Non-Equivalent Ad Valorem Equivalents and Gravity

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Abstract: Specific tariffs are more commonly applied in agriculture than in the rest of the economy. We argue that the volatility of agricultural commodity markets is a contributing factor by showing that higher expected welfare can be achieved with the optimal specific tariff than with its ad valorem counterpart in the presence of volatile market conditions in the exporting countries. Contrary to popular wisdom, more volatility does not warrant higher tariffs unless the distribution of the foreign autarky price is negatively skewed. For arbitrary specific tariffs, the transformation into ad valorem equivalents may decrease or increase the volume of trade and the world price. We also show that countries with more restrictive specific tariffs are less likely to pursue tariff simplification. We estimate a gravity model about beef trade and find that specific tariffs have a small reducing effect, beyond the effect stemming from their ad valorem equivalent rate.

JEL codes: F13, F14, Q17, Q11

Acknowledgements: Financial support from FQRSC, SSHRC and the Canada Research Chair program is gratefully acknowledged. We also wish to thank participants of the 2013 SPAA research network workshop for comments and suggestions.
1. Introduction

Countries have traditionally relied on a wide range of trade policy instruments to limit the flows of foreign imports. Quantitative restrictions like import quotas and voluntary export restraints were once major trade impediments. This motivated a large literature on the non-equivalence between tariffs and quotas (e.g., Bhagwati, 1965; Rodriguez, 1974; Cassing and Hillman, 1985; Young and Anderson, 1982; Syropoulos, 1994) which provided much useful information to policymakers and international trade negotiators. The tariffication of non-tariff barriers in the Uruguay Round of multilateral trade negotiations has contributed to make the world trading system more transparent as most countries increasingly rely on ad valorem tariffs for trade protection. An ad valorem tariff is levied as a percentage of the border price on every unit of a good when imported or exported. As such, it is more transparent than a specific tax which is a fixed monetary amount added to the world price. Thus, without knowledge of the border price, it is impossible to know how restrictive a specific tariff is. Non-ad valorem tariffs are not limited to specific tariffs. According to the WTO (2006, p.186), a mixed tariff is defined as a conditional combination of an ad valorem duty and a specific duty, one applying below a limit, the other applying above it while a compound tariff is a combination of an ad valorem duty and a specific duty, added together or one subtracted from the other. Technical tariffs have their rate or level set as a function of input content, like alcohol or sugar content. The relative importance of such tariffs varies by country and by commodities. The biggest users of non-ad valorem tariffs are Switzerland with 80% of its tariff lines being non-ad valorem ones, Russia (13.1%), the United States (8.2%), Norway (6.8%), the European Union (4.7%) and Japan (3.3%). In terms of commodities, specific tariffs are imposed much more often on agricultural and food commodities than on non-agricultural products as shown by Table 1. Babili (2009) points out that specific tariffs make up 20% of all agricultural tariff lines. However, Table 2 shows that non-ad valorem tariffs are not equally popular across agricultural and food products. Because a specific tariff lowers the relative price of more expensive varieties of a good, it induces a “quality upgrading” or Alchian-Allen effect (Falvey, 1979). Based on this reasoning, Chowdhury (2012) contends that specific tariffs discriminate against less developed exporters of low-priced agricultural commodities.

Agricultural commodities are known to have volatile prices. This is due to their highly inelastic supply in the short run and its sensitivity to weather shocks. This volatility contributes to protectionism in the form of expensive domestic support programs and restrictive tariff and
non-tariff trade barriers (Larue and Ker, 1993). Table 1 shows that except for Australia, Chili and New Zealand, the average tariff on agricultural products is typically much higher than for non-agricultural products. This is especially apparent for countries like Norway, Switzerland, Japan and Turkey. Tariff-peaks are generally much higher for agricultural goods than for non-agricultural goods (Fontagné, Guérin, Jean, 2005). Still, Table 1 shows that some countries, like Canada, notoriously known for its high tariff peaks on dairy imports, have sizeable proportions of agricultural imports allowed in duty-free.

The volatility of agricultural prices contributes to the restrictiveness of trade barriers but also to the form that they take. We use a simple partial equilibrium model to show how volatility in the foreign autarky price affects a welfare-maximizing government’s choice between an *ad valorem* and specific tariff. The model shows that a specific tariff is welfare superior to an *ad valorem* tariff when the foreign export supply is volatile. In addition, we show that a specific tariff that is equivalent to an *ad valorem* tariff under stable markets conditions ends up being more trade-reducing when international markets are volatile.\(^1\)

The presence of specific tariffs in tariff schedules has implications on the measurement of the incidence of various factors conditioning agricultural trade flows. It is common practice to transform specific tariffs into *ad valorem* equivalents when estimating a gravity equation on disaggregated agricultural trade data (e.g., Winchester et al., 2012, Raimondi and Olper, 2011). While providing parsimony, such a practice is not without adverse consequences because specific and *ad valorem* tariffs are not equivalent when high frequency shocks are impacting on supply and demand functions in the rest of the world.\(^2\) Simply using *ad valorem* tariff equivalents, without any correction, leads to biased trade cost elasticities in gravity models. We rely on the estimation of a gravity model for beef trade to show the differential impact of specific tariffs.

The rest of this paper is organized as follows. The next section reviews the literature on the non-equivalence between specific and *ad valorem* tariffs. In Section 3, we develop a simple theoretical framework allowing for shocks in the rest of the world to induce volatility in the domestic price and the volume imported in the importing country. We derive the best specific

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\(^1\) Trade policy instruments are “fully” equivalent if they generate identical market equilibria. Non-equivalence is usually analyzed by anchoring comparisons at common values of a specific variable. For example, Bhagwati’s (1965) made welfare comparisons of quotas and tariffs generating the same volume of imports when domestic production is monopolized.

\(^2\) The conversion of non-*ad valorem* tariffs into *ad valorem* equivalents is not a simple exercise as documented by the methodologies described in Stawowy (2001) and Bouet et al. (2008).
and ad valorem tariffs under the premise that the foreign export supply can shift up or down from a given mean foreign autarky price. We posit that the latter is distributed according to a triangular distribution. Mean-preserving spreads are used to analyze the effects of increased volatility, but we also use mean-preserving skews to show that the shape of the distribution matters in the comparison of policy instruments. The best specific tariff dominates the best ad valorem tariff when the foreign export supply is subject to random shocks. Contrary to popular wisdom, the best ad valorem tariff must be reduced when the world market is more volatile, except when shocks are highly negatively skewed. Section 4 addresses the issue of converting specific tariff into ad valorem equivalents and the changes in expected welfare, trade volume and world prices. The effect of converting specific tariffs in ad valorem equivalents on the volume traded is generally ambiguous and hence must be ascertained empirically. Section 5 provides empirical evidence regarding the size of the biases on expected trade flows and key elasticities from the estimation of gravity models with and without correction for the transformation of specific tariffs. Our results suggest that specific tariffs hinder trade more than what is captured by their ad valorem rate and that the WTO’s tariff simplification objective would boost trade.

2. Specific and Ad Valorem Tariffs Comparisons

The comparison of specific and ad valorem taxes has a long history in public economics and in international trade that goes, according to Suits and Musgrave (1953), as far back as Wicksell (1896). It has been known for a long time that specific and ad valorem tariffs are equivalent when domestic and import goods are produced under perfect competition and in the absence of risk, market failures and policy reprisals from trade partners. Deviations from these conditions induce non-equivalence and the welfare ranking generally varies from one case to another. We discuss a few of these cases.

Brander and Spencer (1984) compare specific and ad valorem instruments and show that a specific subsidy is the best policy when imports are supplied by a foreign monopolist and the domestic demand is sufficiently convex. Das and Donnenfeld (1987) find that specific tariffs and quotas are equivalent and better than ad valorem tariffs when a country uses trade restrictions to influence the choices made by a foreign monopolist regarding price, quantity and quality. Larue and Lapan (2002) analyze a case involving a domestic monopolist competing with

3 Older studies often used the term unit taxes instead of specific taxes.
legal and illegal imports and show that the specific tariff dominates other instruments because it makes the monopolist’s residual demand more elastic. They also show that the dominance of ad valorem tariffs over import quotas, as found in Bhagwati (1965) can be reversed in the presence of smuggling. Jorgensen and Schröder (2005) show that specific tariffs provide a higher level of welfare than ad valorem tariffs allowing the same levels of imports under monopolistic competition. The intuition relates to the free entry and exit of firms. There are more domestic firms operating under the specific tariff than under the ad valorem tariff which entails lower prices and higher welfare under the specific tariff.

There are also several cases for which the dominance of the specific tariff over the ad valorem tariff is reversed. Kowalczyk and Skeath (1994) demonstrate that the optimal ad valorem tariff is superior welfare-wise to the optimal specific tariff when import demand is linear and imports are supplied by a foreign monopolist. In Lockwood and Wong (2000), two countries are involved in a two-stage game in which they first choose the type of tariffs before setting the rate or level of their tariff. Perfect competition prevails everywhere and there are only two goods. The key insight is that an offer curve distorted by a specific tariff tends to be less elastic than an offer curve distorted by an ad valorem tariff that generates the same level of tax revenues. As a result, countries involved in a trade war are more aggressive when waging war with specific tariffs than with ad valorem ones.

3. Volatility, Skewness and Optimal tariffs
We begin by revisiting the standard equivalence case under partial equilibrium. We then introduce shocks on the foreign export supply and show how this impacts on welfare and the volume of trade.

Let the excess demand of the importing country be expressed as:

\[ p^d = a - bq, \forall q \in \left[ 0, \frac{a}{b} \right], \]

where \( p^d \) is the domestic price in the importing country, \( q \) is the volume of imports and hence the difference between domestic demand and supply functions and \( a \) is the autarky price in the importing country. The foreign export supply function is given by:

\[ p^s = c + dq, \forall q > 0, \]

where \( p^s \) is the price received by foreign firms, \( c \) is the foreign autarky price and \( a > c > 0, b > 0, d > 0 \). In this case the volume of exports/excess supply is the difference between domestic supply and demand. The imposition of a non-prohibitive specific
tariff distorts the foreign export supply curve by shifting it up and creating a wedge between \( p^d \) and \( p^s \) such that : \( p^*_r + t = p^d_r \). Similarly, for a non-prohibitive \textit{ad valorem} tariff, the foreign export supply function shifts up, but the shift is not a parallel one: \( p^*_r(1 + \tau) = p^d_r \). The equilibrium quantities traded under both types of tariffs are: \( q_t = \frac{a - c - t}{b + d} \) and \( q_r = \frac{a - c(1 + \tau)}{b + d + d\tau} \). The importing country maximizes welfare by choosing an optimal tariff.

Welfare is defined as the area under the excess demand function between the importing country’s autarky price (demand parameter \( a \)) and the equilibrium world price. This welfare measure equals the sum of consumer surplus, domestic producer surplus and government revenue. In the specific tariff case, the importing country’s problem boils down to:

\[
\max_t w_t = \int_0^{p^*_r} d q - (p^*_r q_r) .
\]

The optimal welfare-maximizing specific tariff is \( t^o = \frac{(a - c)d}{b + 2d} \).

Similarly, the optimal \textit{ad valorem} tariff is defined as: \( \tau^0 \equiv \arg \max_{\tau} \int_0^{p^*_r} d q - (p^*_r q_r) = \frac{(a - c)d}{bc + (a + c)d} \). As claimed at the outset, both optimal tariffs are equivalent welfare-wise because:

\[
\begin{align*}
W^t &= \left. \frac{(a - c - t)(ab + 2dt + b(-c + t))}{2(b + d)^2} \right|_{t=t^o} = \frac{(a - c)^2}{2(b + 2d)}, \\
W^\tau &= \left. \frac{(a - c(1 + \tau))(bc(-1 + \tau) + a(b + 2d\tau))}{2(b + d + d\tau)^2} \right|_{\tau=\tau^o} = \frac{(a - c)^2}{2(b + 2d)},
\end{align*}
\]

which is greater than the welfare under free trade.

\[\text{\textsuperscript{4}}\] Naturally, if \( t^{\max} \) is the maximum tariff under which some trade is observed, then for \( t' > t^{\max} \) we have: \( p^*_r + t' > p^d_r \). When tariffs are this high, there is “water in the tariffs” or redundant protection. Because we are interested in terms of trade effects, prohibitive tariffs are not pertinent.

\[\text{\textsuperscript{5}}\] It is easy to verify that this formula is the reciprocal of the foreign export supply elasticity. Setting \( \tau = \frac{1}{\eta'} \equiv \frac{1}{\partial q / \partial p'} \left( c + d q_r \right) = \frac{d(a - c(1 + \tau))}{bc + ad} \) and isolating \( \tau \), we obtain \( \tau^o = \frac{(a - c)d}{bc + (a + c)d} \).
\[ w_{\beta} = \frac{(a-c)^2}{2(b+2d+\frac{d^2}{b})}. \]

For benchmarking, when \( \{a=10, b=1, c=2, d=1\} \), we find that \( t^0 = 2.66, \tau^0 = 0.57 \) and since the world price since \( p^*_{ij} = 4.66 \), the \textit{ad valorem} equivalent specific tariff is equal to the \textit{ad valorem} tariff: \( \frac{t^0}{p^*_{ij}} = \tau^0 \).

The tariffs \( t^0 \) and \( \tau^0 \) are referred to by Max Corden (1984, p.82) as the orthodox optimal tariffs. These taxes are optimal (and equivalent) because they address the inability of private importing firms to harness their joint monopoly power in the absence of other distortions.\(^6\) Under these conditions, an import quota can also achieve the first-best solution for the importing country because what matters is to get to the optimal level for foreign exports. This is the so-called “terms-of-trade” argument which is at the heart of the new literature on the economics of trade agreements (e.g, Bagwell and Staiger, 2002).\(^7\)

Recent evidence (e.g., Broda and Weinstein, 2008; Bagwell and Staiger, 2011) suggests that terms-of-trade effects are empirically pertinent in trade policy analysis.\(^8\) This implies that government analysts can estimate the parameters of the import demand and foreign export supply functions and compute the tariff formulae in response to changing market conditions. For example, let us assume that the foreign autarky price, parameter \( c \gg 0 \), changes. The orthodox optimal specific tariff \( t^0 \) is decreasing in \( c \), and so is the \textit{ad valorem} orthodox optimal tariff \( \tau^0 \). Intuitively, the government chooses a lower tariff when the foreign autarky price is higher because more favorable terms of trade cannot provide much gain if the level of trade is very low. Accordingly, the tariffs must be reduced to insure that enough imports get in when

\(^6\) In the presence of a few domestic firms, Larue and Gervais (2002) show that the welfare-maximizing tariff is not optimal because it must address the terms-of-trade externality and the inefficient pricing in the domestic market.

\(^7\) When all government are allowed to be policy-active, it is well known that « big » countries can win a tariff war (Kennan and Reisman, 1988; Syropoulos, 2002), but it is more likely that countries end up worse off than under free trade (Johnson, 1951; Felbermayr et al., 2012). Thus, the purpose of trade agreements is to prevent governments from falling into a terms-of-trade-driven prisoner’s dilemma.

\(^8\) Looking at tariff lines of various countries, there are always a few tariff peaks that are obviously not consistent with the internalization of terms of trade externalities. However, these make up a small percentage of all tariff lines for agricultural products. Zero tariffs are “optimal” when the importing country’s import volume is too small to impact on world prices. As a result, they are consistent with the theory if the importing country is “small”.

the foreign autarky price is higher. The impetus to cut the tariff in response to an upward shift in the foreign export supply is stronger under an ad valorem tariff than under a specific tariff as indicated below:

\[
\frac{-\partial t^o / \partial c}{t^o} = \frac{1}{a-c} < -\frac{\partial r^o / \partial c}{r^o} = \left( \frac{1}{a-c} \right) \left( \frac{ab + 2ad}{bc + ad + cd} \right)
\]

since \( a > c > 0 \). The percentage reduction in tariff is larger for the ad valorem tariff than for the specific kind. From our numerical example, it is easy to verify that \( t^o \) decreases by 11.3% and 12.4% when \( c \) increases from 1 to 2 and from 2 to 3 while \( r^o \) decreases by 17.6% and 18.3%. This is so because the spread between the world price and the domestic price is increasing in the world price (constant) when an ad valorem (specific) tariff is used. These results provide intuition for the results we will derive under volatility.

A welfare-maximizing importing country may not be able to implement state-contingent tariffs when there is much volatility in the export supply function. It may be constrained by its ability to access and or process new information or it may be constrained through international commitments in its ability to respond to shocks. Even if a country could implement state-contingent policies, it may refrain from making frequent changes so not annoy its trade partners.\(^9\) Thus, we ask: what about the equivalence if tariffs are only downward flexible from a relatively low bound level or not flexible at all? If specific and ad valorem tariffs are non-equivalent, what are the implications for welfare, the volume of trade and world prices? These issues are especially important in the wake of the high and volatile agricultural commodity prices observed since 2006.\(^10\) The FAO (2009) estimated that the 2008 spike in food prices added 115 million persons to the pool of people afflicted by chronic hunger.

We introduce volatility in our benchmark model by randomizing the autarky price in the foreign country/rest of the world, parameter \( c \) in the foreign export supply equation.\(^11\) Variations in this parameter may reflect foreign technology shocks (like weather shocks

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\(^9\) The WTO’s trade policy review for Argentina (p.ix) makes this point: « The use of trade policy to achieve short-term objectives requires constant policy adjustments that add to the complexity of the trade regime, making it less predictable. » However, Rose’s (2013) analysis shows that most countries generally favor stable tariff and non-tariff barriers even during economic downturns.

\(^10\) Agricultural commodity prices have been more volatile during the last ten years than in the decade before that, but Jacks, O’Rourke and Williamson (2011) have shown using data going back to the 1700s that commodity prices have always been volatile.

\(^11\) We will also refer to the foreign autarky price as the intercept of the foreign export supply function. In our setting, the importing country determines the world price through its tariff. This is why the volatility is not directly about the world price, but about the foreign export supply function.
impacting crop yields) or foreign demand shocks or unforeseen policy changes in the rest of the world. Let us assume that parameter $c$ in the foreign export supply function is distributed according to a triangular distribution with mean $c_{\text{moy}}$, mode $c_m$ and lower and upper bounds $c_l$ and $c_u$. The density of the triangular distribution is given by:

$$
\phi(x) = \begin{cases}
0 & \text{for } x < c_l, \\
\frac{2(x - c_l)}{(c_u - c_l)(c_m - c_l)} & \text{for } c_l \leq x \leq c_m, \\
\frac{2(c_u - x)}{(c_u - c_l)(c_u - c_m)} & \text{for } c_m < x \leq c_u, \\
0 & \text{for } c_u < x.
\end{cases}
$$

The triangular distribution has the advantage of being bounded and can easily be parameterized to be symmetric or skewed. Because its mean is $c_{\text{moy}} = \frac{c_l + c_m + c_u}{3}$, we can introduce mean-preserving spreads by simply making offsetting changes in the lower and upper bounds: $c_l' = c_l - \varepsilon, c_u' = c_u + \varepsilon$, where $0 < \varepsilon < c_l$, without changing the mode $c_m$. Generally, triangular distributions with $c_l = c_{\text{moy}} - \lambda_l, c_m = c_{\text{moy}} - \lambda_m, c_u = c_{\text{moy}} + \lambda_l + \lambda_m$ have the same mean and we can implement mean-preserving spreads and mean-preserving skews by adjusting the lambdas. The $\lambda_m$ parameter positions the mode relative to the mean. A symmetric distribution is obtained by setting $\lambda_m = 0 < \lambda_l$. The most positively skewed distribution is obtained when the lower bound and the mode coincides, and this occurs when $\lambda_l = \lambda_m$. By the same token, the most negatively skewed distribution occurs when $\lambda_l = -2\lambda_m > 0 > \lambda_m$. So when $\lambda_l > \lambda_m > 0$, the distribution is positively skewed and when $\lambda_l > 0 > \lambda_m$ the distribution is negatively skewed. A mean-preserving spread can then be obtained by increasing $\lambda_l$.

We assume that the importing country is risk neutral and that it cannot make any adjustment after it has set its tariff. The government maximizes:

$$
E[w_k] = \int_{c_l}^{c_m} w_k \phi(x) \, dx + \int_{c_m}^{c_u} w_k \phi(x) \, dx, \text{ where } k = \{t, \tau\}.
$$

**PROPOSITION 1:** 1) The non-flexible specific tariff that maximizes expected welfare is given by:
\[ t_{nf} = -\frac{(c_a^3 + c_i^3 - 3c_u c_m^2 - 3c_u c_m^2 + 4c_m^3 - 3a(c_u^2 + c_i^2 - 2c_u c_m - 2c_i c_m + 2c_m^2))d}{3(c_u^2 + c_i^2 - 2c_u c_m - 2c_i c_m + 2c_m^2)(b + 2d)} \]  

(3)

It is increasing, invariant or decreasing with respect to mean-preserving spreads depending on the distribution of the foreign autarky price being negatively skewed, symmetric or positively skewed.

2) The non-flexible ad valorem tariff that maximizes welfare is:

\[ \tau_{nf} = \frac{d \left( 2AB(b - d) + 6a^2Cd - bA \right)}{b^2A + b(A + 4AB)d + 2a(B + 3aC)d^2}, \]

where \( A \equiv \left( c_u^4 + c_i^4 - 4c_u c_m^3 - 4c_i c_m^3 + 6c_m^4 \right), \quad B \equiv \left( c_u^3 + c_i^3 - 3c_u c_m^2 - 3c_i c_m^2 + 4c_m^3 \right) \) and \( C \equiv \left( c_u^2 + c_i^2 - 2c_u c_m - 2c_i c_m + 2c_m^2 \right). \) It is declining with mean-preserving spreads.

**PROOF:** 1) The tariffs are the solutions to the maximization of expected welfare. Replacing \( c_i, c_u, c_m, c_{moy} - \hat{\lambda}_i \) and \( c_{moy} - \hat{\lambda}_m \) in eq. (3), leaving the mode unchanged, it is easy to show that the specific tariff is increasing, invariant or decreasing with respect to the mean-preserving spread:

\[ \frac{\partial t_{nf}}{\partial \hat{\lambda}_i} = \frac{-9d \lambda_m^3 \left( 2\lambda_i + \lambda_m \right)}{(b + 2d) \left( 2\lambda_i^2 + 2\lambda_i \lambda_m + 5\lambda_m^2 \right)^2} < 0 \]

(5)

depending on \( \lambda_m \leq 0 \). When the triangular distribution is symmetric (\( \lambda_m = 0 \)), the optimal non-flexible specific tariff reduces to: \( t_{nf} = \frac{(a - c_m)d}{b + 2d} \) and it is clearly unaffected by mean-preserving spreads.

2) The optimal non-flexible ad valorem tariff is defined by a very complex expression. However, when the lower bound and the mode of the distribution of the foreign autarky price are the same, the effect of a mean-preserving spread reduces to:

\[ \frac{\partial \tau}{\partial \lambda_i} \Bigg|_{\lambda_m = \lambda_i} = \frac{4ab(b + 2d)(ad + bc_{moy})\lambda_i}{\left( 2a^2d^2 + 2ad(2b + d)c_{moy} + 2b(b + d)c_{moy}^2 + b(b + d)\lambda_i^2 \right)^2} < 0 \]

(6)

This is so because the importing country wants to make sure that there will be enough trade when very high foreign autarky prices are drawn. Under the assumption of a symmetrically distributed foreign autarky price, the optimal ad valorem tariff is given by:
The derivative of this expression with respect to the mean-preserving spread parameter $\lambda_i$ is also negative:

$$\frac{\partial \tau^{nf}_{i}}{\partial \lambda_i} = -\frac{12ab(b+2d)(ad+bc_{moy})\lambda_i}{\left(6a^2d^2+6ad(2b+d)c_{moy}+6b(b+d)c_{moy}^2+b(b+d)\lambda_i^2\right)^2} < 0. \quad (7)$$

A mean-preserving spread induces a reduction in the \textit{ad valorem} tariff when the foreign autarky price is most positively-skewed and when it is symmetrically distributed. We can infer that a mean-preserving spread will cause a tariff reduction for any positively-skewed distribution. By continuity, a case involving a very slightly negatively skewed distribution will be qualitatively similar to the symmetric case: a mean-preserving spread will induce a tariff reduction. When the distribution is most negatively skewed and the mode and the upper bound coincide, we have:

$$\frac{\partial \tau^{nf}_{i}}{\partial \lambda_i} = \lambda_i \left(\frac{2a^2d + a(2b-2d)c_{moy} - 2bc_{moy}^2 - 0.5b\lambda_i^2}{(a^2d^2 + ad(2b+d)c_{moy} + b(b+d)c_{moy}^2)\lambda_i^2 + b(0.125b + 0.125d)\lambda_i^4} \right)$$

$$= 2\lambda_i \left(\frac{G + 3.375b(b+d)\lambda_i^2}{(G\lambda_i^2 + b(1.6875b+1.6875d)\lambda_i^4)\lambda_i^2} \right)$$

$$G \equiv 13.5 \left(a^2d^2 + ad(2b+d)c_{moy} + b(b+d)c_{moy}^2\right)$$

It can be shown that $\lim_{\lambda_i \to 0} \frac{\partial \tau^{nf}_{i}}{\partial \lambda_i} \leq 0, \forall \lambda_i \geq 0$, with the equality holding when $x \to 0$. \textbf{QED}

The above proposition contends that the adjustment of specific tariffs by countries concerned about their terms of trade to mean-preserving spreads or increased volatility depends on the skewness of foreign autarky prices. When foreign autarky prices are negatively skewed, the possibility of very low prices, compared to the mode, a higher specific tariff is called for. With \textit{ad valorem} tariffs, a reduction is warranted when world markets become more volatile. This runs counter to the popular notion that world market volatility triggers protectionism in agriculture (e.g., Larue and Ker, 1993). With a fixed specific (an \textit{ad valorem})

\[12\] The FAO food price index (2013) has displayed much volatility since 2007. Many exporting countries levied export taxes in 2008 while several importing countries lowered their import tariffs (Tangerman, 2011). The extent by which countries were reacting to the level or the volatility of world prices has not been ascertained.
tariff, the margin between the domestic price and the world price is constant (increases) when the foreign export supply function shifts upward instead of decreasing as it would when tariffs are fully flexible. As a result, the ad valorem tariff can be likened to a “high maintenance” instrument in the sense that more can be gained from state-contingent adjustments than with the specific tariff. Figure 1 illustrates the argument. The vertical axis depicts the level of welfare while the horizontal axis is the foreign autarky price. The fixed/non-flexible tariffs in Figure 1 are set to be equivalent at a given foreign autarky price $\overline{c}$. When the foreign autarky price decreases from $\overline{c}$, welfare increases most under flexible/adjustable tariffs and less under non-flexible tariffs. In fact, welfare increases least under the fixed/non-flexible ad valorem tariff. Similarly, when the foreign autarky price increases from $\overline{c}$, welfare decreases, but more so under the non-flexible ad valorem tariff than under a specific one. This insight is useful for the ranking of optimal specific and ad valorem tariffs under volatility.

**PROPOSITION 2:** When the foreign autarky price is distributed according to a symmetric triangular distribution, the best non-flexible specific tariff dominates its ad valorem counterpart in terms of expected welfare unless the difference between autarky prices and the slope of the foreign export supply function are sufficiently small.

**PROOF:** Inserting the specific and ad valorem tariffs that maximize expected welfare in the expected welfare functions under the assumption that the foreign autarky price follows a symmetric triangular distribution, we get the following expected welfare expression when imports are subject to the best specific tariff:

$$E\left[W^s\right] = \frac{1}{12} \left( \frac{6(a-c_{moy})^2}{b+2d} + \frac{b\lambda_t^2}{(b+d)^2} \right)$$

(8)

and the following for the expected welfare under the best ad valorem tariff:

$$E\left[W^a\right] = \frac{36(a-c_{moy})^2(ad+bc_{moy})^2 + 6b(a^2+b+2c_{moy}(a(-b+d)+bc_{moy}))\lambda_t^2 + b^2\lambda_t^4}{12(b+2d)\left(6(ad+bc_{moy})^2 + b^2\lambda_t^2\right)}$$

(9)

The difference between (8) and (9) is:
\[ E[W_{e}] - E[W_{e}^{*}] = \frac{bd^{2}\lambda^{2}}{12(b+d)^{2}(b+2d)(6(ad+bc_{moy})^{2}+b^{2}\lambda^{2})} \]  

Solving for the roots of (10), we find one negative, which can readily be discarded, two zeros, which reflect that both types of tariffs are equivalent in the absence of volatility, and a positive root \( \lambda_{c} = \sqrt{\frac{6(a-c_{moy})}{ab+2ad+bc_{moy}}\sqrt{b}} \) which matters only as long as it supports a positive minimum foreign autarky price: \( \lambda_{c} < c_{moy} \). The last inequality holds only for a low enough choke price, \( a \), and a foreign export supply with a low enough slope, \( d \). Thus, the specific tariff dominates the ad valorem tariff once volatility is introduced except for very special parameter values that allow very little trade. QED

To shed more light on how fixed tariffs must be set depending on the distribution of the foreign autarky price and on the dominance of one tariff over the other, we compare the performance of both types of tariffs by taking sets of 10,000 draws of parameter \( c \) from triangular distributions with the same mean \( (c_{moy} = 2) \) and we compute welfare levels by replacing \( t^{0} \) and \( \tau^{0} \) in the welfare expressions in (1) by \( t^{nf} \) and \( \tau^{nf} \). We compare the mean and the variance of the welfare series as well as the moments of the volume of trade and of the world price. The left-hand side results in Table 3 pertain to fixed tariffs. The government chooses a tariff knowing it will not be able to make a single adjustment in response to changes in the foreign autarky price \( c \). When the foreign autarky price is symmetrically distributed, volatility does not alter the best non-flexible specific tariff, but it brings about a reduction in the best ad valorem tariff as per Proposition 1. Expected welfare increases under both types of tariffs following a mean-preserving spread in the foreign autarky price, but more so under the specific tariff. The country ends up importing more on average when the foreign export supply is more volatile and this is more evident under the specific tariff. In terms of the volume of trade, the best specific tariff tends to be more restrictive. Because there is less trade under the specific tariff, the world price has a lower mean and a higher variance.

When parameter \( c \) is drawn from a negatively skewed distribution, the best non-flexible tariffs are higher because larger differences between domestic and world prices are needed to accommodate instances of very low world prices. The specific tariff is a better instrument in
terms of expected welfare. As opposed to the symmetric case, there is on average more trade under the specific tariff than under the \emph{ad valorem} tariff. When the distribution is positively skewed, tariffs are set at less restrictive levels. The best specific tariff dominates while letting on average a smaller and more stable volume of imports. The stability in imports however translates into a more volatile world price.

One of the objectives of the GATT was to make the world trading system more predictable for firms engaged in international trade. This is why tariff binding, or the commitment not to increase a tariff above a certain bound, is one of the GATT’s core principles (Article II). One implication is that exporting firms know that the worst import tax their product will face is the bound rate. Differences between bound and applied tariffs can be small or quite substantial. For the United States, average bound and average applied tariffs are the same, but for Norway the simple average bound tariff on ag (non-ag) commodities is 132% (3.2%) while the corresponding simple average Most Favored Nation applied tariff is 55.8% (0.5%).\textsuperscript{13} By binding tariffs at a lower level, an importing country loses upward-flexibility.\textsuperscript{14} In our simulations, we bind the specific and \emph{ad valorem} tariffs at their optimal values in the absence of volatility. We had shown that they were fully equivalent at that point and this makes for a logical point from which we can allow downward adjustments. Thus, countries are allowed to make reductions when the foreign autarky price is higher than expected.

Results on the right-hand side of Table 3 allow for downward tariff adjustments from a bound level. When tariffs are allowed to be downward-flexible, higher levels of welfare become feasible. The specific tariff remains dominant welfare-wise, but its advantage over the \emph{ad valorem} tariff is naturally smaller. Because tariffs can be reduced when world prices are high, this has a mitigating effect and welfare does not decrease as fast as when tariffs are fixed and the world price increases. As a result, the variances of welfare and other variables are lower than when tariffs are fixed. The volume of trade is on average lower under the best specific tariffs.

\textsuperscript{13} See \url{http://stat.wto.org/TariffProfiles/NO_E.htm}.
\textsuperscript{14} The enhanced stability should make it easier for domestic importers and foreign exporters to develop long term relationships in a world in which there are firm-specific fixed exports costs. We do not take such benefits into account nor do we model the concessions that must be made by countries to secure lower bound tariffs from their trade partners. The first-best solution in our setting is to implement state-contingent tariffs by choosing very high bound tariffs. Norway follows this strategy with its very high bound tariffs on agricultural imports. New applied tariffs are adopted by Parliament every year when the state budget is presented, but the Norwegian Agricultural Authority has the power to grant reductions during the year. It granted over 3000 tariff reductions in 2011 (WTO, 2012 p.29-30).
Proposition 2 is derived under the assumptions that all agents are risk-neutral and that the government maximises expected welfare. The introduction of loss aversion by domestic producers (e.g., Freund and Ozden, 2008; Tovar, 2009) would reinforce the dominance of the specific tariff. In this context, producers would experience substantial losses when the foreign autarky price falls. By keeping the margin between domestic and world prices constant, the specific tariff would offer better protection against downside risk associated with the foreign autarky price.

4. Tariff Conversion and Non-Equivalent Ad Valorem Equivalents

We now analyze the potential impact of transforming specific tariffs into ad valorem equivalents for arbitrary specific tariff levels. The implications of such transformations are pertinent for policymakers, trade negotiators and modellers. Gravity models are typically estimated on low-frequency data (i.e., annual data) and an average world price must be used to transform a specific tariff into an ad valorem equivalent. The world price is endogenous as it depends on the type and setting of the tariff. Under the assumption the foreign autarky price follows a triangular distribution, the average world price under a specific tariff is:

\[
\bar{p}_t = \int_{c_t}^{c_u} \left( x + dq_t \right) \frac{2(x - c_t)}{(c_u - c_t)(c_m - c_t)} dx + \int_{c_t}^{c_u} \left( x + dq_t \right) \frac{2(c_u - x)}{(c_u - c_t)(c_m - c_t)} dx - b\left(c_u^3 + c_t^3 - 3c_u c_t^2 - 3c_t c_m^2 + 4c_m^3\right) + 3\left(c_u^2 + c_t^2 - 2c_u c_m - 2c_t c_m + 2c_m^2\right) d\left(a - t\right)
\]

(10)

From (10), we can compute ad valorem equivalents for different specific tariffs under different distributions about the foreign autarky price: 

\[
\tau^{eq} = \frac{t}{\bar{p}_t}.
\]

PROPOSITION 3: The ad valorem equivalent of a given specific tariff \( t \) is decreasing in the degree of positive skewness of the distribution of the foreign autarky price, holding the mean of the distribution constant.

PROOF: Replacing \( c_u \) by \( c_{moy} + \lambda_t m \), \( c_m \) by \( c_{moy} - \lambda_m \) and \( c_t \) by \( c_{moy} - \lambda_t \) in (10) and taking the derivative with respect to \( \lambda_m \), we find that:

\[
\frac{\partial \bar{p}_t}{\partial \lambda_m} = \frac{3d(a - t) \lambda_t F + b(3c_{moy} \lambda_t F + 2(\lambda_t - \lambda_m)^2(\lambda_t^2 + 4\lambda_t \lambda_m + \lambda_m^2))}{(b + d)(\lambda_t - \lambda_m)^2(2\lambda_t + \lambda_m)^2}
\]

(11)
where $F \equiv (2\lambda_i^2 + 8\lambda_i\lambda_m - \lambda_m^2), \lambda_i > 0, \lambda_m > 0$. The denominator of the above expression is positive and so is the numerator. When $\lambda_i > \lambda_m > 0$, $F > 0$ and the numerator is positive. When $\lambda_i > 0, \lambda_m < 0, F > 0$ because $\lambda_i > -2\lambda_m$ as the mode cannot exceed the upper bound of the triangular distribution. Thus, the world price is increasing when the distribution of the foreign autarky price becomes more positively skewed, even though the mean of the foreign autarky price remains unchanged. As a result, the ad valorem equivalent to a given specific tariff $t$ will be lower. QED

Figure 2 illustrates ad valorem equivalents for the four distributions we used in previous simulations. The line with the lowest (highest) slope represents ad valorem equivalents when the autarky price in the foreign country follows a positively (negatively) skewed distribution. The superimposed lines are associated with symmetric distributions. They reflect the invariance of the optimal non-flexible specific tariff to mean-preserving spreads. Figure 2 shows that ad valorem equivalents are higher (lower) when the distribution of the foreign autarky price is negatively (positively) skewed. In all cases, the mean of the intercept of the foreign export supply function is the same and the slope parameter is always constant. The wide range of the expected world price is due entirely to the skewness of the distribution of shocks on the intercept of the foreign export supply function. This means that temporary export bans in a small subset of exporting countries can cause a substantial increase in the annual world price of a given commodity. There were indeed a few exporting countries that implemented short-lived export bans in 2008 that were accused of exacerbating the price spike in agricultural commodity prices (e.g., Martin and Anderson, 2011). We can now compare ad valorem equivalents to specific tariffs and discuss the implications of tariff simplification.

The expected volume of trade under the specific tariff is

$$E[q_i] = \int_{c_i}^{c_{i_m}} q_i \phi(x) dx + \int_{c_{i_m}}^{c_{i}} q_i \phi(x) dx$$

where $q_i = \frac{a-c-t}{b+d}$. With the mean-preserving skews and spread parameters which express the mode and bounds in terms of the mean, we obtain:

$$E[q_i] = \frac{\lambda_i^2 (2a-2t-2c_{moy} - \lambda_m) + \lambda_i \lambda_m (2a-2t-2c_{moy} - \lambda_m) + \lambda_m^2 (5a-5t-5c_{moy} + 2\lambda_m)}{(b+d)(\lambda_i - \lambda_m)(2\lambda_i + \lambda_m)}$$

(12)
This expression is obviously decreasing in the specific tariff \( t \). It is increasing and convex in \( \lambda_m \).

The more positively skewed the distribution of foreign autarky prices, the higher the expected volume of trade. If the specific tariff is transformed into an ad valorem equivalent by taking the average world price given by (10), the expected volume of trade under the ad valorem equivalent is:

\[
E \left[ \frac{q_t}{p_t} \right] = c \int b + d \left( 1 + \frac{t}{p_t} \right) \phi(x) dx + \int c \left( 1 + \frac{t}{p_t} \right) \phi(x) dx.
\]

Using the mean-preserving skewness and spread coefficients, we obtain:

\[
E \left[ \frac{q_t}{p_t} \right] = -5a - t + 5c_{moy} + 3\lambda_t + \frac{3(a - c_{moy})\lambda_t}{\lambda_t - \lambda_m} - 2\lambda_m + \frac{6(a - c_{moy} - \lambda_t)\lambda_m}{2\lambda_t + 2\lambda_m} \quad (13)
\]

where \( J = 2ad + 2bc_{moy} + b\lambda_m \). The above expression is decreasing in the specific tariff and increasing and convex in \( \lambda_m \).

**PROPOSITION 4:** The expected volume of trade after an ad valorem transformation can increase or decrease depending on the skeweness of the distribution of the foreign autarky price.

**PROOF:** We know that the expected volume of trade will be the same before and after the ad valorem transformation when \( t=0 \). Under the specific tariff, the expected volume decreases linearly with \( t \):

\[
\frac{\partial E[q_t]}{\partial t} = -\frac{2\lambda_t^2 + 2\lambda_t\lambda_m + 5\lambda_m^2}{(b + d)(\lambda_t - \lambda_m)(2\lambda_t + 2\lambda_m)} \quad (14)
\]

The expected volume of trade after the ad valorem transformation is also decreasing in \( t \):

\[
\frac{\partial E \left[ \frac{q_t}{p_t} \right]}{\partial t} = -\frac{(M\lambda_t^2 + M\lambda_t\lambda_m + \lambda_m^2(5ad + 5bc_{moy} - 2b\lambda_m))^2}{(b + d)(M\lambda_t^2 + (M - 3dt)\lambda_t\lambda_m + \lambda_m^2(5ad - 6dt + 5bc_{moy} - 2b\lambda_m))^2} \quad (15)
\]
where $M \equiv 2ad + 2bc_{\text{moy}} + b\lambda_m$.

The slopes $\frac{\partial E[q_i]}{\partial t} \bigg|_{\lambda_m \to 0.5\lambda} = \frac{\partial E \left[ q_i \frac{t}{\bar{p}} \right]}{\partial t} \bigg|_{\lambda_m \to 0.5\lambda}$ and $\frac{\partial E[q_i]}{\partial t} \bigg|_{\lambda_m \to 0} = \frac{\partial E \left[ q_i \frac{t}{\bar{p}} \right]}{\partial t} \bigg|_{\lambda_m \to 0}$ are equivalent at two of the limits but they differ when $\lambda_m \in \left( \frac{\lambda_i - \lambda_0}{2}, 0 \right)$, where we have

$$-\frac{\partial E[q_i]}{\partial t} > -\frac{\partial E \left[ q_i \frac{t}{\bar{p}} \right]}{\partial t} \Leftrightarrow E[q_i] > \partial E \left[ q_i \frac{t}{\bar{p}} \right]$$

for any given tariff. Therefore when the distribution of the foreign autarky price is negatively skewed, $\lambda_m \in (0, \lambda_i)$, the volume of trade falls after the ad valorem transformation. When the distribution is positively skewed, it can be shown that

$$\frac{\partial E[q_i]}{\partial t} \bigg|_{\lambda_m \to \lambda_i} \approx -\infty < \frac{\partial E \left[ q_i \frac{t}{\bar{p}} \right]}{\partial t} \bigg|_{\lambda_m \to \lambda_i} \approx \frac{-1}{b + d} G,$$

where $G \geq 1; G \bigg|_{t=1} = 1; \partial G / \partial t > 0$.

Thus, the transformation of specific tariffs in ad valorem equivalents would increase global trade when the distribution of the foreign autarky price is positively skewed. QED

The results reported in Table 4 are for three arbitrary fixed specific tariffs $t = 1, 2, 3$. To get an idea of their relative magnitude, the optimal specific tariffs reported in Table 2 vary between 2.5 and 2.73. The ad valorem equivalent to $t = 3$ has a very wide range (i.e., 32%-82%) due to the effect of mean-preserving skews in the distribution of the foreign autarky price on the world price. This means that the timing of the conversion can have a strong incidence on the outcome. This is why it is proposed in WTO working documents that tariff conversions be based on three years of data. The specific tariff welfare-dominate the ad valorem equivalent, particularly so under mean-preserving positive skews. Expected welfare under the specific tariff (ad valorem equivalent) is highest (lowest) when the distribution of foreign autarky prices is

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positively skewed. This is when a country would lose the most from tariff simplification. These
simulations are similar to our theoretical results because the arbitrary specific tariff is set at a
level close to its optimum. At \( t = \{1, 2\} \), the transformation of the specific tariff induces an
increase (decrease) in expected welfare when the distribution of the foreign autarky price is
negatively skewed (symmetric or positively skewed). When shocks are symmetric, the welfare
loss is small (large) at low (high) specific tariffs, but the advantages of the specific tariff under
positive skewness and of the ad valorem tariff under negative skewness are larger at \( t = 1 \) than
at higher tariffs. Thus, countries are likely to prefer to keep their high specific tariffs than to
transform them in ad valorem equivalents. As a result, we would expect low specific tariffs to
be more likely to be converted. There is some anecdotal evidence that this is the case. The
United States was recently reminded following its WTO trade policy review that many of its non‐
ad valorem are also tariff peaks, but it showed no interest in reducing and simplifying them
(WTO, 2013b p.317 and 366). Argentina is among few countries that has a lower average tariff
on agricultural products than on other goods. Its specific tariffs, which accounted for 8% of its
tariff lines in 2006, were not very restrictive. They were all converted in 2010 (WTO, 2013). To
investigate the matter more thoroughly, we regressed the ad valorem equivalent tariff on its
lagged level, a dummy variable that equals one when the tariff is actually a non-ad valorem
tariff, a dummy variable that equals one when the importing and exporting countries are
involved in a trade agreement, a dummy variable that equals one when the importing country
has cases of Bovine Spongiform Encephalopathy (BSE), the importing country’s population and
the importing country’s per capita GDP, using panel data for 42 trading countries and 11 years,
1995-2005. The results in Table 5 shows that current tariff rates are strongly conditioned by the
one-year lagged rate, trade agreements, importer’s population and the presence of BSE cases in
the importing country. All of the coefficients have the expected signs and all are significant
except for the importer’s per capita GDP. As for whether countries using of non-ad valorem
tariffs have lower or higher ad valorem tariff equivalents, the estimated coefficient suggests that
countries relying on non-ad valorem tariffs tend to be more protectionist when it comes to beef
trade. The implied interpretation of the coefficient and its variance is that

\[ 1 + \tau^{aw} = 1.94 \left(1 + \tau^{a}\right), \]

where \( \tau^{aw} \) is the ad valorem equivalent of non-ad valorem tariffs and

\[ \exp \left(\beta_i - 0.5 \text{ var} (\beta_i)\right) - 1. \]

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\[ ^{16}\text{ The elasticity interpretation of a dummy variable in a model with a log dependent variable is: } \exp \left(\beta_i - 0.5 \text{ var} (\beta_i)\right) - 1. \]
\( \tau^* \) represents ad valorem tariffs. Thus, if \( \tau^* \) is set at its mean level in our sample (22.66%), this means that \( \tau_n^* = 138\% \) which is close to its mean level of 106% in our sample.

Table 3 showed that the volume of trade is consistently lower under the optimal specific tariff than under optimal ad valorem tariff counterpart whether tariffs are not flexible at all or downward-flexible. In contrasts, Table 4 shows that the volume of trade under arbitrary specific tariff can be higher or lower than under the ad valorem equivalents depending on whether the distribution of foreign shocks is negatively or positively skewed. When shocks are positively skewed, trade can be substantially higher after tariff simplification. Accordingly, the econometric estimation of the volume of trade can be biased when a correction is not made for the presence of specific tariffs when the distribution of shocks on market conditions in the rest of the world is skewed. This correction entails adding a dummy variable for specific tariff to capture any other impact beyond the one already accounted for through their ad valorem rate. In light of these simulation results, we estimate a gravity model with and without correction to investigate the implications of the tariff specific correction on parameter estimates/elasticities and to ascertain whether specific tariffs have a negative or positive effect on trade once their ad valorem correspondence is taken into account.

5. A Gravity Application: Non-equivalent Ad valorem Equivalents and Trade Flows

In order to measure the incidence of the conversion of specific tariff into ad valorem equivalents, we rely on a gravity model for a disaggregated agricultural product. Gravity models are typically estimated on annual data. As demonstrated with the above simulations, the changing market conditions occurring within a year make specific and ad valorem tariffs non-equivalent. However, the non-equivalence in terms of the volume of trade depends on the asymmetry in the distribution of foreign shocks. Thus, the issue must be resolved empirically. We chose beef for our experiment because it is a commodity with a volatile price with imports limited by ad valorem and non-ad valorem tariffs.

The dataset has a panel structure featuring 40 countries and 11 years (1995-2005). The volume traded between country pairs comes from the COMTRADE database, while tariff data comes from UNCTAD’s TRAINS database. Chilled and frozen beef products as defined by the HS system were merged to create one aggregate. Tariffs are trade-weighted averages and we use \( \ln (1 + \tau) \) as the ad valorem tariff variable. Specific tariffs were transformed into ad valorem
equivalents using unit values. A dummy variable was added to capture additional effects associated with non-ad valorem tariffs. An interaction variable involving the non-ad valorem dummy and the ad valorem tariff was used to account for the fact that the significance of the non-equivalence depends on the level of the tariffs, as shown in the simulations in Table 4. A dummy variable was used to account for non-tariff barrier reductions associated with regional trade agreements. GDP, per capita GDP and population are collected from the International Monetary Fund (IMF) World Economic Outlook database. These variables are meant to capture market size effects. We ended up using the GDPs for the importing and exporting countries in our specification. Bilateral distances are collected from the Centre d’Études Prospectives et d’Informations Internationales (CEPII). We use the bilateral distance measure proposed by Head and Mayer (2002) that accounts for dispersion in economic activities within each country. Diseases are major trade impediments, often resulting in import bans. This is why we use dummy variables to designate exporting and importing countries with cases of Bovine Spongiform Encephalopathy (BSE). Exporting countries with BSE cases are expected to export less. For importing countries, the sign of the coefficient is ambiguous because the substitution effect of imported beef for domestic beef may be offset by a substitution effect favoring other meat and protein sources at the expense of beef products.

We rely on the popular PPML estimator to address the problems of the zeros and the heteroskedasticity in our trade data. We use importing country, exporting country and year fixed effect dummies to account for the panel structure of our data. The choice of ad valorem versus non-ad valorem tariffs is assumed exogenous, given that we are focussing on a single commodity over a short period of time. As argued previously, most countries do not change their tariffs very often. However, because a few do, we must determine whether $\ln (1 + \tau)$ is exogenous or endogenous. We relied on the two-step procedure suggested by Cameron and Trivedi (2010, p.607-609) to test the null of exogeneity. We used the residuals of the tariff equation in Table 5 and inserted it as an additional regressor in the Poisson trade equation. The latter uses the level of trade as dependent variable and the estimated coefficients are reported in Table 6, except the ones about fixed effects. The exogeneity of the tariff rate, or more

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17 When GDP was decomposed into per capita GDP and population, only per capita GDP in the importing country turned out significant. We also tried to proxy market size effects with beef production (from FAOstat) in the current year or lagged one period instead of or with GDPs, but they were not significant.

18 The two-step procedure developed by Helpman, Melitz and Rubinstein (2008) has the advantage of dealing with the standard selection bias as well as with the bias stemming from the heterogeneity of firms. Because the heterogeneity bias is more severe that the selection bias in their empirical analysis, their model can be seen as a major improvement over tobit and hurdle estimators. However, one drawback is that the second step or trade volume equation assumes homoscedastic errors.
precisely $\ln(1+\tau)$, could not be rejected, given the low t-statistic for the \textit{tariff\_residual} coefficient. This outcome is consistent with the fact that using $\ln(1+\tau)$ or its prediction from the tariff model does not change the estimated vector of coefficients of the trade model very much.

Overall, the coefficients have signs that are consistent with our priors and are generally statistically significant. For example, the distance elasticity is negative and significant. Importer’s GDP has a positive and significant effect on trade, unlike the exporter’s GDP which is not statistically different from zero. BSE has been a major problem for exporting countries, even when the number of reported cases was very low. The elasticity effect of BSE for exporting countries is -22.5%.

Furthermore, all else equal, importing countries with BSE cases import less, even though the coefficient is significant at 7% when the alternative hypothesis is one-sided. The participation in free trade agreements has no effect once tariff reductions are controlled for.

We can infer that the ad valorem rate has a significant and negative effect on beef trade even though its coefficient must be adjusted to have an elasticity interpretation. This is so because the variable is defined as $\ln(1+\tau)$ and the regression coefficient $\beta_{\ln(1+\tau)}$ measures

$$\frac{\Delta \text{Trade} / \text{Trade}}{\Delta \tau / (1+\tau)}.$$  

The elasticity is obtained by multiplying $\beta_{\ln(1+\tau)}$ by the ratio $\frac{\tau}{1+\tau}$. This correction is important because beef tariffs range from 0 to 369%. The average in our sample being 50%, the ad valorem tariff elasticity is -0.07. A 10% increase in the tariff rate, from 50% to 55%, would reduce trade by 0.7%. The effect of non-ad valorem tariffs can be measured as  

$$\exp(\beta_{na} + \beta_{na}*\ln(1+\tau))-1.$$  

If we use the average of $\ln(1+\tau)$ for our sample, we obtain an elasticity of -0.69. If instead, we use the average $\ln(1+\tau)$ when a specific tariff is converted, the elasticity is -0.99. The impact of specific tariffs that arise from volatility, above and beyond the impact of their ad valorem equivalent rate, is to reduce trade less than one percent.

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19 The formula is $100^*[\exp(\beta_{\text{BSE\_EXP}}-0.5\text{var}(\beta_{\text{BSE\_EXP}}))]-1$, where beta is the estimated coefficient, var stands for variance and exp stands for the exponential function. There has been some controversy about the computation of this elasticity and of its variance. See van Garderen and Shah (2002) for a thorough discussion. In our case, the variance of the coefficient is very small and its exclusion does not change the estimated elasticity.
6. Conclusion

The WTO is committed to have its members simplify their tariff schedule. Specific, mixed, compound and technical tariffs are relatively more common in agriculture than in other sectors. More specifically, WTO working document no.12 on tariff simplification proposes that “at least [90] per cent of ] All bound tariffs on agricultural products in a Member’s Schedule shall be expressed as simple *ad valorem* tariffs”. The transparency argument has long been used to motivate the conversion of import quotas and non-ad valorem tariffs in ad valorem equivalents. Bhagwati (1988) best depicts it through an analogy about the effect of light on Dracula: if exposed to public scrutiny, protectionism will decline. Prof. Bhagwati’s reasoning is based on two crucial, but false assumptions. The first is that people do not know the extent by which trade is distorted. This might have been true in the 1980s, but ad valorem equivalents can be freely and easily obtained by trade negotiators, academics, industry analysts, reporters and anybody with an internet connection. With the multiplicity of regional trade agreements, sectors most vulnerable to import competition are the object of reports on television and in newspapers. Those sectors seeking import protection do not hide, rather openly court public opinion and agricultural lobbies have been very good at it. This brings us to the second assumption which wrongly posits that most people, including politicians, understand the benefits of exploiting comparative advantage (Baron and Kemp, 2004). The tariffication of import quotas in agriculture has not prevented countries from shielding their “sensitive products” from import competition. There has been no sense of urgency to cut tariff peaks, quite the contrary, even if this delays the conclusion of the Doha Round and regional trade agreements.

We argue that the reason why specific tariffs are relatively more common in agriculture than in other sectors is because agricultural markets are more volatile and specific tariffs are better than ad valorem tariffs under these conditions. Our theoretical framework supports the orthodox optimal tariff argument as a special case. Absent volatility in the foreign autarky price, an importing country is indifferent between an ad valorem tariff and a specific tariff to exploit its terms of trade. Volatility in foreign markets, namely in the foreign autarky price, is introduced through a triangular distribution which makes it simple to changes in the variance or in the skewness without altering the mean of the distribution. The disadvantage of the ad valorem

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20 Similarly, concerns about food security would suggest that it is best to open up to as many supply sources as possible. Yet, for many people food security is seen as a valid argument to justify restrictive import tariffs.
tariff results from the fact that the domestic-world price differential automatically falls when the foreign autarky price decreases instead of increasing to fully exploit terms of trade. Interestingly, the optimal ad valorem tariff decreases when the random foreign autarky price undergoes a mean-preserving spread. This result challenges the notion that protectionism grows in response to more volatility (Larue and Ker, 1993). Skewness also affects the welfare differential between the optimal specific tariff and its ad valorem counterpart as well as the endogenous world price and volume of trade. This has important implications on the incentive to embark on tariff simplification and on the consequences of such endeavor.

Our theoretical results suggest that countries will low specific tariffs are more likely to convert them in ad valorem tariffs. The empirical implication is that the average ad valorem equivalent of specific tariffs should exceed the average ad valorem tariff. We use a regression to control for other determinants to show that this is actually the case for beef tariffs. Our theoretical results also suggest that specific tariffs can exert a positive or a negative effect on trade volumes, above and beyond their effect through the ad valorem equivalent tariff rate, depending on the skewness of the distribution of the foreign autarky price. We tested this effect through a gravity model and found a small negative effect on beef trade.

Our results have obvious policy implications. The fact that specific tariffs are better trade policy instruments than ad valorem tariffs on welfare ground ought to be taken under consideration in the debate over tariff simplification which rests on the questionable merit of the transparency argument. Surely, allowing countries to maintain high ad valorem bounds below which they can adjust applied tariffs at different levels for any given time period makes trade protection far less transparent and predictable than by allowing countries to set applied specific tariffs at bound levels.
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WT/TPR/M/275/Add.1
Figure 1. Implications of being able to adjust the optimal tariff when there are shocks on the foreign autarky price.
Table 1. Average tariffs and proportions of duty free tariff lines and lines with non-\textit{ad valorem} tariffs for selected countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Average Import Tariff</th>
<th>% Duty Free Tariff Lines</th>
<th>% Non Ad Valorem Tariff Lines</th>
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<td>All Products</td>
<td>Ag Products</td>
<td>Non-Ag Products</td>
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<td>15.6</td>
<td>8.7</td>
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<td>13.9</td>
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<td>31.4</td>
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<td>8.1</td>
<td>6.9</td>
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<td>23.3</td>
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<td>21.4</td>
<td>6.3</td>
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<td>55.8</td>
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<td>1.4</td>
<td>2.1</td>
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<td>8.7</td>
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<tr>
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<td>43.5</td>
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<td>8.0</td>
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<td>41.7</td>
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<td>United States</td>
<td>3.5</td>
<td>5.0</td>
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<td>Vietnam</td>
<td>9.8</td>
<td>17.0</td>
<td>8.7</td>
</tr>
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</table>

Source: \url{http://www.wto.org}

\textsuperscript{21} South Africa, Botswana, Lesotho, Namibia and Swaziland belong to a custom union and hence have the same external tariffs.
Table 2. Frequency of non-ad valorem tariff lines for various agricultural and food products

<table>
<thead>
<tr>
<th>HS code</th>
<th>Product</th>
<th>Total Tariff Lines</th>
<th>Non-Ad Valorem lines</th>
<th>%</th>
<th>HS code</th>
<th>Product</th>
<th>Total Tariff Lines</th>
<th>Non-Ad Valorem lines</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0102</td>
<td>Live bovine</td>
<td>125</td>
<td>53</td>
<td>42.40</td>
<td>0202</td>
<td>Meat bovine</td>
<td>135</td>
<td>80</td>
<td>59.26</td>
</tr>
<tr>
<td>0103</td>
<td>Live swine.</td>
<td>77</td>
<td>21</td>
<td>27.27</td>
<td>0203</td>
<td>Meat swine</td>
<td>252</td>
<td>143</td>
<td>56.75</td>
</tr>
<tr>
<td>0104</td>
<td>Live sheep and goats.</td>
<td>64</td>
<td>14</td>
<td>21.88</td>
<td>0204</td>
<td>Meat sheep</td>
<td>254</td>
<td>130</td>
<td>51.18</td>
</tr>
<tr>
<td>0105</td>
<td>Live poultry</td>
<td>171</td>
<td>31</td>
<td>18.13</td>
<td>0207</td>
<td>Meat poultry</td>
<td>732</td>
<td>412</td>
<td>56.28</td>
</tr>
<tr>
<td>0401</td>
<td>Milk, cream</td>
<td>133</td>
<td>43</td>
<td>32.33</td>
<td>0404</td>
<td>Whey</td>
<td>198</td>
<td>98</td>
<td>49.49</td>
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<tr>
<td>0402</td>
<td>Milk, cream</td>
<td>273</td>
<td>107</td>
<td>39.19</td>
<td>0405</td>
<td>Butter</td>
<td>732</td>
<td>412</td>
<td>56.28</td>
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<tr>
<td>0406</td>
<td>Cheese</td>
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<td>252</td>
<td>52.83</td>
<td>0407</td>
<td>Birds' eggs</td>
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<td>38.00</td>
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<td>59</td>
<td>45.38</td>
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<td>Vegetables</td>
<td>256</td>
<td>53</td>
<td>20.70</td>
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<td>65</td>
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<td>21</td>
<td>12.00</td>
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<td>74</td>
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<td>0712</td>
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<td>46</td>
<td>45.10</td>
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<td>Cucumbers</td>
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<td>46</td>
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<td>Bananas</td>
<td>32</td>
<td>7</td>
<td>21.88</td>
<td>0804</td>
<td>Dates, figs</td>
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<td>25</td>
<td>16.78</td>
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<tr>
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<td>183</td>
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<td>72</td>
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<td>6</td>
<td>9.09</td>
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<td>79</td>
<td>47.59</td>
<td>1001</td>
<td>Wheat</td>
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<td>26</td>
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<tr>
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<td>7</td>
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<td>1101</td>
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<td>13</td>
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<td>44.44</td>
<td>1102</td>
<td>Cereal flours</td>
<td>107</td>
<td>41</td>
<td>38.32</td>
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<tr>
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<td>Oats.</td>
<td>29</td>
<td>6</td>
<td>20.69</td>
<td>1103</td>
<td>Cereal groats</td>
<td>195</td>
<td>84</td>
<td>43.08</td>
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<tr>
<td>1005</td>
<td>Maize (corn)</td>
<td>73</td>
<td>14</td>
<td>19.18</td>
<td>1104</td>
<td>Cereal grains</td>
<td>287</td>
<td>112</td>
<td>39.02</td>
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<tr>
<td>1006</td>
<td>Rice</td>
<td>253</td>
<td>153</td>
<td>60.47</td>
<td>1701</td>
<td>Sugar</td>
<td>164</td>
<td>118</td>
<td>71.95</td>
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<tr>
<td>1007</td>
<td>Sorghum.</td>
<td>32</td>
<td>8</td>
<td>25.00</td>
<td>1702</td>
<td>Other sugars</td>
<td>325</td>
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<td>32.62</td>
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<tr>
<td>1008</td>
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<td>118</td>
<td>35</td>
<td>29.66</td>
<td>1704</td>
<td>Sugar conf.</td>
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<tr>
<td>1011</td>
<td>Wheat flour</td>
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<td>13</td>
<td>36.11</td>
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<td>Cocoa paste,</td>
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<td>Cocoa pwd.</td>
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<td>1806</td>
<td>Chocolate</td>
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<tr>
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<td>Pasta</td>
<td>179</td>
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Table 3. Performance of fixed and downward-flexible specific ($t$) and valorem tariff ($\tau$) under mean-preserving spreads and mean-preserving skews.

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<th>Non-flexible tariffs</th>
<th>Downward-flexible tariffs</th>
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<td>spread</td>
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<td>$c_1 = 0.5$</td>
<td>$c_1 = 0$</td>
<td>$c_1 = 0$</td>
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<tr>
<td>$c_m = 2$</td>
<td>$c_m = 2$</td>
<td>$c_m = 2.5$</td>
</tr>
<tr>
<td>$c_u = 3.5$</td>
<td>$c_u = 4$</td>
<td>$c_u = 3.5$</td>
</tr>
<tr>
<td>mean $t$ (variance)</td>
<td>2.6667</td>
<td>2.6667</td>
</tr>
<tr>
<td>mean $\tau$ (variance)</td>
<td>0.5667</td>
<td>0.5630</td>
</tr>
<tr>
<td>mean $w_t$ (variance)</td>
<td>10.7002</td>
<td>10.7422</td>
</tr>
<tr>
<td>mean $w_{\tau}$ (variance)</td>
<td>10.6727</td>
<td>10.6923</td>
</tr>
<tr>
<td>mean $q_t$ (variance)</td>
<td>2.6642</td>
<td>2.6649</td>
</tr>
<tr>
<td>mean $q_{\tau}$ (variance)</td>
<td>2.6723</td>
<td>2.6799</td>
</tr>
<tr>
<td>mean $p_t^s$ (variance)</td>
<td>4.6691</td>
<td>4.6684</td>
</tr>
<tr>
<td>mean $p_{\tau}^s$ (variance)</td>
<td>4.6773</td>
<td>4.6834</td>
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</table>
Figure 2. Ad valorem equivalents under different mean-preserving skewed and symmetric distributions. Ad valorem equivalents are higher (lower) when the distribution of foreign shocks is negatively (positively) skewed.
Table 4: Ad valorem equivalents and specific tariffs

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<th>t=2</th>
<th></th>
<th>t=1</th>
<th></th>
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<tr>
<td></td>
<td>base</td>
<td>spread</td>
<td>neg.skew</td>
<td>pos.skew</td>
<td>base</td>
<td>spread</td>
</tr>
<tr>
<td></td>
<td>(c_i = 0.5)</td>
<td>(c_i = 0)</td>
<td>(c_i = 0.5)</td>
<td>(c_i = 0)</td>
<td>(c_i = 0.5)</td>
<td>(c_i = 0)</td>
</tr>
<tr>
<td></td>
<td>(c_m = 2)</td>
<td>(c_m = 2)</td>
<td>(c_m = 2.5)</td>
<td>(c_m = 1.5)</td>
<td>(c_m = 2)</td>
<td>(c_m = 2.5)</td>
</tr>
<tr>
<td></td>
<td>(c_w = 3.5)</td>
<td>(c_w = 4)</td>
<td>(c_w = 3.5)</td>
<td>(c_w = 4)</td>
<td>(c_w = 3.5)</td>
<td>(c_w = 4)</td>
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<tr>
<td>(\tau^{eq})</td>
<td>0.6667</td>
<td>0.6667</td>
<td>0.8203</td>
<td>0.3158</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>mean (w_i) (\text{(variance)})</td>
<td>10.6493 (2.8332)</td>
<td>10.6971 (4.1678)</td>
<td>10.7448 (3.9816)</td>
<td>10.5263 (2.3417)</td>
<td>10.5674 (4.1739)</td>
<td>10.5716 (3.4535)</td>
</tr>
<tr>
<td>mean (w_r) (\text{(variance)})</td>
<td>10.6165 (2.9635)</td>
<td>10.633 (5.2778)</td>
<td>10.4288 (5.0256)</td>
<td>10.3578 (2.8053)</td>
<td>10.5075 (2.1877)</td>
<td>10.5332 (3.8971)</td>
</tr>
<tr>
<td>mean (q_i) (\text{(variance)})</td>
<td>2.4959 (0.0937)</td>
<td>2.4968 (0.1669)</td>
<td>2.5009 (0.1344)</td>
<td>2.5096 (0.1344)</td>
<td>2.9959 (0.0937)</td>
<td>2.9968 (0.1669)</td>
</tr>
<tr>
<td>mean (q_r) (\text{(variance)})</td>
<td>2.4949 (0.1464)</td>
<td>2.4960 (0.2607)</td>
<td>2.2560 (0.2239)</td>
<td>3.19268 (0.1736)</td>
<td>2.9952 (0.1275)</td>
<td>2.9963 (0.2271)</td>
</tr>
<tr>
<td>mean (p_i^s) (\text{(variance)})</td>
<td>4.5041 (0.0937)</td>
<td>4.5032 (0.1669)</td>
<td>4.4991 (0.1344)</td>
<td>4.4904 (0.1344)</td>
<td>5.0041 (0.0937)</td>
<td>5.0032 (0.1669)</td>
</tr>
<tr>
<td>mean (p_r^s) (\text{(variance)})</td>
<td>4.5031 (0.0527)</td>
<td>4.5024 (0.0939)</td>
<td>4.2542 (0.0676)</td>
<td>5.1736 (0.1003)</td>
<td>5.0034 (0.0651)</td>
<td>5.0027 (0.1159)</td>
</tr>
</tbody>
</table>
Table 5 Regression of ad valorem tariff equivalents on beef products

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficients</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagged tariff</td>
<td>0.6682</td>
<td>0.000</td>
</tr>
<tr>
<td>Non-ad valorem dummy</td>
<td>1.0798</td>
<td>0.000</td>
</tr>
<tr>
<td>Trade agreement dummy</td>
<td>-0.3619</td>
<td>0.000</td>
</tr>
<tr>
<td>BSE_Import dummy</td>
<td>-0.0516</td>
<td>0.000</td>
</tr>
<tr>
<td>Import_population</td>
<td>1.099</td>
<td>0.000</td>
</tr>
<tr>
<td>Import_GDP per capita</td>
<td>-0.0093</td>
<td>0.613</td>
</tr>
</tbody>
</table>

R²=0.97

Note: Coefficients on importer, exporter and year fixed effects not reported. The tariff data is from TRAINS.
Table 6. Gravity and correction for non-ad valorem tariffs

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficients</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{Ln_Distance} )</td>
<td>-0.6204</td>
<td>0.000</td>
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<tr>
<td>( \text{Comlang} )</td>
<td>0.6840</td>
<td>0.000</td>
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<tr>
<td>( \text{Ln_GDP_imp} )</td>
<td>1.4819</td>
<td>0.001</td>
</tr>
<tr>
<td>( \text{Ln_GDP_exp} )</td>
<td>0.2612</td>
<td>0.291</td>
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<tr>
<td>( \text{Ln(1 + } \tau \text{)} )</td>
<td>-0.2099</td>
<td>0.060</td>
</tr>
<tr>
<td>( \text{Non-ad valorem} )</td>
<td>5.308</td>
<td>0.000</td>
</tr>
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<td>( \text{Ln(1 + } \tau \text{) *Non-ad valorem} )</td>
<td>-2.239</td>
<td>0.000</td>
</tr>
<tr>
<td>( \text{Trade Agreement} )</td>
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<tr>
<td>( \text{BSE_imp} )</td>
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<td>( \text{BSE_exp} )</td>
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<td>( \text{tariff_residual} )</td>
<td>0.0934</td>
<td>0.431</td>
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</table>

Pseudo R2=0.84

Note: importer, exporter and year fixed effect coefficients not reported.