand as $q^k_{ij} = A^k_j \left[p^k_i(q^k_{ij}, Q^k_{ij'}) \right]^{-\varepsilon^k} (\tau^k_{ij})^{-\varepsilon^k} (T^k_{ij})^{-\varepsilon^k}$, where q^k_{ij} is implicitly defined. Standard calculations show that the elasticity of bilateral trade to a change in demand from third countries is:

$$\frac{Q^k_{ij'}}{x^k_{ij}} \frac{\mathrm{d}x^k_{ij}}{\mathrm{d}Q^k_{ij'}} = - \frac{(\gamma^k - 1)(\varepsilon^k - 1)}{[1 + (\gamma^k - 1)\varepsilon^k] y^k_i / Q^k_{ij'} - (\gamma^k - 1)\varepsilon^k} < 0. \quad (8)$$

Hence, for given expenditures and price indexes (term A^k_j), negative (positive) demand shocks in third countries yield a rise (fall) in bilateral trade in incumbent destinations under cost convexity. If the shocks in third markets are large, this may reduce the variable profit in market j enough to trigger an exit and increase the duration of exports in incumbent markets. ■

The above proposition identifies a link between the sum of foregone trade flows and export duration that can be confronted to data.

4. Model specification, data and descriptive statistics

Introducing variable marginal costs in a multi-country trade model makes the analysis complex because prices depend on export volumes, which themselves depend on prices. Hence, we cannot provide an explicit expression of equilibrium prices and a trade equation that can be directly estimated. However, we can test the main prediction of our model by studying the impact of shocks prevailing in third countries on bilateral export duration. Indeed, in the short run, there would be no impact if marginal costs are constant. In contrast, if marginal costs increase with output size, we would expect past exits to increase the survival of current flows.

When a third country imports less from a given exporting country, this will lead to a decrease in production and price and make the exporter more competitive in other importing countries and more likely to survive. Events such as the Russian embargo and the Unites States-China trade war have shown that large terminated trade flows have strong effects on export duration in other markets. Consider the consequences of the 2014 Russian import embargo on Canadian frozen pork. Russia was the largest importer of Canadian frozen pork before 2014, but after the embargo, Canadian firms increased their number of tons of frozen pork exported to China and the United States by 14.6% and 11.4%, respectively. They also reduced the total number of tons of frozen pork exported worldwide by 10% and increased the total number of tons of fresh pork exports by 11%. Almost all of the growth in Canadian fresh pork exports was due to increases in exports to Japan and Mexico.[8] Interestingly, Canadian production has remained stable, with total hog slaughter slowly increasing since 2013, despite the Russian embargo.[9] Canadian firms relied on "fallback" markets or large export markets to reallocate their Russian sales.[10] A large domestic market may serve this purpose, as indicated by Vannoorenberghe (2012), who shows that a firm's domestic sales tend to be more volatile when the share of exports in the firm's total sales increases. If the lost market is very large and the firm already exports to many destinations, the reduction in average variable cost will make it easier to penetrate new markets, but if the untapped markets are small, the cumulative effect of fixed export costs will induce the firm to favor intensive margin adjustments and cut its production. The United States-China trade dispute has had this sort of impact on United States soybean exports. The United States soybeans were exported to 30 countries in 2016, with China being the largest market. The drop in United States exports to China in 2018 triggered exports to 11 new destinations that, along with intensive margin adjustments in fallback markets, could not prevent a substantial reduction in total exports.[11] While this anecdotal evidence about terminated flows is consistent with our theoretical arguments, it is no substitute for a thorough multi-product multi-country export duration analysis.

4.1. Model specification

The distribution of duration is modeled *via* the probability of ending a trade flow in product k from an exporting country to destination country j at each period t.[12] For each exporting

[8] Trade statistics are from StatCan's Canadian International Merchandise Trade Database, http://www5.statcan.gc.ca/cimt-cicm/home-accueil?lang=eng.

[9] Slaughter statistics are from Agriculture and Agrifood Canada, http://www.agr.gc.ca/eng/industry-markets-and-trade/market-information-by-sector/red-meat-and-livestock.

[10] In their analysis of the Russian embargo on EU exports, Cheptea and Gaigné (2020) find a relatively small increase (7%) in new destinations targeted by EU exporters.

[11] see https://www.fb.org/market-intel/u.s.-soybean-exports-to-China-fall-sharply.

[12] Although our theoretical model is about firms, our empirical results are derived from country-level data. Under common assumptions, analyzing the relationship between the duration of export flows of firms and their origin country is straightforward. With symmetric firms and constant marginal costs, if one firm is forced to exit, all of the other firms from the same exporting country will also be forced to exit. With firms with heterogeneous produc-

country, product-destination pairs are indexed as a product-destination trade flow ℓ, and Υ_ℓ is the survival time for flow ℓ. We can then define the discrete-time hazard rate as:

$$h_{\ell t} := P(\Upsilon_\ell < t+1 | \Upsilon_\ell \geq t, \mathbf{X}_{\ell t}) = F(\mathbf{X}'_{\ell t}\beta + \nu_{\ell t}) \quad (9)$$

where $h_{\ell t}$ is the probability that a particular trade relation terminates at a given time t, $\mathbf{X}^k_{\ell t}$ is a vector of covariates (including the exits from third markets at $t-1$, our interest variable), and $\nu_{\ell t}$ is a function of time that allows the hazard rate to vary across periods (Hess and Persson, 2012). $F(.)$ is a cumulative distribution function ensuring that $h_{\ell t} \in [0, 1]$. We tested three estimators for the hazard rate model: the probit model, the complementary log-log (cloglog) model and the logit model. Unlike the Cox proportional specification, these estimators have the advantage of taking into account multiple spells and unobserved heterogeneity (Hess and Persson, 2012).

We follow Besedeš and Prusa (2006b), Hess and Persson (2012), Peterson *et al.* (2017), and Bojnec and Fertő (2009) in relying on covariates that include market size proxies, such as GDP per capita and population,[13] and trade cost proxies, such as tariffs, distance, common language, contiguity, a landlocked indicator, religious openness and the presence of livestock diseases. A multiple-spell indicator is included to account for learning from past export spells, and the exchange rate volatility is included to account for risk. Helble (2006) finds that the presence of different religions within a country promotes trade. Distance is expected to increase the likelihood of an export failure, while sharing a common language is expected to lower search costs, similar to sharing a land border (contiguity) (Rauch, 1999). Frankel *et al.* (1998) argues that having a common language is an indicator of taste similarity. Landlocked destinations are associated with higher trade costs and with a higher probability of export failure. Besedeš and Prusa (2006b) use multiple spells as an indicator of trading experience. Past contacts reduce search costs and make entry and survival easier. On the other hand, easier entries make exits less costly and favor frequent entries and exits. Multiple spells take the value 1 if the exporter-importer-product triplet experiences multiple spells and zero otherwise. [14]

The novel element in our export survival specification is the level of foregone sales from *exits*. We do not use changes in export sales to third countries, as such changes can be due to price variations while export volumes remain unchanged. Rather, we use the fall of exports associated

tivities, the probability of a positive flow for an exporting country is determined by the probability that the most productive firm in the exporting country can make a weakly positive profit. When marginal costs increase, Proposition 1 shows that the correlation between the probability of export for the country and for its most productive firm is not as strong. Nevertheless, variables that make firms more likely to export generally correlate with the survival of an exporting country's trade flow. However, Proposition 2 suggests that with an increasing marginal cost, it is important to augment the typical hazard rate equation with a terminated flows variable.

[13]With homothetic CES preferences, aggregate consumption depends on market size. However, given that importing countries vary greatly in their level of development, many empirical studies rely on per capita income and population to allow for income distribution effects.

[14]We also ran our models with the number of previous spells and obtained similar results.

with exits from foreign markets. In this case, changes in exports due to exits are necessarily associated with a shift in production. Our prior is that past exits increase the survival of current flows.

In addition, among traditional covariates, we contend that the effect of tariffs has not been properly estimated in previous export duration studies, prompting authors to try to rationalize a theoretically inconsistent empirical result possibly caused by endogeneity bias. As argued by Trefler (1993), trade protection adjusts to the level of trade and confounds the negative effect of tariffs on trade. We believe that the problem also extends to export duration. Therefore, we apply the two-stage residual inclusion (2SRI) procedure developed by Terza *et al.* (2008) to test and correct for the presence of an endogenous regressor. The 2SRI estimator is consistent and easy to implement. In the first step, we regress the applied tariff on the observable factors impacting duration augmented by one or more identifying instrumental variables. The residuals are then saved and used as an additional regressor in the second-stage duration regression, which also includes the tariff. The presence of the residuals as an extra regressor corrects for the endogeneity of the tariff variable. The null of tariff exogeneity can be tested directly by checking the significance of the correcting regressor. In the first stage, we implement the following auxiliary regression for each exporting country $T_{\ell t} = \alpha Z_{\ell t} + \tilde{\mathbf{X}}'_{\ell t}\beta + \rho_{\ell t}$, where $\tilde{\mathbf{X}}_{\ell t}$ includes the covariates of the duration equation, except the tariff, $Z_{\ell t}$ includes the identifying instruments, and $\rho_{\ell t}$ captures unobservable confounder latent variables (omitted variables) that influence the outcome of $h_{\ell t}$ while being correlated to tariffs but uncorrelated with the instruments.

Valid instruments must be highly correlated with applied tariffs and uncorrelated with the hazard rate. Potential candidates can be found in sectoral gravity studies that have dealt with endogenous tariffs, such as Buono and Lalanne (2012) and Fontagné *et al.* (2019), and studies about the setting of applied and bound tariffs, such as Nicita *et al.* (2018). These authors used either past applied tariffs $T_{\ell,t-1}$, past bound tariffs $T^b_{\ell,t-1}$ (the maximum most-favored nation tariff level for a given commodity line) or prohibitive tariff rates $T^p_{\ell t}$ (*i.e.,* the one that corresponds to zero import flows) as instruments.[15] As stated by Nicita *et al.* (2018), tariffs above prohibitive rates cannot affect imports and, by the same token, cannot affect duration. Formally, the computation of the prohibitive bound tariff uses a linear approximation around the level of imports so that $T^p_{\ell t} = T_{\ell t}(1 + 1/\eta_{\ell t})$, where $\eta_{\ell t}$ is the elasticity of import demand for the destination-product pair ℓ at year t.[16] This formula shows that countries with high prohibitive tariffs tend to have

[15] The protection for sale hypothesis suggests that tariffs are conditioned by past import-production ratios. Unfortunately, production data for disaggregated product categories do not exist. This is why lagged applied tariffs and lagged bound tariffs are more commonly used instruments.

[16] The formula can be obtained from a linear bilateral import demand of the form $p^w_{\ell t} T_{\ell t} = A - Bq_{\ell t}$ with $A, B > 0$ and $p^w_{\ell t} = p_{\ell t}/T_{\ell t}$. It follows that $T^p_{\ell t} = T_{\ell t}(1 + 1/\eta_{\ell t})$, where $\eta_{\ell t} \equiv \frac{\partial q_{\ell t}}{\partial p^w_{\ell t} T_{\ell t}} \frac{p^w_{\ell t} T_{\ell t}}{q_{\ell t}}$. In a monopolistic trade model with CES preferences, elasticity is an exogenous parameter that does not depend on tariffs. Several studies simply pick an elasticity of substitution, but we used a gravity model to estimate an import elasticity for each product. In this setting, the demand is convex, but a first-order Taylor expansion of import demand (1) around

higher applied tariffs. Higher tariffs are also conducive to black market activities that flourish when countries have weak institutions. We use the transparency index, $TI_{j,t}$ of country j at year t as a second instrument to explain applied tariffs.[17]

4.2. Data sources

The dataset covers 235 product categories over the 2005-2014 period. The products, defined at the 6-digit HS level, can be classified into 6 broad groups: cereals, fruits and vegetables, meat, oilseeds, dairy products and cocoa. Exports originate from six large exporting countries (Australia, Brazil, Canada, France, Germany and the United States) and are shipped to 176 potential destinations. Using disaggregated data allows us to more accurately characterize the dynamics of trade because a successful export episode for one product can hide a multitude of failures when analyzing highly aggregated data.

Bilateral import values X_{ijt}^k and tariffs T_{ijt}^k come from the website of World Integrated Trade Solutions (WITS). The Tariff Analysis Online tool from the World Trade Organization (WTO) was used to obtain tariffs that were not in WITS. Most countries have an average agricultural tariff of 15 to 18 percent, but tariff peaks in excess of 100 percent are relatively common. Data series on languages, distances, colonies and borders were downloaded from the GeoDist database of the Centre d'Études Prospectives et d'Informations Internationales (CEPII). The religious openness index data primarily came from the CIA World Factbook. The Britannica Book for 2013 was used to fill in missing observations. The religious openness index (ROI) is defined as in Helble (2006), $ROI_{ij} = \sum_i d_{ri} \sum_j d_{rj}$ with $i \neq j$, where d_{ri} is equal to unity if each of the world's five main religions r is present in country i and zero otherwise. A higher ROI_{ij} indicates that more religions are present in both countries.

Real exchange rate volatility was constructed from the IMF's International Financial Statistics data on monthly nominal exchange rates and the Consumer Price Index (CPI). We follow the recent work of Héricourt and Nedoncelle (2018) in constructing a bilateral real exchange rate (RER) volatility index σ_{jt}^{RER} for each exporting country. The bilateral RER is defined as $RER_{j,m,t} = e_{j,m,t} p_{j,t} / p_{dom,t}$, where $e_{j,m,t}$ denotes the nominal exchange rate of the domestic currency with respect to destination j's currency at the end of month m of year t, and $p_{j,t}$ and $p_{dom,t}$ represent the consumer price index of the destination and, respectively, domestic country in year t. The bilateral RER volatility index is defined as the yearly standard deviation of monthly log differences in real exchange rate: $\sigma_{jt}^{\text{RER}} = \left(\sum_{m=1}^{12} [(\ln \text{RER}_{j,m+1,t} - \ln \text{RER}_{j,m,t}) - \mu_{jt}]^2 / 11 \right)^{1/2}$, where μ_{jt} stands for the mean. The effect of exchange rate volatility on exports is notoriously

observed tariffs $\tilde{T}_{ij}^k$ implies $q_{ij}^{k,\prime} = q_{ij}^k(\tilde{T}_{ij}^k) - \varepsilon^k \frac{q_{ij}^k(\tilde{T}_{ij}^k)}{\tilde{T}_{ij}^k}(T_{ij}^k - \tilde{T}_{ij}^k)$, so that $q_{ij}^{k,\prime} = 0$ when $T_{ij}^k = \tilde{T}_{ij}^k(1 + 1/\varepsilon^k)$.

[17] The transparency index was downloaded from the website of Transparency International. It is an indicator of public sector corruption that ranges between 0 and 100, from most to least corrupted countries.

ambiguous (*e.g.*, McKenzie, 1999; Bonroy *et al.*, 2007). Data for GDP per capita and population come from the World Development Indicators of the World Bank.

Animal disease outbreaks often trigger temporary trade bans and induce the adoption of stricter regulations and standards that permanently increase production costs. Meatpackers in countries that have had bovine spongiform encephalopathy (BSE) cases, such as Canada and the United States, must remove "specified risk materials". Bans may also affect the reputation of targeted exporting countries and diminish export survival for other products.[18] Our measure takes into account the dynamic process of disease outbreaks, that is, the recovery period of a country affected by animal diseases. To account for the recovery period, we constructed BSE and avian flu variables that take the value 1 until one year after the last infected animal was destroyed.

4.3. Descriptive statistics

Table 1 reports the mean number of destinations, mean and median export durations in years by exporter and product category. It also reports on the average number of exits and entries by product category and by exporting country for the year 2014.[19] Regardless of the product category, United States agricultural exports reach more destinations than Australian, Brazilian, and Canadian exports, but fewer destinations than French and German exports. Geography matters, with France and Germany being close to many other EU members and several other European countries. Nevertheless, product groups also matter. The average number of destinations buying European products is particularly high for dairy and cocoa products. "Cocoa products" is the product group with the highest number of destinations for Brazil, Germany and the United States, and second highest for Canada and France.[20] Canada's small number of destinations for its dairy products can be explained by its dairy supply management policy, which discourages imports and exports.

In terms of mean and median export durations, in Table 1, the country rankings are similar to those for destinations, with Germany and France having the longest mean and median

[18] According to the World Organization for Animal Health (OIE) guidelines, it takes three months for a country experiencing avian influenza to regain its disease-free status after the last infected poultry has been destroyed and all premises have been disinfected. Avian influenza was found to reduce trade (Paarlberg *et al.*, 2007; Johnson *et al.*, 2015). Several countries have had to deal with BSE (Zongo and Larue, 2019). Canada implemented the Enhanced Feed Ban (EFB) initiative in 2007, even though it was dealing with only a few BSE cases at the time. This and other BSE-related initiatives contributed to Canada being labeled a "controlled BSE risk" country by the World Organization for Animal Health.

[19] Using a single year makes for sharper comparisons across products and countries.

[20] Cocoa beans can be easily imported and processed into exportable products. In 2014, Canadian and United States exports of cocoa and chocolate products were close ($1.22 billion *vs* $1.3 billion); the countries had similar export compositions, with 4 of the 11 HS products accounting for 97% and, respectively, 86% of all cocoa and chocolate exports, but differed in terms of destinations, with 33 for the United States and 13 for Canada. Most of Canada's cocoa exports end up in the United States and are exported by a plant operated by a Swiss multinational. Once the United States orders are filled, the plant has little capacity left to serve other destinations. A fixed capacity is an extreme form of cost convexity. United States exports are also highly concentrated, with Canada, Korea, Japan and Australia accounting for 54%, 5.9%, 4.2% and 4.2% of the total, respectively.

Table 1: **Average number of destinations, mean and median duration of bilateral export flows, exits and entries of foreign markets, by exporting countries in 2014**

Products	Brazil	Canada	USA	Australia	France	Germany
All product groups						
Destinations	8.95	7.28	19.82	10.47	30.12	30.32
Duration mean (median)	5.1 (4)	4.2 (2)	4.6 (3)	5 (4)	6.1 (7)	6.2 (7)
No. of exits	9.09	8.17	8.5	9	5.68	4.92
No. of entries	1.6	1.45	3.04	1.81	6.93	5.19
Meats						
Destinations	12.14	9.39	20.40	16.12	22.45	22.70
Duration mean (median)	4.9 (3)	4.2 (2)	4.7 (3)	5.2 (4)	5.7 (6)	5.5 (5)
No. of exits	7.2	8.13	8.45	8.35	5.05	3.9
No. of entries	1.13	1.01	2.56	2.63	6.14	4.43
Dairy						
Destinations	6.82	5.02	25.42	20.72	75.24	64.35
Duration mean (median)	3.7 (2)	3.5 (2)	5.2 (5)	5.8 (6)	7.1 (10)	6.6 (9)
No. of exits	1.04	1.91	5.5	3.8	9.29	10
No. of entries	0.97	0.95	3.11	1.07	12.64	10.35
Fruits and Vegetables						
Destinations	10.36	2.63	18.76	9.81	24.87	20.66
Duration mean (median)	4.8 (3)	3.1 (2)	5.3 (4)	5.1 (4)	6.1 (8)	6.1 (7)
No. of exits	7.31	4.84	6.59	6.11	6.65	3.9
No. of entries	1.42	0.44	2.42	1.31	8.7	4.1
Cereals						
Destinations	10.03	14.24	30.46	7.65	29.93	30.01
Duration mean (median)	4.1 (3)	4.3 (2)	5 (4)	4.5 (3)	5.9 (6)	6.1 (7)
No. of exits	12.65	11.04	10.48	11.3	5.25	5.25
No. of entries	1.89	3.18	3.63	1.53	6.62	5.25
Oilseeds						
Destinations	5.96	8.69	20.59	8.14	24.19	29.71
Duration mean (median)	4.4 (3)	4.7 (3)	5.3 (4)	4.6 (3)	5.8 (6)	6.3 (9)
No. of exits	9.1	8.19	7.84	9.78	5.07	4.25
No. of entries	1.36	1.82	3.44	2.17	5.02	4.83
Cocoa						
Destinations	26.22	11.83	32.95	13.02	64.13	65.55
Duration mean (median)	5.3 (4)	4.1 (3)	5.7 (6)	4.7 (3)	6.9 (10)	7.1 (10)
No. of exits	13.69	11.04	9.26	13.19	7.09	7.45
No. of entries	4.36	3.18	3.02	2.29	9.54	6.18

durations, and Canada the lowest. Product perishability reduces survival probability, as shown by the mean and median durations for fruits and vegetables and meats.[21] Differences between mean and median durations suggest that the length of export spells is skewed. For Australia,

[21]The shorter marketing window for perishable products makes marginal destinations more likely to disappear, as exporters hurry to unload their supplies.

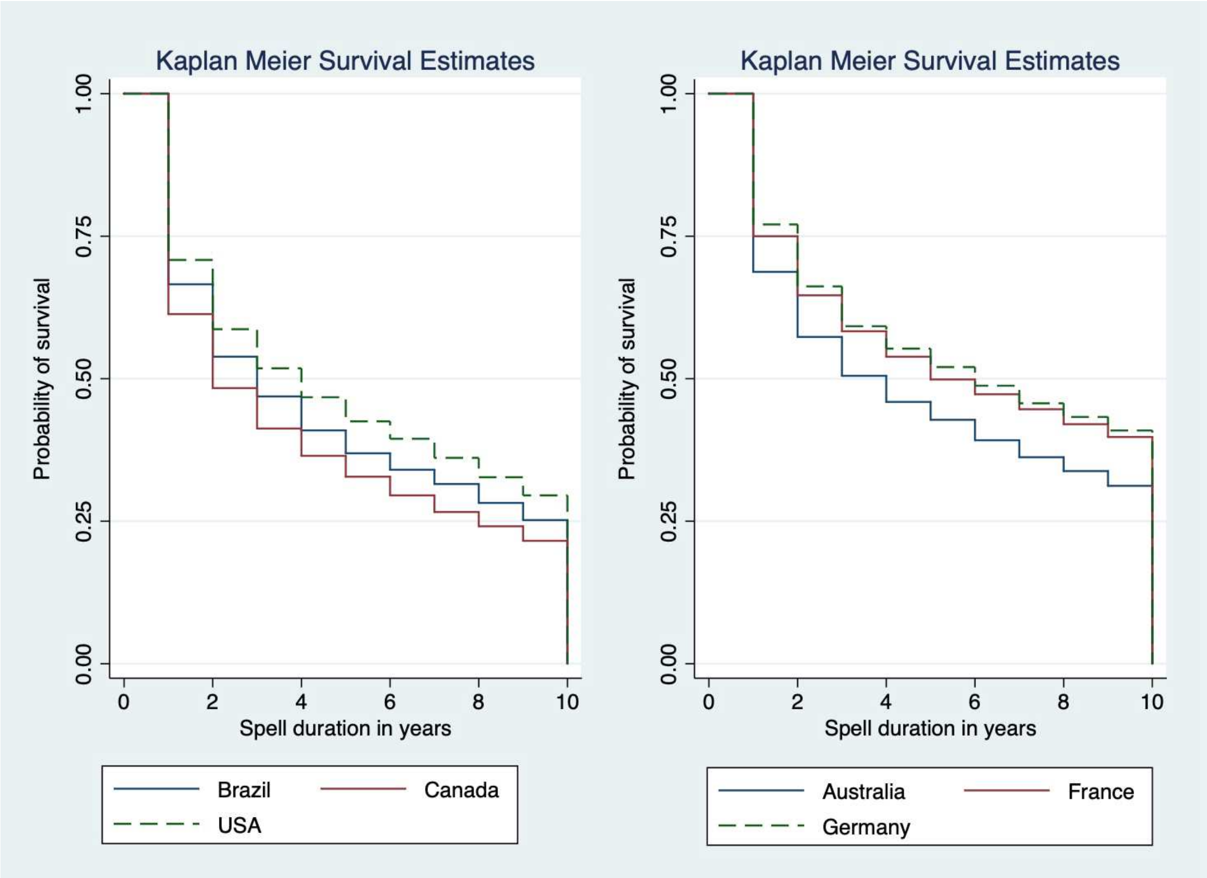

Figure 2: **Kaplan-Meier estimates for spells of different lengths**

Brazil, Canada and the United States, export spells for most product categories are right-skewed with more flows failing before the mean survival than after it. For Germany and France, export duration is left-skewed for almost all product categories. Complementary Kaplan-Meier survival estimates are shown in Figure 2. The drop in export survival after a year is large for all exporting countries, but more so for Canada, Brazil and Australia. Export survival reductions are more subtle after 4 years, but the cumulative reductions are such that German and French exports that have survived the first 10 years are twice as likely to survive a year longer than Canadian exports that have also survived 10 years.

Table 1 also reports on the average number of exits and entries by product category and by exporting country for the year 2014.[22] One might be tempted to argue that countries exporting to more destinations have more exits and new trade flows. For example, France and Germany have more exits and entries for dairy products than other exporting countries do, but the opposite is observed for fruits and vegetables. Thus, participation in a large common market and in several free trade areas and sharing a common currency must lower the number of exits and facilitate entries. French and German entries are higher across all product groups, and their exits are

[22]Using a single year allows sharper comparisons across products and countries.

Table 2: **The effect of lost markets on new markets and on fallback markets, by exporting country**

	Brazil	Canada	USA	Australia	France	Germany
	Explained variable: Sum of new trade flows					
Sum of terminated flows at t-1	0.282***	0.824***	-0.107***	0.133	-0.120***	-0.742***
	(4.24)	(36.19)	(-4.11)	(0.87)	(-3.99)	(-14.21)
Observations	1,158	1,266	1,723	1,393	1,676	1,662
R^2	0.52	0.64	0.25	0.30	0.30	0.53
	Explained variable: Number of new trade flows					
No. of terminated flows at t-1	0.023*	0.028*	0.098***	0.053***	0.123***	0.030
	(2.59)	(2.79)	(6.59)	(5.61)	(4.61)	(1.21)
Observations	1,880	1,880	1,880	1,880	1,584	1,576
R^2	0.70	0.592	0.56	0.60	0.64	0.60
	Explained variable: Sum of exports to fallback markets					
	China	USA	Mexico	China	Germany	France
Sum of terminated flows at t-1	0.309***	0.712***	0.541**	0.0078***	0.097**	1.350***
	(6.02)	(9.48)	(2.38)	(3.22)	(2.91)	(4.05)
Observations	1,158	1,588	1,587	1,393	1,676	1,662
R^2	0.52	0.92	0.89	0.30	0.29	0.68

*Note: All estimations include product fixed effects and year fixed effects. See the text for the definition of variables and data sources. Robust t statistics are in parentheses, with ***, **, and * denoting significance at the 1% level, 5% level, and 10% level, respectively.*

lower for cereal oilseeds and cocoa products. Additionally, Australia, Brazil, Canada and the United States have rather similar numbers of exits and entries across product groups and in aggregate.

Table 2 reports on three sets of regression results. The first set of results concerns the relationship between foregone exports from summing up terminated export flows at $t-1$ and the sum of new export flows at t, while controlling for other factors through product and year fixed effects. For Australia, Brazil and Canada, new export sales increase with the sum of terminated export flows. The reverse is observed for the United States, France and Germany, which export to significantly more destinations. The number of destinations matters because larger (or more profitable) markets are served first, and an exporting country serving a large number of destinations is left with very small potential new markets when reallocating foregone sales from larger markets.

The relationship between terminated and new markets can also be examined in terms of the number of lost destinations and the number of new destinations. The contemporaneous correlations between these two variables for Brazil, Canada and the United States are 0.37, 0.44 and

0.44, respectively. For Australia, France and Germany, the correlations are 0.31, 0.43 and 0.39. During any given year, there is most likely a great deal of feedback between the number of lost destinations and the number of new destinations, as suggested by Proposition 2. To sort out a causal link between the latter and the former, we regress the number of new destinations on the lagged number of terminated destinations, along with product and year fixed effects. As per our prior, a positive effect is found for all six exporting countries, but Germany's coefficient lacks estimation precision. These results suggest that terminated and new destinations are related.[23]

Our theoretical model also points out that forgone exports from terminated trade flows trigger intensive margin adjustments, and this is all the more so in "fallback" markets. The domestic market of an exporting country is an obvious fallback market. The main export destination(s) can also help smooth out variations in total exports following the termination of trade flows. The bulk of Canada's agricultural exports head to the United States, and one would expect Canadian exporters to turn to United States importers to make up for lost third markets. Table 2 shows that Canadian agricultural exports to the United States increase by 0.712% when Canada's foregone sales from vanishing trade flows increase by 1%. We chose Mexico as the fallback market for United States exporters, although Canada and China were other likely candidates. A 1% increase in foregone United States exports from terminated United States trade flows increases United States exports to Mexico by 0.54%. Furthermore, China is a buffer market for Australian and Brazilian exports, and France and Germany are each other's buffers, as shown by the positive and statistically significant coefficients. The difference in the size of the coefficients suggests that German exporters rely more intensively on the French market in reacting to terminated trade flows than French exporters do on the German market.

5. Results

In this section, we report on the incidence of lagged foregone export flows, tariffs and other covariates on export failure. The results of our various discrete-time hazard models (probit, cloglog and logit) without correcting for tariff endogeneity can be found in Table 3. This table reports only the coefficients associated with the volume of exits and tariffs, even though all of the models were estimated with the full set of covariates. The negative tariff coefficients for Australia and Brazil suggest that higher tariffs decrease the probability of an export failure. For Canada, the United States, France and Germany, higher tariffs do not have a statistically significant effect on export failure. Taken together, these results are inconsistent with theory and misleading as to the effect of tariffs on the probability of an export failure. Tariff coefficients suggesting that higher tariffs decrease the risk of an export failure are not unusual in export duration studies. Attempts at rationalizing this peculiar outcome typically appeal to the no-

[23]The relationships would be stronger if monthly or weekly data could be used, as some products, such as fresh fruits and vegetables and fresh meats, must be marketed within a year.

tion that higher tariffs reduce competition for incumbent firms. However, reduced competition implies that some exporting firms have exited. As shown in our theoretical section, incumbent firms reduce their production in response to higher tariffs and earn lower profits, making them more likely to exit in the event of a negative demand shock. We argue that the incorrect sign for tariff coefficients is due to an endogeneity bias. Countries may make tariff adjustments in response to rapid import increases and to pressure from domestic lobbies (*i.e.*, a positive duration shock in our model) or to changes in market conditions, in an effort to exploit terms of trade. WTO members are constrained in their ability to make tariff adjustments, but those with high bound tariffs and low applied tariffs have "policy space" to make upward tariff adjustments. WTO members with low bound tariffs typically resort to anti-dumping, countervailing or other safeguard measures in responding to rent-seeking lobbies. As pointed out by Trefler (1993), the theory of endogenous protection predicts that higher levels of import penetration will lead to greater protection. Accordingly, tariff endogeneity ought to be expected in export duration regressions, and the tariff coefficients reported in Table 3 are downward biased. Because the log likelihood values are quite similar across estimators for the six exporting countries in Table 3, subsequent analyzes will rely on the probit estimator.

To correct for the presence of an endogenous regressor, we applied the 2SRI procedure developed by Terza *et al.* (2008). We used the transparency index and the prohibitive tariff as instruments. As a robustness test, we replaced the prohibitive tariff instrument with lagged bound tariffs. The validity of the 2SRI approach first hinges on the condition that selected instruments make a significant contribution in the first-stage auxiliary tariff regression. The results regarding individual coefficients presented in Table 4 are quite suggestive about the adequacy of the prohibitive tariff and the transparency index as instruments. Standard practice entails computing joint significance tests to confirm that variations in the proposed instruments explain a significant portion of variations in the endogenous regressor. As recommended by Cameron and Trivedi (2005) and in the spirit of Stock and Yogo (2005), an F-statistic in excess of 10 can be used to validate the strength of instruments when the number of instruments is low. For Brazil, Canada, the United States, Australia, France and Germany, the F-statistics are 58.4, 22.6, 12.3, 37.2, 216.1 and 86.3, respectively. The second condition for the 2SRI approach for detecting an endogeneity bias is for the first-stage residuals to be highly significant in the second-stage regression. The first-stage residuals act as a correcting regressor in second-stage regressions, and a test regarding the significance of the correcting regressor is a test regarding the null hypothesis of exogenous tariffs. For any other 2-step procedure, the standard errors of the second-stage regressions must be corrected to account for the noise in generating the correcting regressor from the first-stage regression. We used the exact correction proposed by Terza *et al.* (2016), which is more accurate than the bootstrapping alternative. Tables 5 and 6 present the second-stage regression results by groups of 3 exporting countries. The coefficient for the first-stage residuals is highly significant and negative for all exporting countries. The

Table 3: **Partial results regarding the decomposition of the probability of export failure with exogenous tariffs, by exporting country**

Exporting country		Probit	Cloglog	Logit
Brazil	Applied tariffs	-0.00105*	-0.000551	-0.00214**
		(-1.96)	(-1.57)	(-2.14)
	Volume of exits	-0.175***	-0.167 ***	-0.325***
		(-58.45)	(-55.54)	(-57.42)
	Log likelihood	-29736.42	-29680.83	-29756.68
	Pseudo-R^2	0.201	0.190	0.204
Canada	Applied tariffs	0.0015	0.0014	0.00182
		(1.85)	(2.04)	(1.72)
	Volume of exits	-0.0402***	-0.0362 ***	-0.073 ***
		(-12.82)	(-12.39)	(-12.32)
	Log likelihood	-27734.15	-28011.49	-27704.09
	Pseudo-R^2	0.907	0.090	0.100
USA	Applied tariffs	0.000265	0.000456	0.000373
		(0.62)	(1.07)	(0.51)
	Volume of exits	-0.0068**	-0.0022	-.0146**
		(-2.73)	(-0.89)	(-3.28)
	Log likelihood	-52264.22	-52933.13	-52215.36
	Pseudo-R^2	0.106	0.103	0.105
Australia	Applied tariffs	-0.000235	- 0.0000714	- 0.00079
		(-0.97)	(-0.24)	(-1.37)
	Volume of exits	-0.129***	-0.130 ***	-0.258 ***
		(-26.71)	(-26.71)	(-27.24)
	Log likelihood	-27704.09	-27959.99	-28121.30
	Pseudo-R^2	0.284	0.279	0.282
France	Applied tariffs	0.00078	0.00037	0.0013
		(1.85)	(0.99)	(2.00)
	Volume of exits	-0.0153***	-0.0124 **	-0.0286 ***
		(-4.18)	(-3.31)	(-4.38)
	Log likelihood	-41260.431	-41844.272	-41234.533
	Pseudo-R^2	0.484	0.506	0.484
Germany	Applied tariffs	0.00047	0.00025	0.00086
		(1.10)	(0.61)	(1.14)
	Volume of exits	-0.023 ***	-0.0195***	-.0411***
		(-6.16)	(-5.37)	(-6.31)
	Log likelihood	-39039.299	-39595.140	-39001.517
	Pseudo-R^2	0.4919	0.481	0.4919

*Notes: All estimations include control variables. See the text for the definition of variables and data sources. Robust t statistics are in parentheses, with ***, **, and * denoting significance at the 1% level, 5% level, and 10% level, respectively.*

null hypothesis of exogenous tariffs is soundly rejected in all cases. The coefficients for the first-stage residuals for France, Germany and the United States are very close in size and are larger than those for Australia, Brazil and Canada.

Table 4: **First-stage regressions regarding tariffs in the 2SRI approach**

	Explained variable: Applied bilateral product-level tariffs					
	Brazil	Canada	USA	Australia	France	Germany
Prohibitive tariffs	0.068***	0.0378*	0.115***	0.052***	0.249***	0.263***
	(8.93)	(2.29)	(3.73)	(4.25)	(17.51)	(12.67)
Transparency index	0.0614***	0.0283***	0.0289***	0.061***	0.110***	0.00172
	(7.16)	(3.91)	(3.85)	(7.88)	(12.50)	(7.02)
Volume of exits	-0.115***	-0.0635***	-0.0340***	-0.146*	0.00364	-0.0615**
	(-8.12)	(-6.55)	(-5.74)	(-2.01)	(0.14)	(-2.84)
Distance	4.522***	-5.839***	-3.624***	4.927***	-3.026***	-2.644***
	(6.14)	(-13.70)	(-7.15)	(9.08)	(-7.90)	(-9.31)
Contiguity	-2.330***	-27.19***	-4.549*		-3.997***	-8.695***
	(-6.53)	(-19.55)	(-2.29)		(-6.55)	(-5.94)
Common off. language	-2.918***	1.245***	-3.918***	-3.349***	5.530***	12.72***
	(- 9.66)	(3.58)	(-3.90)	(-4.05)	(14.19)	(-3.69)
Landlocked	-2.744***	-1.903***	-2.37***	-3.912***	1.033*	- 0.0963
	(-8.72)	(-4.34)	(-5.31)	(-9.41)	(2.55)	(0.27)
Religious openness	-0.488***	-0.0791***	0.00405	-0.0277	-0.433***	-0.404***
	(-5.59)	(-2.65)	(0.11)	(-0.81)	(-11.25)	(-11.94)
Exchange rate volatility	4.323***	3.863***	3.736***	2..862***	1.359***	0.682**
	(7.68)	(7.01)	(6.67)	(5.31)	(4.49)	(2.96)
BSE disease	-1.94***	1.239***	1.488***		6.232***	5.766***
	(-8.05)	(6.69)	(10.29)		(13.23)	(11.68)
Avian flu	2.455***	0.966	1.844 ***			
	(4.11)	(4.68)	(3.44)			
GDP per capita	-1.100***	-0.755***	-0.513**	-1.492***	0.547**	1.004***
	(-10.74)	(-3.89)	(-3.17)	(-7.00)	(3.18)	(4.61)
Population	0.472***	1.090***	0.627***	0.528***	1.533***	1.393***
	(5.68)	(13.86)	(6.64)	(4.69)	(16.49)	(14.18)
Multiple spells	0.944	1.152	0.611	3.225***	3.430***	3.361***
	(1.12)	(1.06)	(1.27)	(3.84)	(6.50)	(5.55)
RTAs	4.698***	-3.687***	-2.809***	-1.459***	1.045	0.0601
	(7.24)	(-5.48)	(-10.27)	(-3.37)	(1.82)	(0.15)
Observations	172,000	174,604	178,988	174,522	131,660	144,325

*Notes: See the text for the definition of the variables and data sources. Robust t statistics are in parentheses, with ***, **, and * denoting significance at the 1% level, 5% level, and 10% level, respectively.*

For each exporting country in Tables 5 and 6, the first column reports regression results featuring time-variant and time-invariant covariates such as distance and contiguity. The second column is based on regressions with importer fixed effects. Using or not using standard gravity variables influences the magnitude of coefficients for time-varying variables and, in some cases, even their sign.[24] We find that higher tariffs and terminated trade flows at $t-1$ increase and decrease the probability of export failures, respectively, consistent with proposition 2 and the

[24] The trade creation effects of trade agreements estimated from gravity models are also greatly affected by the choice between standard gravity variables and country pair fixed effects (Magee, 2008).

Table 5: **Decomposition of the probability of export failure: Brazil, Canada and the USA**

Explanatory Variable	Explained variable: Duration of bilateral product-level exports					
	Brazil		Canada		USA	
	RE	FE	RE	FE	RE	FE
Terminated flows	-0.180***	- 0.095***	- 0.039***	-0.038***	-0.0035***	-0.0598***
Applied tariffs	0.0018**	0.0025***	0.0071***	0.0018***	0.0219***	0.0015***
Distance	1.040***		0.648***		0.998***	
RTA	0.062		-0.024		-0.378***	
Contiguity	-0.410***		-0.880***		-1.110***	
Common off. language	-1.071***		-0.505***		-0.628***	
Landlocked	0.264***		0.8288***		1.206***	
Religious openness	-0.038***		-0.0129***		-0.022***	
BSE disease	1.043***	0.209***	0.0057	0.0686***	0.1758 ***	0.238***
Avian flu	-0.109*	-0.033	0.412 ***	0.504***	0.730***	0.451***
Exchange rate volatility	-1.157***		0.046		0.714*	
GDP per capita	-0.284***		-0.247***		-0.30***	
Population	-0.225***		-0.235***		-0.405***	
Multiple spells	-2.308***	-0.832***	-2.880***	-0.872***	-1.771***	-0.37***
1st-stage residuals	-0.007***	-0.00137	-0.0143***	-0.0017***	-0.038***	-0.00166***
Constant	1.082**	5.364	3.718***	3.418***	1.201***	1.890***
Importer-year effects	random	fixed	random	fixed	random	fixed
Product FE		Yes		Yes		Yes
Observations	172,000		174,604		178,988	
Log likelihood	-28254.35	-30072.08	-27615.06	-20446.55	-51514.47	-60310.85
Pseudo-R^2	0.233		0.117		0.120	

*Notes: See the text for the definition of the variables and data sources. RE and FE stand for random and, respectively, fixed importer-year effects. ***, **, and * denote significance at the 1% level, 5% level, and 10% level, respectively.*

theoretical discussion about tariffs. The only exception is the insignificant coefficient for terminated flows/exits for the regression with importer fixed effects for Germany. The correction for tariff endogeneity more strongly affects the tariff coefficients, but it also affects the coefficients for terminated trade flows. Comparing the results from Tables 3 and 6, one can see that the incidence of terminated flows for Germany is reduced by 52%, while for France, the corrected effect is 61% stronger. Endogeneity biases are lower for non-European countries.

Foregone trade flows have a particularly large decreasing effect on the probability of export failure for agri-food products originating from Brazil and Australia. Tariff coefficients are highly significant and have the anticipated positive sign. Comparing tariff coefficients across

Table 6: **Decomposition of the probability of export failure: Australia, France and Germany**

Explanatory Variable	Explained variable: Duration of bilateral product-level exports					
	Australia		France		Germany	
	RE	FE	RE	FE	RE	FE
Terminated flows	-0.132***	-0.094***	-0.0247***	-0.062***	-0.0110*	0.00127
Applied tariffs	0.0015***	0.0016***	0.0349***	0.0017***	0.0319***	0.0068***
Distance	0.895 ***		2.482***		2.860***	
RTA	0.120***		-0.113**		-0.128**	
Contiguity			-0.872***		-1.998	
Common off. language	-0.048		-1.153***		20.80	
Landlocked	0.297***		0.708***		0.0830	
Religious openness	-0.015***		0.0353***		0.0281***	
BSE disease			-1.909***	0.028	-1.367***	0.365***
Avian flu			0.412 ***	0.504***	-0.0584	-1.667
Exchange rate volatility	-2.361**		-0.595***		-0.410***	
GDP per capita	-0.155***		-0.791***		-0.817***	
Population	-0.1285***		-0.491***		-0.586***	
Multiple spells	-2.528***	-1.85***	-2.653***	-0.853***	-3.016***	-0.564***
1st-stage residuals	-0.0084***	-0.0033***	-0.0494***	-0.001*	-0.05***	-0.017***
Constant	0.367***		-4.38***		-5.856***	
Importer-year effects	random	fixed	random	fixed	random	fixed
Product FE		Yes		Yes		Yes
Observations	174,522		131,660		144,325	
Log likelihood	-26465.96	-23933.49	-29731.77	-28053.15	-27508.53	-28271.66
Pseudo-R^2	0.322		0.628		0.642	

*Notes: See the text for the definition of variables and data sources. RE and FE stand for random and, respectively, fixed importer-year effects. ***, **, and * denote significance at the 1% level, 5% level, and 10% level, respectively.*

exporters, we find that coefficients estimated from regressions with importer fixed effects are quite similar for Australia, Brazil, Canada and France. German exports are relatively more prone to failure after a tariff hike, while the reverse is true for United States exports. The results from regressions with standard gravity variables displayed in "RE" columns find similarly low tariff effects for Australia, Brazil and Canada and similar higher tariff effects for the United States, France and Germany.

Our model specification has both tariffs and RTAs as explanatory variables. Once the tariff reductions of RTAs are removed, RTAs can influence export duration through regulatory harmonization and by simplifying the paperwork associated with exports and imports. While less restrictive nontariff barriers are expected to increase export survival, lower fixed export costs make entries and exits easier. Destinations with which Canada has a RTA, all else being equal, including tariffs, have a lower probability of experiencing an interruption. This is consistent with the findings of Ghazalian *et al.* (2011) about the potency of NAFTA's nontariff provisions in boosting the intra-NAFTA meat trade. From Tables 5 and 6, one can see that the negative effect of RTAs on export failure is larger for United States agri-food exports than for Canadian exports. It could be that United States RTAs have more potent nontariff provisions than Canadian RTAs, which would suggest that United States trade negotiators have more bargaining power than their Canadian counterparts. It could also be that United States firms are better at exploiting nontariff provisions. RTAs also reduce the probability of export failures for Germany and France. The positive RTA coefficient in Table 6 suggests that Australian firms find it easier to enter and exit destinations participating in an RTA with Australia. The RTA coefficient for Brazil is not statistically significant, which simply means that the incidence of RTAs is channeled only through tariff reductions.

Distance is a major natural impediment to trade at the extensive and intensive margin. Its effect encompasses more than just transport costs. It exerts a strong and highly positive influence on the probability of an export failure. The results from the "RE" columns show that distance has a similar effect on the export failure rate of Brazilian, Australian and United States flows. Canadian flows are the most resilient to the adverse effects of distance on export survival, while German and French flows are the most sensitive to distance. Canadian exports to the United States are particularly resilient, as suggested by the contiguity coefficient in Table 5. A glance at Table 5 reveals that United States exports to Canada and Mexico are also resilient. The contiguity coefficient for Brazil in Table 5 is much smaller than those for Canada and the United States. These contiguity coefficients are consistent with large fallback markets and convex costs. The contiguity coefficient for France is also large and significant, as expected. The coefficient for Germany is even larger but not statistically significant. As for animal diseases, we expect weakly positive coefficients, given that the probability of an export failure for exports of live animals directly concerned ought to increase and that export of other agricultural products may also become less resilient due to perceptions that the exporting country has weak regulations. Focusing on models with importer-time fixed effects, we find BSE and avian flu positive and significant coefficients for Brazil, Canada and the United States. Australia did not have BSE and avian flu cases. For France (Germany), the avian flu (BSE) reduced export duration, but BSE (avian flu) does not have a significant effect. Sharing a language increases export duration, particularly for Brazil, but not so much for Australia. All else being equal, exports to landlocked destinations have a higher probability of being terminated, especially for exports originating from Canada or the United States. As expected, religious openness has a small negative impact on export failure, regardless of where exports originate. The theoretical effect of exchange rate volatility on exports is ambiguous (Bonroy *et al.*, 2007), and our results reflect this, with no significant effect for Canada and a decreasing (increasing) effect on the probability of termination of Australian, Brazilian, French and German (United States) export flows.[25]

We interpret multiple spells as an indicator of experience in export markets. Firm managers can learn much from past export spells, whether from the identification of trustworthy and untrustworthy business partners, administrative requirements, contract negotiations, and operational challenges in meeting public and private standards. Firms learning from past mistakes become more resilient and should face a lower probability of export failure. However, lower export costs also make it easier for firms to enter and exit in response to shocks in foreign markets. The theoretical ambiguity is resolved by the negative and significant multiple spell coefficients reported in Tables 5 and 6. Clearly, past failures, whether of their own or of national rivals, make firms more resilient. Focusing on the first column regressions with gravity variables, one can see that the coefficients for multiple spells are quite large and similar across exporting countries.

Importing countries' market size is a major determinant of trade. In models involving consumers with homothetic preferences, increases in GDP due to increases in GDP per capita or in population have the same effect. We allowed for different effects in our empirical export duration model. The sign of the coefficients for GDP per capita and population is negative, as expected, and the magnitude of the two coefficients is very close among Australia, Brazil and Canada. For France and Germany, an increase in GDP per capita is significantly more potent than a similar increase (in %) in population. Perhaps French and German products are more vertically differentiated. Market size (the sum of the population and GDP per capita coefficients) increases export survival most for firms from European countries, followed by those from the United States, Brazil, Canada and Australia.

We also performed a series of robustness tests on our specification. The results are succinctly summarized, but tables are available upon request. Even though our choice of instruments has gone through a validation process, we wanted to see how the replacement of one instrument would impact the results. We use the bound tariff as one of the instruments, keeping the transparency index as a second instrument. We use the bound tariff $T^b_{\ell t}$ of country j on product k in year t as an instrument because it imposes an upper limit on tariffs set by WTO members and countries very rarely change their bound tariffs. Most bound tariffs were negotiated long ago and can be treated as exogenous. While some countries have high bound tariffs and relatively low applied tariffs, it is assumed that countries with high bound tariffs tend to have higher

[25] Thus, a year with strong currency devaluations and strong appreciations may see firms engaging in exports when their country's currency is strongly devalued and exiting when the currency appreciates. If the currency exhibits high volatility the following year, firms will re-enter, and annual data will show continuous flows. Small intra-year currency variations may not provide the sort of short-lived profitable export opportunities required for firms to export.

applied tariffs. Countries that have high bound tariffs have more flexibility in making tariff adjustments in response to industry pressure. All robustness tests tend to suggest that tariffs are negatively correlated with trade duration. In addition, we ascertain the robustness of the results by replacing the aggregate value of trade flows terminated at $t-1$ with the number of trade flows terminated at $t-1$. Using a different variable to account for recent exits does not alter the results very much. For example, the coefficient for applied tariffs regarding the export failure of Canadian export flows changes from 0.00275 to 0.00274.

6. Conclusion

Empirical studies about export duration report that entries and exits are frequent and export spells are short (*e.g.*, Sabuhoro *et al.*, 2006). This is somewhat puzzling considering the non-trivial size of fixed export costs just to comply with standards (Ferro *et al.*, 2015) and the importance of sunk search costs (Roberts and Tybout, 1997). Accordingly, one would expect a selection favoring high-productivity firms resilient to adverse demand shocks on export markets (Helpman *et al.*, 2008). A second puzzle from the empirical literature on export duration is the ubiquitous positive or insignificant effects of tariffs on export duration. We address these two puzzles by developing a monopolistic competition multi-destination trade model, whose predictions are then confronted to data regarding the exports of over 200 agricultural products to a large set of destinations from six large exporting countries: Australia, Brazil, Canada, France, Germany and the United States.

We developed a trade model in which marginal costs vary with output, so that markets are interconnected through the factory-gate price. The interconnection of markets through costs has nontrivial implications for the relationship between productivity, export survival and the number of destinations. One advantage of our multi-destination model is that it makes it possible to show that when firms have convex production costs and face fixed export costs that vary across destinations, more productive firms can support a higher sum of fixed export costs, but they may end up selling to fewer but larger destinations with higher individual fixed export costs. An increase in productivity may prompt a firm to abandon two or more profitable markets and enter a larger market. Thus, the relationship between productivity and the number of destinations is not monotone. Cost convexity also implies that the level of foregone output from terminated trade flows, all else being equal, reduces average cost and increases export duration for all remaining destinations.

Whether marginal costs are constant or variable, established theory posits that higher tariffs weakly increase the likelihood of an export failure.[26] Because there was little support in

[26] All else being equal, increasing a prohibitive tariff should have no impact on export survival. If exports are observed, a lower tariff increases export survival, all else being equal.

previous empirical export survival studies, we hypothesized that tariffs may be endogenous, possibly because tariffs and export survival are influenced by common nonobservable factors and/or because of the lobbying for protection conducted by firms competing with foreign exports when shocks increase trade at the intensive and extensive margins and hence export survival, as documented in the literature (*e.g.*, Grossman and Helpman, 1994).

Our findings confirm theoretical predictions about the ties between exits and export duration for remaining and new flows. Aggregate foregone sales from export flows terminated at $t-1$ have a strong negative impact on the probability of export failure. This is true for all exporting countries in our sample. This is consistent with market linkages induced by cost convexity. Regarding the second puzzle, we find that applied tariffs decrease or do not affect the likelihood of an export failure, when treated as exogenous. This peculiar theory-inconsistent outcome is robust across exporting countries and discrete-time hazard estimators. Domestic firms adversely affected by foreign supply shocks inducing surges in foreign exports may be able to convince their government to make upward tariff adjustments. Because the shocks lower the probability of an export failure and increase tariffs, the confounding effect of the shocks creates a negative bias in the estimated tariff coefficients. We corrected for endogeneity with Terza *et al.* (2008)'s two-stage residual inclusion procedure. The duration models corrected for tariff endogeneity show that tariffs adversely affect the survival of agri-food export flows.

In terms of policy implications, governments must not automatically equate reliance on a few export markets and frequent entries and exits as symptoms of a productivity problem. As the United States-China trade dispute shows, higher tariffs adversely impact export duration. It also shows that it can be particularly difficult for firms to replace a large market, especially if the firms were exporting to many destinations before the dispute. In such cases, untapped markets are likely to be small, and the cumulative effects of fixed export costs make it unlikely that the addition of new destinations will make up for the loss of a very large destination. Had United States agricultural exports been easy to relocate, there would not have been a United States market facilitation program instigated to mitigate the incidence of trade disruptions on United States farmers' income. Our descriptive analysis revealed that Canadian spells tend to be shorter, and that Canadian, Australian and Brazilian firms export to fewer destinations than United States firms, which in turn export to fewer destinations than French and German firms. Canada's access to a very large market, such as that of the United States, makes it easier for Canadian firms to buffer trade disruptions involving third countries. This is particularly important for trade in agricultural products, the prices of which tend to be volatile because of production rigidities and product perishability. One can understand the urgency that Canada and Mexico felt during the negotiations of the United Sates-Mexico-Canada trade agreement. The same applies to Northern African countries seeking preferential access to the EU market.

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