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Domestic Support and Tariff Reductions in the Presence of Non-Tariff Barriers:
A Gravity Model for Primary and Processed Agricultural Products[1]

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Abstract: Agricultural trade liberalization negotiations are currently at a crossroads. Progress was made to eliminate export subsidies, but small open economies' demand for lower domestic support and tariffs on agricultural goods do not find much support among large policy active countries. Many non-tariff barriers still also impede agricultural trade. This paper presents the theoretical foundations of a gravity model to explain trade flows of both primary agricultural commodities and processed foods. At the consumer level, commodities are differentiated according to their country of origin while primary agricultural goods are homogenous from the buyers' perspective. However, primary goods can not be substituted costlessly across destinations from the sellers' perspective due to differences in technical and sanitary regulations between countries. These assumptions yield well-behaved import demand functions at the consumer level and export supply functions at the producer level. Imperfect substitutability at the consumption and production levels is summarized in two important structural parameters. The role of these parameters in explaining bilateral trade patterns is illustrated for a three-country world market using a numerical example. The simulation investigates whether it is more important for a small open economy that large policy active countries reduce agricultural tariffs or domestic support. It also addresses the implications of tariff escalation on trade flows.

Keywords: Agri-food trade liberalization; Gravity models; tariffs; domestic support; tariff escalation.

J.E.L. Classification: Q17, F13

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1. Introduction

Despite broad globalization pressures, import tariffs in agricultural and food industries remain particularly high compared to the industrial sector. The Organisation for Economic and Co-operation Development (OECD) estimated that the average tariff for agricultural and agri-food products in OECD countries was 36 % in 2003, whereas it was 63 % for a sample of non-OECD countries (OECD, 2004). In comparison, successive rounds of negotiations that begun in the 1940s managed to reduce tariffs on industrial products from an average of 40 % after the Second World War to nearly 4 % (OECD, 2003). Unfortunately, the lessons from this spectacular exercise in trade liberalization have not inspired WTO members to pursue a path of rapid trade liberalization for agricultural products. In spite of the tariffication process undertaken in the Uruguay Round, non-tariff barriers (NTB) remain important impediments to agri-food trade (UNCTAD, 2005). Furthermore, several countries support agriculture with production subsidies and supply controls. On the positive side, the potential trade-distorting effect of domestic subsidies was recognized in the Uruguay Round and as a result ceilings are imposed on coupled support (*i.e.* subsidies that are tied to current production). The OECD estimated that the support granted to agricultural producers represented 32 % of total agricultural receipts in 2003 and the share of trade-distorting support represented approximately 75 % of total support (OECD, 2004).

Despite the existing level of border protection and the fact that the multilateral negotiations of the Doha Round are currently stalled, there are signs that protectionism in agriculture will not resist indefinitely to broad globalization forces. Some headway has been achieved in certain areas, like the gradual elimination of export subsidies, the adoption of four bands to structure tariff cuts, and the transformation of specific tariffs into ad valorem

equivalents (WTO, 2005). Tariff and domestic support reductions have different effects on the volume of trade and welfare, even in the simplest settings. In order to best exploit the modest efforts of WTO members to liberalize agriculture, it is crucial to develop a thorough understanding of the implications of tariff and domestic support reductions in the presence of non-tariff barriers for both primary commodities and processed agricultural products. Primary and processed products are linked in production and as such policies aimed to influence one will also have an incidence on the other. However, primary and processed agricultural products are often taxed at very different rates. Tariff escalation is a fairly common phenomenon. In short, it is not obvious which of tariff reductions and domestic support reductions have the biggest welfare impacts and hence which should be singled out for more intense negotiations by WTO members.

The objective of the paper is to develop a framework to analyze the impacts of tariff and domestic support reductions stemming from multilateral and regional agreements in the presence of non-tariff barriers on the volume of trade of primary and processed agricultural products. To our knowledge, there are no theoretical trade models that have accounted for both non-tariff barriers and vertical linkages between primary and processed agricultural products. Our theoretical model builds on the gravity[1] model of Lai and Trefler (2004) and it has the advantage of generating predictions amenable to empirical testing. Gravity models may have different theoretical foundations and hence different specifications (Evenett and Keller, 2002). We posit that trade flows are conditioned by bilateral trade costs and some country-specific productivity shocks. We rely on numerical simulations to illustrate the impacts of tariff and/or domestic support reductions on the volume of trade and prices.

There exists a considerable literature on the estimation of welfare gains resulting from trade liberalization in agricultural trade. The bulk of the efforts involve large-scale Computable

General Equilibrium (CGE) models.[2] While these models are able to generate detailed predictions about output, factor prices and factor allocation across sectors, they are often calibrated at a particular point in time and rely on parameters borrowed from other studies.[3] In contrast, our model can be econometrically estimated to generate parameters that are consistent with one another and rigorous statistical inference about various hypotheses can be conducted.[4] However, such an endeavour is beyond the scope of the current paper.

The remainder of the paper is structured as follows. The next section sets the foundations of the gravity based trade model in a partial equilibrium framework. Comparative static effects of unilateral liberalization are presented in the third section and contrasted with the usual textbook results. The fourth section introduces a three-country world market structure to underline the importance of non-tariff barriers in the assessment of the welfare consequences of trade liberalization. Specifically, it analyzes whether it is more important for a small open economy to have partners reduce tariffs or domestic support. The final section presents the potential implications of the theoretical model for empirical purposes.

2. The Model

The theoretical framework must be able to identify the separate effects of domestic support, tariff barriers and geographic variables such as trade costs in the determination of bilateral trade patterns. To account for trade in primary agricultural commodities, the monopolistic competition model of Lai and Trefler (2004) is augmented with the introduction of supply-side rigidities along the lines of Geraci and Prewo (1982) and Bergstrand (1985). Processed goods are differentiated according to their country of origin and the number of varieties supplied by each country is fixed. We appeal to the well known Armington assumption that posits that imports and domestic goods are imperfect substitutes for one another (Armington, 1969). Primary goods are

assumed to be homogenous products and hence perfectly substitutable across origins from the processing firms' perspective. However, it is assumed that destinations cannot be substituted perfectly from the exporters' perspective due to non-tariff barriers. This assumption is captured by a constant-elasticity-of-transformation (CET) cost function. Finally, coupled domestic support is introduced in the supply decisions of agricultural producers.

Suppose there are $i = 1, \ldots, N$ countries in which consumers have identical preferences over G goods. There are N_{gj} varieties of good g ($g = 1, \ldots, G$) produced in country j ($j = 1, \ldots, N$). Consumers' preferences in each country are summarized by Cobb-Douglas preferences over goods and a CES type utility function over varieties. Let $q_{gij}(\omega)$ be country i's consumption of good g produced in country j with ω indexing varieties. Let the parameter $\eta_g > 1$ measure the elasticity of substitution between varieties. The utility function is:

$U_i = \prod_{g=1}^{G} U_{gi}^{\alpha_g}$ with:

$$U_{gi} = \left(\sum_j \int_0^{N_{gj}} q_{gij}(\omega)^{\frac{(\eta_g-1)}{\eta_g}} d\omega \right)^{\frac{\eta_g}{(\eta_g-1)}} \tag{1}$$

Under the assumption of monopolistic competition in the production of processed goods and constant average variable costs, profit maximization implies:

$$p_{gj} = \eta_g \left(\eta_g - 1 \right)^{-1} c_{gj} \tag{2}$$

where p_{gj} is the price received by firms in country j, and c_{gj} is the constant marginal cost of production for good g in country j.

From the consumers' standpoint, two-stage budgeting allows to compute conditional expenditures on individual varieties in terms of hypothetical expenditure allocations across goods. Using (2), country i's demand function for the variety of good g supplied by country j is:

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$$q_{gij} = \alpha_g Y_i \frac{(\eta_g - 1)}{\eta_g} \frac{(\tau_{gij} c_{gj})^{-\eta_g}}{\sum_k (\tau_{gik} c_{gk})^{1-\eta_g} N_{gk}} \tag{3}$$

where Y_i is aggregate income in country i, and $\tau_{gij} \geq 1$ represents trade costs (tariffs, transportation, etc.) associated with shipping good g to location i from country j. For the time being, it is assumed that income is exogenous. Imports in country i are equal to the aggregate consumption of each variety multiplied by the number of variety:

$$M_{gij} = N_{gj} q_{gij} = \alpha_g Y_i \frac{(\eta_g - 1)}{\eta_g} \frac{(\tau_{gij} c_{gj})^{-\eta_g} N_{gj}}{\sum_k (\tau_{gik} c_{gk})^{1-\eta_g} N_{gk}} \tag{4}$$

In the above framework, processed commodities, like cheese and pork meat, are differentiated from the consumers' perspective. Primary products, like milk and hogs, are usually considered homogenous goods. This assumption is far from being heroic and it is analytically convenient. Allowing primary products to be differentiated would dramatically exacerbate the dimensionality of the model because of the vertical linkages between primary and processed goods.

The premise in what follows is that although primary products are homogeneous, they are not likely to be freely substituted between foreign markets from the exporting country's perspective. Many of the reasons motivating the imperfect substitutability of primary agricultural products across destinations revolve around non-tariff barriers. For example, agricultural products often need to meet sanitary or packaging criteria 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.[5]

Let us assume that the production function of the agricultural good is homothetic and that the cost function of a representative producer of primary product g in country j is:

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$\phi_{gj}\left(\mathbf{w}_j\right)I_{gj}^{\beta}$; $\beta > 1$; where I_{gj} denotes country j's production of primary goods, $\phi(\cdot)$ is a sub-cost function and $\mathbf{w}$ is a vector of input prices. Following Geraci and Prewo (1982), Bergstrand (1985) and Baier and Bergstrand (2001), the aggregate output of the primary good is:

$I_{gj} = \left(\sum_{i=1} I_{gij}^{(1+\gamma_g)/\gamma_g}\right)^{\gamma_g/(1+\gamma_g)}$ where γ_g is the constant elasticity of transformation (CET) developed by Powell and Gruen (1968) to analyze agricultural supply. If γ_g is zero, primary products cannot be substituted across destinations while a value of infinity would imply that products can be freely substituted. A distinguishing feature of our framework relative to the ones in the aforementioned literature is that we interpret the CET function as a cost function and not simply as an aggregator function.[6] As mentioned by Baier and Bergstrand (2001), the parameter γ_g provides an analytically and empirically tractable means of letting the data determine the degree of substitutability between markets. Note that the parameter is indexed by g thus suggesting that substitution across destinations may be easier to achieve for certain commodities than others.

Profits are defined as:

$$\pi = \sum_{i=1} h_{gi} s_{gij} t_{gij} I_{gij} - \phi_{gj}\left(\mathbf{w}_j\right)I_{gj}^{\beta} \tag{5}$$

where $s_{gij} \geq 1$ is the production subsidy equivalent in the production of primary good g offered by country j and $t_{gij} \leq 1$ measures the bilateral trade costs for the primary product.[7] Note that the production subsidy offered in country j is also indexed according to the destination of the primary product. In theory, domestic support should not be conditional on the ultimate destination of the product, but introducing this notation serves however two purposes. First, the subsidy equivalent is measured as a percentage of the domestic price in destination i and

domestic prices vary across destinations. Second, the variable s_{gij} can be adjusted to account for both export and production subsidies.

As apparent from the previous profit definition, 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. Note that the notion of homogeneity among primary goods is supported by the condition that the price received in market i is independent from the origin of the product. However, goods 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 trade originates from the technological side and, as a result, there is no arbitrage condition between prices of primary good g in any given market (*e.g.*, $h_{gj} \neq h_{gk}$).

Consider the profit maximization problem of a representative primary producer in country j. Profit maximization yields the following set of first-order conditions:

$$\frac{\partial \pi}{\partial I_{gij}} = h_{gi}s_{gij}t_{gij} - \beta\phi_{gj}\left(\mathbf{w}_j\right)\left(\sum_{i=1}I_{gij}^{(1+\gamma_g)/\gamma_g}\right)^{((\beta-1)\gamma_g-1)/(1+\gamma_g)} I_{gij}^{1/\gamma_g} = 0; \quad \forall i = 1,\ldots,N$$

At the profit maximization solution, we find: $I_{gij}/I_{gkj} = \left(h_{gi}t_{gij}/h_{gk}t_{gkj}\right)^{\gamma_g}$. Solving the full system of first order conditions yields the bilateral export supply equations:

$$I_{gij} = \beta^{-1/(\beta-1)}\phi_{gj}\left(\mathbf{w}\right)^{-1/(\beta-1)}\left(\frac{\left(h_{gi}s_{gij}t_{gij}\right)^{\gamma_g}}{\left(\sum_{i=1}\left(h_{gi}s_{gij}t_{gij}\right)^{1+\gamma_g}\right)^{(\gamma_g(\beta-1)-1)/((1+\gamma_g)(\beta-1))}}\right) \tag{6}$$

The following assumptions are made to facilitate the interpretation of the subsequent comparative static exercise.

Assumption 1: $\gamma_g > 1/(\beta-1)$.

This inequality states that destinations can be substituted relatively freely (low non-tariff barriers) only if returns to scale are sufficiently decreasing (as measured by the parameter β). This insures that the export supply function from country j to destination i is increasing in the price (h_{gi}) paid in market i ($\partial I_{gij}/\partial h_{gi} > 0$ for $j \neq i$) and decreasing in prices observed in other destinations.

Assumption 2: $\partial I_{gij}/\partial h_{gi} > \left| \partial I_{gij}/\partial h_{gj} \right|$ and $\left| \partial M_{gij}/\partial h_{gj} \right| > \partial M_{gij}/\partial h_{gi}$.

The above assumption stipulates that for the primary and the processed goods, own-price effects dominate cross-price effects. From assumption 2 and the functional forms in (4) and (6), it can be shown that : $\partial I_{gij}/\partial s_{gij} > \left| \partial I_{gij}/\partial s_{gii} \right|$, $\left| \partial I_{gij}/\partial t_{gij} \right| > \left| \partial I_{gij}/\partial t_{gkj} \right|$ and $\left| \partial M_{gij}/\partial \tau_{gij} \right| > \left| \partial M_{gij}/\partial \tau_{gkj} \right|$.

Assuming that one unit of primary good is required to produce one unit of processed good, the market clearing conditions restrict country k's total purchase of primary goods to be equal to its shipments of the final good to all destinations:

$$\sum_{j=1} I_{gkj} = \sum_{i=1} M_{gik} \quad \forall g \tag{7}$$

In all, there are N equilibrium conditions that solve for the primary good prices in N countries.

3. Comparative static for the two-country case

A two-country example is presented to investigate the properties of the model and provide a first look at potential trade liberalization effects following changes in tariffs and domestic subsidies for different levels of non-tariff barriers. We adopt a two-country partial equilibrium structure to more easily delineate the implications of vertical linkages. Given that preferences are weakly separable, substitution effects between any two products in different groups are function of the income effect. Because income is held fixed in partial equilibrium, there can be no cross-price

effects following a change in a policy parameter. Accordingly, the comparative static focuses on a single sector. We can set incomes in both countries such that $Y_1 = Y_2 = 1$, treat input prices (such as labour and capital) as exogenous and normalize the sub-cost function $\phi(\mathbf{w})$ to one. We rule out corner solutions to focus on the implications of "bilateral dumping" in primary and processed goods. As such, each country produces the primary good and consumes part of it and exports the rest. The same can be said about processed goods. As will soon become evident, the analysis is quite complicated in spite of all the simplifying assumptions.

The market clearing conditions are:

$$CC_1 : \left(M_{g11} + M_{g21}\right) - \left(I_{g11} + I_{g12}\right) = 0$$
$$CC_2 : \left(M_{g22} + M_{g12}\right) - \left(I_{g22} + I_{g21}\right) = 0$$

(8)

Differentiating the system in (8) with respect to the two endogenous variables (the primary price in each country) and the tariff and subsidy policies yields:

$$
\begin{bmatrix} dCC_1 \\ dCC_2 \end{bmatrix} =
\begin{bmatrix} \dfrac{\partial CC_1}{\partial h_{g1}} & \dfrac{\partial CC_1}{\partial h_{g2}} \\ \dfrac{\partial CC_2}{\partial h_{g1}} & \dfrac{\partial CC_2}{\partial h_{g2}} \end{bmatrix}
\begin{bmatrix} dh_{g1} \\ dh_{g2} \end{bmatrix}
+
\begin{bmatrix} -\dfrac{\partial I_{g11}}{\partial s_{g11}} - \dfrac{\partial I_{g11}}{\partial s_{g21}}\dfrac{h_{g1}}{h_{g2}} & -\dfrac{\partial I_{g12}}{\partial s_{g12}}\dfrac{h_{g1}}{h_{g2}} - \dfrac{\partial I_{g12}}{\partial s_{g22}} \\ -\dfrac{\partial I_{g21}}{\partial s_{g11}} - \dfrac{\partial I_{g21}}{\partial s_{g21}}\dfrac{h_{g1}}{h_{g2}} & \dfrac{\partial I_{g22}}{\partial s_{g12}}\dfrac{h_{g1}}{h_{g2}} - \dfrac{\partial I_{g22}}{\partial s_{g22}} \end{bmatrix}
\begin{bmatrix} ds_{g11} \\ ds_{g22} \end{bmatrix}
$$
$$
+
\begin{bmatrix} \dfrac{\partial M_{g11}}{\partial \tau_{g21}} & \dfrac{\partial M_{g21}}{\partial \tau_{g12}} \\ \dfrac{\partial M_{g12}}{\partial \tau_{g21}} & \dfrac{\partial M_{g22}}{\partial \tau_{g12}} \end{bmatrix}
\begin{bmatrix} d\tau_{g21} \\ d\tau_{g12} \end{bmatrix}
+
\begin{bmatrix} -\dfrac{\partial I_{g11}}{\partial t_{g21}} & -\dfrac{\partial I_{g12}}{\partial t_{g12}} \\ -\dfrac{\partial I_{g21}}{\partial t_{121}} & -\dfrac{\partial I_{g22}}{\partial t_{112}} \end{bmatrix}
\begin{bmatrix} dt_{g21} \\ dt_{g12} \end{bmatrix}
$$

where $\tau_{gii} = t_{gii} = 1$ because there are no trade impediments to local sales. It should be emphasized that when we interpret changes in the vector $\mathbf{ds}_g$ as changes in domestic subsidies only, the constraint $ds_{gij} = ds_{gjj}\left(h_{gj}/h_{gi}\right)$ must be imposed in the total differentiation of (8) because subsidy levels must be the same across destinations. The unconstrained case involves

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domestic and export subsidies. In order to isolate the effects of domestic support reduction, we

will focus on the constrained case. The above system can be rewritten in compact form as:

$$\begin{bmatrix} dCC_1 \\ dCC_2 \end{bmatrix} = \mathbf{J} \begin{bmatrix} dh_{g1} \\ dh_{g2} \end{bmatrix} + \mathbf{S} \begin{bmatrix} ds_{g11} \\ ds_{g12} \end{bmatrix} + \mathbf{T} \begin{bmatrix} d\tau_{g21} \\ d\tau_{g12} \end{bmatrix} + \mathbf{\Upsilon} \begin{bmatrix} dt_{g21} \\ dt_{g12} \end{bmatrix} \tag{9}$$

where $\mathbf{J}$ is the Jacobian matrix of the system. For further reference, denote the elements of the

Jacobian by: $\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$.

Lemma 1: *The Jacobian has a dominant diagonal such that* $|a_{ii}| > \sum_{j \neq i} |a_{ij}|$.

Proof: See the technical appendix.

Lemma 2: *The Jacobian matrix is negative definite. At the equilibrium vector of prices, the*

determinant of the Jacobian matrix, denoted $|\mathbf{J}|$, *is positive.*

Proof: See the technical appendix.

Lemmas 1 and 2 imply that the elements of the Jacobian have the following signs: $\begin{bmatrix} - & + \\ + & - \end{bmatrix}$.

Moreover, the negative definiteness of the Jacobian implies that $(-1)^r |_r\mathbf{J}_r^{\pi}| > 0$; where $_r\mathbf{J}$ and

$\mathbf{J}_r$ are matrices for which the first r rows and first r columns of matrix $\mathbf{J}$ are retained

respectively and π refers to permutations involving the rth row and column. Hence, the impact

of a change in either 1) domestic support (s_{gij}), 2) primary goods' trade costs (t_{gij}); and 3) final

goods' trade cost (τ_{gij}) can be investigated using Cramer's rule.

We also assume that a change in domestic support in country j has a greater impact on the

price of the primary commodity in country j than in country i.

Assumption 3: $\left| dh_{gj} / ds_{gij} \right| > \left| dh_{gi} / ds_{gij} \right|$.

Reduction in domestic support

This section investigates the effect of a change in domestic support on the endogenous variables of the model. Proposition 1 summarizes the effects of changing the level of domestic support on prices of primary goods and on bilateral trade flows of primary and processed products.

Proposition 1: *A decrease in domestic support offered by country 1: i) increases the price of the primary good in both countries;. ii) decreases domestic and export sales of the primary good for country 2; iii) increases country 2's export sales of primary goods but has an ambiguous impact on its domestic sales; iv) decreases domestic and exports sales of the processed goods for both countries.*

Proof: See the technical appendix.

Proposition 1 is rather intuitive. As expected, the country that reduces its production subsidy on the primary good experiences decreases in domestic and export sales for that good while the export sales of its trading partner increase. This outcome is due to the increases in the prices of the primary good in both countries induced by the subsidy reduction. However the increase in the price of the primary good in the country that lowered its subsidy offset only partially the subsidy reduction. A decrease in the production subsidy of the primary good increases the marginal cost of production of processed commodities and the price paid by consumers. Because this occurs in both countries, exports and domestic sales of the processed commodity fall in both countries. Hence, the reduction of the production subsidy jointly decrease exports and domestic sales of

both primary and processed products in the trade liberalizing country[8], but the effect on the trading partner's domestic sales of the primary product is ambiguous.[9]

Change in market access rules for primary goods

We now turn our attention to the impacts of changes in primary good's trade costs. Trade costs can take many forms, but the discussion is cast in terms of tariffs because they are directly related to market access and are under the control of policymakers.

Proposition 2: *A decrease in country 2's tariff on the primary good: i) has an ambiguous effect on (decreases) the price of the primary good in country 1 (2), but it reduces the spread between the prices of the primary good ; ii) has an ambiguous impact on (increases) domestic (export) sales of country 1's primary good ; iii) has an ambiguous impact on (decreases) country 2's export (domestic) sales of primary goods; iv) has an ambiguous impact on (increases) country 1(2)'s domestic and export sales of the processed products.*

Proof: See the technical appendix.

Because of the many ambiguities, the results presented in Proposition 2 are less intuitive than those presented in Proposition 1. As such, they reveal the complexity of modeling bilateral trade in vertically-related products and justify the space devoted to our two-country example. The impacts of a decrease in country 2's tariff on imports of the primary good produced in country 1 (*i.e.*, an increase in t_{g21} in our notation) has an ambiguous effect on the price of the primary good in country 1. As shown in the appendix, the direction of the change hinges on the sign of

$$\left| \mathbf{J}_{1,\Upsilon_1} \right| = a_{22} \left(\partial I_{g11}/\partial t_{g21} \right) - a_{12} \left(\partial I_{g21}/\partial t_{g21} \right) \quad \text{where} \quad a_{22} < 0, \quad \partial I_{g11}/\partial t_{g21} < 0, \quad a_{12} > 0 \text{ and}$$

$\partial I_{g21}/\partial t_{g21} > 0$. In a model with unidirectional trade, improved market access bring about an

increase in the price of the exporter and a decrease in the price of the importer. The latter remains true in our model, but the former need not happen because $\left|\mathbf{J}_{1,\Upsilon_1}\right| \underset{<}{\geq} 0$. The term $\left(\partial I_{g11}/\partial t_{g21}\right)a_{22}$ is positive as it embodies the reduction in the domestic supply of primary good in country 1 and a vertical linkage effect that reflects the excess demand for primary goods (including imports from country 1) from processors in country 2 relative to the supply of primary product. This is offset by the negative effect due to the product $-\left(\partial I_{g21}/\partial t_{g21}\right)a_{12}$ which captures the lower demand from processors in country 1 that results from the decrease in the price of the primary good produced in country 2. The fact that the price of the primary good in country 1 may be negatively affected by the decrease in country 2's tariff is peculiar, but this does not preclude the expected convergence effect of liberalization on the prices of the primary good.

As for the bilateral trade in primary goods between the two countries, the decrease in country 2's tariff increases market access for the primary good exported by country 1. The resulting lower price for country 2's primary product encourages that country's production of processed products which in turn translate into higher domestic and export sales of processed goods by country 2. Naturally, exports of primary products from country 1 increase at the expense of country 2's domestic sales, but domestic sales of primary products in country 1 need not decline. Note that this result differs from the standard partial equilibrium analysis and is directly related to the ambiguous effects of the reduction in country 2's tariff on primary products on country 1's domestic and export sales of processed products. The fall in the price of the primary good produced in country 2 is beneficial to processors in both countries, but the competitive position of processing firms in both countries has been altered as the impact of the

tariff reduction is relatively stronger in the country practicing trade liberalization. Still, the aggregate volume of trade in processed goods increases due to the lower tariff on country 2's primary good.

Change in market access rules for processed goods

Finally, the effects of changes in final goods' trade costs on the price of primary agricultural goods and bilateral trade flows are analyzed. For simplicity, trade costs are referred to as import tariffs in what follows; although they can represent a myriad of other costs (transportation, brokerage fees, etc.). Proposition 3 investigates the effects of changes in market access on prices of primary goods and bilateral trade flows in primary and final goods. It is worth pointing out that unlike for the primary good trade cost, an increase in τ_{gji} should be interpreted as an increase in country *j*'s tariff on processed goods imported from country *i*.

Proposition 3: *A decrease in country 2's tariff on the processed good exported by country 1: i) increases (has an ambiguous effect on) the price of the primary good in country 1 (2), but if the price of the primary good in country 2 increases, it does not increase as much as in country 1; ii) increases country 1's exports of the processed good, but it decreases its domestic sales; iii) has an ambiguous impact on sales of the processed good by country 2; iv) increases country 1's domestic sales of the primary good, but has an ambiguous impact on its exports; and finally v) increases country 2's exports of the primary good and has an ambiguous effect on its domestic sales.*

Proof: See the technical appendix.

The effect of country 2's reduction of its tariff on processed goods increases the demand for imports of processed goods from country 1 which in turn increases the demand for primary

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goods in country 1. As a result, the price of the primary good in country 1 increases. The price of the primary good in country 2 may also increase. This peculiar outcome is likely to occur when the increase in the price of the primary good from country 1 induces a large increase in the demand for the primary good produced in country 2 and when country 1's exports of processed products increase significantly in response to the lower tariff. As a matter of fact, country 2's exports of primary goods to country 1 increase in response to the reduction in its tariff on processed goods.

One might expect the tariff reduction to lower country 2's domestic sales of processed goods because of the substitution effect between country 1 and country 2's processed goods, but this need not happen because the effects on country 1's exports of primary goods and country 2's domestic sales of primary goods happen to be ambiguous. On the other hand, the decrease in domestic sales of processed goods in country 1 is more in line with what one would expect in a standard partial equilibrium trade model without cross-hauling.

Table 1 summarizes the comparative static exercises presented in this section. The results are reported for three liberalization scenarios (*i.e.* reducing domestic support and lowering tariffs). As a set, they reveal the complexity of modeling bi-directional trade in vertically-related products even when the number of countries is restricted to two.

4. Which of tariff reductions and domestic support reductions should a small open economy prioritize in the presence of non-tariff barriers?

This section presents numerical simulations based on a 3-country version of the framework introduced in the previous two sections. Our objective is to investigate whether it is preferable to have large policy countries lower tariffs or domestic subsidies on agricultural goods from the perspective of a small open economy in the context of multilateral negotiations. It is generally recognized that tariffs are more distorting than domestic support policies because they distort

both production and consumption decisions.[10] As such, one could be tempted to conclude that negotiators should be more aggressive on tariff reductions than on domestic support reductions. However, the argument favouring tariff reductions is less evident when one considers that supply-side rigidities and non-tariff barriers are pervasive in the agricultural sector and that vertical linkages between primary and processed goods can drastically impact on the effects of tariff reductions. In particular, partial tariff liberalization scenarios and less than comprehensive disciplines on domestic support may cause situations in which disciplining domestic support yields greater benefits than tariff reductions. The parameter γ plays a key role on the direction and magnitude of the effects induced by changes in policies targeted at primary goods. In fact, it creates a "technical partner bias". A low value of γ imply that producers of the primary good and processing firms in any given country are more dependant on each other because primary goods are not as easily transferable between the domestic and export markets as final goods. Conversely, a high value of γ implies that primary good suppliers can supply all countries without making significant adjustments to their product.

In what follows, we assume that consumers derive utility from consuming a manufactured good and a processed food product. There is no income effect in the consumption of the food product due to quasi-linear preferences of consumers that legitimizes the partial equilibrium structure of the model. The downstream food processing firms combine the primary agricultural goods with labour to produce the processed good/food. It is assumed that the price of labour is exogenous to the agri-food sector. The technology in the downstream agri-food sector follows closely the assumptions of Lai and Trefler (2004) and Alvarez and Lucas Jr. (2006) as labour (denoted L_j) and the primary good (denoted I_j) enter a Cobb-Douglas production function such that: $TFP_j I_j^{1-\theta} L_j^{\theta}$; where TFP_j is the total factor productivity specific to each

country. Factor prices in country j are respectively denoted by h_j and w_j. The supply of labour is perfectly elastic from the perspective of agri-food firms and thus perceive w_j as a constant. Under these assumptions, marginal cost in country j is: $c_j = \varpi_j w_j^\theta h_j^{1-\theta}$; where $\varpi_j \equiv 1/TFP_j$. In the upstream market, cost minimization under the technology constraint yields the following cost function: $\phi_j(\mathbf{w}) I_j^\beta \equiv \phi_j w_j I_j^\beta$.

There is little arguing that the U.S. and the EU are the two most important economic powers and that they both heavily subsidize agriculture. As such, one or the other is the main trade partner of a very large number of countries. Consequently, a three-country trade model is the simplest structure allowing us to investigate agricultural trade liberalization scenarios from the perspective of a small open economy. It is assumed that income in the small open economy, also referred to as the third country, is about five times lower than the income in the large countries. The third country is heavily dependent on export markets and does not support its agricultural sector with coupled subsidies. Hence, $s_{13} = s_{23} = s_{33} = 1$ is observed in country #3 while $s_{11} = s_{21} = s_{31} = s_{12} = s_{22} = s_{32} = 1.5$ in the two large economies. The import tariffs in the upstream agricultural sector of countries #1 and #2 are set such that they yield a tariff-equivalent measure of 50%; hence $t_{12} = t_{13} = t_{21} = t_{23} = 0.67$. The trade costs in the downstream agri-food sector of countries #1 and #2 are set to $\tau_{12} = \tau_{13} = \tau_{21} = \tau_{23} = 2$ which imply 100% ad valorem tariffs. Country #3 pursues a free trade policy.

The above baseline values were purposely chosen to portray tariff escalation as higher duties are applied on processed products and lower duties are applied on primary goods. Tariff escalation measures are often based on the effective rate of protection, but the validity of such measures is questionable when the small country assumption does not hold (Golub and Finger,

1979). The Effective Rate of Protection (ERP) of product j is computed as: $ERP = \dfrac{T_j - \sum_i \tilde{a}_{ij} T_i}{\sum_i \tilde{a}_{ij} T_i}$;

where T_j is the tariff applied on product j, $\tilde{a}_{ij} = a_{ij} \left(p_i / p_j \right)$ and the a_{ij}'s are input-output coefficients. When terms of trade are endogenous, as in our framework, a better measure of tariff escalation is the tariff wedge between input i and output j: $TW = T_j - T_i$. When the processed product is more protected than the input $TW > 0$ and $ERP > t_j > t_i > 0$.

There are three market clearing conditions in our three-country model:

$$I_{k1} + I_{k2} + I_{k3} = \Lambda_k \left(M_{1k} + M_{2k} + M_{3k} \right); \quad k = 1, 2, 3 \tag{10}$$

where $\Lambda_k \equiv (\theta)^{-\theta} (1-\theta)^{\theta} \varpi_k \left(w_k / h_k \right)^{\theta}$ is the conversion factor between the primary and the processed goods. It is assumed that tariff revenues are rebated to consumers in a lump-sum fashion and that export and domestic subsidies are financed through lump-sum taxation. Finally, welfare boils down to the sum of consumers' surplus, firms' profits and net government revenues. The latter term includes tariff revenues minus subsidy payments:

$$TR_j = \sum_{i=1} \left(t_{ji} + 1 \right) h_j I_{ji} - \sum_{i=1}^{3} \left(s_{ij} - 1 \right) h_i I_{ij} + \sum_{i=1}^{3} \left(\tau_{ji} - 1 \right) p_{ji} M_{ji} \tag{11}$$

The market clearing conditions in (10) and the import demand and export supply functions defined in (4) and (6) provide the necessary structure to solve for the three endogenous prices $\{ h_1, h_2, h_3 \}$.

Table 2 lists the actual values of each parameter used in the baseline solution. The structural parameters pertaining to countries #1 and #2 are assumed to be identical. However, technological differences are introduced between the two large countries and the small open economy (country #3). Specifically, it is assumed that the productivity in the downstream and upstream agri-food sectors is higher in country #3. In the simulated liberalization scenarios, we

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allow parameters γ and η to vary. The former measures the degree of substitution across export markets for primary agricultural goods (i.e., low substitution implies significant non-tariff barriers) while the latter measures substitution between country-specific varieties of processed goods. Three scenarios are simulated. In the first, linear cuts are applied to domestic support holding tariffs constant. In the second, linear tariff cuts are applied while holding domestic support constant. Cuts are assumed to be applied in ten equal incremental steps until free trade is achieved. Given the initial starting values in Table 2, domestic support is reduced from 50% to 45%, … all the way down to 0%. Similarly, tariffs on processed and primary goods are respectively cut from their initial values of 100% and 50% to 90% and 45% and so on until free trade is achieved. Note that tariff escalation remains along the liberalization paths, but the extent of tariff escalation (measured by *TW*) is reduced as tariffs converge to zero.[11] Finally, a more ambitious liberalization scenario is simulated in which domestic support and tariffs are decreased linearly and simultaneously.

Figure 1 illustrates the evolution of country 3's welfare when tariffs and/or domestic support is reduced and γ and η are set to 2. Reductions in domestic support have adverse effects on the welfare of country 3 if tariffs are held fixed. Early on in the tariff-only liberalization scenario, tariff cuts also decrease welfare, but tariff cuts have the desired positive effects once the liberalization process has reached the half-way mark. Gains from the more ambitious liberalization scenario are observed even later, that is when the tariff on processed (primary) goods is down to 30% (15%) and the subsidy is down to 15%. The results in Figure 1 reflect the declining significance of the benefits accruing to processing firms in the small country as production subsidies offered by large countries decline. The relatively low value of γ imply that agricultural producers in the small country are confronted to significant non-tariff barriers

and cannot easily increase their export sales when domestic support is lowered in the large countries. Consequently, the price of the primary good in country 3 increases rather modestly as liberalization progresses, as illustrated in Figure 2. Agricultural producers benefit from higher prices, but downstream firms in country 3 must cope with higher marginal costs. The price of processed goods in country 3 reacts to this cost-push effect, which is stronger under the tariff-only scenario, as illustrated in Figure 3.

Figures 4 and 5 show the evolution of country 3's exports of primary and processed goods. In the domestic support-only (tariff-only) liberalization scenario, exports of processed goods decrease (increase) (Figure 5) while exports of primary goods increase under all three scenarios (Figure 4). Domestic sales of primary goods increase at similar rates under the two partial liberalization scenarios (Figure 6) while domestic sales of processed goods fall regardless of the scenario chosen (Figure 7). The sums of domestic and export sales for the primary and processed goods at various stages of liberalization are depicted in Figures 8 and 9. Under the domestic support-only scenario, total sales of primary (processed) products increase (decrease) as large countries cut their subsidies. As noted before, this liberalization scenario decreases overall welfare for country 3 which clearly benefits from the lower prices for primary goods caused by the large countries' production subsidies.

When tariff protection is the only instrument being reduced, country 3 experiences small gains from liberalization because it cannot increase exports significantly due to the relatively low value of γ and η. Figure 4 and 5 illustrate the export paths for primary and processed goods. While simultaneous cuts in domestic subsidies and tariffs stimulate exports of primary goods, the same cannot be said about exports of processed products as they stay relatively constant due to the offsetting effects of the decrease in domestic support on the marginal cost of domestic processors and the effect of the tariff cuts on processed goods on the demand for these goods.

In a tariff-only liberalization scenario, domestic sales of the primary good increase (see Figure 6), but domestic sales of the processed good decrease (see Figure 7). The latter impact is caused by the greater demands for imports from large countries. The increase in the domestic demand for primary goods explains the increases in country 3's domestic sales of primary goods. Domestic sales of the processed good fall under the domestic support-only and tariffs-only liberalization scenarios, but exports decrease in the domestic support-only scenario and increase in the tariff-only scenario.

Clearly, the best scenario for the small country is the most ambitious liberalization scenario even though the gains begin to materialize only near the end of the process. In fact, global free trade maximizes world welfare. Yet when confronted with the mutually exclusive options of lowering tariff or decreasing domestic support, the small open economy obtains a greater utility when tariff cuts are implemented. It is worth pointing out that small and moderate cuts in both tariffs and domestic support from the highly distorted initial equilibrium actually *decrease* the small country's welfare. This simple numerical illustration rationalizes the seemingly bold demands of many small exporting countries in multilateral negotiations. In this instance, "small steps" in multilateral negotiations would impose sustained losses in welfare for country 3 and the promise of future gains from trade liberalization might seriously be questioned.

Simulation results presented in Figures 1-9 are conditioned on specific values of γ and η. Figure 10 illustrates the welfare paths for country 3 when primary goods are more substitutable across export destinations and when consumers can more easily substitute processed goods from different countries (*i.e.,* $\gamma = \eta = 8$). Keeping in mind that Figures 1 and 10 have different welfare scales, we can see that the gains are much more spectacular and that the possibility of initial welfare losses has vanished as the small country's welfare is

monotonically increasing in the level of liberalization for all three scenarios considered. In this instance, reductions in domestic support in large countries generate larger welfare gains than tariff reductions. Figure 11 and 12 analyze the implications of asymmetries in the conditioning parameters (i.e., $\gamma = 8, \eta = 2$ and $\gamma = 2, \eta = 8$. The welfare patterns in Figure 11 are very similar to Figure 10 and domestic support reductions ought to be prioritized by the small country if a more ambitious liberalization process cannot be initiated. This ranking contrasts with the evidence presented in Figure 12. In this case, the presence of more important non-tariff barriers makes tariff-reductions as desirable as domestic support reductions. More importantly, the presence of more important non-tariff barriers drastically reduces welfare. The gains from trade in Figure 10 are roughly 10 times higher than those in Figure 12 under the full liberalization scenario!

Interesting insights about tariff escalation can also be gained by examining the simulation results. Much is being said about tariff escalation, but what are the implications of reducing it? As mentioned before, tariff escalation is reduced as tariffs are reduced. A glace at Figures 1, 10, 11 and 12 suggests that reductions in tariff escalation do not bring about significant increases in welfare when only tariffs are lowered. To gain some insight as to why this is the case, consider that when the tariff wedge is large, the production subsidy component of the tariff in the primary sector is much larger than the net subsidy component in the processing sector. Recall that the tariff on imports of the primary good implies a tax on the processing sector which is exceeds the production subsidy component of the import tariff on final goods. Bridging the gap between the two encourages exports of the final good as illustrated in Figure 5, but it does not significantly increase welfare because of the remaining distortions in the primary sectors of the large countries.

5. Concluding Remarks

Multilateral negotiations pertaining to agricultural trade liberalization are currently at a crossroads. Small open economies are pressing large policy-active countries to lower their subsidies while pressures to open up borders to trade in agricultural products are meeting resistance from a subset of small and large economies. This paper builds a theoretical gravity model to explain trade flows of primary and processed agricultural products. At the consumer level, commodities are differentiated according to their country of origin while primary agricultural goods are homogenous from the buyers' perspective. To account for the notoriety of non-tariff barriers in agriculture, it is assumed that primary goods can not be substituted costlessly across destinations from the sellers' perspective. Examples of non-tariff barriers include technical and sanitary regulations. These assumptions yield well-behaved import demand functions at the consumer level and export supply functions at the producer level. Imperfect substitution in consumption and production is captured by two structural parameters. The role of these parameters in explaining bilateral trade patterns is investigated through numerical simulations of a three-country international trade models involving vertically-linked products.

The numerical simulations provide insights as to whether it is more important for a small open economy to reduce tariffs or domestic support. It is assumed that two identically large countries use import tariffs to restrict trade in primary and processed commodities. Our benchmark is characterized by tariff escalation, a relatively common phenomenon for agricultural products. Like the United States and the European Union, our large countries also offer coupled domestic support to domestic producers of the primary good. The small country is a free trader. When substitutions in consumption and in production are limited due to important non-tariff barriers and strong product differentiation, it is shown that reducing domestic support while holding tariffs fixed actually decreases the small country's welfare. Under the tariff-only

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liberalization scenario, welfare initially decreases but increases near the end of the process. Free trade is obviously the first-best policy from the world and the small country's perspective. However, the small country would prefer the status quo over a scenario in which the large countries propose aggressive cuts in domestic support and timid tariff cuts. The failure to quickly raise welfare in small economies may seriously undermine their convictions about the benefits of multilateral trade negotiations. Sustained welfare losses could incite to negotiate preferential trade agreements or worse to embrace an import-substitution strategy.

The stumbling blocks to achieve sizeable welfare gains under various liberalization scenarios depend on production efficiency parameters in each country, but also on relative importance of non-tariff barriers. Our simulations show that non-tariff barriers drastically reduce welfare gains under all liberalization scenarios. They also impact on the ranking of the scenarios (tariff-only versus domestic support-only). Consequently, it is imperative to gain knowledge of the value of the parameter that accounts for non-tariff barriers. Our gravity model lends itself to an econometric analysis. However, the vertical relationships between primary and processed goods raise particularly challenging issues such as non-linear restrictions across equations and endogeneity.

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Table 1. Summary of the comparative static for the two-country example.

Variable	↓ domestic support in country i	↓ country j's import tariff on primary good g	↓ country j's import tariff on final good g
Prices of the primary good			
Country i	↑	↑ / ↓	↑
Country j	↑	↓	↑ / ↓
Quantities of primary good			
Exports of country i	↓	↑	↑ / ↓
Domestic sales of i	↓	↑ / ↓	↑
Exports of country j	↑	↑ / ↓	↑
Domestic sales of country j	↑ / ↓	↓	↑ / ↓
Quantities of processed goods			
Exports of country i	↓	↑ / ↓	↑
Domestic sales of country i	↓	↑ / ↓	↓
Exports of country j	↓	↑	↑ / ↓
Domestic sales of country j	↓	↑	↑ / ↓

Table 2. Structural parameters in the baseline numerical solution

Parameters	Value
Income	$Y_1 = Y_2 = 5Y_3 = 5$
Cost share of labour in the downstream market level	$1-\theta = 0.5$
Productivity in the processing sector	$\omega_3 = 0.75\omega_1 = 0.75\omega_2 = 1$
Price of labour	$w_1 = w_2 = w_3 = 1$
Productivity parameter in the upstream sector	$1.33\phi_1 = 1.33\phi_2 = \phi_3 = 0.75$
Cost function parameter in the upstream sector	$\beta = 2$
Import tariffs for the primary good in sector 2	$t_{11} = 1.5t_{12} = 1.5t_{23} = 1$ $1.5t_{21} = t_{22} = 1.5t_{23} = 1$ $t_{31} = t_{32} = t_{33} = 1$
Import tariffs for the consumer-ready good in sector 2	$0.5\tau_{11} = \tau_{12} = \tau_{13} = 2$ $\tau_{21} = 0.5\tau_{22} = \tau_{23} = 2$ $\tau_{31} = \tau_{32} = 0.5\tau_{33} = 2$
Domestic support / export subsidy	$s_{12} = s_{22} = s_{32} = 1.5$ $s_{12} = s_{22} = s_{32} = 1.5$ $s_{13} = s_{23} = s_{33} = 1$
Varieties in the manufacture and agri-food sectors	$N_1 = N_2 = N_3 = 10$
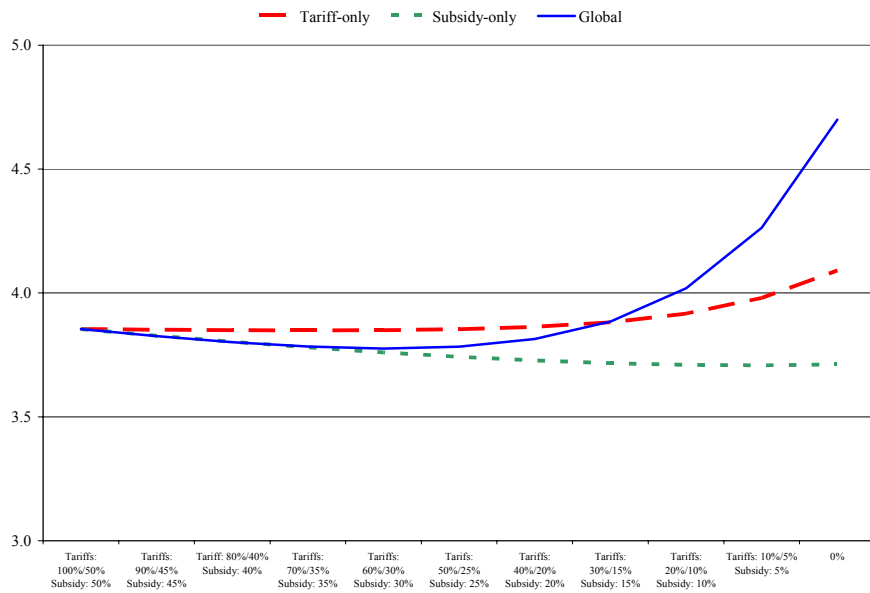
Figure 1. Country 3's welfare $(\gamma = 2; \eta = 2)$
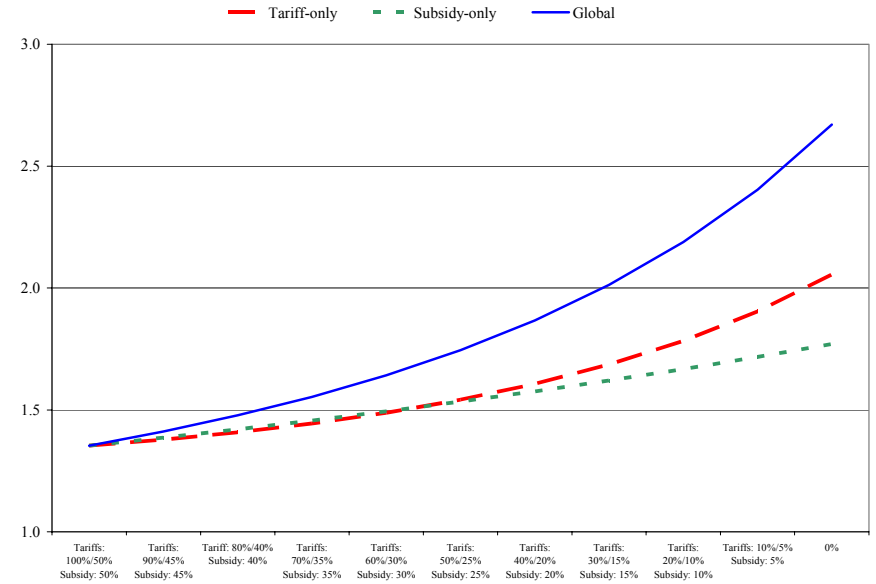

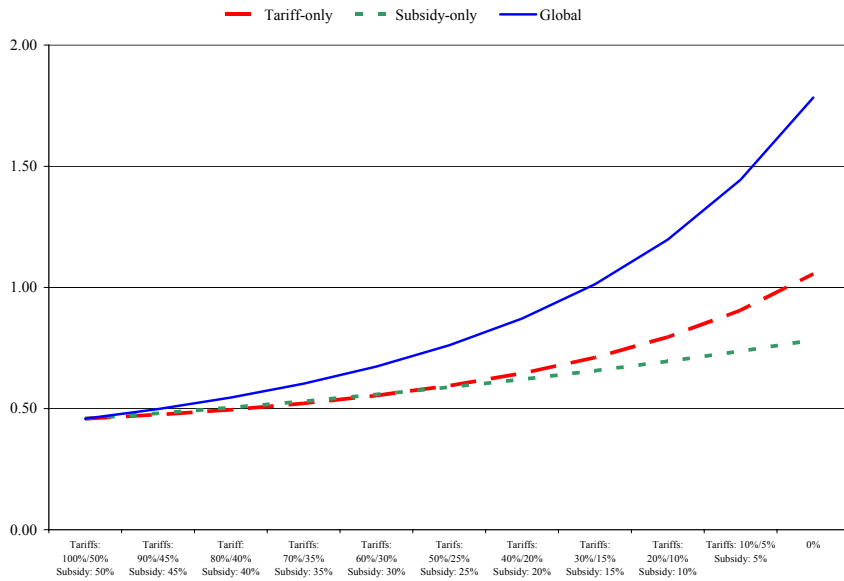Figure 3. Country 3's price of the processed good $(\gamma = 2; \eta = 2)$

Figure 2. Country 3's price of the primary good $(\gamma = 2; \eta = 2)$
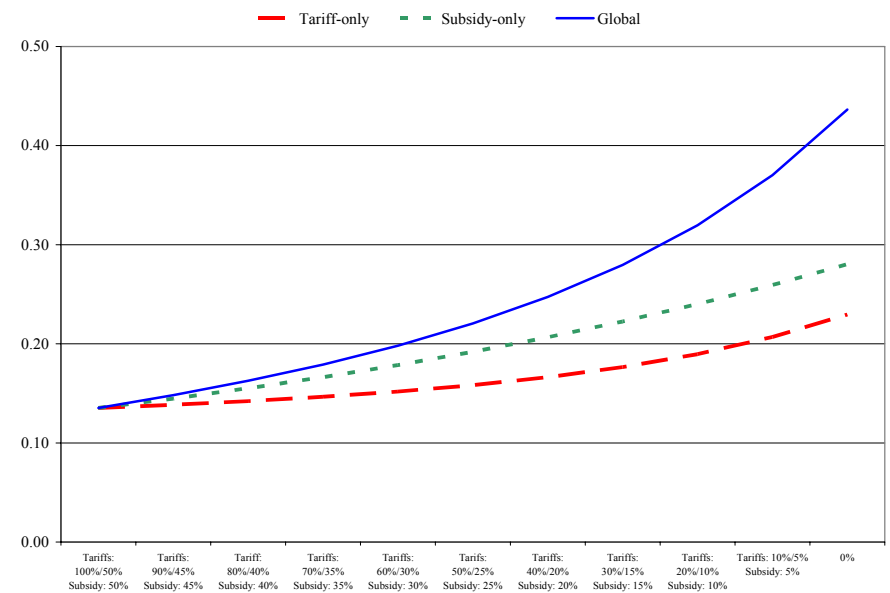

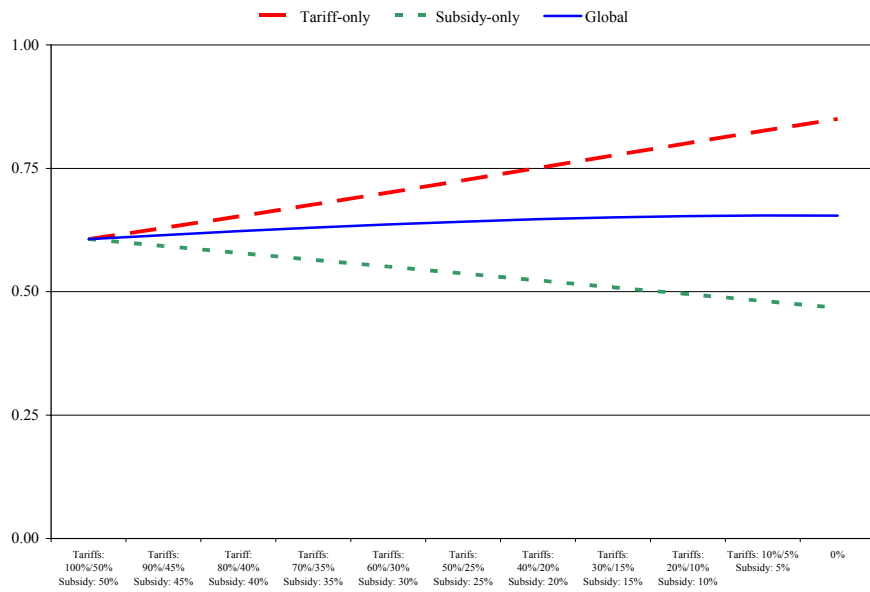Figure 4. Country 3's exports of primary goods $(\gamma = 2; \eta = 2)$

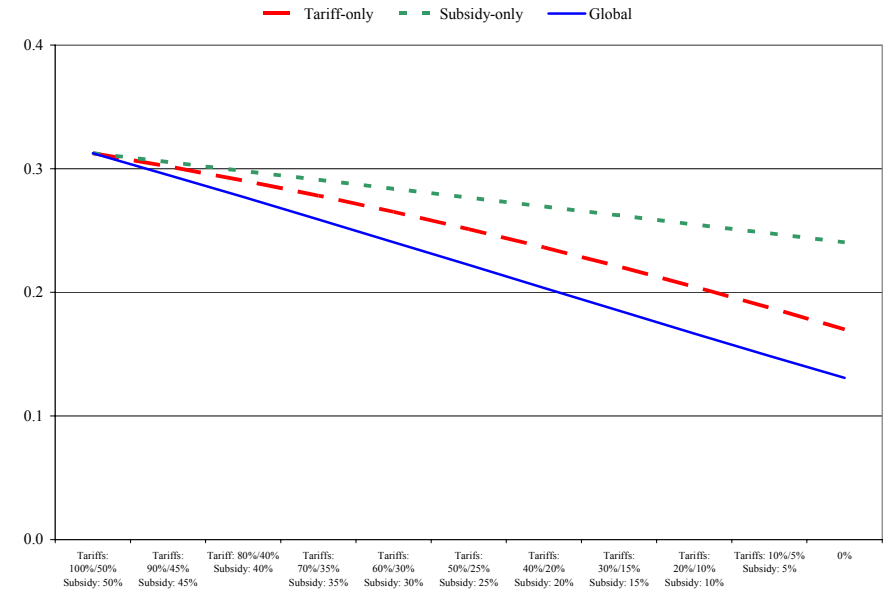Figure 5. Country 3's exports of processed goods $(\gamma = 2; \eta = 2)$

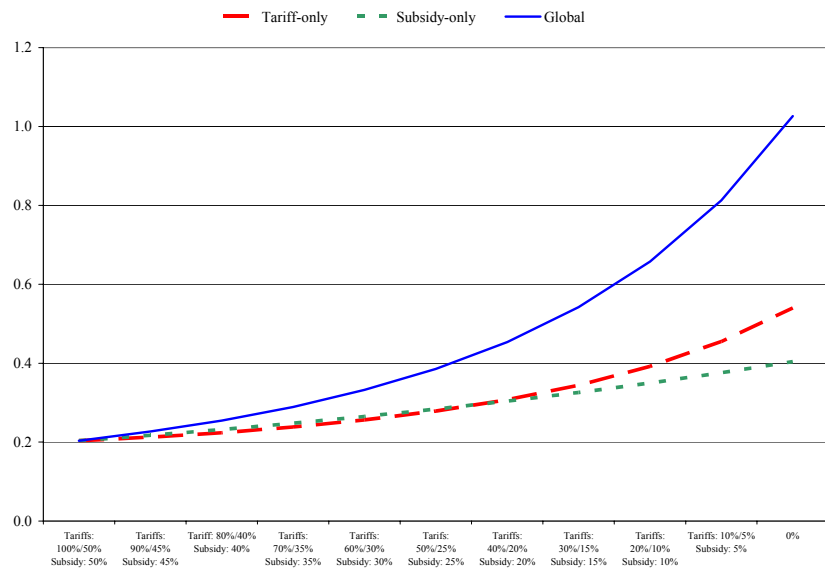Figure 7. Country 3's domestic sales of processed goods $(\gamma = 2; \eta = 2)$

Figure 6. Country 3's domestic sales of primary goods $(\gamma = 2; \eta = 2)$
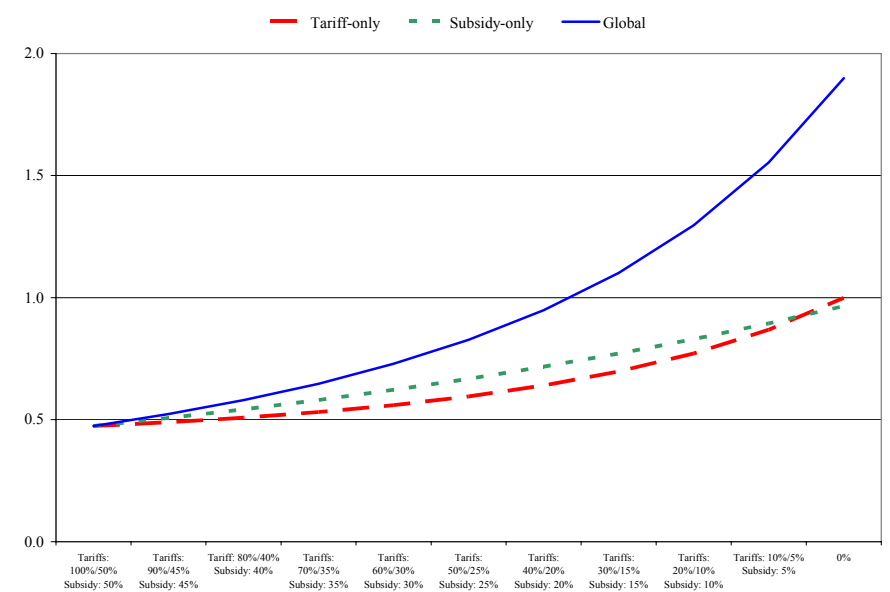

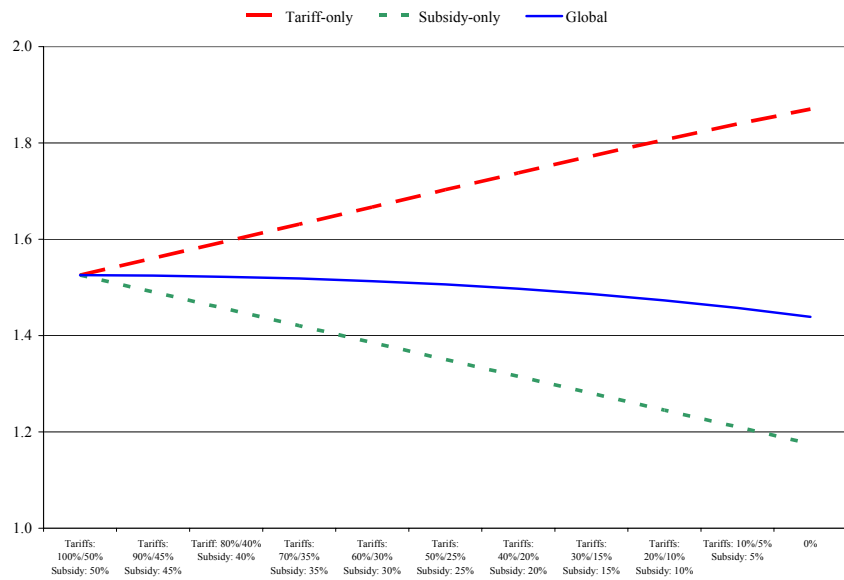Figure 8. Country 3's total sales of primary goods $(\gamma = 2; \eta = 2)$

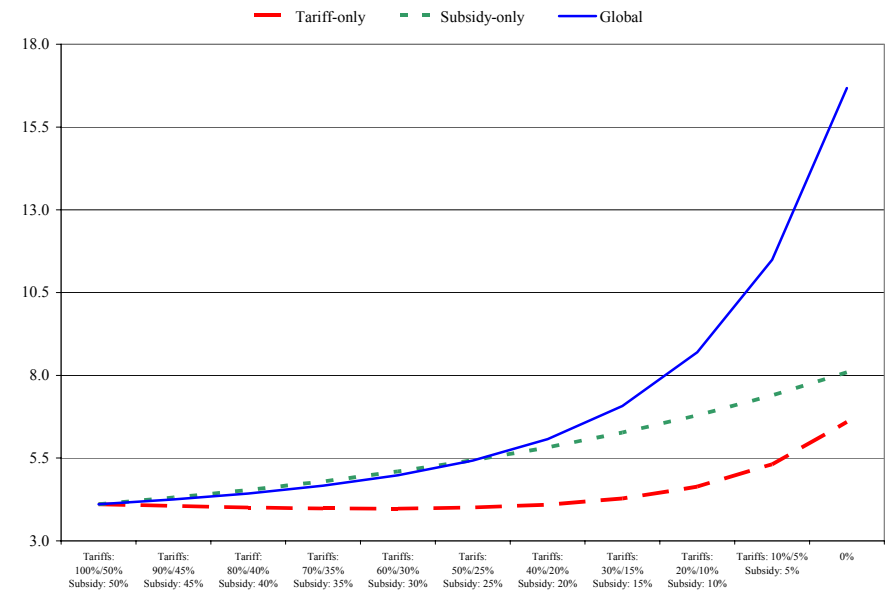Figure 9. Country 3's total sales of processed good $(\gamma = 2; \eta = 2)$
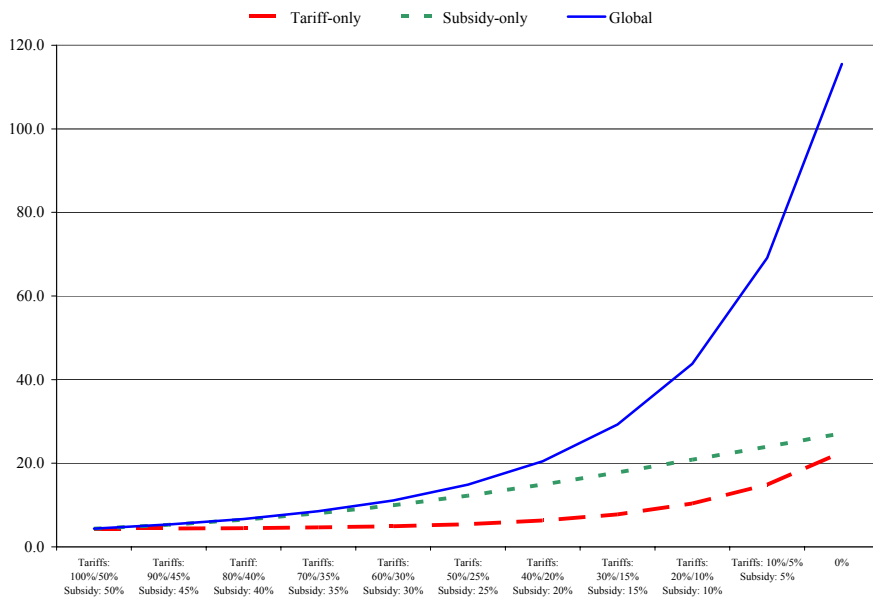

Figure 11. Country 3's welfare $(\gamma = 8; \eta = 2)$
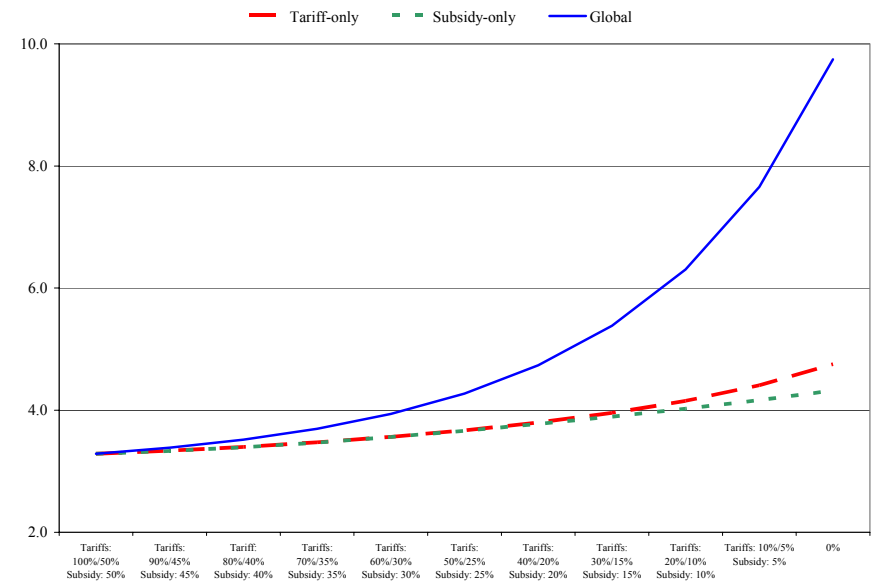

Figure 10. Country 3's welfare $(\gamma = 8; \eta = 8)$

Figure 12. Country 3's welfare $(\gamma = 2; \eta = 8)$

Technical appendix

Proof of Lemma 1: A matrix M has a dominant diagonal element if for some $p \gg 0$ we have that $Mp \ll 0$. This condition implies that $|a_{11}| > |a_{12}|$. The terms a_{11} and a_{12} are:

$$a_{11} = -\theta_g^{\theta_g+1}(1-\theta)^{-\theta_g}\left(1/\varpi_{g1}\right)h_{g1}^{\theta_g-1}w^{\theta_g}\left(I_{g11}+I_{g12}\right)$$
$$+ p_{g1}\left((1+\gamma_1)\delta_1\sum_{h=1,2}\left(s_{g1h}t_{g1h}\right)I_{g1h}^2 D_{1h}^{\delta_1-1}-(\gamma_1/h_{11})\sum_{h=1,2}I_{g1h}\right) \tag{12}$$
$$+\left(M_{g11}+M_{g21}\right)\left((\eta_1-1)N_{g1}\chi_1^{-1}\left(\tau_{g11}^{1-\eta_1}+\tau_{g21}^{1-\eta_1}\right)c_{g1}^{-\eta_1}-c_{g1}^{-1}\eta_1\right)$$

$$a_{12} = p_{g1}\delta_g\left(1+\gamma_g\right)\sum_{h=1,2}\left(s_{g2h}t_{g2h}\right)I_{g1h}^2 D_{gh}^{\delta_1-1}$$
$$+\left(M_{g11}+M_{g21}\right)\left(\eta_g-1\right)N_{g2}\chi_g^{-1}\left(\tau_{g12}^{1-\sigma_1}+\tau_{g22}^{1-\sigma_1}\right)c_{g2}^{-\sigma_1} \tag{13}$$

where $\delta_g \equiv \left(\gamma_g(\beta-1)-1\right)\big/\left((1+\gamma_g)(\beta-1)\right)$ (with $\delta_g(1+\gamma_g) > 0$), $\Delta_g \equiv \alpha_g\left((\eta_g-1)/\eta_g\right)$,

$$\chi_g \equiv N_{g1}\left[\left(\tau_{g11}c_{g1}\right)^{1-\eta_1}+\left(\tau_{g21}c_{g1}\right)^{1-\eta_1}\right]+N_{g2}\left[\left(\tau_{g12}c_{g2}\right)^{1-\eta_1}+\left(\tau_{g22}c_{g2}\right)^{1-\eta_1}\right] > 0, \qquad \text{and}$$

$$D_{gj} \equiv \left(h_{g1}s_{g1j}t_{g1j}\right)^{1+\gamma_g}+\left(h_{g2}s_{g2j}t_{g2j}\right)^{1+\gamma_g} > 0.$$

Subtracting (13) from (12) yields:

$$p_{g1}\sum_{h=1,2}\left(\theta_g\left(1+\gamma_g\right)\left(s_{g1h}t_{g1h}\right)I_{g1h}^2 D_{gh}^{\theta_1-1}\left(s_{g1h}t_{g1h}-s_{g2h}t_{g2h}\right)-I_{g1h}\left(\frac{\gamma_g}{h_{g1}}\right)\right)$$
$$-\theta_g^{\theta_g+1}(1-\theta)^{-\theta_g}\left(1/\varpi_{11}\right)h_{g1}^{\theta_g-1}w^{\theta_g}\left(I_{g11}+I_{g12}\right)-\left(M_{g11}+M_{g21}\right)c_{g1}^{-1}\eta_g \tag{14}$$
$$+\left(M_{g11}+M_{g21}\right)\left(\sigma_g-1\right)\chi_g^{-1}\left(N_{g1}\left(\tau_{g11}^{1-\sigma_g}+\tau_{g21}^{1-\sigma_g}\right)c_{g1}^{-\sigma_g}-N_{g2}\left(\tau_{g12}^{1-\sigma_g}+\tau_{g22}^{1-\sigma_g}\right)c_{g2}^{-\sigma_g}\right)$$

All terms in the previous equation are negative except for the first one. In a world with no trade costs and no domestic support on primary products $\left(t_{g2h}=t_{g1h}=1; s_{g2h}=s_{g1h}=1\right)$, the whole expression in (14) is negative which implies that $|a_{11}| > |a_{12}|$. In a world with trade costs, but no domestic support, we have that $t_{g11}-t_{g21}=1-t_{g21} > 0$ and thus a sufficient condition for (14) to

be negative is that $\left(\gamma_g - (\beta-1)^{-1}\right)I_{g11}D_{g1}^{\theta_g-1}\left(1-t_{g21}\right) - \gamma_g h_{g1}^{-1} < 0$ because we know that

$\left(t_{g12}-t_{g22}\right) = \left(t_{g12}-1\right) < 0$. From (6) we know that $\left(\gamma_g - (\beta-1)^{-1}\right)I_{g11}D_{g1}^{\theta_1-1} - \gamma_g h_{g1}^{-1} < 0$ and

$-\left(\gamma_g - (\beta-1)^{-1}\right)I_{g11}D_{g1}^{\theta_g-1}s_{g21}t_{g21} < 0$; which establishes that $|a_{11}| > |a_{12}|$. The proof when

domestic support is positive follows the same pattern. **Q.E.D.**

Proof of Lemma 2: This result appeals directly to Lemma 1 and theorem M.D.5 in Mas-Colell *et al.* (1995).

Proof of proposition 1: Let $\mathbf{J}_{1,S_1}$ be a matrix in which the first column of the Jacobian is replaced by the first column of matrix $\mathbf{S}$ (denoted $\mathbf{S}_1$) while setting $ds_{g22} = 0$:

$$\mathbf{J}_{1,S_1} = \begin{bmatrix} \partial I_{g11}/\partial s_{g11} + \left(\partial I_{g11}/\partial s_{g21}\right)\left(h_{g1}/h_{g2}\right) & a_{12} \\ \partial I_{g21}/\partial s_{g11} + \left(\partial I_{g21}/\partial s_{g21}\right)\left(h_{g1}/h_{g2}\right) & a_{22} \end{bmatrix} \tag{15}$$

Using Cramer's rule, we have that: $\text{sign}\left[dh_{g1}/ds_{g11}\right] = \text{sign}|\mathbf{J}_{1,S_1}|$ given that

$dh_{g11}/ds_{g11} \equiv \left|\mathbf{J}_{1,S_1}\right|/|\mathbf{J}|$. The determinant is:

$$\begin{aligned} \left|\mathbf{J}_{1,S_1}\right| &= a_{22}\left(\partial I_{g11}/\partial s_{g11} + \left(\partial I_{g11}/\partial s_{g21}\right)\left(h_{g1}/h_{g2}\right)\right) \\ &\quad - a_{12}\left(\partial I_{g21}/\partial s_{g11} + \left(\partial I_{g21}/\partial s_{g21}\right)\left(h_{g1}/h_{g2}\right)\right) < 0 \end{aligned} \tag{16}$$

The negative definiteness of the Jacobian implies that the product of the first terms on the right hand-side of (16) is negative (theorem M.D.2 of Mas-Colell *et al.*, 1995). The product of the second term is greater than zero because $\mathbf{J}$ has a dominant diagonal; thus making the expression in (16) unambiguously negative as $\partial I_{gi1}/\partial s_{gi1} > 0$ (from equation (6)). The impact of country 1's

subsidy on the price of the primary good in country 2 is determined by $dh_{g2}/ds_{g11} \equiv |\mathbf{J}_{2,S_1}|/|\mathbf{J}|$.

Because $|\mathbf{J}|$ is positive, we have that: $\text{sign}[\partial h_{12}/\partial s_{11}] = \text{sign}|\mathbf{J}_{2,S_1}|$; with:

$$|\mathbf{J}_{2,S_1}| = -a_{21}\left(\partial I_{g11}/\partial s_{g11} + \left(\partial I_{g11}/\partial s_{g21}\right)\left(h_{g1}/h_{g2}\right)\right)$$
$$+ a_{11}\left(\partial I_{g21}/\partial s_{g11} + \left(\partial I_{g21}/\partial s_{g21}\right)\left(h_{g1}/h_{g2}\right)\right) < 0 \tag{17}$$

The second product on the right hand-side of (17) is negative because $\mathbf{J}$ is negative definite (thus $a_{11} < 0$) and assumption 3. Hence, country 1's domestic support for its primary good g is negatively correlated with the price of the primary good in country j; $j \neq i$. This proves part i).

We now jump to the proof of part iv) because we will use it for the proof of parts ii) and iii). The impact of a change in domestic support offered by country 1 on sales of processed products is computed from totally differentiating the export supply and import demand functions. Let us consider first the two last parts of the proposition. Part *iii*) is proven by analyzing the impacts of primary good prices on the sales of processed goods. Differentiating the import demand functions defined in (4) with respect to the subsidy offered by country 1 yields:

$$dM_{g11} = \frac{\partial M_{g11}}{\partial h_{g1}}\frac{\partial h_{g1}}{\partial s_{g11}}ds_{g11} + \frac{\partial M_{g11}}{\partial h_{g2}}\frac{\partial h_{g2}}{\partial s_{g11}}ds_{g11} \tag{18}$$

$$dM_{g21} = \frac{\partial M_{g21}}{\partial h_{g1}}\frac{\partial h_{g1}}{\partial s_{g11}}ds_{g11} + \frac{\partial M_{g21}}{\partial h_{g2}}\frac{\partial h_{g2}}{\partial s_{g11}}ds_{g11} \tag{19}$$

Using (4), it is relatively easy to show that $\partial M_{g11}/\partial h_{g2} > 0 > \partial M_{g11}/\partial h_{g1}$. Moreover, assumptions 2 and 3 states that $|\partial M_{g11}/\partial h_{g1}| > \partial M_{g11}/\partial h_{g2}$ and $|\partial h_{gi}/\partial s_{gi}| > |\partial h_{gj}/\partial s_{gi}|$; implying that: $\partial M_{g11}/\partial s_{g11} > 0$. As previously mentioned, the import demand functions defined in (4) imply that: $\partial M_{g21}/\partial h_{g2} > 0 > \partial M_{g21}/\partial h_{g1}$ which under the assumption that

$\left| \partial M_{g21} / \partial h_{g1} \right| > \partial M_{g21} / \partial h_{g2}$ and $\left| \partial h_{gi} / \partial s_{gi} \right| > \left| \partial h_{gj} / \partial s_{gi} \right|$ implies $\partial M_{g21} / \partial s_{g11} > 0$; thus proving part *iii*).

Finally, to derive the impact of a subsidy on the other country's sales of processed commodities, we totally differentiating the import demand functions with respect to s_{g1} and using (4), it is easy to show that $\partial M_{g12} / \partial h_{g1} > 0$, $\partial M_{g22} / \partial h_{g1} > 0$, $\partial M_{g12} / \partial h_{g2} < 0$ and $\partial M_{g22} / \partial h_{g2} < 0$. Under certain regularity conditions, $\partial M_{g12} / \partial s_{g1} > 0$ and $\partial M_{g22} / \partial s_{g1} > 0$; which completes the proof of part *iv*).

We now consider parts *ii*) and *iii*). First, we differentiate the export supply functions of countries 1 and 2 with respect to s_{g11}:

$$dI_{g11} = \frac{\partial I_{g11}}{\partial s_{g11}} ds_{g11} + \frac{\partial I_{g11}}{\partial h_{g1}} \frac{\partial h_{g1}}{\partial s_{g11}} ds_{g11} + \frac{\partial I_{g11}}{\partial h_{g2}} \frac{\partial h_{g2}}{\partial s_{g11}} ds_{g11} \tag{20}$$

$$dI_{g21} = \frac{\partial I_{g21}}{\partial s_{g1}} ds_{g11} + \frac{\partial I_{g21}}{\partial h_{g1}} \frac{\partial h_{g1}}{\partial s_{g1}} ds_{g11} + \frac{\partial I_{g21}}{\partial h_{g2}} \frac{\partial h_{g2}}{\partial s_{g1}} ds_{g11} \tag{21}$$

$$dI_{g12} = \frac{\partial I_{g12}}{\partial h_{g1}} \frac{\partial h_{g1}}{\partial s_{g11}} ds_{g11} + \frac{\partial I_{g12}}{\partial h_{g2}} \frac{\partial h_{g2}}{\partial s_{g11}} ds_{g11} \tag{22}$$

$$dI_{g22} = \frac{\partial I_{g22}}{\partial h_{g1}} \frac{\partial h_{g1}}{\partial s_{g11}} ds_{g11} + \frac{\partial I_{g22}}{\partial h_{g2}} \frac{\partial h_{g2}}{\partial s_{g11}} ds_{g11} \tag{23}$$

Equation (20) summarizes the three effects of a subsidy on domestic sales of the primary product. From equation (6), the direct effect of the subsidy is to increase domestic sales $\left(\partial I_{gii} / \partial s_{g1i} > 0 \right)$. The production subsidy has two indirect effects through its impact on the price of the primary product in countries 1 and 2. Proposition 1 already showed that $\partial h_{g1} / \partial s_{g11} < 0$ and $\partial h_{g2} / \partial s_{g11} < 0$. Because the export supply function to one particular destination country is

respectively positively and negatively correlated with the price prevailing in that country and the other country (see equation (6)), the second term of the right-hand side of (20) is negative and the third is positive. The ambiguity simply reflects the potential for a Metzler-like effect (backward-bending supply). However, we will show that under our assumptions and the market clearing condition $\dfrac{dI_{g11}}{ds_{g11}} + \dfrac{dI_{g12}}{ds_{g11}} = \dfrac{dM_{g11}}{ds_{g11}} + \dfrac{dM_{g21}}{ds_{g11}}$, a domestic subsidy increases domestic sales.

The right-hand side terms of (21), (22) and (23) are signed using a similar argument. Moreover, under assumptions 2 and 3, $\partial I_{gii}/\partial h_{gi} > \left| \partial I_{gii}/\partial h_{gj} \right|$ and $\left| \partial h_{gi}/\partial s_{gii} \right| > \left| \partial h_{gj}/\partial s_{gii} \right|$; which lead to $dI_{g21}/ds_{g11} > 0$ and $dI_{g12}/ds_{g11} < 0$. However, these conditions are not sufficient to unambiguously sign $\partial I_{g22}/\partial s_{g11}$. From the market clearing condition, we find that:

$\dfrac{dI_{g11}}{ds_{g11}} = -\dfrac{dI_{g12}}{ds_{g11}} + \dfrac{dM_{g11}}{ds_{g11}} + \dfrac{dM_{g21}}{ds_{g11}} > 0$ which rules out a Metzler effect and resolves the ambiguity about the effect of domestic support on domestic sales; which completes the proof of parts *ii* and *iii*). **Q.E.D.**

Proof of proposition 2: The proof of proposition 2 is structured along the lines of the proof of proposition 1. At the outset, it should be reiterated that an increase in t_{gij} can be construed as an *increase* in market access or a *decrease* in the tariff rate as the degree of friction falls. Let $\mathbf{J}_{1,\Upsilon_1}$ be a matrix in which the first column of the Jacobian is replaced with the first column of matrix Υ (denoted Υ_1) while setting $dt_{g12} = 0$: $\mathbf{J}_{1,\Upsilon_1} = \begin{bmatrix} \partial I_{g11}/\partial t_{g21} & a_{12} \\ \partial I_{g21}/\partial t_{g21} & a_{22} \end{bmatrix}$. Because $\partial h_{g1}/\partial t_{g21} = \left| \mathbf{J}_{1,\Upsilon_1} \right| / \left| \mathbf{J} \right|$, we need to investigate the sign of the numerator: $\left| \mathbf{J}_{1,\Upsilon_1} \right| = a_{22}\left(\partial I_{g11}/\partial t_{g21} \right) - a_{12}\left(\partial I_{g21}/\partial t_{g21} \right)$ where $a_{22} < 0$ and $a_{12} > 0$. From (6), it can be

ascertained that country 2's tariff reduction increases country 1's exports at the expense of its domestic sales: $\partial I_{g11}/\partial t_{g21} < 0$ and $\partial I_{g21}/\partial t_{g21} > 0$. Lemmas 1 and 2 cannot be used to resolve the ambiguity and without stronger assumptions, the effect of reducing country 2's trade barrier on country 1's price of the primary product cannot be unambiguously signed. The impact of country 2's tariff reduction on its own domestic price is determined by: $\partial h_{g2}/\partial t_{g21} = |\mathbf{J}_{2,\Upsilon_1}|/|\mathbf{J}|$;

with $|\mathbf{J}_{2,\Upsilon_1}| = -a_{21}\left(\partial I_{g11}/\partial t_{g21}\right) + a_{11}\left(\partial I_{g21}/\partial t_{g21}\right)$. The first product in the expression is positive while the second negative. Lemmas 1 and 2 imply that the absolute value of a_{11} is greater than a_{21} and assuming that $\left|\partial I_{g11}/\partial t_{g21}\right| < \partial I_{g21}/\partial t_{g21}$, the effect of a reduction in country 2's tariff on the price of country 2's intermediate good is unambiguously negative. If the tariff reduction elicit changes in opposite directions for h_{g1} and h_{g2}, the spread will be reduced. However, this is so even when both prices decrease because the following expression is positive:

$sign\left(|\mathbf{J}_{1,\Upsilon_1}| - |\mathbf{J}_{2,\Upsilon_1}|\right) = sign\left\{\left(\partial I_{g11}/\partial t_{g21}\right)\left(a_{22} + a_{21}\right) - \left(\partial I_{g21}/\partial t_{g21}\right)\left(a_{12} + a_{11}\right)\right\}$. The positive sign is due to Lemmas 1 and 2 and equation (6). Therefore, if h_{g1} decreases, it cannot decrease more than h_{g2}. This proves part *i)*.

Setting aside parts *ii)* and *iii)* for the time being and moving to part iv), we differentiate the demand functions for the processed good with respect to t_{g21}:

$$dM_{g11} = \frac{\partial M_{g11}}{\partial h_{g1}}\frac{\partial h_{g1}}{\partial t_{g21}}dt_{g21} + \frac{\partial M_{g11}}{\partial h_{g2}}\frac{\partial h_{g2}}{\partial t_{g21}}dt_{g21}; \qquad dM_{g21} = \frac{\partial M_{g21}}{\partial h_{g1}}\frac{\partial h_{g1}}{\partial t_{g21}}dt_{g21} + \frac{\partial M_{g21}}{\partial h_{g2}}\frac{\partial h_{g2}}{\partial t_{g21}}dt_{g21},$$

$$dM_{g12} = \frac{\partial M_{g12}}{\partial h_{g1}}\frac{\partial h_{g1}}{\partial t_{g21}}dt_{g21} + \frac{\partial M_{g12}}{\partial h_{g2}}\frac{\partial h_{g2}}{\partial t_{g21}}dt_{g21} \text{ and } dM_{g22} = \frac{\partial M_{g22}}{\partial h_{g1}}\frac{\partial h_{g1}}{\partial t_{g21}}dt_{g21} + \frac{\partial M_{g22}}{\partial h_{g2}}\frac{\partial h_{g2}}{\partial t_{g21}}dt_{g21}.$$

Using (4), it is easy to show that $\partial M_{gij}/\partial h_{gj} < 0$ and $\partial M_{gij}/\partial h_{gi} > 0$, $i \neq j$. We also have that

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$\left|\partial M_{gij}/\partial h_{gj}\right|>\left|\partial M_{gij}/\partial h_{gi}\right|$ which implies that the sign of dM_{g11}/dt_{g21} and dM_{g21}/dt_{g21} cannot

be unambiguously signed although dM_{g12}/dt_{g21} and dM_{g22}/dt_{g21} are positive.

To prove parts *ii*) and *iii*), differentiate country 2's intermediate good supply functions

with respect to t_{g21} to obtain: $dI_{g12}=\dfrac{\partial I_{g12}}{\partial h_{g1}}\dfrac{\partial h_{g1}}{\partial t_{g21}}dt_{g21}+\dfrac{\partial I_{g12}}{\partial h_{g2}}\dfrac{\partial h_{g2}}{\partial t_{g21}}dt_{g21}$ and

$dI_{g22}=\dfrac{\partial I_{g22}}{\partial h_{g1}}\dfrac{\partial h_{g1}}{\partial t_{g21}}dt_{g21}+\dfrac{\partial I_{g22}}{\partial h_{g2}}\dfrac{\partial h_{g2}}{\partial t_{g21}}dt_{g21}$. Using the results in part *i)* and the definition of supply

functions in (6), we can show that the two main terms in dI_{g12} have offsetting effects whose

relative strength cannot be ascertained. From part *i)* and assumption 2, $\left|\partial h_{g1}/\partial t_{g21}\right|<\left|\partial h_{g2}/\partial t_{g21}\right|$

and $\left|\partial I_{gij}/\partial h_{gj}\right|>\left|\partial I_{gii}/\partial h_{gj}\right|$; which implies dI_{g22}/dt_{g21} is unambiguously negative proving part

iii). The proof of part *ii*) follows the same pattern and is omitted. **Q.E.D.**

Proof of proposition 3: The proof is quite similar to the previous ones. Let $\mathbf{J}_{1,\mathbf{T}_1}$ be a matrix

built from the Jacobian matrix; the difference being that the first column is the first column of

matrix $\mathbf{T}$ (denoted $\mathbf{T}_1$) assuming $d\tau_{g12}=0$: $\mathbf{J}_{1,\mathbf{T}_1}=\begin{bmatrix}-\partial CC_1/\partial\tau_{g21} & a_{12}\\ -\partial CC_2/\partial\tau_{g21} & a_{22}\end{bmatrix}$. The sign of

$\partial h_{g1}/\partial\tau_{g21}$ depends on the sign of $\left|\mathbf{J}_{1,\mathbf{T}_1}\right|=-a_{22}\left(\partial CC_1/\partial\tau_{g21}\right)+a_{12}\left(\partial CC_2/\partial\tau_{g21}\right)$. Given that

$\partial CC_1/\partial\tau_{g21}=\partial M_{g21}/\partial\tau_{g21}<0$ and $\partial CC_2/\partial\tau_{g21}=\partial M_{g22}/\partial\tau_{g21}>0$, that $\left|a_{22}\right|>a_{12}>0$ from

Lemmas 1 and 2, and $\left|\partial M_{g21}/\partial\tau_{g21}\right|>\partial M_{g22}/\partial\tau_{g21}$ from assumption 2, then a reduction in

country 2's tariff on processed goods imported from country 1 increases the price of the primary

good in country 1 ($\partial h_{g1}/\partial\tau_{g21}<0$). The effect on the price of the primary good in country 2 is

determined by: $\partial h_{g2}/\partial\tau_{g21}=\left|\mathbf{J}_{2,\mathbf{T}_1}\right|/\left|\mathbf{J}\right|$; where: $\left|\mathbf{J}_{2,\mathbf{T}_1}\right|=a_{21}\left(\partial CC_1/\partial\tau_{g21}\right)-a_{11}\left(\partial CC_2/\partial\tau_{g21}\right)$. All

products in the previous expression are negative and the sign of $\left|\mathbf{J}_{2,\mathbf{T}_1}\right|$ cannot be unambiguously

determined without additional assumptions. However, it is easy to see that:

$$sign\left(\left|\mathbf{J}_{1,\mathbf{T}_1}\right|-\left|\mathbf{J}_{2,\mathbf{T}_1}\right|\right)=sign\left(-\frac{\partial CC_1}{\partial\tau_{g21}}\left(a_{22}+a_{21}\right)+\frac{\partial CC_2}{\partial\tau_{g21}}\left(a_{12}+a_{11}\right)\right)<0.$$ This shows that if an

increase in τ_{g21} induce decreases in the price of primary products in both countries, the decrease

in country 1 will be more severe than in country 2. This proves part $i)$.

We now jump to part iv) and differentiate the bilateral export supply functions for

primary products with respect to τ_{g21} to obtain: $dI_{g11}=\dfrac{\partial I_{g11}}{\partial h_{g1}}\dfrac{\partial h_{g1}}{\partial\tau_{g21}}d\tau_{g21}+\dfrac{\partial I_{g11}}{\partial h_{g2}}\dfrac{\partial h_{g2}}{\partial\tau_{g21}}d\tau_{g21}$ and

$dI_{g21}=\dfrac{\partial I_{g21}}{\partial h_{g1}}\dfrac{\partial h_{g1}}{\partial\tau_{g21}}d\tau_{g21}+\dfrac{\partial I_{g21}}{\partial h_{g2}}\dfrac{\partial h_{g2}}{\partial\tau_{g21}}d\tau_{g21}$. From the results in part $i)$ and equation (6) it follows

that $dI_{g11}/d\tau_{g21}<0$. However, even though part $i)$ and assumption 2 jointly imply that

$\left|\partial h_{g2}/\partial\tau_{g21}\right|<\left|\partial h_{g1}/\partial\tau_{g21}\right|$ and $\left|\partial I_{gij}/\partial h_{gj}\right|>\left|\partial I_{gii}/\partial h_{gj}\right|$, the sign of $dI_{g21}/d\tau_{g21}$ cannot be

unambiguously determined. This proves part $iv)$.

The output of country j's varies with changes in its own tariff according to:

$$dI_{g12}=\frac{\partial I_{g12}}{\partial h_{g1}}\frac{\partial h_{g1}}{\partial\tau_{g21}}d\tau_{g21}+\frac{\partial I_{g12}}{\partial h_{g2}}\frac{\partial h_{g2}}{\partial\tau_{g21}}d\tau_{g21}\quad\text{and}\quad dI_{g22}=\frac{\partial I_{g22}}{\partial h_{g1}}\frac{\partial h_{g1}}{\partial\tau_{g21}}d\tau_{g21}+\frac{\partial I_{g22}}{\partial h_{g2}}\frac{\partial h_{g2}}{\partial\tau_{g21}}d\tau_{g21}.$$

Using equation (6) and the inequalities $\left|\partial h_{g2}/\partial\tau_{g21}\right|<\left|\partial h_{g1}/\partial\tau_{g21}\right|$ and $\left|\partial I_{gij}/\partial h_{gj}\right|>\left|\partial I_{gii}/\partial h_{gj}\right|$,

we can infer that $dI_{g12}/d\tau_{g21}<0$. However, these conditions are not sufficient to unambiguously

determine the sign of $dI_{g12}/d\tau_{g21}$. This proves parts $v)$. The proofs for part $ii)$ and $iii)$ follow

closely the previous proof and are omitted.

Endnotes

[1] The international trade's version of gravity implies that trade between two countries is proportional to their economic sizes respective and inversely proportional to the distance which separates them. Leamer and Levinsohn (1995) argue that gravity-based models have produced some of the clearest and most robust results in the economics science. See Eaton and Kortum (2002), Evenett and Keller (2002), and Debaere (2005) for insightful applications of the gravity model. Anderson and van Wincoop (2004) provide an excellent survey of the literature.

[2] Notable examples include the Global Trade Analysis Project (GTAP, see Hertel, 1997; Keeney and Hertel, 2005), the AGLINK model (OECD, 2002) and the Agricultural Trade Policy Simulation Model (UNCTAD, 2002).

[3] DeRosa and Gilbert (2005) investigate the predictive power of CGE and gravity type models. They find that "naïve" gravity model tends to over-predict intra-bloc trade expansion (especially over horizons of five years and less) and "naïve" CGE model tends to under-predict it.

[4] Abdelkhalek and Dufour (1998) propose a method to bring "statistical objectivity" in assessing the uncertainty about simulation results of CGE models, but their approach has not been widely used in practice.

[5] Rauch and Feenstra (1999) discussed these costs in a context of networks in international trade.

[6] The microeconomic foundations of this cost function are the following. Suppose that the production process can be decomposed into two different stages. First, each firm produces an aggregate output that is subsequently tailored to each particular market. Customizing the aggregate output leads to less (more) individual destination-specific output assuming that $\gamma_g < (>) \ 0$.

[7] The link with the usual rate of subsidy $\kappa_{gij} \geq 0$ can be recovered through $s_{gij} \equiv 1 + \kappa_{gij} \geq 1$. Similarly, we can relate the usual ad valorem tariff T_{gij} to the trade cost measure through $t_{gij} \equiv 1/(1 + T_{gij}) \leq 1$. An increase in t_{gij} can be interpreted as a decrease in the ad valorem tariff.

[8] Paarlberg (1995) and Desquilbet and Guyomard (1998) find similar results when studying export subsidies on bulk and processed commodities in a perfectly competitive environment.

[9] A subsidy on domestic primary production can be viewed by trading partners as a ploy to provide a competitive advantage to processing firms, but such a subsidy also lowers the price of primary goods in other countries. As it shall be demonstrated later, lowering a tariff on primary products makes it easier to domestic processors to acquire foreign primary goods, but it may not necessarily confer similar benefits to processing firms in other countries.

[10] This argument was also verified empirically in a study by ERS (2001). They found that eliminating tariffs would account for most (52 percent) of the potential increase in the world price increase whereas domestic subsidies account 31 percent of the total agricultural price impacts of all policies. Although export subsidies can be decomposed as a production subsidy and consumption tax, they account for a relatively small share (13 percent) of the total price distortions caused by agricultural tariffs and subsidies because they are less popular.

[11] François and Martin (2006) examine various market access reforms and their impact on tariff escalation. For example the swiss formula is more effective than linear tariff cuts in reducing tariff escalation.