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Trade liberalisation effects on agricultural goods at different processing stages

Lota D. Tamini*,†, Jean-Philippe Gervais‡ and Bruno Larue†
†Laval University, Québec City, Canada; ‡North Carolina State University, Raleigh, USA

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Abstract

A two-stage gravity-based model is used to explain cattle and beef bilateral trade flows between 42 countries. The model parameters are estimated using a double-hurdle model with a multivariate sample selection procedure. The parameter estimates are used to simulate probabilities of new trade flows and the increase in existing trade flows following reductions in import tariffs, export subsidies and domestic support. The results show that adjustments in beef exports occur at both the extensive and intensive margins. Full liberalisation would entail adjustments in the extensive margins for developing economies that are about six-fold the adjustments under partial liberalisation.

Keywords: gravity model, heterogeneous firms and international trade, beef/cattle trade, WTO-Doha-round

JEL classification: Q17, F13

1. Introduction

The liberalisation process for agri-food commodities is comparable with 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 implementation period was about 60 per cent (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 liberalisation.

*Corresponding author: Département d'économie agroalimentaire et des sciences de la consommation, Université Laval, 2425 rue de l'agriculture, Québec, QC, Canada G1A 0V6. E-mail: lota.tamini@eac.ulaval.ca

Agri-food markets have distinct features from industrial sectors that are potentially important in determining trade liberalisation impacts. The 2004 world trade report of the World Trade Organisation (WTO) identified major structural change in the composition of agricultural trade with trade in processed products growing more rapidly and becoming more important than trade in primary agricultural goods. This trend is observed across countries and agricultural product groups in spite of evidence about tariff escalation (Elamin and Khaira, 2003). Domestic support policies (e.g. input and output price subsidies) are ubiquitous in agriculture and their reduction represents one of the greatest challenges in the current round of WTO negotiations. As such, comprehensive liberalisation plans must recognise vertical linkages between upstream and downstream sectors and 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 liberalisation scenarios. A theoretical model accounting for vertical linkages between a processed commodity (e.g. bovine meat) and primary commodity (e.g. cattle) is developed to explain bilateral trade flows in primary and processed commodities within the same agri-food supply chain. It allows us to consider a rich environment of policy simulations in which the liberalisation scenarios might affect both market levels in a supply chain simultaneously. We also analyse the extent by which this growth in trade is due to the emergence of new trade flows, referred to as a 'new-friend' effect, and to the strengthening of the existing trade flows, a so-called 'old-friend' effect. The literature has only recently started to address empirically the relationship between the extensive margin of trade (number of exporting firms) and the intensive margin of trade (exports per firm). Felbermayr and Kohler (2006) argue that proper accounting for both the extensive and intensive margins contributes to resolving the 'distance puzzle' in the gravity literature that refers to puzzling increases in the elasticity of bilateral trade with respect to distance over time. Using aggregate time series data, Helpman *et al.* (2008, hereafter HMR) found that the growth in world trade since 1970 was primarily due to increases in bilateral trading volumes between country pairs that had 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 three-digit level for a selected group of 23 developing countries over the 1970–1997 period.

A two-stage gravity model is estimated to explain the existence and the size of trade flows for primary and processed products. The first-stage models the decision of domestic firms to export to another country. HMR (2008) show that the extensive trade margin can be identified using country-level data. The probability of exporting to a given destination is a function of destination-specific variables and bilateral trade costs. It provides a proxy for the extensive margin of trade. In the second stage, trade volumes are determined by a gravity equation that builds on

Anderson and van Wincoop (2003). This equation is estimated using Yen's (2005) multivariate sample selection approach, which is an extension of Cragg's (1971) double-hurdle procedure to ensure that predicted trade flows are weakly positive.

The theoretical model assumes that each firm produces a different processed food variety and all varieties are aggregated through a Constant Elasticity of Substitution (CES) utility function. At the primary market level, we assume that primary commodities are not differentiated from the buyers' perspective. 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. This specification captures the resistance in trade flows induced by the existence of non-tariff barriers.[1] The CET assumption has the advantage of capturing supply rigidities when proceeding with liberalisation simulations.

The empirical application focuses on the cattle/beef trade flows of 42 countries/regions. Out of the 861 country pairs in our sample, cross-hauling in beef is observed for 43 per cent of these pairs. Cross-hauling in cattle is less frequent at 24 per cent.[2] Moreover, tariffs, domestic support and export subsidies vary a lot across countries. For example, the European Union (EU)'s tariff and export subsidy for bovine meat are both in excess of 50 per cent, while some countries, like Australia, follow a *laissez-faire* policy. Finally, evidence of plant-level heterogeneity in beef processing (e.g. Nguyen and Ollinger, 2006) coupled with asymmetric trade costs form a basis to explain the zeros in bilateral trade flows.

Aggressive and moderate liberalisation scenarios are simulated to assess the importance of the new- and old-friend effects. The first scenario involves aggressive liberalisation plans that call for the elimination of import tariffs, export subsidies and domestic support. The moderate liberalisation scenario mimics a potential Doha 'compromise' outcome in which export subsidies are eliminated, but tariffs and domestic support are partially reduced. Overall, the simulations indicate that the adjustments occurring at both the intensive and extensive margins are small for cattle trade. Trade liberalisation impacts in the beef sector are more substantial. The results for non-OECD countries are striking. These countries witness on average an adjustment in the extensive margin under aggressive liberalisation that is about 6-fold the adjustment under moderate liberalisation. Average beef

1 Most studies that investigate the tariff equivalent impact of NTBs assume perfect substitution between domestic and imported goods such that the tariff equivalent is measured as the difference between the domestic and the world price. Yue *et al.* (2006) have extended this approach by incorporating trade costs. Disdier *et al.* (2008) estimated the own-price elasticity of import demands and use them to compute the tariff equivalent of NTBs.

2 Buhr and Kim (1997) develop a dynamic production model and show that the US beef wholesale sector use cattle imports to smooth out the impacts of changes in market conditions. This explains why a large beef-producing country, such as the USA, would continue to be a major producer and importer of beef and cattle.

exports increase in all scenarios, but the aggressive liberalisation impacts are noticeably larger than the moderate liberalisation outcomes. Clearly, an ambitious liberalisation path is necessary for the primary objective of the Doha Round to be fulfilled.

2. The theoretical model

The theoretical model draws from the framework developed by Anderson and van Wincoop (2003) and HMR (2008). Assume that there are Z ($z = 1, \ldots, i, j, \ldots, Z$) countries with consumers endowed with identical preferences over bovine meat (beef) consumption. Let the beef sector be denoted by superscript M. Consumers' preferences are captured by a CES-type utility function over varieties. Let $q_i(\omega)$ be country i's consumption of one beef product variety with ω indexing varieties. The parameter η measures the elasticity of substitution between beef varieties and hence $\eta > 1$. The utility function in country i is

$$U_i = \left(\int_{\omega \in \Xi_i^M} q_i(\omega)^{(\eta-1)/\eta} \, \mathrm{d}\omega \right)^{\eta/(\eta-1)} \quad (1)$$

where Ξ_i^M is the set of beef varieties available in country i.

Each beef processing firm within a country produces a different variety with N_j^M being the (fixed) number of varieties in country j. All firms have access to the same technology with the exception of a firm-specific productivity shock. Assume that the technology for beef production in country j can be represented by a constant returns to scale Cobb–Douglas production function: $\mathrm{TFP}_j(\omega) I_j^{\psi^M} K_j^{(1-\psi^M)}$, where $\mathrm{TFP}_j(\omega)$ is a total factor productivity index specific to a firm in country j,[3] I_j and K_j, respectively, denote cattle and capital used in beef production and ψ^M the cattle cost share. The cattle and capital factor prices are denoted by h_j and r_j, respectively. The supply of capital is perfectly elastic from the perspective of beef processors and as such they perceive r_j as a constant. Under these assumptions, marginal cost is $c_j = \varpi_j^M(\omega) r_j^{(1-\psi^M)} h_j^{\psi^M}$, where $\varpi_j^M(\omega) \equiv ((1-\psi_M)^{-(1-\psi_M)}(\psi_M)^{-\psi_M})/\mathrm{TFP}_j(\omega)$. The variable $\varpi_j^M(\omega)$ is a firm-specific productivity parameter with country-specific support $\varpi_j^M(\omega) \in [\underline{\varpi}_j^M, \bar{\varpi}_j^M]$.[4]

We follow HMR (2008: 451) and assume that only a fraction of firms in country j (V_{ij}^M) export to a particular destination i. This fraction is determined by a threshold productivity shock defined by the existence of a destination-

3 Helpman *et al.* (2008) assume the productivity shock follows a Pareto distribution. They test alternative specifications and report that their results are robust to different distributional assumptions.

4 Following Helpman *et al.* (2008), it is assumed that the distribution function of ϖ is identical across countries, but the support of the distribution is country specific.

specific fixed export cost. Firms will export to a destination if they earn positive profits. For an exporting firm in country j, profit maximisation implies

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

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

From the consumers' standpoint, two-stage budgeting allows for 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. The *net* trade costs include the import tariff (denoted by $\tau_{ij}^M \geq 1$), export subsidies offered by country j (denoted by $s_j^M \leq 1$ and invariant across export markets) and the effect of distance summarised by $d_{ij}^{\vartheta^M}$ with $\vartheta_M > 0$ and $d_{ij} = d_{ji}$. Country i's demand function for a variety supplied by country j is as in Feenstra (2004: 152–153):

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

where Y_i represents income in country i and α is the share of income spent on beef.

Assumptions about productivity and the existence of fixed export costs imply only a fraction of firms export to a particular destination. Country i's imports from j are equal to the consumption of each variety defined in equation (3) multiplied by the number of exported varieties ($V_{ij}^M N_j^M$), thus capturing the impact of the firm-specific productivity shock. Using equation (2), we can write total imports as:

$$M_{ij} = V_{ij}^M N_j^M q_{ij} = \alpha Y_i \frac{(T_{ij}^M h_j^{\psi^M} \tilde{c}_j^M)^{-\eta} V_{ij}^M N_j^M}{\sum_z (T_{iz}^M h_z^{\psi^M} \tilde{c}_z^M)^{1-\eta} N_z^M} \tag{4}$$

where $\tilde{c}_j^M \equiv r_j^{(1-\psi^M)}$ and $T_{ij}^M \equiv s_j^M \tau_{ij}^M d_{ij}^{\vartheta^M} \theta_j^M$ subsumes the *net* trade costs and domestic policies.

For future reference, we define the relationship between beef production in country j (denoted Q_j^M) and the total demand faced by country j by:

$$M_{ij} = \frac{M_{ij}}{\sum_z M_{zj}} Q_j^M. \tag{5}$$

Substituting the import demand function in equation (4) for M_{ij} on the right-hand side of equation (5) yields

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

where $\lambda_j^M \equiv \sum_z Y_z (T_{zj}^M h_j^{\psi^M} \tilde{c}_j^M)^{-\eta} V_{zj}^M N_j^M / \sum_z (T_{iz}^M h_z^{\psi^M} \tilde{c}_z^M)^{1-\eta} N_z^M$. Equation (6) combines the intensive and extensive margins of beef trade. It is similar to HMR's (2008, equation 6) generalised version of Anderson and van Wincoop's (2003) gravity equation. The main difference in the current context is in the treatment of cattle prices as explained subsequently.

There are N_j^I cattle producers in country j. We assume that cattle are homogenous products from the buyers' (i.e. processors) perspective. The cattle production function is assumed to be homothetic and thus the cost function of a *representative* cattle producer in country j is: $\Psi_j \tilde{i}_j^\beta$, where $\tilde{i}_j$ denotes a cattle farm's output in country j, $\beta > 1$ is a cost parameter, $\Psi_j \equiv \varpi_j^I w_j^{\psi^I} \ell_j^{1-\psi^I}$ is a country-specific sub-cost function with w and l denoting the price of labour and land, respectively, ϖ^I a productivity parameter and ψ^I the labour cost share. Both prices are exogenous to the cattle and beef sectors. Following Baier and Bergstrand (2001), a cattle farm's total output in country j can be decomposed as: $\tilde{i}_j = \left(\sum_{i=1} \tilde{i}_{ij}^{(1+\gamma)/\gamma}\right)^{\gamma/(1+\gamma)}$, where γ is a CET parameter and i_{ij} denotes cattle shipments from country j to i. If γ 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:

$$\pi_j = \sum_{i=1} h_i T_{ij}^I \tilde{i}_{ij} - \Psi_j \tilde{i}_j^\beta \tag{7}$$

where h_i is the price of cattle paid by processors in country i and $T_{ij}^I \equiv \theta_j^I s_j^I \tau_{ij}^I d_{ij}^{-\vartheta_I}$ subsumes the *net* trade costs and domestic supports in the cattle sector. The variable $s_j^I \geq 1$ measures export subsidies, $\theta_j^I \geq 1$ measures domestic cattle support and $\tau_{ij}^I \leq 1$ represents the tariff of country i on imports from country j. As apparent from the profit definition in equation (7), 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. The expected bilateral cattle trade flow equation is a function of the fraction of firms (denoted V_{ij}^I) exporting to a particular destination given the firm-specific productivity parameter.

Solving the profit maximising first-order conditions yields the bilateral cattle export supply equation at the country level:

$$I_{ij} = V_{ij}^I N_j^I \tilde{i}_{ij}$$
$$= \beta^{(1-\beta)^{-1}} (\tilde{c}_j^I)^{(1-\beta)^{-1}} \left(\frac{(T_{ij}^I h_i)^{\gamma}}{\left(\sum_z (T_{ij}^I h_z)^{1+\gamma}\right)^{(\gamma(\beta-1)-1)/((1+\gamma)(\beta-1))}} \right) V_{ij}^I N_j^I \quad (8)$$

where N_j^I represents the number of cattle producers in country j and $\tilde{c}_j^I \equiv w_j^{\psi^I} \ell_j^{1-\psi^I}$. The inequality $\gamma > 1/(\beta - 1)$ assures that the second-order conditions are satisfied, in which case destinations can be substituted relatively freely (low non-tariff barriers associated with a high γ) only if decreasing returns to scale are not too large (as measured by the parameter β). As in the beef sector, an identity relates cattle bilateral trade flows to total cattle demand in country i. Let C_i^I denote country i's total purchases of cattle, then we have:

$$I_{ij} = \left(\frac{I_{ij}}{\sum_z I_{iz}} \right) C_i^I, \quad (9)$$

To simplify the notation, we define $\mathrm{B} \equiv (1+\gamma)^{-1}(\gamma + \gamma^{-1}(\beta - 1)^{-1}) > 0$. Substituting the supply equation in equation (8) for the I_{ij} variable of the right-hand side of the identity in equation (9) allows us to rewrite country j's cattle supply to country i as:

$$I_{ij} = (\tilde{c}_j)^{-\gamma^{-1}(\beta-1)^{-1}} (C_i^I)(\lambda_i^I)^{-1} \frac{\left(T_{ij}^I h_i\right)^{\gamma}}{\left(\sum_z (T_{iz}^I h_z)^{1+\gamma}\right)^{\mathrm{B}}} V_{ij}^I N_j^I Q_j^I \quad (10)$$

where $\lambda_i^I \equiv \sum_z (\tilde{c}_z)^{-\gamma^{-1}(\beta-1)^{-1}} (N_z^I)/(T_{iz}^I h)^{\gamma} / \left(\sum_z (T_{zj}^I h_z)^{1+\gamma}\right)^{\mathrm{B}}$ and Q_j^I is cattle production in country j. As in equation (6), equation (10) combines the intensive and extensive margins of cattle trade.

Vertical linkages are defined by a series of market-clearing conditions. For any given country, market clearing restricts the total cattle purchases to be equal to (proportionally adjusted) shipments of beef to all destinations:

$$\sum_z I_{iz} = \Lambda_i \sum_z M_{zi} \quad (11)$$

where $\Lambda_j \equiv (\psi^M/1 - \psi^M)^{(1-\psi^M)} \varpi_j (r_j/h_j)^{(1-\psi^M)}$ is the conversion factor between cattle and beef in country j and is a function of technology and factor prices. Overall, there are Z equilibrium conditions that can be used to solve for cattle prices in all Z countries.

3. The empirical framework

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. This is problematic when estimating a log-linearised version of the import demand and export supply schedules. Dropping zero observations can introduce significant biases in the estimation as well as conceal important information about trade determinants. Our empirical framework is based on HMR's (2008) firm-level decision model which itself borrows from Melitz (2003). The impacts of firms' heterogeneity on international trade are now well documented (see for example Bernard and Jensen, 1999); however, relatively few studies account for 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 the non-observed heterogeneity across firms.[5]

We assume that trade flows result from: (i) the firms' decision to engage or not in exporting and (ii) the firms' chosen level of trade. The estimation strategy naturally follows in two separate stages. First, the estimation procedure accounts for market penetration (i.e. whether firms in the aggregate find it profitable to enter a foreign market). We use a binary variable to determine whether exports to a particular destination are positive and this indicator depends on a latent variable with a censored distribution and potential correlation between the error terms of the primary and processed goods. Second, the estimation procedure for the volume of trade rules out negative predicted trade flows (equations 12 and 13). It can be construed as a generalisation of Cragg's (1971) double-hurdle (DH) model,[6] because we use the multivariate sample selection procedure developed by Yen (2005) for the first hurdle. As a result, 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 (estimated with the double-hurdle model) and the latter refers to the number of exporting firms in a given country (estimated with the bivariate probit).

3.1. 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 markets. A logarithm transformation of equations (6) and (10) yields the

5 Silva and Tenreyro (2006) account for zero trade flows in estimating trade elasticities using a Poisson pseudo-maximum-likelihood model.

6 Hillberry (2002) argues a DH model is more efficient when there is an important number of zeros in the data, because there may not be a strong relationship between positive and zero trade flow observations. Chaney (2008) found support for the latter argument and showed that while some variables affect export decisions in a particular market, they do not impact trade levels directly and/or in the same way.

following equations to be estimated:

$$\ln M_{ij} = \ln Y_i + \ln V_{ij}^M + \ln N_j^M Q_j^M - \eta \ln(\tilde{c}_j^M) - \eta \ln h_j^{\psi^M} - \eta \ln T_{ij}^M - \ln \delta_i^M - \ln \lambda_j^M + v_{ij}^M \tag{12}$$

$$\ln I_{ji} = \ln C_j^I + \ln V_{ji}^I + \ln N_i^I Q_i^I - \gamma^{-1}(\beta - 1)^{-1} \ln \tilde{c}_i^I + \gamma \ln h_j + \gamma \ln T_{ji}^I - \ln \delta_i^I - \ln \lambda_j^I + v_{ji}^I \tag{13}$$

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

Recall that cattle prices are simultaneously determined along with trade flows due to vertical linkages in production. We use a log-linear equation to instrument cattle prices:

$$\ln h_j = \vartheta_0 + \vartheta_1 \ln \mathrm{dist}_{j\cdot} + \vartheta_2 \ln \tau_{j\cdot}^I + \vartheta_3 \ln \tau_{j\cdot}^M + \vartheta_4 \ln s_j^M + \vartheta_5 \ln \theta_j^M + \vartheta_6 \ln \tau_{\cdot j}^I + \vartheta_7 \ln \tau_j^M + \vartheta_8 \ln s_j^M + \vartheta_9 \ln \theta_j^M + \vartheta_{10} \ln w_j + \vartheta_{11} \ln r_j + \vartheta_{12} \ln \ell_j + \vartheta_{13} \ln Q_j^I + \vartheta_{14} \ln Q_j^M + \vartheta_{15} \ln Y_j + \varepsilon_j \tag{14}$$

where $\mathrm{dist}_{j\cdot} \equiv \sum_z \omega_z^{\mathrm{GDP}} \mathrm{dist}_{jz}$ is a remoteness variable (Helliwell, 1998) based on the GDP weight of country z (ω_z^{GDP}) relative to the aggregate GDP of its trading partners, $\tau_j^I \equiv \sum_z \omega_{jz}^I \tau_{jz}^I$ and $\tau_j^M \equiv \sum_z \omega_{jz}^M \tau_{jz}^M$ are the average applied tariffs for cattle and beef with ω_{jz}^I and ω_{jz}^M representing the import weight of country j from country z relative to total imports, $\tau_j^I \equiv \sum_z \omega_{zj}^I \tau_{zj}^I$ and $\tau_j^M \equiv \sum_z \omega_{zj}^M \tau_{zj}^M$ are the average outward applied tariffs for cattle and beef with ω_{zj}^I and ω_{zj}^M representing the export weight of country j to country z relative to total exports, s_j^M and θ_j^M are the export subsidies and domestic support offered by country j, $s_j^M \equiv \sum_z \omega_{jz}^M s_z^M$ is the average inward export subsidy variable; $\theta_j^M \equiv \sum_z \omega_{jz}^M \theta_z^M$ is an average inward domestic support variable[7], Q_j^I and Q_j^M are, respectively, total output of cattle and beef, Y_j is the GDP, ℓ_j, w_j and r_j are the land rents, the wage rate and the price of capital in country j, respectively, and ε_j is a well-behaved stochastic error term.

3.2. Selling in a foreign market

In the system defined by equations (12) and (13), the fractions of firms exporting $V_{zk}^{(\cdot)}$ are generally not observed and must be inferred. Following Melitz (2003), we consider that selling in a given foreign market implies that firms must pay some fixed costs. While all firms in country j sell output

7 Domestic and export subsidies for live cattle in the sample are all zero.

domestically, only a fraction of firms sells abroad. The ability to export is conditional on the firm-specific productivity factor. Using a zero profit condition, we define a latent variable (E_{ij}) as 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. The latent variable in the beef sector can be expressed as:

$$\ln E_{ij}^{M} = \kappa_0^M + \Gamma_j^M + \chi_i^M + \kappa_1^M(\theta_j^M s_j^M \tau_{ij}^M) + \kappa_2^M d_{ij} + \xi_{ij}^M \quad (15)$$

where κ_0^M is a constant term, $\kappa_1^M \equiv (1-\eta)$, $\kappa_2^M \equiv \vartheta_M \kappa_1^M$, and $\Gamma_j^M \equiv (1-\eta)\ln(\varpi_j \tilde{c}_j^M h_j^{\psi^M}) - \kappa_j$ are the exporter-fixed effects,[8] $\chi_i^M \equiv -\ln \delta_i^M + \ln Y_i - \kappa_i$ is the importer fixed effect and ξ_{ij}^M is a random error term. Sunk cost and some non-trade factors certainly play a role in determining the 'new-friend' effect and their impact is captured by country-specific fixed effects. The major difference between equation (15) and HMR's (2008) firm-level selection equation is the inclusion of asymmetric bilateral trade policies. Following Eaton and Kortum (2002), we impose little structure on how transport costs vary with distance and relied on dummy variables to capture potential non-linear effects. We considered six distance intervals (in km): [0, 600), [600, 1200), [1200, 2400), [2400, 4800), [4800, 9600) and [9600, maximum].

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 the beef sector because of the existence of decreasing returns to scale in cattle production. As a result, we propose a log-linear approximation of the latent variable in the cattle sector:

$$\ln E_{ji}^{I} = \kappa_0^I + \Gamma_i^I + \chi_j^I + \kappa_1^I(\theta_i^I s_i^I \tau_{ji}^I) + \kappa_2^I d_{ji} + \xi_{ji}^I \quad (16)$$

where κ_0^I is a constant term, Γ_i^I is the exporter-fixed effect, χ_j^I is the importer-fixed effect and ξ_{ji}^I is an error term.

3.3. Estimation strategy

The empirical model is defined by equations (12)–(16). An observation in our sample consists of a pair of trade flows $\{I_{ji}, M_{ij}\}$. HMR (2008) assumed that the productivity parameter was drawn from a Pareto distribution. This parametric assumption allowed them to obtain an estimate of $V_{ij}^{(\cdot)}$. Due to the highly non-linear structure of the model, we are unable to estimate a structural form of the model that would allow us to retrieve a direct estimate of $V_{ij}^{(\cdot)}$. However, there exists a direct relationship between the predicted probabilities

8 Feenstra (2004) argues that fixed effects are appropriate to estimate the average impact of the border barriers relative to cross-border trade. We use this insight in modelling the firms' decision to sell in a foreign market.

stemming from a bivariate Probit model applied to equations (15) and (16) and the share of domestic firms selling abroad ($V_{ij}^{(\cdot)}$). We exploit this relationship and use the predicted probabilities as proxies for the extensive margin of trade.

Second, an extension of Cragg's (1971) double-hurdle model is used instead of a Tobit model to explain trade flows and prevent predictions to be negative.[9] We define the latent variables for the beef and cattle sectors that determine if trade flows are positive by:

$$\tilde{h}^{M}(\tilde{z}^{M}, \tilde{\delta}^{M}) + u^{M} \quad \text{and} \quad \tilde{h}^{1}(\tilde{z}^{1}, \tilde{\delta}^{1}) + u^{1} \tag{17}$$

where $h^{(\cdot)}$is a function that maps the vector of explanatory variables ($\tilde{\mathbf{z}}$) of the sample selection equation and the associated vector of parameters ($\tilde{\boldsymbol{\delta}}$) and $u^{(\cdot)}$are random error terms. The specification of equation (17) is based on McCallum's (1995) gravity equation and includes GDP of the exporting and importing countries, distance, trade policies and dummy variables for common border and common language.

The error terms ξ_{ij}^{M} and ξ_{ji}^{I} in Equations (15) and (16) are assumed to be jointly distributed with mean zero and variance–covariance matrix Ω, but independent of the error terms v_{ji}^{I} and v_{ij}^{M} from the trade flow equations in (12) and (13) as well as from the error terms u_{ji}^{I} and u_{ij}^{M} in the censoring Equation (17). We follow Yen's (2005) multivariate sample selection procedure model and assume that the error structure $\boldsymbol{\upsilon} = [\mathbf{v}, \mathbf{u}]'$ are distributed as a 2 × 2-variate normal with zero mean and variance–covariance matrix:

$$\boldsymbol{\Sigma} = \begin{bmatrix} \Sigma_{uu} & \Sigma_{vu} \\ \Sigma_{uv} & \Sigma_{vv} \end{bmatrix},$$

where $\Sigma_{uu} = E(\mathbf{uu}')$, $\Sigma_{vu} = \Sigma_{uv}' = E(\mathbf{vu}')$ and $\Sigma_{vv} = E(\mathbf{vv}')$. We use a simulated method to estimate the four-equation model. Puhani (2000) and Yen *et al.* (2003) argue that simulated maximum likelihood (SML) estimators perform better than two-step (TS) procedures in a system context.[10] The SML procedure also allows for potential contemporaneous correlation across equations, which is important given vertical linkages.

9 The selection equations pertain to the fractions of firms that export and are estimated with a bivariate probit. The first hurdle's purpose is to ensure that predicted trade flows stemming from the second hurdle are non-negative.

10 Helpman *et al.* (2008) use a TS procedure in the context of a single-equation model. They first obtain an estimate of the latent variables in equations (15) and (16) by using the estimated probabilities obtained from a Probit model. This estimate is then used as a consistent estimate for the extensive margin when estimating the second step 'augmented' gravity equation (using strictly positive trade flows). In the current context, a TS procedure would involve estimating a system of 'augmented' gravity equations with a seemingly unrelated estimation procedure in the second stage.

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 1999–2001 and are derived from the UNCDTAD trade deflator dataset. Trade policies are also collected from the ATPSM data set 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/regions based on the TRAINS data set. The domestic support measure is taken from the ATPSM database and reflects a UNCTAD compilation of various (trade-distorting) domestic support measures, converted to *ad valorem* equivalent rates.[11] It avoids possible double counting, particularly 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 Organisation (FAO) Agricultural Producer Price series and FAO Statistical Yearbook, respectively. Beef production is collected from the FAOSTAT database of the FAO. Gross domestic product (GDP) statistics 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 Organisation database. The price of capital is proxied by the price of investment derived from the Penn World Tables. The data set 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 resulted in a data set of 42 countries/regions that are listed in Appendix (Table A1). They account for 61 and 68 per cent of cattle and beef global trade, respectively. Zero trade flows between country pairs occur 64 and 42 per cent of the time for cattle and beef, respectively. Table 1 presents descriptive statistics of the variables used in the model.

Table 2 presents the regression results of the OLS estimator applied to Equation (14). The purpose of this regression is to instrument cattle prices using the predicted values. The coefficient of determination of the regression (R^2) is 0.49, which is high for a cross-sectional estimation. However, the degrees-of-freedom penalty is large as the adjusted R^2 is 0.20. As expected, the remoteness index and GDP have a negative impact on cattle prices. The positive and statistically significant impact of the beef applied tariff was also expected as higher applied tariffs for beef increase domestic cattle prices. The impact of cattle applied and outward tariffs are not statistically significant. These tariffs tend to be much lower and less dispersed than their beef counterparts. Thus, it comes as no surprise that beef outward applied tariffs

11 The data set is built using WTO members' notifications and strictly includes policies classified as trade-distorting.

Table 1. Descriptive statistics of the variables

Variable	Mean	Standard deviation	Minimum	Maximum
GDP (USD)	659,084.5	1,989,730.0	5,949.7	9,737,783.0
Wage (USD)	9,166.2	10,143.1	464.0	33,174.0
Capital (USD)	70.8	45.7	30.3	318.8
Land (USD)	1,152.6	2,937.8	12.1	15,008.3
Beef total production (MT)	503,686.0	1,454,473.0	0.0	8,103,483.0
Beef bilateral trade (MT)	1,864.2	21,556.8	0.0	397,409.8
Beef applied tariffs (%)	31.1	56.5	0.0	345.0
Beef domestic support (%)	4.0	18.9	0.0	113.2
Beef export subsidies (%)	5.6	25.3	0.0	130.0
Cattle production (MT)	2,204,532.0	4,066,158.0	0.0	197e+7
Cattle bilateral trade (MT)	1,007.1	17,786.9	0.0	613,886.9
Cattle price (USD/MT)	1,196.7	678.8	450.2	3,656.2
Cattle applied tariffs (%)	6.2	13.2	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 2. OLS estimates of the reduced form cattle price equation

Variable	Description	Coefficients	Standard error
ℓ_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)	−0.050	0.174
$\tau_{j\cdot}^M$	Applied tariffs (beef)	**0.330**	**0.096**
s_j^M	Export subsidies (beef)	0.012	0.139
θ_j^M	Domestic support (beef)	0.123	0.111
$\tau_{\cdot j}^I$	Outward tariff (cattle)	0.008	0.077
$\tau_{\cdot j}^M$	Outward tariff (beef)	**−0.215**	**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	

Note: Coefficients in bold are significant at the 5 per cent level.

have a negative and statistically significant impact on cattle prices. That result is intuitive; reducing trade cost increases the demand of cattle.

Table 3 presents the estimates of the parameters – along with their standard errors – in the cattle and beef trade equations in (12) and (13) and the

Table 3. Estimates of the structural parameters for the beef import demand and cattle export supply schedules

Parameters	Cattle	Beef
Trade equations[a]		
Elasticities (γ – cattle; η – beef)	1.86 (0.09)	4.26 (0.18)
Distance (ϑ_I – cattle; ϑ_M – beef)	−0.51 (0.13)	−0.38 (0.04)
Cost function (ψ_I – cattle; ψ_M – beef)	0.91 (0.33)	0.69 (0.01)
Censoring correction equations[b]		
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)
Percentage of correctly predicted observations	0.75	0.65
Extensive margin equations[c]		
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	

[a]Estimates obtained from equations (12) and (13) for beef and cattle, respectively.
[b]Estimates obtained from equation (17) for beef and cattle.
[c]Estimates obtained from equations (15) and (16) for beef and cattle, respectively.
Standard errors are reported between parentheses. 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: 465).

participation decision equations in (15) and (16). Table 3 also reports the estimated coefficients of the sample selection equation that corrects for the censoring nature of trade flows. Because the presence of zero trade flows can lead to a substantial heteroskedasticity bias if the trade level equation is log-linearised (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 3 are reasonable and statistically significant at the 5 per cent level. The correlation coefficient of the error terms of the participation equations and of the error terms of the multivariate sample selection equations are statistically significant at the 5 per cent level, but are not reported here for sake of brevity. The elasticities of transformation (γ) and substitution (η) 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 1) and suggests that cattle markets are segmented.[12] The distance coefficients (ϑ^M for beef and ϑ^I for cattle) have the expected negative sign. In absolute value, the magnitude of the distance elasticity for cattle $\left(\left|\gamma \times \vartheta_I\right| = 0.95\right)$ and for beef ($|\gamma \times \vartheta_M| = 1.62$) is similar to previous estimates reported in the literature (e.g. Anderson and van Wincoop, 2004).

The estimation results of the sample selection equation (17) reveal that exporter and importer GDP measures are statistically significant at the 5 per cent level and have a positive impact on the probability to observe positive cattle and beef trade flows. Bilateral tariffs do not have a statistically significant impact on the probability to have non-zero trade flows in the cattle sector, but have a statistically significant impact for beef. Finally, the coefficients for the distance variable have the expected sign.

Focusing on the Probit equations that explain whether domestic firms will enter a foreign market, the coefficients for the distance variable reveal that increasing the distance between the trading partners decreases the probability to trade. The coefficient for tariff has the expected sign and is strongly significant in the beef equation, while the same coefficient in the cattle equation is not significant 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 cross-sectional analysis to find a low R^2 (Wooldridge, 2002: 265) and our application is no exception. The pseudo-system R^2 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 liberalisation scenarios

The parameter estimates can be used to simulate trade liberalisation scenarios. The first statistic of interest is the probability of exporting to a particular

12 Baier and Bergstrand (2001) report a point estimate of 8.56 with a 90 per cent 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).

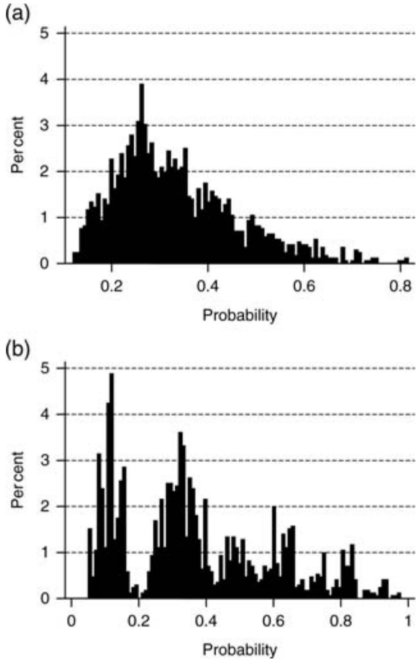

Fig. 1. (a) Frequency distribution of the predicted probabilities associated with decision to sell into cattle export markets. (b) Frequency distribution of the predicted probabilities associated with decision to sell into beef export markets.

destination which can be computed as (Dong *et al.*, 2004):

$$\Pr(E_{ij}^{(\cdot)} = 1) = \Phi\left(\frac{(\mathbf{z_{ij}}\boldsymbol{\delta}^{(\cdot)})}{\sigma_{\xi^{(\cdot)}}}\right) \tag{18}$$

where Φ is the standard normal cumulative distribution function and σ_ξ is the estimated variance parameter of the firm's selection mechanism (equation (15) for beef and equation (16) for cattle). As noted before, the impact of trade policy changes on the extensive margin of trade is proxied by changes in the probability to export. Reductions in barriers to trade lower the firm-specific productivity parameter necessary to earn positive profits in a foreign market.[13] Figure 1a and b illustrates the frequency distribution of the probabilities defined in equation (18) that measure decisions to enter a foreign market. The probability distribution for cattle trade flows clearly

13 Reductions in barriers to trade are likely to have other general equilibrium effects that are not captured by the model. For example, trade liberalisation is likely to lead to a reallocation of resources within and across exporting countries, raise aggregate productivity and thus further increase the extensive margin of trade.

resembles a chi-squared distribution, whereas the distribution in Figure 1b has no recognisable shape.

To analyse the impacts of trade liberalisation scenarios, the intensive margin of trade is proxied by the conditional expectation of exports (see Yen and Rosinski, 2008) evaluated at different levels of protection:

$$E(I(M) > 0(M > 0)) = \exp\left(\frac{f^{(\cdot)}(\mathbf{x}^{(\cdot)}, \boldsymbol{\Theta}^{(\cdot)}) + \sigma^2_{v^{(\cdot)}}}{2}\right)\left(\frac{\Phi(\tilde{\hbar}^{(\cdot)}(\tilde{\mathbf{z}}, \tilde{\boldsymbol{\delta}}) + \rho_{vu}\sigma_v)}{\Phi(\tilde{\hbar}^{(\cdot)}(\tilde{\mathbf{z}}, \tilde{\boldsymbol{\delta}}))}\right) \tag{19}$$

where the parameter ρ_{vu} represents the coefficient of correlation between u and v. Equation (19) is the expected trade-level conditional on observing trade partnerships.

We compute two different liberalisation scenarios: (i) an aggressive liberalisation scenario that eliminates all import tariffs, export subsidies and domestic support and (ii) a moderate liberalisation scenario that depicts a potential Doha 'compromise' outcome. The moderate scenario involves removing export subsidies and cutting trade-distorting domestic support by 50 per cent. The extent of tariff cuts depends on whether protection is implemented through 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 'moderate liberalisation' scenario includes tariff cuts of 20 per cent when cattle/beef imports are restricted by a TRQ and 50 per cent in all other instances. The implicit assumption is that beef products currently protected by a TRQ are likely to be designated as sensitive – a notion introduced in the Doha Framework Agreement (World Trade Organization, 2008) – and thus warrant distinct tariff cuts. It is important to note that neither scenarios entail full liberalisation as this would require addressing non-tariff barriers to trade as well as green box domestic support that is reputedly non-trade distorting.

Table 4 reports the impacts of the two liberalisation scenarios on cattle and beef exports for a subset of countries (Brazil, Canada, EU, Ghana, South Africa and the USA). The USA represents a large and fairly open developed country, whereas the EU represents a policy active developed country. Results from Canada illustrate the impacts for a 'small' and open developed economy, whereas Ghana and South Africa represent, respectively, small and medium sized economies. Finally, Brazil represents a 'large' developing economy. The results are presented in terms of the percentage change relative to the *baseline* solution representing the average of the 1999/2001 trade flows.

5.1. Cattle sector

Trade liberalisation would induce a small increase in the average probability of firms engaging in cattle trade. Under the aggressive liberalisation scenario,

Table 4. Impacts of trade liberalisation on cattle and beef exports

Selected countries	Per cent change with respect to baseline			
	Cattle		Beef	
	Aggressive scenario	Moderate scenario	Aggressive scenario	Moderate scenario
Brazil				
Average 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 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 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 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 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 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 probability to export	0.79	0.20	17.21	0.75
Average exports across destinations	0.14	0.00	1.85	0.64

the increase in the average probability over the entire sample is less than 1 per cent. Accordingly, we can conclude that aggressive liberalisation would not spur many ‘new friendships’ among global cattle traders. The increase is even smaller (0.2 versus 0.8 per cent) in the case of moderate liberalisation. The country level impacts of liberalisation are very much similar to the aggregate probability measure. These results arise because of the small coefficients for policy variables in cattle equation in Table 3. The average probability to export increases more for developing economies such as Ghana, South Africa and Brazil than for developed economies.

If trade liberalisation does not create new cattle trade partnerships, perhaps liberalisation could induce significant increases in existing trade flows. Actually, average conditional exports increase by less than one tenth of one per cent under the aggressive liberalisation 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 per cent while a large exporter like the USA sees its export average trade flow decrease by 0.3 per cent.

Overall, the impacts under moderate liberalisation 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 moderate scenario (e.g. South Africa).

5.2. Beef sector

The average probability of firms to engage in bilateral trading relationships is marginally higher under moderate liberalisation than under the baseline situation (an increase of 0.75 per cent). However, trade liberalisation impacts in the beef sector are not as muted as in the cattle sector. The small impact of moderate liberalisation 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 moderate liberalisation increases for all of the other countries listed in Table 4. Interestingly, the number of bilateral relationships increases overall under aggressive liberalisation despite the significant reduction registered in the EU. This illustrates that moderate liberalisation 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 per cent under moderate liberalisation while the increase is 19.7 per cent under aggressive liberalisation. A similar argument holds for Brazil, Canada, the USA and South Africa. Hence, trade liberalisation 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 moderate and aggressive liberalisation. Hence, adjustments for the EU occur both at the intensive and extensive margins of trade. Total beef exports from Canada, Brazil and Ghana increase because these three countries experience positive adjustments at both margins. While South African firms find 'new friends' to trade with under both moderate and aggressive liberalisation scenarios, their conditional average export is lower under moderate liberalisation. Total exports could thus decrease or increase because both margins move in opposite directions. A similar argument holds for the USA, because conditional average exports falls under both liberalisation scenarios.

Average statistics often hide potential trade liberalisation 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 liberalisation would generate a rather significant number of new friends. Figure 2a plots the cumulative frequency distribution (CFD) of probabilities that Ghanaian beef exporting firms will develop partnerships with foreign firms under the baseline, aggressive liberalisation and moderate liberalisation scenarios.

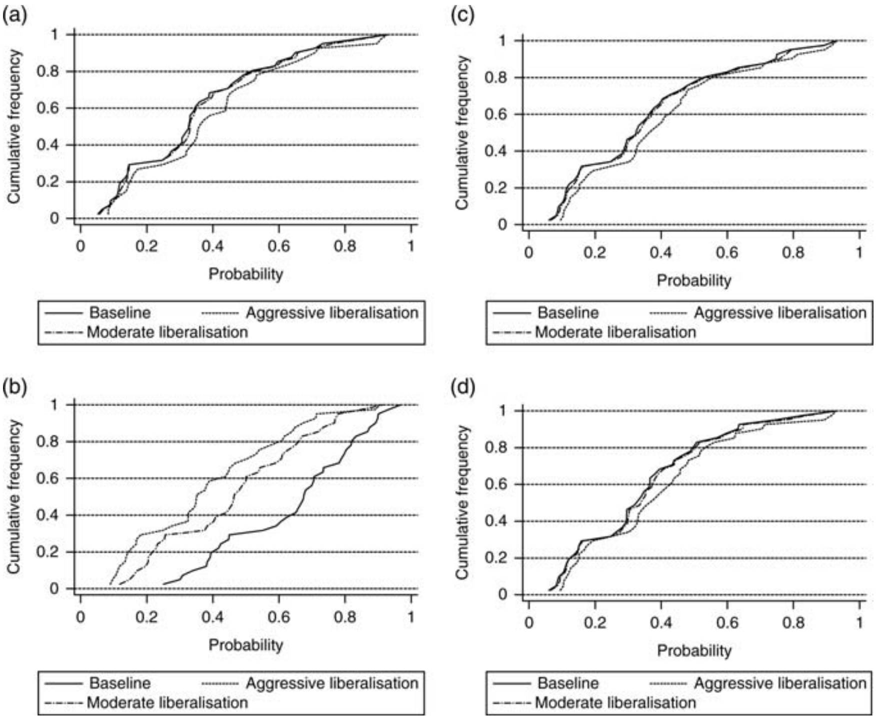

Fig. 2. (a) Cumulative frequency of the probabilities associated with Ghanaian firms exporting beef. (b) Cumulative frequency of the probabilities associated with EU firms exporting beef. (c) Cumulative frequency of the probabilities associated with the US firms exporting beef. (d) Cumulative frequency of the probabilities associated with Canadian firms exporting beef.

This exercise is repeated in Figure 2b–d for, respectively, the EU, US and Canadian firms. Figure 2a reveals that there is no real distinction between the CFD of the baseline and moderate scenarios, thus confirming that the prospects of creating 'new friends' for Ghanaian beef exporting firms under moderate liberalisation are remote. There is, however, a region of the CFD for the aggressive liberalisation scenario (in the interval [0.2; 0.5]) which is strikingly different than the baseline CFD. In that range, an aggressive liberalisation yields higher probabilities and thus a greater share of Ghanaian firms are likely to export in a liberalised environment.

The overall patterns in Figure 2b are starkly different than in Figure 2a. Liberalisation under both the aggressive and moderate liberalisation scenarios entails 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 per cent of the firms have a probability of export of 40 per cent or less. The proportion of firms with a probability of export of at most 40 per cent increases to about 40 per cent under moderate liberalisation and to about 60 per cent under aggressive liberalisation. The CFDs for the USA and Canada shown in Figure 2c and d, 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 distributions of probabilities.

5.3. The development issue in the Doha Round

The agenda of the Doha Round of negotiations heavily emphasises development issues. One of the main objectives of the Round is to have trade contribute to economic growth in developing economies. The evidence in Table 4 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 moderate liberalisation scenario yields lower conditional average cattle and beef exports for South Africa and the EU. Under the aggressive liberalisation scenario, the US conditional average beef exports increase by 7.5 per cent, while cattle conditional average exports decrease slightly. Under the moderate liberalisation scenario, the US conditional exports for both cattle and beef increase slightly.

Table 5 compares the impacts of the two liberalisation scenarios on, respectively, cattle and beef trade when the countries in the sample are classified into OECD and non-OECD members. Trade among OECD members represents 74 and 83 per cent, respectively, of total cattle and beef trade. In the case of cattle, moderate liberalisation yields an increase in the average probability to engage in trade whether trade within or across the two groups is considered. As before, the results are more substantive under the aggressive liberalisation 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 moderate liberalisation cannot quite equalise trade opportunities in the cattle sector. Given the existence of significant impediments to trade in the form of non-tariff barriers in developed countries, this result is not surprising.

Table 5 shows that the average probability to export beef to OECD and non-OECD countries by non-OECD firms increases by 2.7 and 3 per cent, respectively, whereas the average probability to export for firms in OECD countries to OECD and non-OECD countries decrease by 5.6 and 6.5 per cent, respectively. One might be tempted to infer that non-OECD firms gain from trade liberalisation at the expense of OECD firms, but conditional average exports of both subgroups increase under moderate liberalisation and this result is only reinforced under an aggressive liberalisation. Conditional exports are roughly six times greater under aggressive liberalisation than under moderate liberalisation for OECD and non-OECD countries.

Table 5. Trade liberalisation impacts in the cattle and beef sectors for OECD and non-OECD countries

		Average probability to export		Conditional average exports	
		Importer		Importer	
		OECD	Non-OECD	OECD	Non-OECD
Cattle sector					
Aggressive scenario (per cent change relative to baseline)					
Exporter	OECD	0.93	0.55	0.67	0.14
	Non-OECD	1.25	0.70	0.40	0.17
Moderate scenario (per cent change relative to baseline)					
Exporter	OECD	0.16	0.17	0.15	0.03
	Non-OECD	0.21	0.22	0.01	−0.04
Beef sector					
Aggressive scenario (per cent change relative to baseline)					
Exporter	OECD	3.55	6.49	3.37	3.02
	Non-OECD	17.89	22.37	2.63	3.84
Moderate scenario (per cent change relative to baseline)					
Exporter	OECD	−5.58	−6.53	0.75	0.54
	Non-OECD	2.72	3.04	0.53	0.60

This result highlight the importance of ambitious liberalisation plans to fulfil the objective of the Doha Round.

6. Conclusions

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 positions on market access issues and reductions in trade-distorting domestic support for agricultural products. Although 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 liberalisation 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 liberalisation 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 two-stage procedure 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 stage explains trade flows while accounting for potential corner solutions using a multivariate sample selection model. The two-stage model allows us to make inference about the adjustments in trade that occur at the extensive and the intensive margins. Simulated maximum likelihood techniques are used in the second stage because of the correlation in the error terms of the four-equation double-hurdle model. Finally, vertical linkages in cattle and beef production are accounted for by instrumenting cattle prices in trade equations.

Aggressive and moderate liberalisation scenarios are simulated to analyse 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 liberalisation impacts in the beef sector are more significant, in part because tariffs on beef are higher and more dispersed than tariffs on cattle. Under moderate liberalisation, 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. Although the increase in average exports is larger in percentage terms for firms in non-OECD countries than for firms in OECD countries, moderate liberalisation only yields modest adjustments in the intensive margin of trade. Ambitious liberalisation plans seem the only realistic option to fulfil the development objectives of the Doha Round.

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Appendix

Table A1. List of countries

European Union	Chile	Honduras	Pakistan	Venezuela
USA	Colombia	India	Panama	Zimbabwe
Japan	Costa Rica	Indonesia	Peru	
Argentina	Dominican Republic	Israel	Philippines	
Australia	Ecuador	Korea Rep.	South Africa	
Bangladesh	Egypt	Malaysia	Sri Lanka	
Bolivia	Ethiopia	Mexico	Syria	
Brazil	El Salvador	New Zealand	Thailand	
Cameroon	Ghana	Nigeria	Turkey	
Canada	Guatemala	Norway	Uruguay	