Tariff Aggregators in AGE models: Trade Restrictiveness in EU and US Agriculture

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Summary. *This paper provides a summary measure of the Uruguay Round (UR) tariff reduction commitments in the European Union (EU) and the United States (US), using the Mercantilistic Trade Restrictiveness Index (MTRI) as the tariff aggregator. We compute the index for agricultural commodity aggregates assuming a specific (CES) functional form for import demand. The levels of the MTRI under the actual commitments of the UR are computed and compared with two hypothetical cases, the Swiss Formula leading to a 36% average decrease in tariffs and a uniform 36% reduction of each tariff. The results are not only interesting in order to infer how reducing tariff dispersion would help improving market access in future trade agreemen as summary statistics on tariff protection, but they could also be used to feed information into more aggregated models.*

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1. Introduction

Bureau, Fulponi and Salvatici (2000), hereafter BFS, addressed the problem of assessing the tariff reduction commitments undertaken by the European Union (EU) and the United States (US) under the Uruguay Round Agreement on agriculture (URAA). They used the Trade Restrictiveness Index (TRI) and the Mercantilistic Trade Restrictiveness Index (MTRI) in order to solve the tariff index aggregation problem. The TRI, introduced by Anderson and Neary (1996), consists in estimating the uniform tariff that yields the same aggregate utility level as the original tariff structure. The MTRI, introduced by Anderson and Neary (1999), consists in estimating the uniform tariff that yields the same aggregate volume of imports as the original vector of (non uniform) tariffs across a number of imports.

BFS followed a "local approach". That is, they estimated the rates of change of the TRI and MTRI between the year 1995 (first year of the implementation of the URAA) and the year 2000 (end of the implementation period) rather than the level of TRI and MTRI. Based on the same dataset on tariffs and imports, this paper intends to alleviate some of the limitations of the "local approach" followed by BFS in assessing the restrictiveness of the US and UE agricultural trade policy. First, in terms of policy analysis, we compute the level of MTRI and not simply the relative rates of change between two points in time. Second, while BFS only estimated changes in market access for the aggregate set of agricultural and food products covered by the URAA, we also provide indicators of the level market access for 20 subaggregates. The 20 aggregate commodities are consistent with a dataset that is widely used by trade practitioners, the Global Trade Analysis Project dataset (Hertel, 1997). The objective is to define tariff aggregators that could be use into Applied General Equilibrium (AGE) models such as GTAP.

2. Methodology

The practical and theoretical deficiencies of traditional tariff indexes, such as the simple or the trade-weighted average tariff, are well-known (Laird and Yeats, 1988; Anderson and Neary, 1999). Indexes such as the TRI and the MTRI have more solid theoretical foundations, although the definition of such indexes relies on several restrictive assumptions, including the existence of a competitive equilibrium, a single representative consumer, and fixed world prices (i.e. the small country assumption) . Because they are derived from the Balance of trade function, the TRI and the MTRI synthesise the overall effect of trade policy on the economy.[1]

Most AGE models are built on a restricted list of commodities.[2] This requires a substantial aggregation of trade flows and tariffs. However, agricultural tariffs vary a lot within a single product aggregate (e.g. within a single chapter of the *Harmonised System* or HS classification of the United Nations). In addition, tariff reductions under the URAA were taken on the basis of a very detailed list of items and the magnitude of tariff cut also varies a lot within a product category. Therefore, a lot of information on the level of tariff dispersion (and on the change in dispersion over time) is lost when one aggregates tariffs data up to the level that is consistent with CGE models aggregates. In order to be able to take into account the impacts of changes occurring on a very large number of finely differentiated tariff lines, we build on the insights of Bach and Martin (2001) who assume a specific functional for import demand. Their methodology, which aims to develop tariff aggregators for both the expenditure and tariff revenue components of CGE models, can be adapted in order to compute the MTRI.

2.1. Mercantilistic Trade Restrictiveness Index.

The MTRI relies on the idea of evaluating trade policy using trade volume as the reference standard (Anderson and Neary, 1999). The MTRI is defined in terms of the uniform tariff τ which yields the same volume (at world prices) of tariff-restricted imports as the initial vector of (non uniform) tariffs. This can be expressed with import demand functions M, while holding constant the balance of trade function at level B^0:

[1] The balance of trade function summarizes the outcome of and the consumption sector, the production sector and the public behavior by including tariff revenues in the trade expenditure function. Equilibrium of the economy is consistent with a balance of trade that equals an exogenous income.

[2] Anderson and Neary (1999) use Anderson (1998)'s AGE model which is unusually disaggregated as far as the trade structure is concerned. However, even this model relies on 4-digit Harmonised System of classification, while the official WTO tariff commitments of the EU and the US in the food and agricultural sector specify tariffs at the 8 digit level.

$$\tau : M\left[(1+\tau)p^*, B^0\right] = M^0 \qquad (1),$$

where p^* denotes the international price vector of the N goods $k = (1,\ldots,N)$ and M^0 is the value of aggregate imports (at world prices) in the reference period. Define the scalar import demand as

$$M\left(p, p^*, B\right) \equiv \sum_{k=1}^{N} p_k^* I_k^m \qquad (2),$$

where I^m denotes the uncompensated (Marshallian) import demand function and p is the domestic price vector. Accordingly, the MTRI uniform tariff τ would lead to the same volume of imports (at world prices) as the one resulting from the uneven tariff structure, denoted by the N dimensional tariff vector t whose elements are t_k. That is

$$\sum_{k=1}^{N} p_k^* I_k^m \left[p^*(1+\tau), B^0\right] = \sum_{k=1}^{N} p_k^* I_k^m \left[p^*(1+t), B^0\right] \qquad (3).$$

The MTRI can be computed by solving equation (3) for τ. The MTRI derived from (3) provides a measure of trade restrictiveness relative to a free trade reference. If we want to compare our results with those obtained by BFS, who measured changes between two protected situations, we need to be consistent with their "local approach". This means that we need to focus on the *change* in the tariff structure from the initial equilibrium corresponding to the price vector $p^0 = p^*(1+t^0)$ and the new (still distorted) equilibrium corresponding to the price vector $p^1 = p^*(1+t^1)$, rather than free trade. Following Anderson and Neary (1999), we can then define the "uniform tariff surcharge" μ which, when applied to the prices in the new equilibrium, p^1, yields the same volume (at world prices) of tariff-restricted imports as the old equilibrium M^0. Formally,

$$\mu : M\left[(1+\mu)p^1, B^0\right] = M^0 = M(p^0, B^0) \qquad (4).$$

2.2. Empirical estimation of the MTRI.

Having defined the MTRI, for the empirical implementation we model demand through a Constant Elasticity of Substitution (CES) functional form. This function imposes restrictive assumptions on separability, but is widely used in the AGE literature, including in the GTAP model (Hertel et al, 1997).

We assume that the overall basket of goods can be partitioned into J aggregates denoted $j=1,\ldots J$. This requires that the utility function of the representative consumer is separable, so that it can be written as a sum of J functions ϕ_j

$$U(x) = \sum_j \phi_j(u_j(x_j)) \qquad (5).$$

That is, the overall utility function U is built up from lower level sub-utility function u_j. Each vector x_j containts N_j elements. We assume that u_j is a CES function in x_j. We use the popular Armington (1969) assumption that imports are imperfect substitutes of domestic goods. We partition the consumption vector x_j within the j^{th} group into an aggregated domestic good denoted with a suffix d and N_j *-1* traded goods denoted with an index i.

$$u_j(x) = \left(b_{dj}(x_{dj})^{\rho_j} + \sum_i b_{ij}(x_{ij})^{\rho_j} \right)^{\frac{1}{\rho_j}}, \quad i=1,\ldots N_j \qquad (6).$$

Denoting $\sigma_j = \frac{1}{1-\rho_j}$ the elasticity of substitution within the j group, the expenditure devoted to each aggregate j is :

$$e_j(p,u) = \left(\beta_{dj}(p_{dj})^{1-\sigma_j} + \sum_i \beta_{ij}(p_{ij})^{1-\sigma_j} \right)^{\frac{1}{1-\sigma_j}} u_j \qquad (7).$$

The parameters β_{ij} can be calibrated to the initial values of the expenditure shares in the base data, when all domestic prices are set to 1. After deriving the indirect utility function by inverting equation (7), the demand functions of each of the $i=1,.., N_j -1$ imported goods can be found by Roy's identity

$$x_{ij} = \beta_{ij} \frac{p_{ij}^{-\sigma_j}}{\left(\beta_{dj}(p_{dj})^{1-\sigma_j} + \sum_i \beta_{ij}(p_{ij})^{1-\sigma_j} \right)} e_j \qquad (8).$$

Denoting P_j the price index that corresponds to the denominator of the right hand side, the import volume function for the j^{th} aggregate, valued at world prices, is

$$\sum_{i=1}^{N^j} p_{ij}^* x_{ij} = \sum_i p_{ij}^* \beta_{ij} \left(\frac{1}{P_j \cdot p_{ij}{}^{\sigma_j}} \right) e_j \quad \text{with } i=1,\dots, N_j\text{-}1 \qquad (9).$$

When the initial total expenditure e_j^0 (expenditures on both domestic and imports in *j*) is used in the expression (9), we obtain the demand function at the initial level of imports. Since the import volume function is homogeneous of degree zero in the prices of al traded goods, it does not make sense to define trade restrictiveness without selecting an untaxed good or group of goods as reference (Anderson and Neary, 1999). As in Bach and Martin (2001), we solve the problem by taking the domestic good as a numeraire.

The MTRI uniform tariff equivalent τ_j for each aggregate *j* is found by setting the value of the import volume function with the uniform tariff equivalent equal to the initial value of imports (evaluated at world prices).[3]

$$\sum_i p_{ij}^* \beta_{ij} \left(\frac{P_j^\tau}{p_{ij}^* (1+\tau_j)} \right)^{\sigma_j} e_j^0 = \sum_i p_{ij}^* I_{ij}^0 \qquad (10),$$

where I_{ij}^0 are the volume of imports in the initial period (i.e. 1995 or 2000 in our numerical applications), and P_j^τ is the price index

$$P_j^\tau = \left(\beta_{dj} (p_{dj})^{1-\sigma_j} + \sum_i \beta_{ij} \left(p_{ij}^* (1+\tau_j) \right)^{1-\sigma_j} \right)^{-\sigma_j} \qquad (11).$$

The uniform tariff equivalents for each aggregate commodity *j* are found using an optimisation routine in GAMS® package (Brooke et al, 1998), solving for τ_j in equations (10) and (11).

The indicators τ_j are by themselves relevant for the analysis of trade policy. In addition, the τ_j can be used as aggregate tariffs in any trade model with a commodity aggregation and an import demand structure which is consistent with our assumptions.[4] However, rather than using a full

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[3] Since we use the initial total expenditure e_j^0, the uniform tariff equivalent τ_j is only an approximation of the true general-equilibrium measure, since it ignores the change in the tariff revenue.

[4] Bach and Martin (2001) discuss the different tariff aggregators that should be used in different components of a AGE model.

AGE model, we can readily compute an overall MTRI τ that corresponds to the uniform tariff that would keep the overall (i.e. on all $j=1,..,N$ sectors) import volume equal to the initial value. This can be obtained by modifying equation (10) as follows

$$\sum_j \sum_i p_{ij}^* \beta_{ij} \left(\frac{\left(\beta_{dj} (p_{dj})^{1-\sigma_j} + \sum_i \beta_{ij} \left(p_{ij}^* (1+\tau) \right)^{1-\sigma_j} \right)^{-\sigma_j}}{p_{ij}^* (1+\tau)} \right)^{\sigma_j} e_j^0 = \sum_j \sum_i p_{ij}^* I_{ij}^0 \qquad (12).$$

In the same vein, the overall MTRI uniform tariff factor surcharge can be obtained solving for μ in equation (13)

$$\sum_j \sum_i p_{ij}^* \beta_{ij} \left(\frac{\left(\beta_{dj} (p_{dj})^{1-\sigma_j} + \sum_i \beta_{ij} \left(p_{ij}^1 (1+\mu) \right)^{1-\sigma_j} \right)^{-\sigma_j}}{p_{ij}^1 (1+\mu)} \right)^{\sigma_j} e_j^0 = \sum_j \sum_i p_{ij}^* I_{ij}^0 \qquad (13).$$

2. 3. Dataset.

The world prices are the average unit values of imports (c.i.f) over the 1994-96 period. The volumes of imports are taken directly from the respective US and EU datasets (US International Trade Commission and Eurostat's Comext dataset). The Schedule XX that the European Union and the US submitted to the WTO provides the base and bound tariffs at the 8-digit level of the HS classification. The URAA schedule therefore provides information on tariffs in 1995 (that is, after the Uruguay Round tariffication process) and in 2000 (that is, after the implementation of the mandatory 36% average reduction in tariffs). The domestic prices are constructed by multiplying the world price *p** by the *ad valorem* tariff structure (initial, final or counterfactual tariffs) that we are interested in. As a result, the measure of market access focuses only on changes in the tariffs *ceteris paribus*, and is not affected by exogenous price variations (see BFS, 2000 for details on the dataset).

The EU-15 tariff reduction commitments cover 1764 tariff lines, while the US schedule includes 1377 tariff lines. Both the EU and the US apply their bound tariffs on products traded in a Most

Favoured Nation framework. That is, using the URAA schedules as a source of information on tariffs gives a good image of the actual tariff structure, although lower tariffs are applied in the framework of preferential agreements that we did not consider here. For purposes of calculation, we converted specific tariffs into *ad valorem* equivalents, following the same conventions as in BFS (2000).

The data on the total expenditure are taken from the Global Trade Analysis Project (GTAP) version 4 dataset. This comprehensive dataset is widely used in applied analysis, and researchers might be interested in tariff aggregates that match the GTAP classification for simulation purposes. Moreover, the conversion tables from detailed tariff structures (HS 8 digit) to the GTAP sectors are fully available, which makes it possible to aggregate the very detailed list of tariffs of the URAA Schedule into a restricted number of products that correspond to the GTAP system of classification. Finally, the dataset provides the information that is necessary for distinguishing between expenditure spent on domestic products imports for the various aggregates, and also provides elasticities of substitution σ_j that match the list of aggregates.

The original GTAP dataset distinguishes *J=20* agricultural and food aggregate products. In order to include non food other commodities listed in the URAA schedules (mainly agricultural goods listed in Chapters 25 to 53 of the HS classification) we defined an extra aggregate, which does not exist in the original GTAP classification (see Table 1). We ignore one GTAP sector (raw milk), because there is no trade for the corresponding commodity. Overall, we aggregated 1764 tariff lines in the EU (1377 tariff lines in the US) at the 8 digit level of the HS classification up to 20 aggregate products described in Table 1. It is noteworthy that the number of tariff lines in each commodity aggregate is very uneven. Table 1 shows, for example that there are only three tariff lines in the aggregate "paddy rice", while the aggregate "fruits and vegetable" tariff includes 183 tariff lines listed in the EU Schedule.

3. The measure of market access prior to the Uruguay Round Agreement

The computation of the MTRI uniform tariff equivalent τ_j provides an estimate of the trade restrictiveness of the actual tariff structure. It is calculated for the year 1995 in both the EU and the US, making it possible to compare the trade effect of the tariff structure in the two countries prior to implementation of the Uruguay Round commitments. The structure of bound tariffs in the EU and the US differs in several aspects.

Table 2 shows that three product categories in the EU face zero tariff (oilseeds, fibres, wool) while all aggregates tariffs in the US face a strictly positive average tariff. However, this mainly reflect the particular structure of the GTAP classification. Overall, the original 1995 EU tariff schedule included 245 lines with zero tariffs, while the US schedule included 303 lines with zero tariffs. The average non-weighted base tariff was 9.7 % (12.7% if we focus only on the items with a non-zero tariff) in the US, while in the EU the average tariffs were 26.7.0% (31.4%, respectively).

In most sectors, the EU average tariff is larger than the US average tariff, the gap being particularly wide in the grains, meat, sugar and rice sectors. It is worth noting, though, that in the EU, the trade-weighted average tariff is most of the time larger than the non-weighted average, while it is generally the opposite in the US. A trade-weighted average tariff that is smaller than the non-weighted one can result from prohibitive tariffs, or may simply mean that larger tariffs are set on commodities whose demand is particularly elastic. This suggests that higher tariffs are set on sensitive products, in the sense that the government is willing to protect domestic production from imports, as in the case in the US dairy sector.

However, computing the absolute level of the MTRI-uniform tariff also leads to reconsider dramatically the image of the relative rates of protection of the EU and US agricultural sector. The difference between the MTRI-uniform tariff and the non weighted average tariff (Table 4) is much larger in relative terms (and of opposite sign) in the case of the US than in the case of the EU. This suggests that the high tariffs in the US are on a restricted set of very particular goods, most of them being imported in small quantities. In point of fact, very high tariffs are concentrated on specific types of processed food (peanuts, preparations with meat or processed vegetables). High tariffs are also set on dairy products, but the bulk of imports, namely tropical products and live animals that accounts for large import values faces almost zero tariffs. By contrast, in the EU most of the commodities imported in large quantities face significant tariffs, at least under MFN treatment, as it is typically the case in the beef, sugar and grain sectors.

Table 2 shows significant differences between the MTRI and the non-weighted tariff average. This is not surprising, since the non-weighted tariff average bears little relationship with theoretically sound indexes like the MTRI or the TRI.

On the other hand, the values for the trade-weighted average tariffs are often quite close to those given by the MTRI tariff. This empirical finding converges with those of Anderson and Neary (1999), and Bach and Martin (2001) who show that the trade-weighted average tariff is a linear approximation to the tariff aggregator based on the expenditure function. In other terms, the trade-weighted average tariff plays the same role as the Laspeyres price index in consumer theory, providing a fixed-weight approximation that underestimates the "true" height of tariffs because it neglects substitution induced by tariff changes.

This empirical finding can be explored a bit further in the particular case of a CES aggregator function, where the trade-weighted average tariff corresponds to constant expenditure shares. Constant shares correspond to the special case of a Cobb-Douglas sub-utility function, where $\sigma_j = 1$. In such a case, we have the following result (Proof of all propositions are given in the Appendix).

Proposition 1*: In the base equilibrium (that is, with all domestic prices equal to 1), the MTRI uniform tariff coincides with the trade-weighted average tariff when the CES aggregator function becomes Cobb-Douglas.*

Since the values of the σ_j in the GTAP dataset rank between 2.2. and 3.8, it is not surprising that the MTRI for the aggregate level is sometimes close to the value of the trade weighted average tariff. The MTRI uniform tariff is more likely to be higher than the trade-weighted average tariff the more elastic is the demand for tariff-constrained imports. On the basis of empirical calculations with a AGE model, Anderson and Neary (1999) are able to confirm this basic insight, and our empirical use of the MTRI in order to construct sectoral tariff aggregates leads to similar conclusions.[5] In our specific case of a CES aggregator function, we can derive more explicitly the conditions, under which the MTRI exceeds the trade weighted index:

[5] More precisely, Anderson and Neary proved the following proposition: "The MTRI uniform tariff exceeds the trade-

Proposition 2*: In the base equilibrium (that is, with all domestic prices equal to 1): (i) the trade-weighted average tariff overestimates the MTRI uniform tariff when σ <1 (σ denotes, the elasticity of substitution of the CES aggregator function)*; *(ii) the trade-weighted average tariff underestimates the MTRI uniform tariff when* $\sigma > 1$.

Looking at Tables 1 and 2, it is also obvious that the MTRI and the trade-weighted index give very similar results when the number of tariff lines in the aggregate is very small, or when there is little dispersion in tariffs within an aggregate. Figures in Table 2 show that the percentage variation between the MTRI and the trade-weighted average depends positively on the standard error of tariffs, something that is confirmed by elementary descriptive statistics. For the aggregates with a large number of products, the gap between the two indexes can be very large. In the dairy sector, for example, the trade-weighted average underestimates the trade restrictiveness of the pre-URAA tariff structure by 29% in the US and by 9% in the EU. This is also the case in the cattle sector and in the beverages sector in the EU (underestimation of 29% and 23% respectively), and in the oilseeds sector in the US (underestimation of 40%). Overall, for six aggregate EU products out of twenty, the trade-weighted average underestimates the MTRI by more than 10%.In brief, the trade weighted tariff can only be a satisfactory approximation of more theoretically consistent indicators of market access under very specific conditions, and for specific values of the substitution elasticities. In more general cases, when the aggregate includes a large number of heterogeneous tariff lines differ from unity, the trade-weighted average is a poor indicator of the restrictiveness of the tariff structure.

4. The impact of the Uruguay Round and counterfactual scenarios

The computation of the MTRI for the year 2000 makes it possible to evaluate the trade restrictiveness of the tariff structure that results from the URAA. Following BFS, we also want to assess the relative effects of reducing the tariff average and tariff dispersion. We simulated two other tariff reduction schemes in addition to the actual reduction implemented by the EU and the US. The three cases are called Uruguay Round commitments, Swiss Formula and Uniform tariff

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weighted average tariff if: (i) the compensated arc elasticity of demand for the composite tariffed good exceeds one; (ii) the composite tariffed good is normal; and (iii) the trade expenditure function is implicitly separable in tariffed and other goods." (Anderson and Neary, 1999).

reduction respectively. In the three cases, we start from the same tariff structure in 1995 (that is, the initial vector p_i^{95} is the same for each case), but the three schemes lead to three different p_i^{2000} vectors. These may be summarised as follows:

- *Uruguay Round commitments*. The price vector p^{2000} is the one that results from the bound tariffs in year 2000. The resulting tariff structure reflects the obligation of a 36% non-weighted average reduction, but with no constraints placed on the mix of reductions to achieve the overall average (except that each tariff line must be reduced by at least 15%).

- *Swiss Formula*. In this case, we calculate the price vector p^{2000} that would have resulted from a tariff reduction for which higher tariffs would have been subject to larger cuts. The 'Swiss formula' is given in equation (14) and the parameter C is chosen to obtain the same non-weighted average reduction of 36% in tariffs as specified in the URAA. Comparing the value of the MTRI-uniform tariff equivalents with those that actually result from URAA commitments, we can assess the impact of commitments that would have focused more on reducing tariff dispersion than the actual Urugay Round tariff cuts.

$$t_i^{2000} = Ct_i^{1995} / (C + t_i^{1995}) \ . \tag{14}$$

- *Uniform tariff reduction.* Under this scheme, we assume that a uniform 36% reduction is applied to all tariff lines. This will obviously result in the same average reduction as specified under the URAA, but it does not permit countries to allocate the adjustment across commodities. The comparison of the values of the MTRI-uniform tariff equivalents with those that actually result from URAA commitments therefore measures the magnitude of the "dilution effect" that resulted from the distribution of large and small or minimal cuts across tariff lines.

Comparing the values of the MTRI-uniform tariff equivalents of the 2000 tariffs (first column in Table 3) with the MTRI-uniform tariff equivalents of the 1995 tariffs (third column in Table 2), we can assess the actual impact of the URAA in terms of market access. The URAA had an impact in terms of the reduction of the MTRI uniform tariff for each of the 20 products both in the

EU and the US. The absolute values of the reductions are much smaller in the case of the US, as it could have been expected given the low value of the aggregate MTRI uniform tariff equivalent in the base period (see Table 4).

We now turn to the counterfactual scenarios in Table 3. Overall, the results show that the various ways of cutting tariffs only have a very limited impact on the the overall access to the US market, due to the low levels of tariffs in the first place. If the Swiss formula had been applied, the Uruguay Round would have led to considerable increase in market access as measured by the MTRI uniform tariff. In the EU, the Swiss formula would have led to dramatic decrease in trade restrictions in highly protected sectors such as grains, meat, dairy sectors, and also in sectors characterised by a high tariff dispersion such as fruits and vegetables. The US market would also have been more open at the aggregate level (see Table 4), but there are quite a few instances (rice, cereals, sugar, meat) where the Swiss formula does not perform better than the uniform tariff reduction (or even the URAA), while this never happens in the case of the EU.

Tables 3, and 4 show that the URAA has increased access to the market in a way that is very comparable to what would have resulted from a uniform tariff reduction in most sectors. This means that both countries have not allocated tariff cuts in a very 'strategic' way. The results also confirm the finding that the 'dilution' of tariff reduction effect was limited in the EU, as it could have expected since most tariffs were cut by 36% and no tariff was reduced by less than 20%.

Since our results are based on unsophisticated estimates of substitution elasticities (the ones taken out of the GTAP dataset), it is necessary to ask to what extent these may affect the MTRI computation. In table 5 we compute the overall MTRI-uniform tariff equivalents making different assumptions about the values of the substitution elasticities. The elasticities are assumed to range from one third to three times the original values.

Even though the ranking among different scenarios remains the same for the various elasticities assumptions, the MTRI is obviously sensitive to the degree of substitution between products, a result consistent with Proposition 2. Since the large values of the index are more sensitive to the assumption on substitution, the results are more affected by changes in the σ_js in the EU than in the US, where the agricultural sector is less protected.

5. Conclusion

This paper provides a summary measure of the UR tariff reduction commitments in the EU and US, taking into account the impact of changes in a large number of tariff lines. We also evaluated the impacts of alternative tariff cutting procedures, using the MTRI as the tariff aggregator. Under the assumptions presented in the paper, the MTRI is the correct way to measure the consequences of tariff barriers on the volume of imports.

We were able to compute the index for particular commodity aggregates without using a CGE model, but assuming a specific functional form for import demand. Such an approach is easy to implement, since it requires only information on tariffs, import values and total expenditure on each commodity (in addition to the knowledge of the parameters of the demand function). The results are not only interesting as summary statistics on tariff protection, but they could also be used to feed information into more aggregated models.

On the methodological side, the MTRI uniform tariff and the trade-weighted index tend to move closely together when the number of commodities is small (e.g. paddy rice), and when the dispersion of tariffs is low. In other cases, the trade-weighted index underestimates the true impact of the tariff structure on market access, as measured by the MTRI. When we aggregate a large number of tariffs (case of dairy products and vegetables both in the US and the EU), or when the dispersion is large (case of oilseeds in the US, animals in the EU), the two indexes differ significantly.

The difference that we observe between the MTRI and the non-weighted tariff average suggests that AGE or a trade models that rely on aggregate tariffs constructed as simple averages, use poor estimates of the actual tariff structure. This bias is likely to affect the large number of studies, since it is common practice to construct aggregate tariffs as simple averages of the detailed tariffs applied by custom officers, who sometimes work at a level of details corresponding to he HS10 or HS12 digit level (case of the European Union). Constructing the aggregate tariffs used in AGE or trade models as trade weighted averages is obviously more satisfactory. However when one aggregates a large number of goods with a large tariff dispersion into a single commodity, this method also results in significant bias, most of the time an underestimation of the aggregate tariff, as measured by the MTRI.

Appendix

Proof of Proposition 1

With all domestic prices equal to 1 in the base equilibrium, equation (10) becomes

$$\sum_i p_{ij}^* \beta_{ij} \frac{1}{\left(\beta_{dj}(p_{dj})^{1-\sigma_j} + \sum_i \beta_{ij}\left(p_{ij}^*(1+\tau_j)\right)^{1-\sigma_j}\right)\left[p_{ij}^*(1+\tau_j)\right]^{\sigma}} = \sum_i p_{ij}^* \beta_{ij} \qquad \text{(1A).}$$

When σ_j =1, the MTRI uniform tariff equivalent is

$$\tau_j = \frac{1-\beta_{dj}}{\sum_i \beta_{ij} p_{ij}^*} - 1 \qquad \text{(2A).}$$

Recalling that in the base equilibrium $p_i^* = \frac{1}{1+t_i}$, from the above equation we obtain

$$\tau_j = \frac{\sum_i \beta_{ij} t_{ij}}{\sum_i \beta_{ij}} \qquad \text{(3A).}$$

Proof of Proposition 2

We first write equation (10) as follows (dropping the *j* index for the sake of simplicity)

$$\sum_i p_i^* \beta_i \left(\frac{P^\tau}{p_i^*(1+\tau)}\right)^{\sigma} e^0 - \sum_i p_i^* I_i^0 = F(\tau, \sigma) = 0 \qquad \text{(4A).}$$

Assuming that there is a solution $F(\tau^0, \sigma^0) = 0$ and $F_\sigma(\tau^0, \sigma^0) \neq 0$, then by the Implicit Function Theorem in a neighborhood of (τ^0, σ^0) there exists a function $\tau^0 = f(\sigma^0)$ and

$$\frac{d\tau}{d\sigma} = -\left.\frac{F_\tau}{F\sigma}\right|_{\tau = f(\sigma)} \qquad \text{(5A).}$$

The derivatives of the F function are $F_\tau < 0,\ F_\sigma > 0$. Indeed $F_\tau = -\sigma \frac{e^0}{(1+\tau)^2} \sum_i \beta_i \left(\frac{P^\tau}{p_i^*(1+\tau)} \right)^{\sigma-1}$, which is negative. $F_\sigma = \sum_i e^0 \beta_i p_i^* \left(\frac{P^\tau}{(1+\tau)} \right)^\sigma \ln\left(\frac{P^\tau}{(1+\tau)} \right)$, is positive since $\left(\frac{P^\tau}{(1+\tau)} \right) \to 0 \Rightarrow \left(\frac{P^\tau}{(1+\tau)} \right)^\sigma \ln\left(\frac{P^\tau}{(1+\tau)} \right) \to 0$ and $\sigma > 0$. Since the derivatives have opposite signs, τ increases with σ (at least in the neighborood where there exists a solution). Recalling from Proposition 1 that the MTRI and the trade-weighted average tariff coincides for $\sigma = 1$, the result follows immediately.

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TABLES

Table 1. GTAP agricultural commodities and HS-8 tariff lines

Commodities [1]	*GTAP Classification*	*Number of tariff lines EU*	*Number of tariff lines US*
Paddy rice	1	3	3
Wheat	2	3	3
Cereal grains	3	13	12
Vegetables, fruits, nuts	4	183	186
Oilseeds	5	31	16
Sugar cane, sugar beet	6	3	2
Plant based fibers	7	4	7
Other crops	8	111	116
Cattle, sheep, goats, horses	9	14	12
Other animal products	10	73	50
Raw wool, cocoons and hair	12	9	17
Meat: cattle, sheep, goats, horses	19	77	34
Other meat products	20	199	61
Vegetable oils and fats	21	112	70
Dairy products	22	121	118
Processed rice	23	2	3
Sugar	24	10	15
Other food products	25	580	489
Beverages and tobacco	26	87	84
Non-food items (goods listed in URAA, beyond Chapter HS 24)	other	130	79

1. Note : raw milk (GTAP code 20) is excluded because of absence of trade

Table 2. Base Tariffs (year 1995, actual bound tariffs)

Commodities	*Non-weighted average tariff (%)*		*Trade-weighted average tariff (%)*		*MTRI tariff (%)*		*Coefficient of variation of tariffs*	
	EU	*US*	*EU*	*US*	*EU*	*US*	*EU*	*US*
Paddy rice	58.6	3.0	80.5	1.7	80.8	1.7	0.70	0.53
Wheat	57.8	4.9	114.0	4.5	114.0	4.5	0.86	0.27
Cereal grains	45.6	1.1	84.4	0.8	89.8	0.8	0.97	1.00
Vegetables, fruits, nuts	16.8	6.9	57.5	4.2	68.9	4.5	1.28	1.21
Oilseeds	0	23.6	0	4.0	0	6.6	0	2.51
Sugar cane, sugar beet	40.3	2.9	14.2	3.7	14.8	3.7	1.02	0.40
Plant based fibers	0	11.1	0	2.8	0	2.9	0	0.87
Other crops	7.5	3.7	7.8	1.7	8.0	1.8	0.93	2.49
Cattle, sheep, goats, horses	30.2	2.1	36.2	0.1	51.5	0.1	1.52	2.36
Other animal products	4.9	1.1	2.2	0.3	2.6	0.3	1.99	2.12
Raw wool, cocoons, hair	0.1	3.5	0	5.4	0	5.4	0	1.15
Meat: cattle, sheep, goats, horses	62.1	7.0	94.0	1.1	103.2	1.1	1.02	1.67
Other meat products	35.1	4.8	24.7	1.9	26.4	2.0	1.06	0.93
Vegetable oils and fats	14.5	4.5	5.7	3.1	6.8	3.1	1.54	1.15
Dairy products	72.0	26.5	69.7	8.1	76.4	11.4	0.83	1.06
Processed rice	99.2	7.8	126.4	3.4	127.6	3.4	0.52	1.08
Sugar	39.2	26.0	63.9	13.9	67.5	15.2	0.91	1.20
Other food products	28.0	11.8	19.7	5.6	23.7	6.0	1.02	1.71
Beverages and tobacco	15.8	7.2	28.2	2.3	36.7	2.4	1.51	1.24
Non-food items	8.6	3.0	3.6	2.1	3.7	2.1	1.38	1.20

Note: All three tariff indices compare the actual tariff structure with free trade. See text for details.

Table 3. MTRI-uniform tariff equivalents (%) in year 2000: actual bound tariffs and counterfactual scenarios

Commodities	*Uruguay Round commitments*		*Swiss Formula*		*Uniform 36% Tariff Reduction*	
	EU	*US*	*EU*	*US*	*EU*	*US*
Paddy rice	51.9	1.1	23.9	1.5	52.0	1.1
Wheat	73.0	2.9	26.2	3.3	73.0	2.9
Cereal grains	59.9	0.5	24.1	0.7	60.7	0.5
Vegetables, fruits, nuts	58.1	3.0	21.5	2.3	51.6	3.0
Oilseeds	0.0	5.5	0	2.1	0	5.5
Sugar cane, sugar beet	12.0	2.3	9.5	2.8	9.8	2.3
Plant based fibers	0	1.9	0	1.9	0	1.9
Other crops	3.4	1.2	6.0	1.0	5.3	1.2
Cattle, sheep, goats, horses	38.9	0.1	18.8	0.1	39.4	0.1
Other animal products	1.9	0.2	1.8	0.2	1.9	0.2
Raw wool, cocoons, hair	0	3.5	0	3.6	0	3.5
Meat: cattle, sheep, goats, horses	70.5	0.7	24.9	0.8	70.7	0.7
Other meat products	17.5	1.3	13.6	1.4	17.9	1.3
Vegetable oils and fats	5.3	2.1	4.2	2.1	4.9	2.1
Dairy products	53.0	9.0	23.0	3.0	52.1	9.0
Processed rice	82.3	2.2	26.9	2.6	82.3	2.2
Sugar	55.3	10.4	21.9	5.5	45.2	10.4
Other food products	18.7	4.0	12.6	3.0	17.1	4.0
Beverages and tobacco	25.4	1.6	16.4	1.8	27.0	1.6
Non-food items	1.4	1.4	3.0	1.4	2.4	1.4

Note: All three scenarios compare a counterfactual tariff structure with free trade. See text for details.

Table 4: Aggregate Results

Tariff structures (*ad valorem* equivalent, in percentage)	**Standard deviation**	**Mean***	**Coefficient of variation**	**MTRI uniform tariff**	**Trade weighted tariff mean**
US Base rates (year 1995)	18.3	9.7	1.9	3.5	3.3
US Bound rates UR commitments (year 2000)	15.5	7.1	2.2	2.4	2.2**
US Swiss formula scenario (year 2000)	3.5	3.5	0.9	1.9	1.7**
US Uniform reduction scenario (year 2000)	11.7	6.2	1.9	2.4	2.1**
EU Base rates (year 1995)	38.6	26.7	1.4	32.4	25.5
EU Bound rates UR commitments (year 2000)	26.8	17.9	1.5	25.6	17.8**
EU Swiss formula scenario (year 2000)	7.8	11.1	0.7	13.4	8.4**
EU Uniform reduction scenario (year 2000)	24.7	17.1	1.4	24.7	16.3**

* non weighted arithmetic mean; **weighted by 1995 import values

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Table 5. Sensitivity of MTRI uniform tariff to a change in the elasticities of substitution

	European Union				**United States**			
	Base	Uruguay	Swiss	Uniform	Base	Uruguay	Swiss	Uniform
0.3*σ_j	26.0	17.4	9.3	16.6	3.1	2.1.	1.8	2.1
1.3*σ_j	36.5	29.0	14.9	28.0	3.6	2.6	2.0	2.5
2*σ_j	45.5	36.5	17.3	35.4	4.3	3.1	2.3	3.1
3*σ_j	59.8	47.0	18.9	45.5	6.2	4.9	3.2	5.0