# "New-Friend" versus "Old-Friend" Trade Liberalization Effects and their Importance for Developing Economies: Evidence for the Cattle/Beef Sector †


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*Abstract*: A gravity-based model is used to explain cattle and beef bilateral trade flows between forty-two countries. It considers vertical production linkages between the two sectors and appeals to the existence of fixed costs to explain foreign market penetration. The model parameters are estimated using a double-hurdle model with a multivariate sample selection procedure as the second hurdle. The parameter estimates are used to simulate probabilities of new trade flows (new-friend effect) and the increase in existing trade flows (old-friend effect) following reductions in import tariffs, export subsidies and domestic support. The results show that liberalization would generate few new cattle trade flows. However, adjustments in beef exports occur at both the extensive and intensive margins. Trade liberalization would create opportunities for developing economies to expand trade relationships although overall trade impacts are likely to be small unless countries push for aggressive liberalization plans.



*Keywords*: Gravity model, heterogeneous firms and international trade, beef/cattle trade, trade partners, Doha Round.

*JEL Classification*: Q17, F13


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## 1. Introduction

The global trading system is in a critical period. The liberalization process for agri-food commodities is comparable to that of industrial goods 60 years ago. Gibson *et al.* (2001) estimated that the average tariff in agriculture at the end of the Uruguay Round (UR) implementation period was about 60 % (about 12 times the average tariff on industrial goods). This protection from import competition is in addition to export subsidies and domestic support offered by many countries. A ninth round of multilateral trade negotiations was launched in Doha, Qatar in 2001 with developing countries keen on securing significant progress in agricultural trade liberalization.

Most of the lessons that were learned from liberalizing trade in industrial products continue to hold. However, some particularities of agri-food markets add a whole set of new issues that require careful analysis. Trade in processed goods is more important (and growing faster) than trade in primary goods. Domestic support policies (*e.g.* input and output price subsidies) are ubiquitous in agriculture and their reduction represents one of the most formidable challenges of the current round of WTO negotiations. As such, comprehensive liberalization plans must recognize vertical linkages between upstream and downstream sectors as well as the implications of domestic support on the competitiveness of all agents along supply chains. The objective of the paper is to forecast growth in trade induced by different liberalization scenarios and to determine the extent by which this growth is due to the emergence of new trade flows, the so-called "new-friend" effect, and to the strengthening of existing trade flows which is referred to as the "old-friend" effect.

The literature has only recently started to address empirically the relationship between the extensive margin of trade (number of firms) and the intensive margin of trade (exports per firm). Felbermayr and Kohler (2006) argue that properly accounting for both the extensive and intensive margins contributes to resolving the "distance puzzle" in the gravity literature which refers to puzzling increases in the elasticity of bilateral trade with respect to distance over time (*e.g.,* Disdier and Head, 2008). Using aggregate time series data, Helpman, Melitz and Rubinstein (2008) found that growth in world trade was primarily due to increases in bilateral trading volumes between country pairs that have historically traded with one-another. They suggest that the new friend effect did not significantly contribute to the growth in world trade. This contrasts with sectoral evidence presented by Evenett and Venables (2002) who documented a substantial increase in the number of trading partners at the 3-digit level for a selected group of 23 developing countries over the 1970-1997 period.

Accordingly, this paper proposes a two-stage gravity modeling framework to estimate the parameters conditioning the existence and the size of trade flows for primary and processed products.[1] The first stage, as in Helpman *et al.* (2008), models the decision of individual firms regarding their presence on a particular foreign market. It is assumed that firms are confronted to a destination-specific fixed entry fee to penetrate a market and that firms have access to different technologies which induces heterogeneity in productivity. This assumption is based on the stylized facts that exporting firms are typically in the minority and tend to be more productive and much larger than non-exporting firms (Eaton, Kortum and Kramarz, 2007). Yet, these firms

[1] There exists a large literature on the evaluation of trade liberalization impacts in agriculture. The majority of the studies rely on large scale Computable General Equilibrium (CGE) models (*e.g.*, Fabiosa *et al.*, 2005; Hertel and Martin, 2000). CGE models are powerful tools because they consider substitution effects across sectors in both production and consumption. However, they are not easily amenable to statistical inference.

usually export only a small fraction of their output (*e.g.*, Bernard and Jensen, 1999).[2] The first stage of our model measures the impact of the number of exporting firms on trade flows, and as such, it addresses the extensive margin of trade.

In the second stage, trade volumes are determined conditional on entry and censoring of trade flows. The second stage is represented by a gravity equation that builds on Anderson and van Wincoop (2003). More specifically, it is assumed that each firm produces a different processed food variety and that all varieties are aggregated through a Constant Elasticity of Substitution (CES) utility function. The food commodities (*e.g.,* bovine meat) are produced using a primary commodity (*e.g*, cattle) and other inputs such as capital and labour. The vertical structure of the model builds on the framework developed in Ghazalian *et al*. (2008) as it assumes that primary and processed goods are tradable and that primary commodities are not differentiated from the buyers' perspective. Yet, it is well known that bilateral trade flows can only be identified through some form of imperfect substitutability. Following Baier and Bergstrand (2001), a Constant Elasticity of Transformation (CET) technology is introduced in the upstream sector. Primary goods remain homogenous from the buyers' perspective, but the CET assumption implies that primary producers cannot substitute their output costlessly across destinations because of differences in technical barriers and sanitary regulations.

The empirical application focuses on the beef/cattle world market. The cattle/beef sector was selected because cross-hauling in cattle and beef trade is common. Moreover, tariffs, domestic support and export subsidies vary a lot from one country to another. For example, the European Union (EU)'s tariff and export subsidy for bovine meat are both in excess of 50% while some countries, like Australia, follow a *laissez-faire* policy. Finally, non-tariff barriers are

[2] Chaney (2008) illustrates the bias in estimating the elasticity of trade flows with respect to trade barriers when ignoring the degree of firm heterogeneity.

notoriously disruptive and can introduce supply rigidities at the farm level. The vertical linkages between markets introduce an important econometric challenge because cattle prices are determined simultaneously with cattle and beef trade flows. Because Anderson and van Wincoop (2003) and Baier and Bergstrand (2004) warn that using fixed effects as a substitute for price indexes in gravity equations can cause important omitted variable biases, cattle prices are instrumented in the estimation of the second stage trade decisions.

A full liberalization and a Doha compromise outcome are simulated to assess the importance of the new-friend and old-friend effects. Overall, the simulations indicate that the adjustments occurring at both the intensive and extensive margins are small for cattle trade. Trade liberalization impacts in the beef sector are more substantial. Under the Doha scenario, developing economies see an increase in the number of domestic firms that engage in bilateral beef trade with foreign firms, while firms in OECD countries see their number of trade partnerships decrease. The latter result is driven by the elimination of export subsidies and reductions in trade-distorting domestic support. However, average beef exports conditional on firms engaging in trade increases for firms in both OECD and non-OECD countries. The increase in average exports is larger in percentage terms for firms in non-OECD countries than for firms in OECD countries. The Doha scenario yields rather modest adjustments in the intensive margin of trade.

The remainder of the paper is structured as follows. The next section presents the theoretical foundations of the trade model underlining the implications of vertical linkages between the cattle and beef sectors. The third section introduces the econometric procedure used to estimate the structural parameters of the model. The fourth section presents the estimation results and section five analyzes various liberalization scenarios and their implications in the context of the current Doha Round. The last section concludes.

## 2. The Theoretical model

The theoretical model draws from the framework developed by Ghazalian *et al.* (2008) and Helpman et al. (2008). It is assumed that there are $j = 1,\ldots,J$ countries with consumers endowed with identical preferences over bovine meat (beef) consumption. There are $N_j^M$ beef product varieties produced in country *j* and the number of varieties produced in each country is assumed fixed. Consumers' preferences in each country are captured by a CES-type utility function over varieties. Let $q_{ij}(\omega)$ be country *i*'s consumption of one beef product variety produced in country *j* with $\omega$ indexing varieties. Parameter $\eta$ measures the elasticity of substitution between beef varieties and hence $\eta > 1$. The utility function is:

$$U_i = \left( \sum_z \int_0^{N_j^M} q_{iz}(\omega)^{(\eta-1)/\eta} \, d\omega \right)^{\eta/(\eta-1)} \quad (1)$$

Each beef processing firm produces a given beef product variety. Assume for the time being that they all face the same constant marginal cost denoted $c_j$. Profit maximization implies:

$$p_j / \theta_j^M = \eta (\eta - 1)^{-1} c_j \quad (2)$$

where $p_j$ is the price received by firms in country *j* and $\theta_j^M$ represents domestic support policies offered by country *j*. Domestic production subsidies for the processing sector imply $\theta_j^M < 1$.

From the consumers' standpoint, two-stage budgeting allows to compute conditional expenditures on beef product varieties. The effective price paid by consumers for a given variety is $p_j$ multiplied by trade costs between countries *i* and *j*. Trade costs include the import tariff (denoted by $\tau_{ij}^{M} \geq 1$), export subsidies offered by country *j* when firms sell in *i*, (denoted by $s_{ij}^{M} \leq 1$) and the effect of distance summarized by $d_{ij}^{\vartheta_M}$ with $\vartheta_M > 0$. Because the variable $d_{ij}$ measures distance between countries *i* and *j*, we have that $d_{ij} = d_{ji}$. Trade costs also include export subsidies. Country *i*'s demand function for goods supplied by country *j* is:

$$q_{ij} = \alpha Y_i \frac{(\eta - 1)}{\eta} \frac{\left(\tau_{ij}^{M} s_{ij}^{M} d_{ij}^{\vartheta_M} p_j\right)^{-\eta}}{\sum_z \left(\tau_{iz}^{M} d_{iz}^{\vartheta_M} p_z\right)^{1-\eta} N_z^M} \tag{3}$$

where $Y_i$ is the aggregate income in country *i*, and $\alpha$ is the share of income spent on beef purchases. Using (2), country *i*'s imports from *j* are equal to the aggregate consumption of each variety multiplied by the number of varieties $\left(N_j^M\right)$:

$$M_{ij} = N_j^M q_{ij} = \alpha Y_i \frac{(\eta - 1)}{\eta} \frac{\left(T_{ij}^{M} c_j\right)^{-\eta} N_j^M}{\sum_z \left(T_{iz}^{M} c_z\right)^{1-\eta} N_z^M} \tag{4}$$

where $T_{ij}^{M} \equiv s_{ij}^{M} \tau_{ij}^{M} d_{ij}^{\vartheta_M} \theta_j^M$.

We assume that the technology for beef production can be represented by a constant returns to scale Cobb-Douglas production function: $TFP_j I_j^{\psi_M} K_j^{(1-\psi_M)}$; where $TFP_j$ is a total factor productivity index specific to each country, $I_j$ and $K_j$ respectively denote cattle and capital used in beef production in country *j*. The cattle and capital factor prices in country *j* are denoted by $h_j$ and $r_j$, respectively. Under these assumptions, marginal cost in country *j* is: $c_j = \varpi_j r_j^{(1-\psi_M)} h_j^{\psi_M}$; where $\varpi_j \equiv \left(\left(1-\psi_M\right)^{-(1-\psi_M)} \left(\psi_M\right)^{-\psi_M}\right) \Big/ TFP_j$ can be construed as a productivity parameter. The supply of capital is perfectly elastic from the perspective of beef processors, and as such they perceive $r_j$ as a constant. For future reference, define the relationship between beef production in country *j* (denoted $Q_j^M$ ) and the total demand faced by country *j* by:

$$M_{ij} = \left( M_{ij} \big/ \sum\nolimits_k M_{kj} \right) Q_j^M \tag{5}$$

Inserting the import demand functions of each country in (5) yields:

$$M_{ij} = \left( \lambda_j^M \right)^{-1} Y_i \frac{\left( \varpi_j \tilde{c}_j h_j^{\psi_M} T_{ij}^M \right)^{-\eta}}{\sum_z \left( \varpi_z \tilde{c}_z h_z^{\psi_M} T_{iz}^M \right)^{1-\eta} N_z^M} N_j^M Q_j^M \tag{6}$$

where $\tilde{c}_j \equiv r_j^{\theta_r}$ and $\lambda_j^M \equiv \sum_k Y_k \frac{\left( \varpi_j \tilde{c}_j h_j^{\psi_M} T_{kj}^M \right)^{-\eta} N_j^M}{\sum_z \left( \varpi_z \tilde{c}_z h_z^{\psi_M} T_{kz}^M \right)^{1-\eta} N_z^M}$. In what follows, we depart from Ghazalian *et al.* (2008) by assuming that the cost parameter $\varpi$ is also indexed by destination *i* to represent the ability of a firm in country *j* to export to a specific destination, as in Helpman *et al.* (2008). The productivity parameter of a firm has support $\varpi_{ij}\left(\omega\right) \in \left[ \underline{\varpi}_j, \bar{\varpi}_j \right]$. Defining $G\left(\varpi\right)$ as the density of the firm-specific productivity parameter, the fraction of firms that export beef from country *j* to country *i* can be defined as:

$$V_{ij}^M = \begin{cases} \int_{\underline{\varpi}_j}^{\varpi_{ij}} \varpi^{-\eta} dG\left(\varpi\right) & \text{for } \varpi_{ij} \geq \underline{\varpi}_j \\ 0 & \text{otherwise} \end{cases} \tag{7}$$

Using the specification in (7), no domestic firm can export beef to market *i* if all productivity parameters are equal to the lower bound $\underline{\varpi}_j$. Similarly, all domestic firms in *j* export beef to country *i* if $\varpi_{ij}$ is equal to the upper bound $\bar{\varpi}_j$. Hence, the expected bilateral trade flow equation can be written as follows:

$$M_{ij} = \left( \lambda_j^M \right)^{-1} Y_i \frac{\left( \tilde{c}_j h_j^{\psi_M} T_{ij}^M \right)^{-\eta}}{\sum_z \left( \tilde{c}_z h_z^{\psi_M} T_{iz}^M \right)^{1-\eta} N_z^M} V_{ij}^M N_j^M Q_j^M \tag{8}$$

Equation (8) is similar to Helpman *et al.* (2008)'s generalized version of Anderson and van Wincoop (2003)'s gravity equation. The main difference in the current context will be in the treatment of cattle prices below.

The cattle production function is assumed to be homothetic and thus the cost function of a representative cattle producer in country *j* is: $\psi_j\left(\mathbf{w}_j\right)I_j^{\beta}$; where $I_j$ denotes a cattle farm's output in country *j*, $\beta > 1$ is a cost parameter, $\psi_j\left(\mathbf{w}_j\right) \equiv w_j^{\psi_I}\ell_j^{1-\psi_I}$ is a country-specific sub-cost function with $w_j$ and $\ell_j$ denoting the price of labour and land, respectively. Both prices are exogenous to the cattle and beef sectors. Beef is assumed to be differentiated from the consumers' perspective. Conversely, we assume that cattle are homogenous products from the buyers' (processors) perspective. However, they are not likely to be freely substituted across markets.[3] Following Baier and Bergstrand (2001), a cattle farms' total output can be decomposed as: $I_j = \left(\sum_{i=1} i_{ij}^{(1+\gamma)/\gamma}\right)^{\gamma/(1+\gamma)}$; where $\gamma$ is a constant elasticity of transformation (CET) parameter and $i_{ij}$ denotes cattle shipments from country *i* to *j*. If $\gamma$ is zero, cattle cannot be substituted across destinations while cattle can be freely substituted when $\gamma \to \infty$.

Profits of a representative firm (excluding for the moment potential fixed costs of penetrating a market) are defined as:

$$\pi_j = \sum_{i=1} h_i T_{ij}^I i_{ij} - \psi_j\left(\mathbf{w}_j\right)I_j^{\beta} \qquad (9)$$

where $T_{ij}^I \equiv \theta_j^I s_{ij}^I \tau_{ij}^I d_{ij}^{-\vartheta_I}$ measures trade costs. The variable $s_{ij}^I \geq 1$ measures export subsidies, $\theta_j^I \geq 1$ measures domestic cattle support, $\tau_{ij}^I \leq 1$ represents the tariff of country *i* on imports from

[3] The major motivation behind the imperfect substitutability assumption revolves around non-tariff barriers. For example, agricultural products often need to meet sanitary or packaging regulations that can differ across importing countries. It could be also that importers have particular demands in terms of currency invoicing and delivery terms that discourage destination switching. Rauch and Feenstra (1999) discussed these costs in a context of networks in international trade.

country *j* and $h_i$ is the cattle price producers in country *i*. As apparent from the profit definition in (9), sale revenues in market *i* are derived from the price received in market *i* plus the support offered by country *j* minus the transaction cost of shipping the product from *j* to *i*.[4] Solving the first-order conditions yields the bilateral cattle export supply equation at the country level:

$$I_{ij} = N_j^I i_{ij} = \beta^{(1-\beta)^{-1}} \psi_j\left(\mathbf{w}_j\right)^{(1-\beta)^{-1}} \left( \frac{\left(h_i s_j t_{ij}\right)^{\gamma}}{\left(\sum_z \left(h_z s_j t_{zj}\right)^{1+\gamma}\right)^{(\gamma(\beta-1)-1)/((1+\gamma)(\beta-1))}} \right) N_j^I \qquad (10)$$

where $N_j^I$ represents the number of cattle producers in country *j* .

The inequality $\gamma > 1/(\beta - 1)$ assures that the second order conditions are satisfied. The inequality states that destinations can be substituted relatively freely (low non-tariff barriers associated with a high $\gamma$) only if decreasing returns to scale are not too large (as measured by the parameter $\beta$). As in the beef sector, an identity relates cattle bilateral trade flows to total cattle demand in country *i*:

$$I_{ji} = \left(I_{ji} / \sum_z I_{jz}\right) C_j^I , \qquad (11)$$

where, as before, $C_j^I$ denotes country *j*'s total purchases of cattle. To cut back on the notation, we also define $\mathrm{B} \equiv (1+\gamma)^{-1}\left(\gamma + \gamma^{-1}(\beta-1)^{-1}\right) > 0$.

Using the identity in (11), the trade equation in (10) can be rewritten as:

$$I_{ji} = \left(\psi_i\left(\mathbf{w}_i\right)\right)^{-\gamma^{-1}(\beta-1)^{-1}} \left(C_j^I\right)\left(\lambda_j^I\right)^{-1} \frac{\left(h_j T_{ji}^I\right)^{\gamma}}{\left(\sum_z \left(h_z T_{zi}^I\right)^{1+\gamma}\right)^{\mathrm{B}}} N_i^I Q_i^I \qquad (12)$$

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[4] The notion of homogeneity in cattle is supported by the condition that the price received in market *i* is independent from the origin of the product. However, cattle are not homogenous in a "pure" sense because they cannot be freely substituted across destinations from the producing region's perspective. Hence, the rigidity in cattle trade originates from the supply side, and thus cattle prices are not necessarily arbitraged in equilibrium ($h_j \neq h_k$).

where $\lambda_j^I \equiv \sum_z \left(\psi_j\left(\mathbf{w}_j\right)\right)^{-\gamma^{-1}(\beta-1)^{-1}} \left(N_z^I\right)\left(h_j T_{zj}^I\right)^{\gamma} \Big/ \left(\sum_n \left(h_n T_{nj}^I\right)^{1+\gamma}\right)^{\mathrm{B}}$ and $Q_i^I$ represents total cattle production in country *i*. Because the function $\psi_j\left(\mathbf{w}_j\right)$ can be interpreted as a productivity parameter, it can be indexed by country of origin *j* as well as by the country of destination *i*, just as in the beef sector. Under a similar set of conditions, the expected bilateral cattle trade flow equation is a function of the fraction of firms (denoted $V_{ij}^I$) exporting to that particular destination:

$$I_{ji} = \left(\psi_i\left(.\right)\right)^{-\gamma^{-1}(\beta-1)^{-1}} \left(C_j^I\right)\left(\lambda_j^I\right)^{-1} \frac{\left(h_j T_{ji}^I\right)^{\gamma}}{\left(\sum_z \left(h_z T_{zi}^I\right)^{1+\gamma}\right)^{\mathrm{B}}} V_{ij}^I N_i^I Q_i^I \qquad (13)$$

Vertical linkages are introduced through a series of market clearing conditions. Market clearing conditions restrict country *j*'s total cattle purchases to be equal to its (proportionally adjusted) shipments of beef to all destinations:

$$\sum_z I_{jz} = \Lambda_j \sum_z M_{zj} \quad \text{for } j = 1, \ldots, J \qquad (14)$$

where $\Lambda_j \equiv \left(\psi_M / \left(1-\psi_M\right)\right)^{(1-\psi_M)} \varpi_j \left(r_j / h_j\right)^{(1-\psi_M)}$ is the conversion factor between cattle and beef in country *j* and is function of the cost parameters and factor prices. In all, there are *J* equilibrium conditions to solve for cattle prices in all *J* countries.

**3. The empirical framework**

It is well known that bilateral trade flows at a disaggregated level contain a significant number of "zeros" because trade is often concentrated within a limited number of geographical areas. Researchers have often addressed this issue by aggregating data to a level that yields positive trade flows between all pair of countries. At a disaggregated level, dropping zero observations can introduce significant biases in the estimation as well as conceal important information about trade determinants (Helpman *et al.*, 2008). The empirical framework is based on the latter authors' firm-level decision model. The impacts of firm heterogeneity on international trade are now well documented (see for example Bernard and Jensen, 1999); however relatively few studies model this feature when estimating gravity equations. A standard sample selection procedure can correct for the bias introduced from non-observed bilateral trade frictions, but it cannot correct for non-observed heterogeneity across firms.[5]

The proposed estimation procedure in this paper corrects for firm self-selection into export markets and for the censored nature of trade flows in the spirit of Cragg's double-hurdle model (Cragg, 1971). The basic assumption is that while some variables affect export decisions in a particular market, they may not impact trade levels directly and/or in the same way (see Chaney, 2008; Bernard *et al.*, 2007). The firm's decision to export to a particular market is modeled as a binary variable which depends on a latent variable with a censored distribution. The first-stage is then used to control for the fraction of firms that export to a particular market. In this world of heterogeneous firms, a larger fraction of firms export to the most profitable export destinations. A second correction is made to take into account the censored nature of trade flows. As a result of the double correction, the impact of trade frictions on trade flows can be decomposed into the intensive and the extensive margins, where the former relates to trade volume per exporter and the latter refers to the number of exporting firms in a given country.

*Trade level decisions*

Our framework involves estimating a system of export supply and import demand schedules because of the vertical linkages between cattle and beef productions. Taking a logarithm transformation of (6) and (13) yields the following equations to be estimated:

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[5] Silva and Tenreyro (2006) account for zero trade flows in estimating trade elasticities using a Poisson pseudo-maximum-likelihood model and obtain estimates which are similar to the ones reported in Helpman *et al.* (2008).

$$\begin{aligned}\ln I_{ji} &= \ln C_j^I + \ln V_{ji}^I + \ln N_i^I Q_i^I - \gamma^{-1}(\beta-1)^{-1}\ln\psi_j(\cdot) + \gamma\ln h_i + \gamma\ln T_{ji}^I - \ln\delta_i^I - \ln\lambda_j^I + v_{ji}^I \\ \ln M_{ij} &= \ln Y_i + \ln V_{ij}^M + \ln N_j^M Q_j^M - \eta\ln(\tilde{c}_j) - \eta\ln h_j^{\theta_h} - \eta\ln T_{ij}^M - \ln\delta_i^M - \ln\lambda_j^M + v_{ij}^M\end{aligned} \tag{15}$$

where $\delta_i^I \equiv \left(\sum_z \left(h_z T_{zi}^I\right)^{1+\gamma}\right)^{\mathrm{B}}$, $\delta_i^M \equiv \left(\sum_k \left(T_{ik}^M \tilde{c}_k h_k^{\theta_h}\right)^{1-\eta} N_k^M\right)$ and $v_{ij}^M$ and $v_{ji}^I$ are stochastic error terms with mean zero and variance-covariance matrix $\mathbf{\Sigma}_{vv}$.

*Firms' participation decisions*

In the system defined by (15), the terms $V_{zk}^{(\cdot)}$ are generally not observed and must be inferred. Following Melitz (2003), consider that selling in a given foreign market implies that firms must pay some fixed costs denoted $\mathrm{f}^{(\cdot)}$. While all firms in country *j* sell output domestically, only a fraction of firms sell abroad, denoted $V_{ij}^M$ and $V_{ij}^I$, respectively, for cattle and beef exports to country *i*. The profits of a beef processing firm in country *j* selling to country *i* can be depicted by:

$$\pi_{ij} = \left(p_j - c_{ij}\right)q_{ij} - \mathrm{f}_{ij}^m = \alpha Y_i \eta^{-1}\frac{\left(\varpi_{ij}\tilde{c}_j h_j^{\psi_M} T_{ij}^M\right)^{1-\eta}}{\sum_z\left(\varpi_{iz}\tilde{c}_z h_z^{\psi_M} T_{iz}^M\right)^{1-\eta} N_z^M} - \mathrm{f}_{ij}^m \tag{16}$$

The ability to export is conditional on the firm-specific TFP. Using the zero profit condition, we can define the following latent variable for the beef sector:

$$E_{ij} = \alpha Y_i \eta^{-1}\frac{\left(\underline{\varpi}_j\tilde{c}_j h_j^{\psi_M} T_{ij}^M\right)^{1-\eta}}{\sum_z\left(\varpi_{iz}\tilde{c}_z h_z^{\psi_M} T_{iz}^M\right)^{1-\eta} N_z^M} \Bigg/ \mathrm{f}_{ij}^m \tag{17}$$

The latent variable in (17) is the ratio of the profit of country *j*'s most productive firm to the fixed costs (common to all exporters) when exporting to country *i*. A firm's self-selection into country *i*'s export market is observed if and only if $E_{ij} > 1$. Fixed trade costs are assumed to be stochastic and i.i.d. and have three components: a component common to all exporting firms

$(\kappa_j)$, a component specific to the destination country $(\kappa_i)$ and finally a country-pair specific component $(\kappa_{ij})$. Following the literature on fixed effects,[6] the logarithmic transformation of the latent variable in the beef sector is:

$$\ln E_{ij}^M \equiv e_{ij}^M = \kappa_0^M + \Gamma_j^M + \chi_i^M + \kappa_1^M \left(s_j^M \tau_{ij}^M\right) + \kappa_2^M d_{ij} - \kappa_{ij}^M + \xi_{ij}^M \qquad (18)$$

where $\kappa_0^M$ is a constant term, $\kappa_1^M \equiv (1-\eta)$, $\kappa_2^M \equiv \vartheta_M \kappa_1^M$, $\Gamma_j^M \equiv (1-\eta)\ln\left(\underline{\varpi}_j \tilde{c}_j h_j^{\theta_h}\right) - \kappa_j$ is the exporter fixed effect, $\chi_i^M \equiv -\ln \delta_i^M + \ln Y_i - \kappa_i$ is the importer fixed effect, and $\xi_{ij}^M$ is a random error term. Equation (18) differs from Helpman *et al.* (2008)'s firm level selection equation because of the existence of asymmetric bilateral policies.

A similar approach can be laid out for the primary sector. The major difference is that the latent variable cannot be explicitly solved for as in (17) because of the existence of decreasing returns to scale in cattle production. However, we propose a log-linear approximation of the latent variable in the cattle sector:

$$e_{ji}^I = \kappa_0^I + \Gamma_i^I + \chi_j^I + \kappa_1^I \left(s_{ij}^I t_{ji}^{I-1}\right) + \kappa_2^I d_{ji} - \kappa_{ji}^I + \xi_{ji}^I \qquad (19)$$

where $\kappa_0^I$ is a constant term, $\Gamma_i^I$ is the exporter fixed effect, $\chi_j^I$ is the importer fixed effect, and $\xi_{ji}^I$ is the random error term.

It is assumed that the error terms $\xi_{ji}^I$ and $\xi_{ij}^M$ are jointly distributed normal with mean zero and variance-covariance matrix $\Omega$. Probit equations for the decisions to trade (cattle or beef) are specified as follows:

$$\rho_{zk}^{(\cdot)} = \Pr\left(E_{zk}^{(\cdot)} = 1 \mid \mathbf{z}_{zk}\right) = \Phi\left(\mathbf{z}_{zk}' \boldsymbol{\delta}\right) \qquad (20)$$

[6] Feenstra (2004) argues that fixed effects adequately estimate the average impact of the border barriers relative to cross-border trade. We use this insight in modelling the firm's self-selection process into export markets.

where $\Phi(\cdot)$ is the normal cumulative distribution function, $\mathbf{z}_{zk}$ denotes the vector of explanatory variables for the latent variable $E$ and $\boldsymbol{\delta}$ is the vector of corresponding parameters.

*Estimation strategy*

The approach used to estimate the model defined by equations (15), (18), and (19) is a one-step estimation procedure in the spirit of a double-hurdle model.[7] To fix the procedure, let $q \equiv \ln I \left( \ln M \right)$ denote the log of non-zero bilateral trade flow of cattle (beef)[8] and remember that the terms $V_{zk}^{(\cdot)}$ are not observed. The firm's participation decision represents the first hurdle to be overcame and is modelled by a Probit structure defined by $\Pr\left( E = 1 \mid \mathbf{z} \right) = \Phi\left( \mathbf{z}'\boldsymbol{\delta} \right)$. The non-negativity constraint on trade flows represents the second hurdle and its parameters are estimated using a Multivariate Sample Selection (MSS) procedure developed by Yen (2005).[9] Within this framework, each trade flow is determined by a separate stochastic process with potential correlation across the error terms of all equations. Each trade flow is determined by the following equations:

$$\begin{aligned} \log I\left(M\right) &= f^{(\cdot)}\left(\mathbf{x}^{(\cdot)}, \boldsymbol{\Theta}^{(\cdot)}\right) + v^{(\cdot)} && \text{if} \quad \hbar^{(\cdot)}\left(\tilde{\mathbf{z}}^{(\cdot)}, \tilde{\boldsymbol{\delta}}^{(\cdot)}\right) + u^{(\cdot)} > 0 \\ I\left(M\right) &= 0 && \text{if} \quad \hbar^{(\cdot)}\left(\tilde{\mathbf{z}}^{(\cdot)}, \tilde{\boldsymbol{\delta}}^{(\cdot)}\right) + u^{(\cdot)} \leq 0 \end{aligned} \tag{21}$$

[7] In contrast, Helpman *et al.* (2008) suggest a two-step procedure. They first obtain an estimate of the latent variables $E_{zk}$ by using the estimated probability: $\hat{e}_{zk} = \Phi^{-1}\left(\hat{\rho}_{zk}\right)$. This estimate is then used as a consistent estimate for $V_{zk}^{(\cdot)}$ when estimating the second step "augmented" gravity equation (using strictly positive trade flows).

[8] Country-pair fixed effects in (18) and (19) significantly increase the number of parameters to be estimated. Ranjan and Tobias (2007) suggest a Bayesian approach to get around this problem. Nonetheless, the country-pair fixed effects raise collinearity issues with bilateral trade costs $T_{ij}^{M}$ and $T_{ji}^{I}$. The country-pair fixed effects are thus dropped from the estimation to minimize the number of parameters to be estimated. The empirical specification also includes dummy variables for continents, landlocked countries, common language and border sharing.

[9] Because the logarithmic transformation of the trade volume is undefined when the trade flow is zero, it is customary in the literature to add one unit to all bilateral trade flow values. This practice however can lead to important biases in the estimates of the parameters (Silva and Tenreyro, 2006).

where $f^{(\cdot)}$ is a function that maps the vector of explanatory variables $(\mathbf{x})$ of the trade equations and the associated vector of parameters $(\mathbf{\Theta})$ into trade flows and $v$ are random error terms; $\hbar^{(\cdot)}$ is a function that maps the vector of explanatory variables $(\tilde{\mathbf{z}})$ of the sample selection equations and the associated vector of parameters $(\tilde{\boldsymbol{\delta}})$ and $u$ are random error terms. It is also assumed that $\boldsymbol{\upsilon}=[\mathbf{v},\mathbf{u}]'$ is distributed as a (2x2)-variate normal with zero mean and variance-covariance matrix: $\mathbf{\Sigma}=\begin{bmatrix}\Sigma_{uu} & \Sigma_{vu}\\ \Sigma_{uv} & \Sigma_{vv}\end{bmatrix}$.

where $\Sigma_{uu}=E(\mathbf{uu}')$, $\Sigma_{vu}=\Sigma_{uv}'=E(\mathbf{vu}')$ and $\Sigma_{vv}=E(\mathbf{vv}')$.[10]

The error terms of the firm-level participation equations ($\xi_{ji}^{I}$ and $\xi_{ij}^{M}$) are assumed to be jointly distributed, but independent of $v_{ji}^{I}$, $v_{ij}^{M}$, $u_{ji}^{I}$ and $u_{ij}^{M}$. This assumption implies that the process of selecting into a particular market is not tied to the level of trade, and thus only firms that do trade in the end determine the structural parameters of the system.

To illustrate the potential impacts of censored trade flows, consider a regime in which beef trade (*M*) is observed while there is no trade in cattle (*I*). Dong, Chung and Kaiser (2004), Yen (2005) and Dong and Kaiser (2008) show that the likelihood contribution of the aforementioned regime $\lambda$ can be represented by:

$$L_{\lambda}(\mathrm{q})=\left[\int_{-\infty}^{-\mathbf{z}'\boldsymbol{\delta}^{I}}\int_{-\mathbf{z}'\boldsymbol{\delta}^{M}}^{+\infty}\phi\left(\xi^{I},\xi^{M};\Omega\right)d\xi^{M}d\xi^{I}\right]g\left(v^{M}\right)\int_{u^{M}>-\hbar^{M}(\cdot)}\int_{u^{I}\le-\hbar^{I}(\cdot)}y\left(u^{I},u^{M}\mid v^{M}\right)du^{I}du^{M} \quad (22)$$

where $g\left(v^{M}\right)$ is the marginal density of $v^{M}$ with elements $\left[q-f^{M}\left(\mathbf{x}^{M},\mathbf{\Theta}^{M}\right)\right]$, $y\left(u^{I},u^{M}\mid v^{M}\right)$ is the conditional density of $\left(u^{I},u^{M}\right)$ given $v^{M}$ and $\phi$ is the probability distribution function of the

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[10] We follow Yen (2005) and set the standard deviation of $\mathbf{u}$ to one.

bivariate normal for $\xi^{(\cdot)}$. Consequently, when there is no trade in cattle and beef, the contribution to the likelihood is $L_{\lambda}\left(\mathrm{q}\right)=\left[\int_{-\infty}^{-\mathbf{z}'\boldsymbol{\delta}^{(\cdot)}}\phi\left(\xi;\Omega\right)d\xi\right]\int_{u^M\leq-\hbar^M}\int_{u^I\leq-\hbar^I}y\left(u^I,u^M\right)du^I du^M$. If trade is observed for both cattle and beef, the contribution of this regime to the likelihood is $L_{\lambda}\left(\mathrm{q}\right)=\left[\int_{-\mathbf{z}'\boldsymbol{\delta}^{(\cdot)}}^{+\infty}\phi\left(\xi;\Omega\right)d\xi\right]g\left(\boldsymbol{\upsilon}\right)\int_{u^M>-\hbar^M}\int_{u^I>-\hbar^I}y\left(u^I,u^M\right)du^I du^M$. Given the dichotomous indicator function $\mathrm{I}_j\left(\lambda\right)$ such that $\mathrm{I}_j\left(\lambda\right)=1$ if trade flows – potentially zeros - fall in regime $\lambda$ and $\mathrm{I}_j\left(\lambda\right)=0$ otherwise, the sample likelihood function can then be depicted by: $L=\prod_j\prod_{\lambda}\left[L_{\lambda}\left(\mathbf{q}_j\right)\right]^{\mathrm{I}_j(\lambda)}$.

We use the Geweke-Hajivassiliou-Keane (GHK) smooth recursive conditioning simulator to evaluate the probability integrals of the likelihood function to be estimated (Hajivassilou, McFadden and Ruud, 1996).

Finally, it must be noted that cattle prices are simultaneously determined along with trade flows due to vertical linkages in production. A full information maximum likelihood method was considered, but ultimately abandoned because the procedure failed to converge due to the significant non-linearities in the model. As in Ghazalian *et al.* (2008), we used an instrumental variables technique to instrument cattle prices.[11] The cattle price equation is:

$$\begin{aligned}\ln h_j &= \vartheta_0+\vartheta_1\ln dist_{j\cdot}+\vartheta_2\ln\tau^I_{j\cdot}+\vartheta_3\ln\tau^M_{j\cdot}+\vartheta_4\ln s^M_{\cdot j}+\vartheta_5\ln\theta^M_j\\ &\quad+\vartheta_6\ln\tau^I_{\cdot j}+\vartheta_7\ln\tau^M_{\cdot j}+\vartheta_8\ln s^M_{j\cdot}+\vartheta_9\ln\theta^M_j+\vartheta_{10}\ln w_j\\ &\quad+\vartheta_{11}\ln r_j+\vartheta_{12}\ln\ell_j+\vartheta_{13}\ln Q^I_j+\vartheta_{14}\ln Q^M_j+\vartheta_{15}\ln Y_j+\varepsilon_j\end{aligned} \tag{23}$$

[11] Another approach to address the endogeneity issue would be to model prices as autoregressive processes. However, because of forward contracting in buying and stocking activities, lagged prices could be correlated with the supply and/or demand equation error terms. Moreover, prices could still be correlated through time. Overall, we found that lagged prices were not appropriate instruments.

where $dist_{j\cdot} \equiv \sum_z \omega_z^{GDP} dist_{jz}$ is a remoteness variable (Helliwell, 1998) based on the GDP weight of country $z$ $\left(\omega_z^{GDP}\right)$ relative to the aggregate GDP of its trading partners, $\tau_{j\cdot}^I \equiv \sum_z \omega_{jz}^I \tau_{jz}^I$ and $\tau_{j\cdot}^M \equiv \sum_z \omega_{jz}^M \tau_{jz}^M$ are the average applied tariffs for cattle and beef with $\omega_{jz}^a$ and $\omega_{jz}^f$ representing the import weight of country $j$ from country $z$ relative to total imports, $\tau_{\cdot j}^I \equiv \sum_z \omega_{zj}^I \tau_{zj}^I$ and $\tau_{\cdot j}^M \equiv \sum_z \omega_{zj}^M \tau_{zj}^M$ are the average outward applied tariffs for cattle and beef with $\omega_{zj}^I$ and $\omega_{zj}^M$ representing the export weight of country $j$ to country $z$ relative to total exports, $s_{\cdot j}^M$ and $\theta_j^M$ are the export subsidies and domestic support offered by country $j$, $s_{j\cdot}^M \equiv \sum_z \omega_{jz}^M s_z^M$ is the average inward export subsidy variable; $\theta_{j\cdot}^f \equiv \sum_z \omega_{jz}^f \theta_z^f$ is an average inward domestic support variable[12], $Q_j^I$ and $Q_j^M$ are, respectively, total output of cattle and beef, $Y_j$ is the GDP, $\ell_j$, $w_j$ and $r_j$ are the land rents, the wage rate and the price of capital in country $j$, respectively, and $\varepsilon_j$ is assumed to be a well-behaved stochastic error term.

## 4. Data sources and estimation results

Trade volumes of cattle and bovine meat were obtained from the Agricultural Trade Policy Simulation Model (ATPSM, Peters and Vanzetti, 2004). The ATPSM bilateral trade volumes are reported as an average over 1999 to 2001 and are derived from the UNCDTAD trade deflator dataset. Trade policies are also collected from the ATPSM dataset and correspond to: *i*) applied tariffs found in the Agricultural Market Access Database (AMAD) of the OECD; and *ii*) exports subsidies notified by WTO members. Adjustments were made to applied tariffs so they account for preferential trade agreements between countries included in the dataset based on the TRAINS dataset. The domestic support measure is taken from the ATPSM database and reflects a

[12] There are no domestic and export subsidies for live cattle in the sample.

UNCTAD compilation of various domestic support measures that avoids double counting when domestic policies are combined with border policies (as in the case of administered prices).

Cattle prices and total production are collected from the Food and Agriculture Organization (FAO) Agricultural Producer Price series and FAO Statistical Yearbook respectively. Beef production is collected from the FAOSTAT database of the FAO. Gross Domestic Products (GDP) are collected from the International Monetary Fund (IMF) World Economic Outlook Database. Wages in the manufacturing sector are collected from the United Nations Industrial Development Organization database. The price of capital is proxied by the price of investment derived from the Penn World Tables. The dataset of distances is based on a compilation by the *Centre d'Études Prospectives et d'Informations Internationales* (CEPII). We use the harmonic distance measure as in Head and Mayer (2002). Adjusting for missing and outlier data in the constructed database resulted in a dataset of 42 countries which are listed in Table 1. Zero trade flows between country pairs occur 64 % and 42 % of the time for cattle and beef. Table 2 presents descriptive statistics about the above variables.

Table 3 presents the regression results of the OLS estimator applied to (23). The purpose of this regression is to instrument cattle prices using predicted values computed with independent variables in the model. While only five variables are statistically significant at the 5 percent level, the coefficient of determination of the regression ($R^2$) is acceptable at 0.49. The degrees-of-freedom penalty is however large as the adjusted $R^2$ is 0.197.[13] Table 4 presents the estimates of the structural coefficients of the gravity model along with their standard errors.[14] Because the presence of zero trade flows can lead to a substantial heteroskedasticity bias if the trade level

[13] A more parsimonious specification in which some variables were excluded was also estimated. The adjusted $R^2$ for this specification was 0.22 and only offered a small improvement over the more general specification.

[14] The OLS results of the cattle price equation in (23) are reported in Table 3. The OLS estimates were used to predict cattle prices which were subsequently inserted into the bilateral trade functions.

equation is log-linearized (Silva and Tenreyro, 2006), we report standard errors using the diagonal of the White heteroskedastic-consistent covariance matrix.

The estimates of the elasticity of substitution and transformation in table 4 are reasonable and significant given the standard errors reported between parentheses. The estimates of the variance-covariance matrices of both the participation equation and the multivariate sample selection equations are statistically significant although not reported here for sake of brevity. The elasticities of substitution and transformation are respectively 4.26 and 1.86. The estimate of the CET parameter suggests that cattle exports are imperfectly substitutable across markets. This result is consistent with the degree of cattle price dispersion (see table 2) and suggests that cattle markets are segmented.[15] The distance coefficients are sensible and have the expected negative sign. In absolute value, the magnitude of the distance elasticities (1.62 for cattle and 0.94 for beef) is similar to previous estimates reported in the literature (e.g., Anderson and van Wincoop, 2004). The relative magnitude of the elasticities reflects the fact that transport costs are typically more restrictive for primary products than for processed products.

In the firm-level selection equation, the coefficients for distance indicates that increasing the distance between the trading partners decrease – in a non-monotonic way - the probability to trade.[16] These results are in line with the recent theories involving heterogeneous firms because as trade costs increase with distance, lower-productivity firms no longer find it profitable to serve export markets. The policy parameter in the firms' selection equation for beef has the expected sign and is strongly significant while the policy parameter for cattle is not significant

[15] Baier and Bergstrand (2001) report a point estimate of 8.56 with a 90% confidence interval of 1.37 and 15.75 when using aggregate trade flows. These authors mention that "without any benchmark for comparison, future research into estimating this transformation elasticity seems warranted." (p. 23).

[16] Following Eaton and Kortum (2002) we rely on dummy variables to capture potential non-linear effects. We consider six distance intervals (in kilometres) : [0, 600) , [600,1200 ), [1200, 2400), ; [2400, 4800), [4800, 9600) and [9600, maximum]. The advantage of this formulation for distance effects is that it imposes little structure on how transport costs vary with distance.

despite being consistent with the intuition that a decrease (increase) in the bilateral tariff should increase (decrease) the probability of developing a trade partnership with foreign firms. Finally, sharing a common border has a positive impact on the probability of being present in a market. It is typical in a in a cross-sectional analysis to find a low $R^2$ (Wooldridge, 2002, p. 265; and Yen, 2005), and our application is no exception. The pseudo $R^2$ measure for the selection and participation equations is relatively low at 0.26. We computed the predicted probability to have a non-zero trade flow given the explanatory variables. If the prediction was greater (lower) than 0.5, we regarded the trade flow as being non-zero (zero). Then, we used the overall percentage of correct predictions as a goodness of fit measure. The percentages ranged from 0.65 to 0.77 and were higher for the cattle sector.

## 5. Trade liberalization scenarios

The parameter estimates can be used to simulate trade liberalization scenarios. The first statistic of interest is the probability of exporting to a particular destination which can be computed as:

$$\Pr\left(E_{ij}^{(\cdot)}=1\right)=\Phi\left(\mathbf{z_{ij}}\boldsymbol{\delta}^{(\cdot)}\big/\sigma_{\xi^{(\cdot)}}\right) \tag{24}$$

where $\Phi$ is the standard normal cumulative distribution function and $\sigma_{\xi}$ is the estimated variance parameter of the firm's selection mechanism. There is a direct relationship between probabilities and the share of domestic firms selling abroad. Hence, the impact of trade policy changes on the extensive margin of trade can be proxied by changes in the probability to export. A second probability measure can be computed because of the censored nature of trade flows. The probability to observe positive trade flows is:

$$\Pr\left(I_{ij}\left(M_{ij}\right)>0\right)=\Phi\left(\frac{\mathbf{z_{ij}}\boldsymbol{\delta}^{(\cdot)}}{\sigma_{\xi^{(\cdot)}}}\right)\Phi\left(\frac{\hbar^{(\cdot)}\left(\tilde{\mathbf{z}},\tilde{\boldsymbol{\delta}}\right)}{\sigma_{u^{(\cdot)}}}\right) \tag{25}$$

where $\Phi$ is the standard normal cumulative distribution function and $\sigma_u$ is the estimated variance of the trade equation. Estimates from (24) tell us about the firms' incentives to develop a business relationship with foreign partners while estimates in (25) measure the probability that trade will actually occur, by taking into account the probability of developing business relationships with foreign partners. The probabilities defined in (24) and (25) highlight that for all positive trade flows, two hurdles must be overcome.

Figures 1a and 1b present the frequency distribution of the probabilities defined in (24) which explain the firm-level decision to develop a relationship with a foreign partner. The probability distribution for cattle trade flows clearly resembles a chi-squared distribution while the distribution in Figure 1b is more heteroclite. Figures 2a and 2b illustrate the frequency distribution of probabilities to observe positive cattle and beef bilateral trade flows respectively as predicted by the double-hurdle model in (25). These probabilities account for the decision of individual firms to engage in a trade relationship with foreign firms as well as the decision to ship to that particular market.

The impact of trade liberalization scenarios on the intensive margin of trade is proxied by the conditional expectation of exports (see Dong and Kaiser, 2008; Yen and Rosinski, 2008):

$$E\left(I\left(M\right)\middle|I>0\left(M>0\right)\right)=\exp\left(f^{(\cdot)}\left(\mathbf{x}^{(\cdot)},\boldsymbol{\Theta}^{(\cdot)}\right)+\sigma^2_{v^{(\cdot)}}/2\right)\left(\frac{\Phi\left(\hbar^{(\cdot)}\left(\tilde{\mathbf{z}},\tilde{\boldsymbol{\delta}}\right)+\rho_{vu}\sigma_v\right)}{\Phi\left(\hbar^{(\cdot)}\left(\tilde{\mathbf{z}},\tilde{\boldsymbol{\delta}}\right)\right)}\right) \quad (26)$$

where the parameter $\rho_{vu}$ represents the coefficient of correlation between $u$ and $v$. Equation (26) is the expected trade level conditional on observing trade partnerships.

We compute two different policy liberalization scenarios: 1) a comprehensive liberalization scenario calling for the elimination of import tariffs, export subsidies and domestic support, and 2) a Doha "compromise" outcome. It is unknown at this stage what concessions are likely to emerge at the end of the Doha Round, or even whether it will ever successfully be concluded. We relied on the revised 2008 draft modalities of Ambassador Falconer (WTO, 2008) to build our Doha scenario. The scenario involves removing export subsidies and cutting trade-distorting domestic support by 50%. Tariffs are also lowered depending on whether protection is in the form of a Tariff-rate Quota (TRQ) or a simple tariff. In most cases, TRQs act as *de facto* import quotas as they set a minimum level under which imports are taxed at a very low (often zero) rate. Any imports above the minimum access are taxed at a very high (often prohibitive) rate. The revised 2008 draft modalities state that a "distinct treatment for tariff cuts" should be applied for sensitive products without preventing "substantial improvement" in market access (WTO, 2008). Hence, the "Doha scenario" includes tariff cuts of 20% when cattle/beef imports are restricted by a TRQ, and 50% in all other instances. The implicit assumption is that beef products are likely to be designed as sensitive when currently protected by a TRQ.

Table 5 reports the impacts of the two liberalization scenarios on cattle and beef exports for a subset of countries (Brazil, Canada, EU, Ghana, South Africa, and the U.S.). The U.S. represents a large and fairly open developed country while and the EU represents a policy active developed country. Results from Canada illustrate the impacts for a "small" and open developed economy while Ghana and South Africa represent respectively small and medium-sized economies. Finally, Brazil represents a "large" developing economy. The results are presented in term of the percentage change relative to the baseline solution representing the average of the 1999/2001 trade flows.

*Cattle sector*

Trade liberalization would induce a small increase in the average probability of firms engaging in cattle trade. Under the full liberalization scenario, the increase in the average probability over the entire sample is less than one percent. Accordingly, we can conclude that full liberalization would not spur many "new friendships" amongst global cattle traders. The increase is even smaller (0.2 % versus 0.8 %) in the case of the Doha scenario. The country-level impacts of liberalization are very much similar to the aggregate probability measure. These results arise because of the small coefficients for policy variables in Table 4's cattle equation. The average probability to export increases more for developing economies such as Ghana, South Africa, and Brazil than for developed economies. If trade liberalization does not create new cattle trade partnerships, perhaps liberalization could induce significant increases in existing trade flows. Actually, average conditional exports increase by less than one tenth of one percent under the full liberalization scenario. There are however individual effects that work in opposite directions and tend to offset each other globally. Canadian cattle exports increase by 0.6 % while a large exporter like the US sees its export average trade flow decrease by 0.3 %. Overall, the impacts under the Doha scenario are timid as the adjustments in the intensive and extensive margins of trade are very small. Moreover, some developing economies see their average exports decrease under the Doha scenario (*e.g.,* South Africa).

*Beef sector*

The average probability of firms to engage in bilateral trading relationships is marginally higher under the Doha scenario than under the baseline situation (an increase of 0.75 percent). Trade liberalization impacts in the beef sector are not however as muted as in the cattle sector. The small impact of Doha on potential bilateral relationships is largely driven by the reduction in the average probability to export by EU firms. As anticipated, European firms withdraw from foreign markets as export subsidies and price support schemes for beef are eliminated. The average probability to export under the Doha scenario increases for all the other countries listed in Table 5. Interestingly, the number of bilateral relationships increases overall under full liberalization despite the significant reduction registered in the EU. This illustrates that partial liberalization scenarios may not go far enough if significant adjustments in the extensive margin of trade are desired. For example, the average export probability for Ghanaian firms increases by 2.7 % under the Doha scenario while the increase is 19.7 % under full liberalization. A similar argument holds for Brazil, Canada, the U.S. and South Africa. Hence, trade liberalization has the potential to yield significant "new friends" in beef trade, but only if it goes far enough.

The conditional mean of EU beef exports is lower under both the Doha and full liberalization scenarios. Hence, adjustments for the EU occur both at the intensive and extensive margins of trade. Total beef exports of Canada, Brazil and Ghana increase because these three countries experience positive adjustments at the intensive and extensive margins of trade. While South African firms find "new friends" to trade with under both the Doha and full liberalization scenarios, their conditional average exports is lower under the Doha scenario. Total exports could thus decrease or increase because both margins move in opposite directions. A similar argument holds for the U.S. because conditional average exports falls under both liberalization scenarios.

Average statistics often hide potential trade liberalization effects in the sense that the increase in the average probability may be due to increases in probabilities that are already large. In that case, an increase in average probability would not likely yield a significant number of *new* friends. Conversely, the increase in the average probability may be driven by increases concentrated in initially low probability values. In this instance, trade liberalization would generate a rather significant number of new friends. Figure 3a plots the Cumulative Frequency Distribution (CFD) of probabilities that Ghanaian beef exporting firms will develop partnerships with foreign firms under the baseline, full liberalization and Doha scenarios. This exercise is repeated in Figures 3b, 3c, and 3d for respectively the EU, US and Canadian firms. Figure 3a reveals that there is no real distinction between the CFD of the baseline and Doha scenarios, thus confirming that the prospects of creating "new friends" for Ghanaian beef exporting firms under a potential Doha Round scenario are remote. There is however a region of the CFD for the full liberalization scenario (in the interval $[0.2\,;\,0.5]$) which is strikingly different than the baseline CFD. In that range, full liberalization yields higher probabilities and thus a greater share of Ghanaian firms are likely to export in a liberalized environment.

The overall patterns in Figure 3b are starkly different than in Figure 3a. Liberalization under both the full and Doha scenarios entail mostly removing export subsidies for the EU. As a result, EU beef exports are lower. This reduction in total European beef exports also leads to a decrease in the number of firms exporting. The baseline line indicates that only 20% of the firms have a probability of export of 40% or less. The proportion of firms with a probability of export of at most 40% increases to about 40% under the Doha scenario and to about 60% under the Full liberalization scenario. The CFD of the U.S. and Canada shown in Figures 3c and 3d, respectively, are similar to the CFD of Ghana. The greatest impact on the probability of domestic firms engaging in export activities is for that mid-interval along the distribution of probabilities.

*The development issue in the Doha Round*

The agenda of the Doha Round of negotiations heavily emphasizes development issues. Of the main objectives of the Round is to have trade contribute to economic growth in developing economies. The evidence presented in Table 5 suggests that this objective could be reached by large developing economies like Brazil which gain new friends in beef trade (in the form of higher average probability to export) as well as higher conditional average exports. However, the

Doha scenario yields lower conditional average beef exports in South Africa. Average cattle exports also decrease for developing economies like Ghana, Brazil and South Africa.

Tables 6a and 6b compare the impacts of the two liberalisation scenarios on respectively cattle and beef trade when the countries in the sample are divided up into OECD and non-OECD members.[17] In the case of cattle, the Doha Round yields an increase in the average probability to engage in trade independently of whether trade within or across the two groups is considered. As before, the results are more substantive under the full liberalization scenario. However, it is interesting to note that while adjustments in the extensive margin of trade are qualitatively similar between OECD and non-OECD countries, non-OCED exporting firms see their cattle average exports to both OECD and non-OECD countries increase by a lower percentage than OECD countries. The evidence suggests that the Doha Round cannot quite equalize trade opportunities in the cattle sector. Given the existence of significant impediments to trade in the form of non-tariff barriers, this result is not entirely surprising.

Table 6b suggests that beef exporting firms from non-OECD countries obtain substantial gains from the Doha scenario. The average probability to export to OECD and non-OECD countries increases by 2.7 % and 3 % respectively while the average probability to export for firms in OECD countries to OECD and non-OECD countries decrease by 5.6 % and 6.5 % respectively. Conditional average exports of both subgroups increase under the Doha scenario and this result is only reinforced under full liberalization. The growth in the average probability to export by non-OECD countries towards OECD and non-OECD members is, respectively, 5 and 3 times larger than the impacts for OECD countries. These results suggest that the

[17] Note that in the baseline scenario, trade among OECD members is larger than trade between OECD and non-OECD members and non-OECD members among them. In our database, trade among OECD members represents 74 % and 83 % respectively of total cattle and beef trade.

elimination of export subsidies and reduction in trade distorting support could yield substantial gains for non-OECD countries.

## 6. Conclusion

The Doha Round of multilateral talks at the WTO is at an important juncture. While some progress has been made with respect to disciplining specific forms of export subsidies, there are still significant disparities between WTO members' negotiating position on market access issues and reductions in trade distorting domestic support for agricultural products. While linked, trade flows for primary and processed agricultural products are evolving differently, with trade in processed products growing much faster. We use a gravity-based framework to uncover the potential trade liberalization impacts on primary and processed products at the intensive and extensive margins and apply it to the cattle and beef sectors. The objective is to forecast growth in trade induced by different liberalization scenarios and to determine the extent by which this growth is due to increases in the number of new trade flows (new friends) and to the strengthening of existing trade flows (old friends).

The two most important structural parameters of the model measure the degree of differentiation in beef commodities at the consumers' level and the cattle elasticity of transformation which accounts for non-tariff barriers and other bottlenecks in cattle trade. The framework yields empirically tractable bilateral trade flow equations that are estimated with a double-hurdle model to account for zero trade flows. In the first stage, firms decide whether to incur a fixed cost to develop partnerships with foreign firms. Given this first-stage decision, the second hurdle explains trade flows using a multivariate sample selection model. This estimation strategy addresses the challenges associated with the log-linearization of the trade equation. The double-hurdle model allows us to make inference about the adjustments in trade that occur at the extensive as well as the intensive margins. Simulated maximum likelihood techniques are used because of the assumed correlation in the error terms of the two-stage decision processes. Finally, vertical linkages in cattle and beef production are accounted for by instrumenting cattle prices in trade equations.

A full liberalization scenario and a Doha compromise outcome are simulated to analyze the extent by which new trade flows are created and put pressure on old existing trade flows. Overall, the simulations indicate that very small adjustments occur at both the intensive and extensive margins for cattle trade. Trade liberalization impacts in the beef sector are more significant. Under the Doha scenario, developing economies see an increase in the number of domestic firms engaged in bilateral beef trade with foreign firms, while firms in OECD countries see a decrease in their number of partnerships. The latter result seems to be driven by the elimination of export subsidies and reduction in domestic price support. However, average beef exports conditional on firms engaging in trade increases for firms located in both OECD and non-OECD countries. While the increase in average exports is larger in percentage terms for firms in non-OECD countries than for firms in OECD countries, the Doha scenario only yields modest adjustments in the intensive margin of trade. Ambitious liberalization plans seem the only realistic option to fulfill the development objectives of the Doha Round.

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**Table 1. List of countries**

| Country | ISO Code | ISO Number | Country | ISO Code | ISO Number |
|---|---|---|---|---|---|
| European Union | EUR 15 | 918 | India | IND | 356 |
| United States | USA | 840 | Indonesia | IDN | 360 |
| Japan | JPN | 392 | Israel | ISR | 376 |
| Argentina | ARG | 032 | Korea Rep. | KOR | 410 |
| Australia | AUS | 036 | Malaysia | MYS | 458 |
| Bangladesh | BGD | 050 | Mexico | MEX | 484 |
| Bolivia | BOL | 068 | New Zealand | NZL | 554 |
| Brazil | BRA | 076 | Nigeria | NGA | 566 |
| Cameroon | CMR | 120 | Norway | NOR | 578 |
| Canada | CAN | 124 | Pakistan | PAK | 586 |
| Chile | CHL | 152 | Panama | PAN | 591 |
| Colombia | COL | 170 | Peru | PER | 604 |
| Costa Rica | CRI | 188 | Philippines | PHL | 608 |
| Dominican Rep. | DOM | 214 | South Africa | ZAF | 710 |
| Ecuador | ECU | 218 | Sri Lanka | LKA | 144 |
| Egypt | EGY | 818 | Syria | SYR | 760 |
| Ethiopia | ETH | 231 | Thailand | THA | 764 |
| El Salvador | SLV | 222 | Turkey | TUR | 792 |
| Ghana | GHA | 288 | Uruguay | URY | 858 |
| Guatemala | GTM | 320 | Venezuela | VEN | 862 |
| Honduras | HND | 340 | Zimbabwe | ZWE | 716 |

**Table 2. Descriptive statistics of the model variables**

| Variable | Mean | Standard deviation | Coefficient of variation | Minimum | Maximum |
|---|---|---|---|---|---|
| GDP (US $) | 659,084.5 | 1,989,730.0 | 3.02 | 5,949.7 | 9,737,783.0 |
| Wage (US $) | 9,166.2 | 10,143.1 | 1.11 | 464.0 | 33,174.0 |
| Capital (US $) | 70.8 | 45.7 | 0.65 | 30.3 | 318.8 |
| Land (US $) | 1,152.6 | 2,937.8 | 2.55 | 12.1 | 15,008.3 |
| Beef total production (MT) | 503,686.0 | 1,454,473.0 | 2.89 | 0.0 | 8,103,483.0 |
| Beef bilateral trade (MT) | 1,864.2 | 21,556.8 | 11.56 | 0.0 | 397,409.8 |
| Beef applied tariffs (%) | 31.1 | 56.5 | 1.82 | 0.0 | 345.0 |
| Beef domestic support (%) | 4.0 | 18.9 | 4.76 | 0.0 | 113.2 |
| Beef export subsidies (%) | 5.6 | 25.3 | 4.50 | 0.0 | 130.00 |
| Cattle production (MT) | 2,204,532.0 | 4,066,158.0 | 1.84 | 0.0 | 197e+7 |
| Cattle bilateral trade (MT) | 1,007.1 | 17,786.9 | 17.66 | 0.0 | 613,886.9 |
| Cattle price (US $/MT) | 1,196.7 | 678.8 | 0.57 | 450.2 | 3,656.2 |
| Cattle applied tariffs (%) | 6.2 | 13.2 | 2.14 | 0.0 | 73.8 |
| Cattle domestic support (%) | 0.0 | 0.0 | - | 0.0 | 0.0 |
| Cattle export subsidies (%) | 0.0 | 0.0 | - | 0.0 | 0.0 |

**Table 3. OLS estimates of the reduced form cattle price equation**

| Variable | Description | Coefficients | Standard error |
|---|---|---|---|
| $\ell_j$ | Land Rent | 0.026 | 0.052 |
| $w_j$ | Wage | 0.149 | 0.098 |
| $r_j$ | Price of Capital | -0.387 | 0.242 |
| $dist_{j\cdot}$ | Remoteness | **-1.309** | **0.657** |
| $Q_j^I$ | Cattle output | 0.011 | 0.026 |
| $Q_j^M$ | Beef output | -0.020 | 0.016 |
| $Y_j$ | GDP | **-0.154** | **0.072** |
| $\tau_{j\cdot}^I$ | Applied tariffs (cattle) | 0.008 | 0.077 |
| $\tau_{j\cdot}^M$ | Applied tariffs (beef) | **-0.215** | **0.096** |
| $s_{\cdot j}^M$ | Export subsidies (beef) | 0.012 | 0.139 |
| $\theta_j^M$ | Domestic support (beef) | 0.123 | 0.111 |
| $\tau_{\cdot j}^I$ | Outward tariff (cattle) | -0.050 | 0.174 |
| $\tau_{j\cdot}^M$ | Outward tariff (beef) | **0.330** | **0.096** |
| $s_{j\cdot}^M$ | Inward export subsidy (beef) | 0.203 | 0.664 |
| $\theta_{j\cdot}^M$ | Inward domestic support (beef) | -0.320 | 0.573 |
| $R^2$ | | 0.491 | |
| Adjusted $R^2$ | | 0.197 | |

Coefficients in bold are significant at the 5% level.

## Table 4. Estimates of the structural parameters for the import demand and export supply schedules

| Parameters | Cattle | Beef |
|---|---|---|
| **Trade equation** | | |
| Elasticities ( $\gamma$ - cattle; $\eta$ - beef) | 1.86 (0.09) | 4.26 (0.18) |
| Distance ( $\vartheta_I$ - cattle; $\vartheta_M$ - beef) | -0.51 (0.13) | -0.38 (0.04) |
| Cost function ( $\psi_I$ - cattle; $\psi_M$ - beef) | 1.91 (0.33) | 0.69 (0.01) |
| **Sample selection equation** | | |
| Constant | -0.01 (0.05) | 0.23 (0.22) |
| Trade policies | 0.11 (0.22) | -1.60 (0.32) |
| Distance | -0.05 (<0.01) | -0. 02 (<0.01) |
| Common border | 0.23 (0.18) | 0.70 (0.71) |
| Common language | <0.01 (0.59) | -1.54 (1.67) |
| Exporter GDP | 0.14 (0.01) | 0.39 (0.03) |
| Importer GDP | 0.15 (0.02) | 0.24 (0.11) |
| Covariance between selection and trade | 0.40 (0.08) | 1.71 (0.14) |
| Weighted % correctly predicted | 0.75 | 0.65 |
| **Participation equation** | | |
| Constant | 0.56 (0.19) | 0.91 (0.28) |
| Trade policies | 0.13 (0.19) | -0.72 (0.12) |
| Common border | 0.12 (0.11) | 0.11 (0.17) |
| Common language | -0.01 (0.22) | -0.06 (0.42) |
| Distance | | |
| [0, 600) | - | - |
| [600,1200 ) | -0.20 (0.21) | -0.15 (0.44) |
| [1200, 2400) | -0.17 (0.18) | -0.13 (0.49) |
| [2400, 4800) | -0.11 (0.11) | -0.07 (0.26) |
| [4800, 9600) | -0.18 (0.09) | -0.20 (0.18) |
| [9600, maximum] | -0.39 (<0.01) | -0.37 (0.09) |
| **Pseudo $R^2$** | 0.26 | |
| **Log-likelihood** | -3.47 | |

Notes: Standard errors are reported between parentheses. A total of 1,722 observations are used. Importers and exporters' fixed effects were deleted from the sample selection equation and were replaced by GDP in order to reduce the number of parameters to be estimated. Estimation is carried out using simulated maximum likelihood with 400 GHK replications using numerical gradients. The percentage of accurate predictions offers a goodness-of-fit measure. The Pseudo $R^2$ is calculated as $1-L_{ur}/L_0$ where $L_{ur}$ is the log-likelihood function for the estimated model and $L_0$ is the likelihood function in the model with only an intercept in participation and sample selection equations (Wooldridge, 2002, p 465).

**Table 5. Impacts of trade liberalization on cattle and beef exports**

| Selected countries | Cattle: % change with respect to baseline — Full liberalization | Cattle: Doha scenario | Beef: % change with respect to baseline — Full liberalization | Beef: Doha scenario |
|---|---|---|---|---|
| **Brazil** | | | | |
| Average firm-level probability to export | 0.63 | 0.17 | 14.53 | 2.46 |
| Average exports across destinations | 0.15 | 0.07 | 3.05 | 1.50 |
| **Canada** | | | | |
| Average firm-level probability to export | 0.57 | 0.14 | 15.69 | 2.67 |
| Average exports across destinations | 0.06 | 0.31 | 7.14 | 3.24 |
| **EU** | | | | |
| Average firm-level probability to export | 0.40 | 0.11 | -43.97 | -31.00 |
| Average exports across destinations | -1.16 | -0.34 | -2.69 | -1.74 |
| **Ghana** | | | | |
| Average firm-level probability to export | 0.87 | 0.23 | 19.74 | 2.70 |
| Average exports across destinations | 1.09 | 0.39 | 4.45 | 1.01 |
| **South Africa** | | | | |
| Average firm-level probability to export | 0.80 | 0.21 | 22.44 | 3.15 |
| Average exports across destinations | 0.56 | -0.26 | 0.83 | -0.47 |
| **USA** | | | | |
| Average firm-level probability to export | 0.54 | 0.14 | 20.62 | 2.80 |
| Average exports across destinations | -0.31 | 0.27 | 7.95 | 2.21 |
| **World** | | | | |
| Average firm-level probability to export | 0.79 | 0.20 | 17.21 | 0.75 |
| Average exports across destinations | 0.14 | 0.00 | 1.85 | 0.64 |

## Table 6a. Trade liberalization impacts in the cattle sector for OECD and non-OECD countries

**Full liberalization scenario (% change)**

| | | **Average probabilities to export at the firm level** | | **Conditional average exports** | |
|---|---|---|---|---|---|
| | | Importer | | Importer | |
| | | *OECD* | *Non- OECD* | *OECD* | *Non- OECD* |
| Exporter | *OECD* | 0.93 | 0.55 | 0.67 | 0.14 |
| | *Non- OECD* | 1.25 | 0.70 | 0.40 | 0.17 |

**Doha scenario (% change)**

| | | **Average probabilities to export at the firm level** | | **Conditional average exports** | |
|---|---|---|---|---|---|
| | | Importer | | Importer | |
| | | *OECD* | *Non- OECD* | *OECD* | *Non- OECD* |
| Exporter | *OECD* | 0.16 | 0.17 | 0.15 | 0.03 |
| | *Non- OECD* | 0.21 | 0.22 | 0.01 | -0.04 |

## Table 6b. Trade liberalization impacts in the beef sector for OECD and non-OECD countries

**Full liberalization scenario (% change)**

| | | **Average probabilities to export at the firm level** | | **Conditional average exports** | |
|---|---|---|---|---|---|
| | | Importer | | Importer | |
| | | *OECD* | *Non- OECD* | *OECD* | *Non- OECD* |
| Exporter | *OECD* | 3.55 | 6.49 | 3.37 | 3.02 |
| | *Non- OECD* | 17.89 | 22.37 | 2.63 | 3.84 |

**Doha scenario (% change)**

| | | **Average probabilities to export at the firm level** | | **Conditional average exports** | |
|---|---|---|---|---|---|
| | | Importer | | Importer | |
| | | *OECD* | *Non- OECD* | *OECD* | *Non- OECD* |
| Exporter | *OECD* | -5.58 | -6.53 | 0.75 | 0.54 |
| | *Non- OECD* | 2.72 | 3.04 | 0.53 | 0.60 |

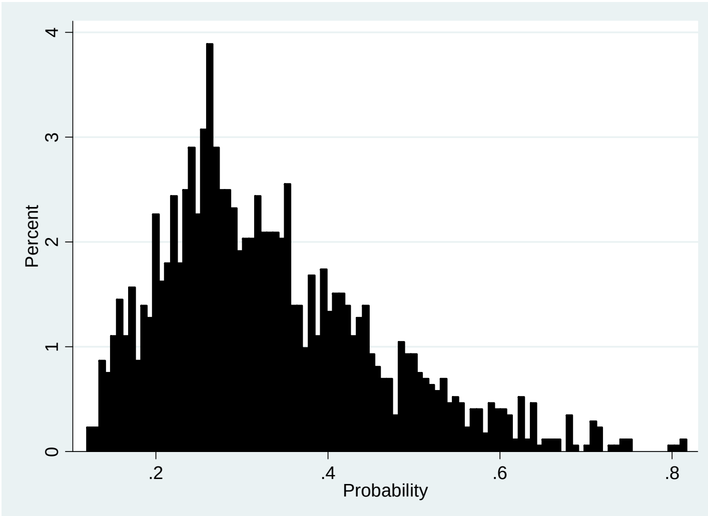


Figure 1a. Frequency distribution of the predicted probabilities associated with firms' self-selection into cattle export markets

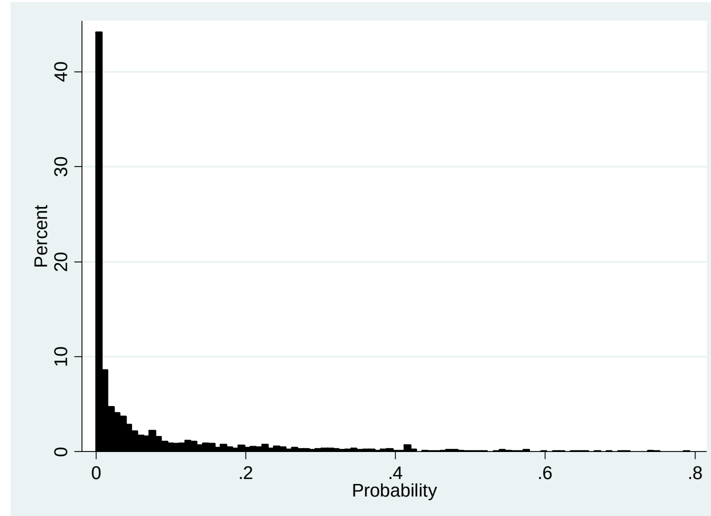


Figure 2a. Frequency distribution of the predicted probabilities to observe positive cattle trade flows according to the double-hurdle model

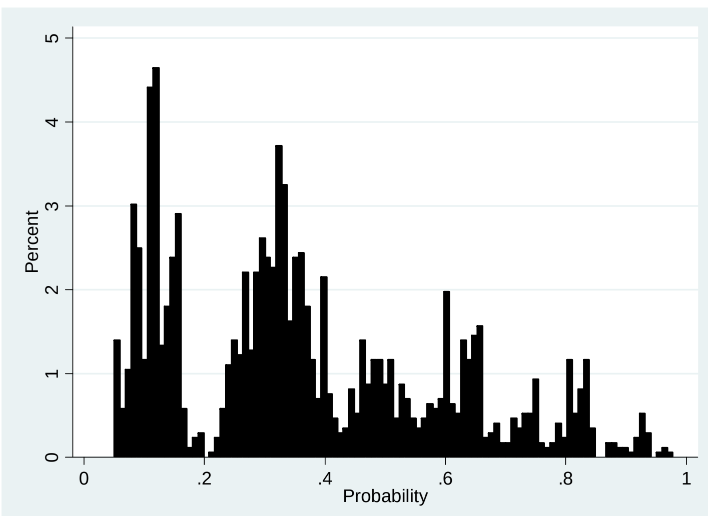


Figure 1b. Frequency distribution of the predicted probabilities associated with firms' self-selection into beef export markets

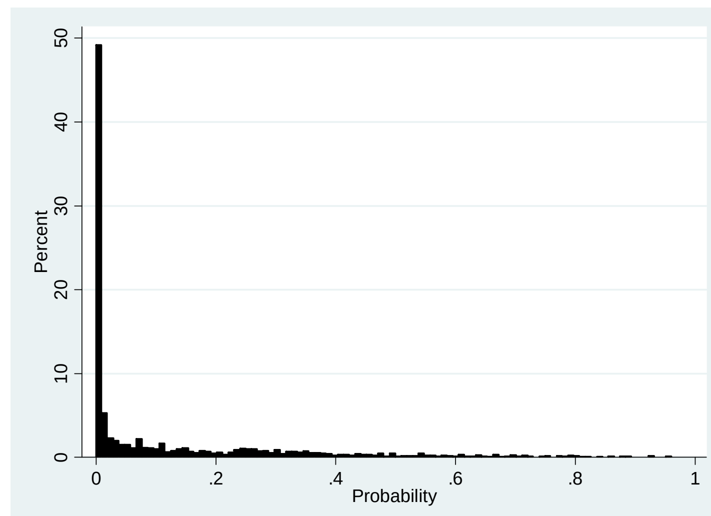


Figure 2b. Frequency distribution of the predicted probabilities to observe positive beef trade flows according to the double-hurdle model

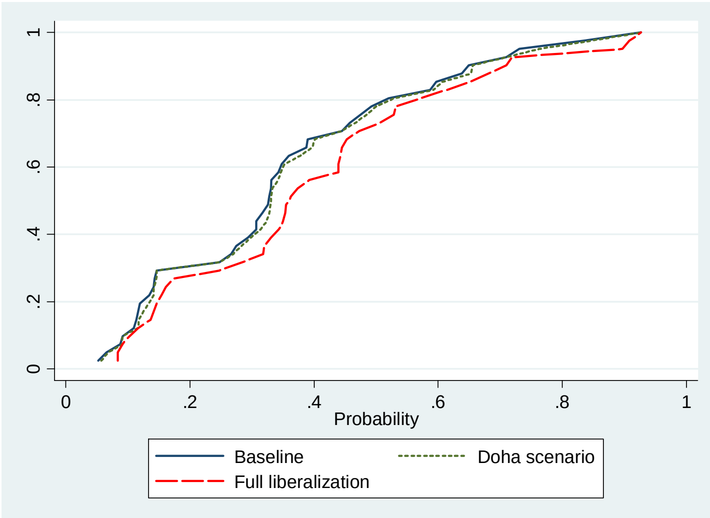


Figure 3a. Cumulative frequency of the probabilities associated with Ghanaian firms exporting beef

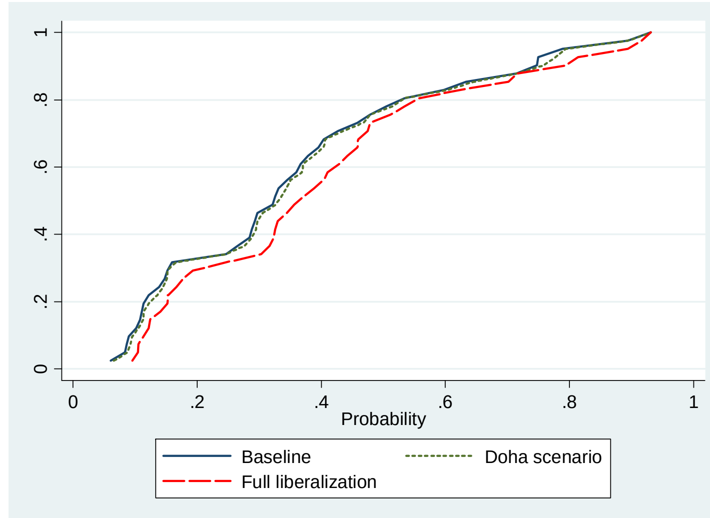


Figure 3c. Cumulative frequency of the probabilities associated with U.S. firms exporting beef

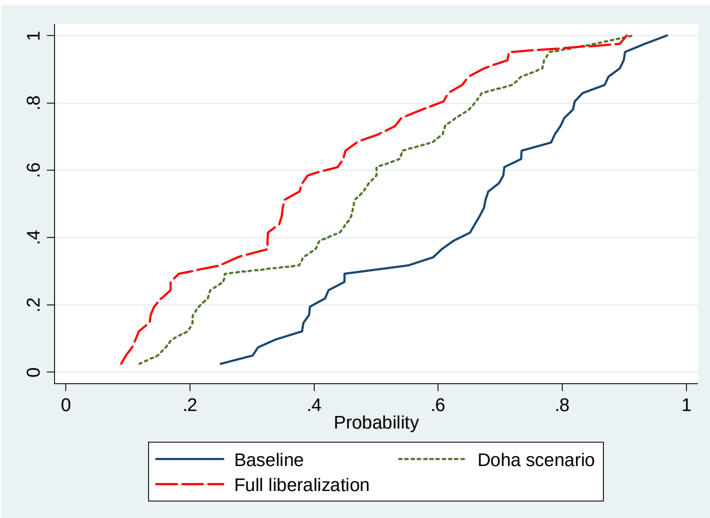


Figure 3b. Cumulative frequency of the probabilities associated with EU firms exporting beef

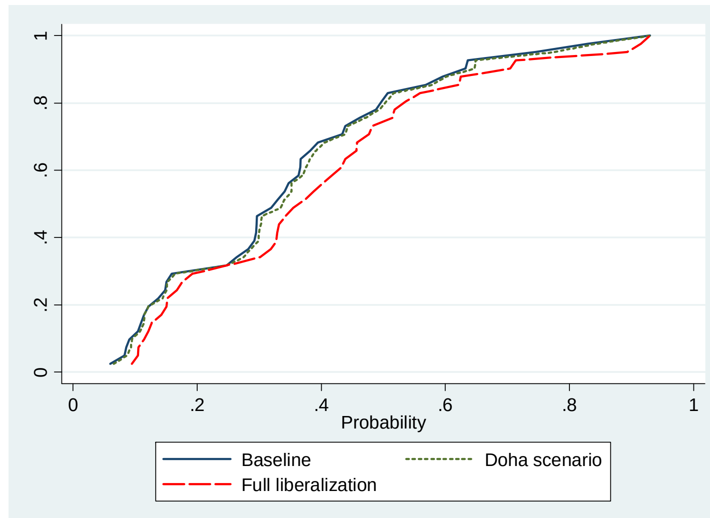


Figure 3d. Cumulative frequency of the probabilities associated with Canadian firms exporting beef