Welfare Impacts of Agricultural and Non-Agricultural Trade Reforms

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Abstract:

The variability of protection rates within sectors is frequently particularly high in agriculture relative to non-agriculture. Standard aggregation procedures ignore the variability within sectors, and underweight the importance of highly protected sectors. It therefore seems likely that they underestimate the potential benefits of agricultural trade reform relative to non-agricultural reform. This study examines this question using a new procedure for aggregating trade distortions. It finds that the key impact of using better aggregators is to increase the benefits of both agricultural and non-agricultural reform. It finds that using optimal aggregation procedures increases the measured importance of agricultural trade reform relative to non-agriculturalreform from a very high initial level, but only by around two percentage points.

JEL: F13, F14, Q13, Q17, Q18. Keywords: agricultural trade, nonagricultural trade; trade distortions; tariffs; aggregation; World Trade Organization; WTO; trade reform.

1 Introduction

Agricultural trade distortions are frequently higher and more variable than those prevailing in other sectors of the economy. This would generally be expected to make them more costly, other things equal, than protection to other sectors. Consistent with this, Anderson, Martin and van der Mensbrugghe (2006, Table 12.6) concluded that almost two-thirds of the cost of global protection—and roughly the same share of the cost of merchandise distortions to developing countries— resulted from agricultural trade barriers. This result is particularly striking given that agricultural trade is less than 10 percent of global trade, and that production is an even smaller share of the global economy. Clearly, the size of the potential welfare gains from reforming agricultural trade raise the priority to be placed on achieving liberalization in this exceedingly difficult sector.

One concern with this finding is that past approaches to modeling reform may have been vulnerable to differences in the approach to aggregation used in global trade reform. Partly because of the heterogeneity of agricultural trade barriers, most of the databases for global trade—such as the widely-used GTAP database—tend to provide a much finer disaggregation of the agricultural sector (20 different sectors over a total of 57) than of the remainder of the economy. As a matter of fact an agricultural related sector in the GTAP database includes 36 product (HS6 nomenclature) when a manufacturing sector includes nearly 200 products. Since the measured cost of non-uniform protection rises with the degree of disaggregation used in analyzing its impact, there is potentially a risk that the higher measured costs of agricultural distortions arise simply from the approach used to analyze the question.

In this paper, we first examine the extent to which agricultural protection is—as is widely asserted—higher and more variable than protection to non-agricultural merchandise trade. We then turn to a newly-developed approach to tariff aggregation that allows us to aggregate from the finest level of disaggregation available in our dataset. Not only does this approach improve our estimates of the overall welfare impacts of liberalization, but it also sharply reduces our vulnerability to differences in the degree of sectoral disaggregation between sectors.

2 Patterns of Agricultural and Non-Agricultural Protection

Based on the MAcMapHS6 database (Boumellassa, Laborde and Mitaritonna, 2009), the world average protection in 2004 is estimated at 5.1 percent, acknowledging that 40 percent of world trade takes place under duty-free Most Favored Nations (MFN) rates. This relatively low *Ad Valorem Equivalent* (AVE) number hides a heterogeneous and complex pattern of protection, reflecting historical and political differences across countries and sectors. Here is a quick overview based on Table 1:

- The average level of protection decreases as the level of a country's development increases: in 2004, the average protection is 3.3 percent for high-income countries (HICs), 9.6 percent for low and middle income countries (MLICs), and 12.2 percent for least-developed countries (LDCs).
- The agricultural sector is more protected (18.9 percent) than the manufactured goods sector (4.5 percent) or the extractive-energy products sector (1.3 percent). This gap reflects the political economy of agriculture in most countries as well as the mechanical

consequences of agriculture's exclusion from previous rounds of multilateral trade negotiations.

The protectionist bias in agriculture and on final products rises with the level of development of a country. Relative to their average level of protection, HICs give appreciably more protection to their agricultural sector. Indeed, rich countries tax their agricultural imports 6.7 times more than manufactured goods. The ratio of agricultural protection to industrial protection decreases for MLICs and LDCs: 2.3 and 1.2, respectively. MLICs and LDCs, with scarce administrative resources, pay more attention to the revenue-raising effects of tariffs than do the industrial countries, where tariffs are a very minor source of revenue.

Table 1 Average tariffs by region and product, Percentage

	World	HICs	MLICs	LDCs
Agricultural goods	18.9	18	20.8	14.1
Industrial goods	4.4	2.7	8.9	11.7
Resources	1.9	0.6	5.6	12.7
All products	5.1	3.3	9.6	12.2

Source: MAcMapHS6v2.1 2004. Note: HICs stand for High Income Countries, MLICs for Middle and Low Income Countries and LDCs for Least Developed Countries.

We know from basic theory that the cost of protection depends not just on the average level of protection, but also upon the dispersion of tariff rates within each category. The importance of tariff dispersion is made very clear by the textbook illustration that the cost of a tariff is related not to the level of protection but to its square. On this dimension, the difference between agricultural and non-agricultural protection rates is even starker than in the case of the mean.

Some key figures of the distribution of the power of the tariff rate are evident in Table 2, which presents estimates for a range of selected countries. First, the global coefficient of variation of the power of the MFN tariff is 82 percent for all products but equals 11 percent for non-agricultural products and nearly 210 percent for agricultural products. So, at the global level, tariff heterogeneity is driven by the sharp difference between agricultural and non-agricultural products and by tariff heterogeneity within the set of agricultural products.

At the country level, the coefficient of variation of the power of tariff varies widely from 0 percent in Hong Kong and 1 percent in Chile to 606 percent in the Solomon Islands. Except for insular economies, Egypt has the largest value for developing countries (121 percent). Among rich countries, Iceland (117 percent), Norway (77 percent), and Switzerland (51 percent) have the most distorted trade policies. In general, intra-agriculture variation is stronger than intra-industry variation for developed countries and most developing countries. However, we can find the reverse situation for countries with comparative advantage in agriculture (Australia, Argentina, Georgia).

Table 2 Coefficient of Variation of the power of the MFN Tariffs, Percentage

	All	Non-agriculture	Agriculture
Argentina	6	7	4
Australia	6	6	2
Bangladesh	9	9	9
Bolivia	2	2	0
Botswana	20	10	45
Burundi	12	12	10
Canada	17	5	40
Chile	1	0	1
Ivory Coast	6	6	6
Egypt	121	11	233
EU25	14	3	30
Georgia	3	3	1
Iran	22	22	23
Japan	47	3	93
Russian Federation	6	5	8
Senegal	6	6	6
South Africa	20	10	45
Switzerland	51	7	84
USA	8	4	17
World	*82*	*11*	*209*

Source: MAcMapHS6v2.1 2004. Note: We compute the trade weighted coefficients of variation of the power of the MFN tariff.

When using a global general equilibrium model to analyze the consequences of reform what matters is not the variation of tariffs within agriculture and non-agriculture as a whole, but within the sectors used in the sectors used in the analysis. If tariffs are highly variable across the agricultural and non-agricultural sectors, but uniform within the sectors used in the analysis, then differences in the dispersion of tariffs may not matter for the conclusions. Figure 1 presents data on the part of the variation in protection that arises from variation within product groups.[1]

Figure 1 shows that the variation in tariffs within the product groups used to model reform is much greater for agriculture than for non-agriculture. Again, the tendency for agricultural tariffs to be more widely dispersed is stronger in regions with high agricultural protection, such as Japan; Korea/Taiwan (China); and Europe. Given the large differences in the dispersion of protection within the aggregated groups we use for analysis, it becomes particularly important to use an approach to aggregation that deals with this problem. Otherwise measures of the overall welfare impacts of liberalization—and of the relative importance for welfare of liberalization in different sectors—are likely to be misleading.

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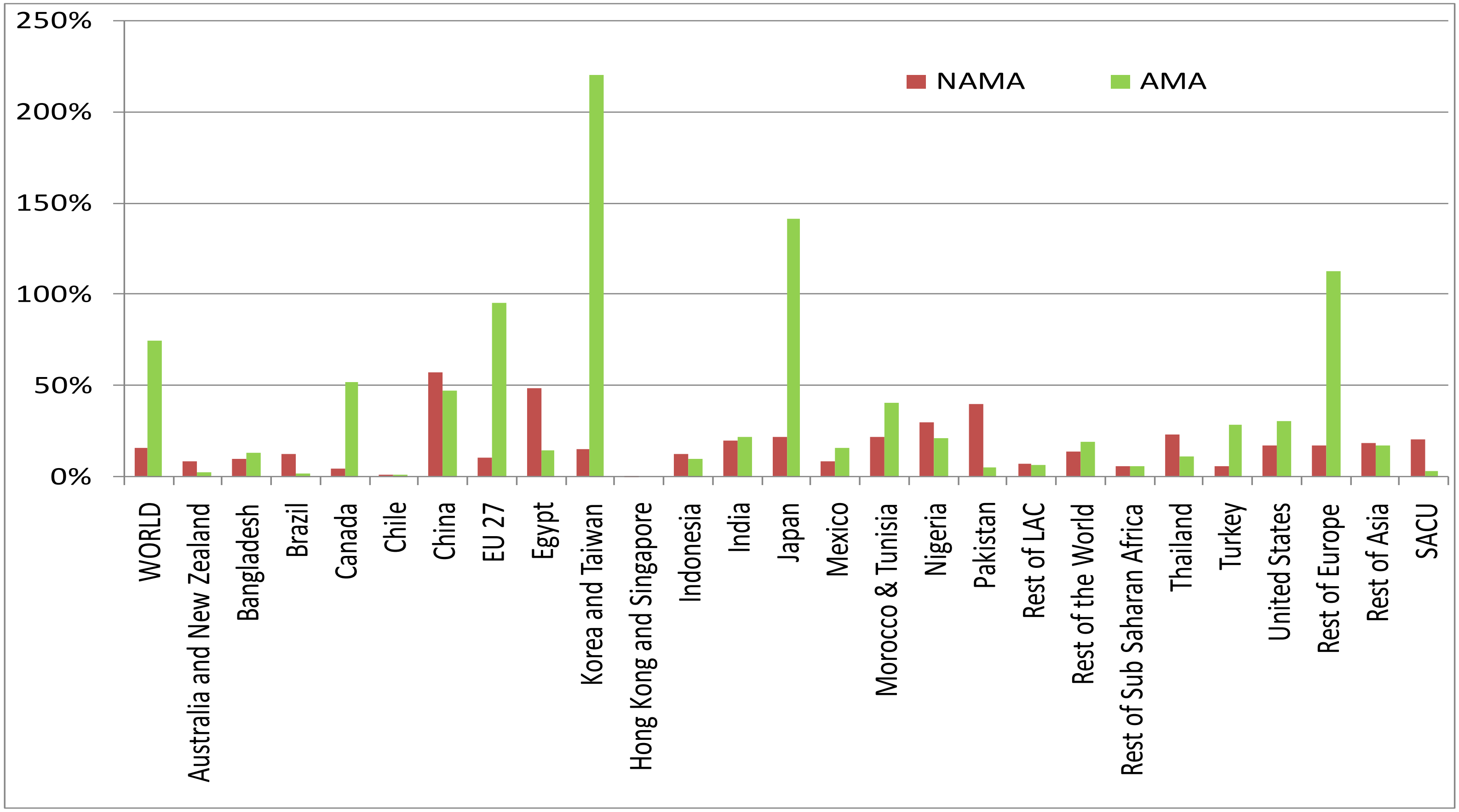
[1] Product groups are defined in Appendix A.

Figure 1 Coefficient of variation within the sectors used to model reform, Percentage



Source: MAcMapHS6v2.1 2004.
Note: For each sub sector given in appendix A, the coefficient of variation of the MFN tariff is computed. Then a simple average across agricultural sectors and industrial sectors is computed.

3 The Aggregation Approach

An important lesson from the literature on tariff aggregation (see Laborde, Martin and van der Mensbrugghe 2011), is that such indexes should be based on a model that relates the index to an economic objective. In this paper, our ultimate focus is on economic welfare, although we are interested in variables such as prices and trade volumes, partly for their own sake, and partly because they influence countries' welfare through terms of trade effects. Like Bach and Martin (2001), we assume that the structure of such a competitive, small open economy can be captured by the income-expenditure condition:

$$e(\boldsymbol{p},u)-r(\boldsymbol{p},\boldsymbol{v})-(\boldsymbol{e}_p-\boldsymbol{r}_p)'(\boldsymbol{p}-\boldsymbol{p}^w)-f=0 \qquad (1)$$

and the set of behavioral equations[2],

$$e_p(\boldsymbol{p},u)-r_p(\boldsymbol{p},\boldsymbol{v})=\boldsymbol{m} \qquad (2)$$

where $e(\boldsymbol{p},u)$ is the expenditure function of the representative household; $\boldsymbol{p}$ is a vector of domestic prices; $\boldsymbol{p}^w$ is the corresponding vector of exogenous external prices; u is domestic utility; $r(\boldsymbol{p},\boldsymbol{v})$ is domestic revenue from production; $\boldsymbol{v}$ is a vector of productive resources; $\boldsymbol{m}$ is the vector of imports, and f is an exogenously-determined net financial inflow from abroad. Given this representation of the economy, we can define a balance-of-trade function, which captures the financial inflow necessary to keep utility u constant when domestic prices $\boldsymbol{p}$ change (Anderson and Neary (1996)) and provides a money measure of welfare changes in a small open economy.

Based on equation (1) but taking the level of utility u^0 as exogenous, B can be written as:

$$B(\boldsymbol{p},u^0) = e(\boldsymbol{p},u^0) - r(\boldsymbol{p},\boldsymbol{v})-(\boldsymbol{e}_p-\boldsymbol{r}_p)'(\boldsymbol{p}-\boldsymbol{p}^w)-f = 0 \qquad (3)$$

Many papers (such as Anderson and Neary 2007) that use the balance-of-trade function to capture, for instance, the trade-restricting impact of distortions use a very simple model to estimate a single aggregator such as the Trade Restrictiveness Index. Here, by contrast, we want to be able to use a two-stage modeling approach that allows us to bring in information—such as

[2]We use bold letters for vectors.

information on the structure of production and domestic demand—that is economically important, but available only at a much higher level of aggregation than data on trade and trade distortions. In this way we can combine detailed information on trade distortions with the information in many more aggregated structural models such as econometrically estimated models of the type popularized by Kohli (2004); or with econometric (Jorgenson and Wilcoxen 1992) or calibrated (Hertel 1997) general equilibrium models.

The potential importance of such aggregation is clear when we recall that models of the type developed by Kohli have only a few sectors, and global computable general equilibrium models are typically solved with around 20 to 25 sectors. With four sectors in an estimated structural model of the type used by Kohli, there would be over 1300 traded goods per sector when using data on tariffs and trade at the highest degree of disaggregation available internationally—the six-digit level of the harmonized system. Even with 25 sectors, there are over 200 traded goods per sector, and tariffs frequently vary greatly within these sectors.

In the first stage of our analysis we compute indices that capture the information about tariffs within sectors. In the second stage, we use these indices to solve a more aggregated model. Deaton and Muellbauer (1980) provide the theoretical underpinnings for this type of two-stage modeling. If the utility function is weakly separable, then the consumer's maximization problem can be decomposed into the maximization of sub-utility functions over categories of products, and at a higher level, maximization of total utility over the sub-utility functions. If another condition—homotheticity of preferences at the lower level—is satisfied, then two stage-budgeting based can be used, with decisions at a higher level of aggregation based on aggregate prices and quantities passed up from the lower level. In a similar fashion, Chambers (1988) and Lloyd (1994) show that weak separability of the production function and homotheticity of the sub-aggregator functions allow two-stage decision-making approaches to be used to represent production technologies.

In the rest of the paper we assume that the conditions needed for the formation of sub-aggregate price and quantity indexes have been met. These assumptions are inherent in use of any aggregates, such as trade-weighted averages, and are not an additional requirement of our approach relative to use of traditional aggregators.

We further assume, following Armington (1969), that domestic products are differentiated from imported products for any given composite good, such as "crops". If the prices of domestically-produced goods are determined by returns on export markets, then $r(\boldsymbol{p},\boldsymbol{v})$ will be invariant to changes in tariffs, and import demand will equal $e_p(\boldsymbol{p}\text{-}\boldsymbol{p}^w)$, allowing further simplification of the model. It is useful to follow standard practice in the computable general equilibrium modeling tradition, and to assume separability between domestic and imported goods. If this is not done, the tariff revenue function may be non-monotonic in the tariff revenue aggregator with two values of the tariff aggregator—one on each side of the peak of the Laffer Curve—being consistent with any given tariff revenue[3]. In the following section, we develop aggregators for the two components of the model—the expenditure and tariff revenue functions—needed to capture the welfare impacts of tariffs in a small, open economy.

The tariff aggregator for expenditure

Based on the assumptions discussed above, we can define an expenditure function consistent with each of the sub-utility functions used in the analysis. If e_i is the expenditure function for commodity group *i*, then:

$$e_i=e_i(\boldsymbol{p}_i,u_i^0) \qquad (4)$$

where $\boldsymbol{p}_i$ is the vector of domestic prices for goods in set *i* and u_i^0 is the initial utility level associated with consumption of goods in this set. Like Bach and Martin (2001), we define the *tariff aggregator for expenditure* on commodity group *i* as the uniform tariff, τ_i^e, which, to maintain sub-utility level u_i^0, requires the same level of expenditure on imported commodities in the group as the observed vector of commodity-specific tariffs. At any given utility level, this aggregator is optimal for measuring the impact of the tariff on domestic prices given any vector of world prices, and hence for the quantity of imports demanded, and the terms of trade in a multi-country model. Since we are assuming homotheticity of the aggregator function, $e_i=p_i.u_i$ where p_i is the price of the composite good, and u_i is the volume of its consumption aggregated at domestic prices.

We can define the tariff aggregator for expenditure on commodity group *i* as the uniform tariff τ_i^e:

$$\tau_i^e=[\tau_i^e|e_i(\boldsymbol{p}_i^w(1+\tau_i^e),\ u_i^0)=e_i(\boldsymbol{p}_i,\ u_i^0)] \qquad (5)$$

[3] Since protection levels are generally determined primarily by political-economy pressures, rather than by tariff revenue goals, this ambiguity cannot be resolved by choosing the tariff rate to the left of the peak of the tariff revenue curve.

Since the commodity aggregators that we use are defined only over traded goods, we can use the homogeneity of degree one of the expenditure function to solve for τ_i^e, obtaining:

$$\tau_i^e = e_i(\boldsymbol{p}_i, u_i^0)/e_i(\boldsymbol{p}_i^w, u_i^0) - 1. \qquad (6)$$

The tariff revenue aggregator

Bach and Martin (2001) propose a tariff revenue aggregator defined in a similar fashion to the expenditure aggregator. A tariff revenue aggregator for commodity group *i* may be defined as the uniform tariff that will yield the same tariff revenue as the observed vector of disaggregated tariffs for that particular group of commodities, conditional on the utility level underlying the expenditure function:

$$\tau_i^R = [\tau_i^R | tr_i(\boldsymbol{p}_i^w(1+\tau_i^R), u_i^0) = tr_i(\boldsymbol{p}_i, \boldsymbol{p}_i^w, u_i^0)] \qquad (7)$$

Manole and Martin (2005) focused on identifying a closed-form solution for this aggregator. Anderson (2009) uses a simpler approach that we follow here, of calculating a trade-weighted average with endogenous quantity weights optimally chosen by the importer at each set of tariffs. At the initial tariff, this weighted average is the same as the conventional fixed-weight average. As tariffs change, the weights in the tariff revenue aggregator are updated using the specified import demand functions, and the two averages diverge. When multiplied by the value of imports at external prices, this weighted average, τ_i^R, returns the correct value of tariff revenues for any given vector of tariff rates.

Solving Global Models

In a single-country, small-open-economy model, the tariff aggregator for expenditure can be introduced into the expenditure function, and the tariff revenue aggregator into the tariff revenue equation, and the model used to solve for the welfare impacts of changes in tariffs. When this is implemented in a global model, however, a major difficulty arises because Walras' Law is not satisfied at the global level. When, for instance, a reduction in a particularly high tariff in one country results in a more rapid decline in expenditures than in tariff revenues, the country experiences a gain in real income without there being any corresponding increase in the value of production to meet the resulting increase in demand.

This problem can be solved, following Anderson (2009), by recognizing that quantity indexes at domestic prices are different from quantity indexes at world prices. Since expenditure on aggregate good *i* at domestic prices must equal expenditure on the good at border prices plus tariff revenue:

$$u_i(1+\tau_i^e)p^w = x_i^*(1+\tau_i^R)p^w \qquad (8)$$

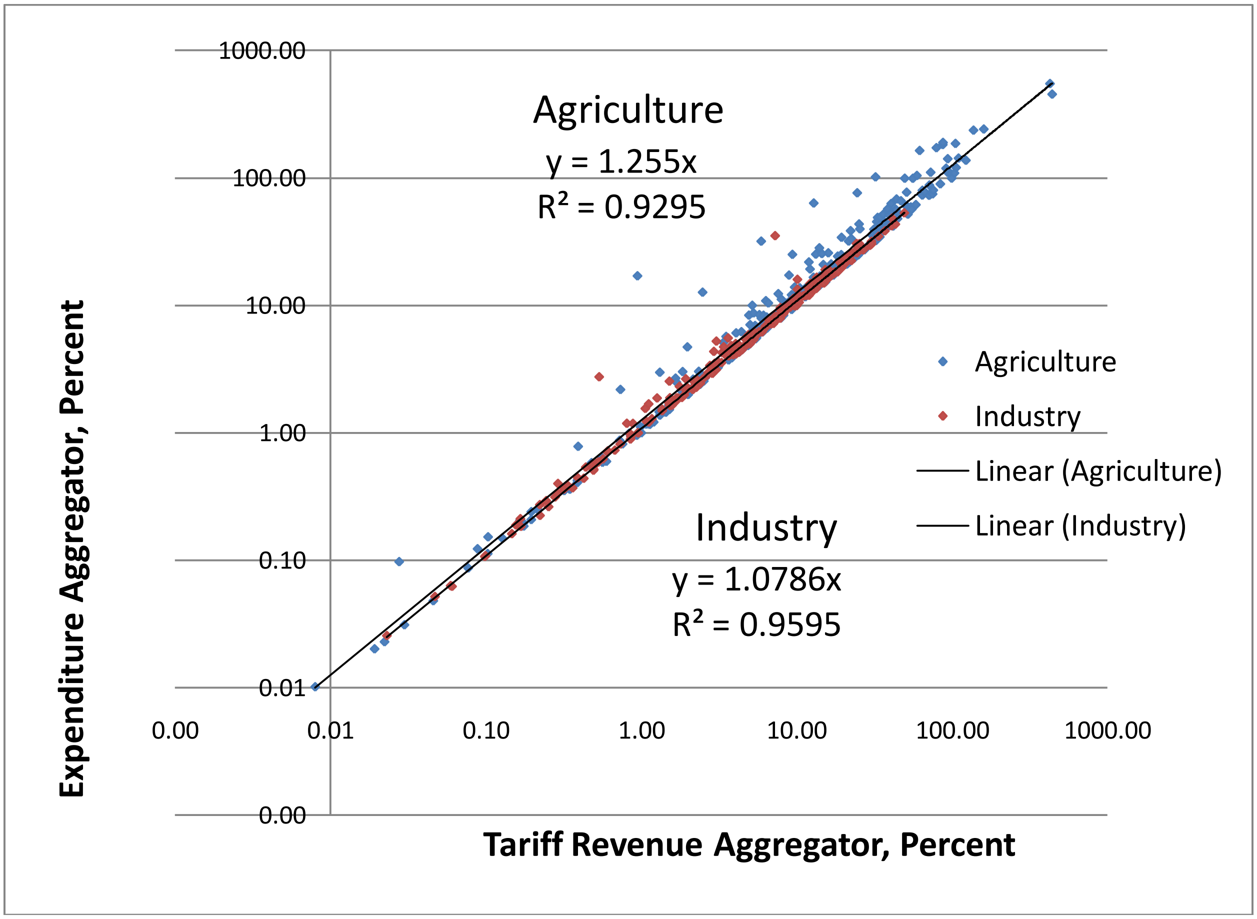
and hence

$$u_i = x_i^*(1+\tau_i^R)/(1+\tau_i^e) \qquad (9)$$

where u_i is the quantity of aggregate *i* consumed in the country (defined over domestic prices); x_i* is the quantity aggregate (at world prices) exported from the rest of the world to the country of interest; and all other terms are as previously defined.

The consequences of equations (8) and (9) are illustrated in Figure 2 by plotting the two indicators for all pairs of regions/sectors. The correlation is high, above 90 percent, but stronger for industry (0.96) than for agriculture (0.93). In addition the slope is much stronger for agriculture, It implies that the expenditure aggregator for agricultural sector is higher than for industry, illustrating also the large “within sector” tariff heterogeneity in agriculture

Figure 2 Measuring protection: Comparing Tariff revenue and Expenditure Aggregators



Source: MAcMapHS6v2.1 2004. Note: For each sub sector given in appendix A, and region of appendix B, we compute the tariff revenue aggregator and the expenditure aggregator based on equations 8 and 9 with an elasticity of substitution equals to 2. Each dot is a country/sector pair

3.1 Implementation

We use a two-tier strategy to implement this approach in the World Bank's LINKAGE global computable general equilibrium model (van der Mensbrugghe 2005) that has been widely used for analysis of major policy reforms. Our first step was to modify the structure of the model to distinguish between the aggregates at domestic and world prices identified in equations (8) and (9). We then calculated the tariff aggregators for expenditure and tariff revenues using the MacMapHS6 v2.1 database (Boumellassa, Laborde and Mitaritonna, 2009) that provides detailed information on bilateral tariffs and trade flows at the HS6 level. Finally, we performed a series of simulation experiments.

The aggregation procedure

For concreteness, we first present a simple illustration based on a one level aggregation problem where HS6 products are aggregated to the sectoral aggregation of the model. Then, we introduce real-world problems such as those arising from differences in the rates of protection applied on goods from different sources; where and where the model for an importing region is an aggregate of different countries. We focus first on the formation of aggregates for a single good, using data at the six-digit product level[4].

The expenditure aggregator

We first illustrate our approach in the simple case where one country imports goods from only one partner, the rest of the world. The Constant Elasticity of Substitution (CES) form is an appealing choice for several reasons: (i) its simplicity and parsimony, (ii) the availability of some relevant parameter estimates; and (iii) the ability to handle situations where the number of firms or commodities is endogenously determined (Feenstra 1994; Zhai 2008). Using a CES aggregator for products *j* being aggregated in group *i*, the price index for composite imported good *i* at domestic prices is (omitting the *i* index) given by:

$$p = (\sum_j \alpha_j (p_j^w(1+t_j))^{1-\sigma})^{1/1-\sigma} \qquad (10)$$

where t_j is the *ad valorem* tariff at the six-digit level of the Harmonized System.

Since our focus in this paper is primarily on aggregation of existing products, the α_j coefficients can be inferred using standard calibration procedures (Mansur and Whalley 1984). Given these values, the value of τ^e can be identified using

$$p = (\sum_j \alpha_j (p_j^w(1+t_j))^{1-\sigma})^{1/(1-\sigma)} = (1+\tau^e).(\sum_j \alpha_j (p_j^w)^{1-\sigma})^{1/(1-\sigma)} \qquad (11)$$

Which defines τ^e as:

$$\tau^e = (\sum_j \alpha_j (p_j^w(1+t_j))^{(1-\sigma)})^{1/(1-\sigma)} / (\sum_j \alpha_j (p_j^w)^{1-\sigma})^{1/(1-\sigma)} - 1 \qquad (12)$$

If we follow the usual convention in calibration of choosing units so that domestic prices equal unity, the α_j's are given by the initial value shares at domestic prices and the initial value of $\tau^e = (\sum_j \alpha_j (1+t_j)^{\sigma-1})^{1/(1-\sigma)} - 1$

[4] Our usage differs slightly from Broda and Weinstein's (2003, p548) distinction between goods at the tariff-line level and varieties supplied by individual countries because we need to distinguish between composite goods, six-digit products, and six-digit varieties.

Base case: the tariff revenue aggregator

As noted above, our tariff revenue aggregator is a trade-weighted index, but differs from the standard trade-weighted index in being calculated using trade weights that adjust in response to changes in tariff rates.

$$\tau^R = \Sigma_i \, t_i . p_i^w . q_i \, / \, \Sigma_k \, p_k^w . q_k \qquad (13)$$

where $q_i = \alpha_i(p_i/p)^{-\sigma}.u$ and, in contrast with the corresponding weight in a traditional trade-weighted-average, the value of q_i adjusts as tariff rates change. τ^R is computed in an aggregation module independent of the global model prior to its inclusion in the global model.

Practical considerations

While the theoretical discussion above considers only aggregation from the finely disaggregated product level up to the composite goods used in a large-scale model, we need to take into account two other levels of aggregation in applied modeling. The first of these arises from the practical problem that some regions in most global models will be aggregates covering more than one economy. A second is the fact that the six-digit products considered above are likely to include varieties supplied by different countries. We deal with this by using three different levels of nesting in the model.

At the highest level of aggregation, in cases where we have multiple importing countries in an importing region, we assume CES preferences across importing countries with an elasticity of substitution σ_0. At the second level of aggregation, we assume CES preferences over the HS6 products within the composite goods appearing in the version of the model that we use. At this stage, our HS6 products are aggregates over varieties imported from all supplying regions. At this level, we use the procedures identified in section (3.1) for the expenditure and tariff revenue aggregators, with elasticity of substitution σ_1. At the third level, we follow the Armington approach, assuming CES preferences across the six-digit varieties from different exporters. At this stage, we use an elasticity of substitution, σ_2 between the products provided by different suppliers.

Parameters

Given the approach to implementation that we have chosen, we need values of three different elasticities of substitution σ_0, σ_1 and σ_2:

- σ_0 is assumed to be equal to 1. We choose this value to hold constant each importer's share in the value of imports, primarily for want of better information;
- σ_1 is determined by the elasticity of substitution between imported six-digit products from all sources within a composite good—such as between apples and oranges within a composite of vegetables and fruits;
- σ_2 is the elasticity of substitution between varieties of six-digit products supplied by different countries/regions.

Assuming small trade shares for each product, which seems a generally reasonable approximation given that we have over five thousand commodities at the HS6 level, these elasticities of substitution seem likely to be very close to the elasticities of demand within the group. This allows us to draw on a number of relevant sets of parameter estimates in the literature. Kee, Nicita and Olarreaga (2008) provide estimates import demand elasticities at the six digit level, which average -3.12 for all HS products. These differ from the σ_1 elasticities that we seek in including substitution between domestic and imported varieties of the same six-digit product. Thus, if we were considering a fruit composite, we would include only substitution between imported apples, oranges and pears, while the Kee, Nicita and Olarreaga elasticities would allow substitution between domestic and imported varieties of each product. The exclusion of apples-to-apples comparisons suggests that our elasticities of substitution might be lower than the average for Kee, Nicita and Olarreaga. However, the high level of disaggregation at which we work suggests that our elasticities of substitution should not be too much lower than the Kee, Nicita and Olarreaga estimates.

Some other indirect evidence on the elasticities of interest is provided by Hummels and Klenow (2005, p712), drawing on Hummels (2001). They consider elasticities of substitution between varieties that are differentiated by HS six-digit product and by country of origin, concluding that these elasticities generally lie between five and ten. To the extent that these elasticities reflect the margins of substitution associated with both σ_1 and σ_2, we might expect them to be greater than our σ_1 elasticities of substitution but less than our desired estimates for σ_2. Broda and Weinstein (2006, p548) define varieties as goods produced by different countries, so that their elasticities of substitution are comparable to our σ_2 measures. They find (2006, p568), that the elasticity rises sharply as the categories considered become more finely distinguished, and estimated an average elasticity of substitution for products at the SITC-5 level (a slightly coarser level than HS6) of 13.1 as against 4.0 at the SITC-3 level. In our core scenario, we use σ_1=2, but also consider alternative values in a sensitivity analysis. For σ_2, we use 10 in our base case, and also perform sensitivity analysis.

In earlier simulation work (Laborde, Martin and van der Mensbrugghe 2011), we found that the aggregate welfare effects of reform were quite sensitive to the value of σ_1 but not particularly sensitive to the value of σ_2. This result reflects the fact that there is enormous variation in tariff rates across commodities, relative to the variation in tariff rates across sources of supply. Where tariffs are *ad valorem* and applied on a Most-Favored-Nation basis, there is, of course, no variation in tariff rates across suppliers. While this situation is, unfortunately, less common than might be hoped, the degree of discrimination across suppliers is reduced by WTO rules requiring that all tariffs be included in preferential trade arrangements, and permitting only a limited range of non-reciprocal preferences to developing countries (Hoekman, Martin and Braga 2009).

One important question is whether agricultural products should have higher values of σ_1 than non-agricultural products. At first blush, this seems a reasonable proposition given the distinction by Rauch (1999) of goods into three groups—commodity; reference-priced goods; and differentiated goods. Elasticities of substitution between suppliers are likely to be higher between commodities than between reference-priced goods, and lowest of all for differentiated products, as found by Broda and Weinstein (2006). But the elasticities of substitution that matter for our analysis are not those between suppliers (σ_2), but those between products (σ_1). It is far from clear that the elasticity of substitution between apples and cauliflowers should be higher than the elasticity of substitution between iron and steel. In the absence of hard econometric evidence on the relative values of the elasticities of substitution between agricultural commodities and those between other commodities in the product groups we use for analysis, we use the same values in all commodity groups.

4 Comparing Agricultural and Non-agricultural Liberalization

To compare the potential relative importance of liberalization in agriculture against that from non-agriculture, we consider the impacts of full liberalization in each sector relative to the effects of total liberalization. The specific commodities used for the modeling are set out in the Appendix.

Key results are summarized in Table 3, which shows the estimated welfare benefits of reform for industrial and developing countries. The table shows these benefits both by the region undertaking the reform, and by agricultural and non-agricultural trade liberalization. In the left-hand side of the table, these results are given in US dollars, relative to the 2004 benchmark year for the GTAP v7 database used in the analysis. In the right-hand side of the table, they are shown in percentage terms relative to the total welfare gain of $257.9bn per year estimated from global trade reform.

With the dataset used in the analysis, agricultural trade liberalization accounts for nearly 79 percent of the total welfare gains from global trade reform even when a standard aggregator is used. The large increase relative to the finding of Anderson, Martin and van der Mensbrugghe (2006) appears to reflect the move to a more recent database for global trade. Using the optimal aggregator raises this share by two percentage points, to just under 81 percent. In the industrial countries, the share of the overall gain coming from agricultural liberalization rises from 65 percent to 75 percent. In the developing countries, the situation is more complex because liberalization of their own non-agricultural sectors is estimated to have negative welfare effects when the standard weighted-average aggregator is used. With the optimal aggregator, agricultural liberalization contributes 92 percent of the welfare gains to developing countries.

Much more striking is the increase in the share of developing countries in the total gains—an increase reported in Laborde, Martin and van der Mensbrugghe (2011). Using the optimal aggregator, this gain accrues primarily as a result of developing countries own liberalization, rather than primarily as a consequence of liberalization in the high-income countries. The most important source of this gain is the virtual disappearance of the apparent losses to developing countries from own-liberalization in their non-agricultural sectors.

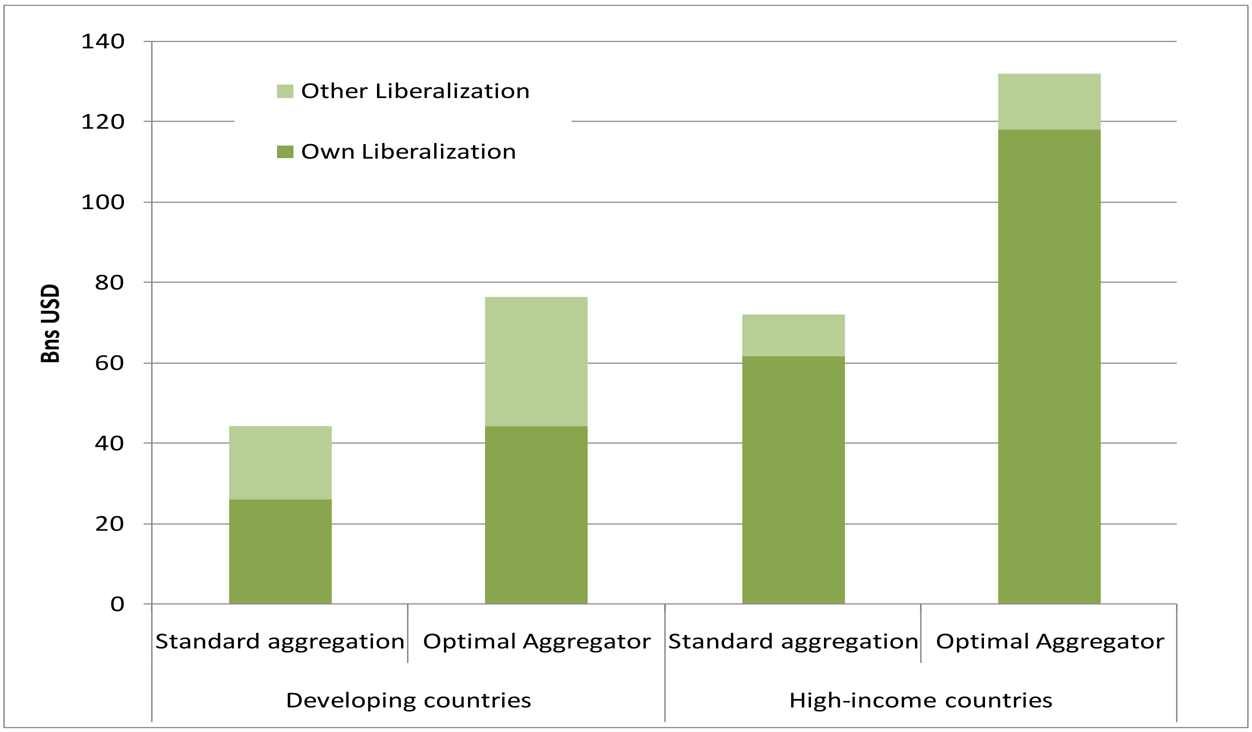
Table 3 Welfare results for liberalization by country groups and by commodity.

-	Gains, by region (US$ billion)			Regional gain (%)[a]		
	Developing countries	High-income countries	World	Developing countries	High-income countries	World
Standard aggregation						
Developing countries liberalize:						
Agriculture and food processing	25.9	10.4	36.3	17.6	7.1	24.7
Other goods and services	-15.6	44.5	28.9	-10.6	30.2	19.6
All goods and services	10.3	55.0	65.2	7.0	37.3	44.3
High-income countries liberalize:						
Agriculture and food processing	18.2	61.6	79.8	12.4	41.8	54.2
Other goods and services	8.8	-6.6	2.2	6.0	-4.5	1.5
All goods and services	27.1	55.0	82.0	18.4	37.3	55.7
All countries liberalize						
Agriculture and food processing	44.2	72.0	116.1	30.0	48.9	78.8
Other goods and services	-6.8	38.0	31.1	-4.6	25.8	21.2
All goods and services	37.4	109.9	147.3	25.4	74.6	100.0
Optimal aggregation						
-						
Developing countries liberalize:						
Agriculture and food processing	44.2	14.0	58.3	17.1	5.4	22.6
Other goods and services	-2.0	45.6	43.6	-0.8	17.7	16.9
All goods and services	42.2	59.6	101.8	16.3	23.1	39.5
High-income countries liberalize:						
Agriculture and food processing	32.2	118.1	150.3	12.5	45.8	58.3
Other goods and services	8.7	-2.9	5.8	3.4	-1.1	2.3
All goods and services	40.9	115.2	156.1	15.9	44.7	60.5
All countries liberalize						
Agriculture and food processing	76.4	132.1	208.5	29.6	51.2	80.9
Other goods and services	6.7	42.7	49.4	2.6	16.6	19.1
All goods and services	83.1	174.8	257.9	32.2	67.8	100.0

Source: Linkage model Simulations.

The share of the agricultural gain to developing countries coming from their own agricultural liberalization – as a group – remains roughly constant, at around 60 percent as is evident in Figure 3. In the high income countries, the share of this gain coming from own liberalization is much higher, at around 86 percent using the standard weighted averages, and rises to 89 percent using the optimal aggregator. However, in each case, the important change is the increase in the magnitude of the gains from agricultural trade reform, rather than the increase in the importance of those obtained from own-liberalization.

Figure 3 The importance of own-liberalization in the gains from agricultural trade reform



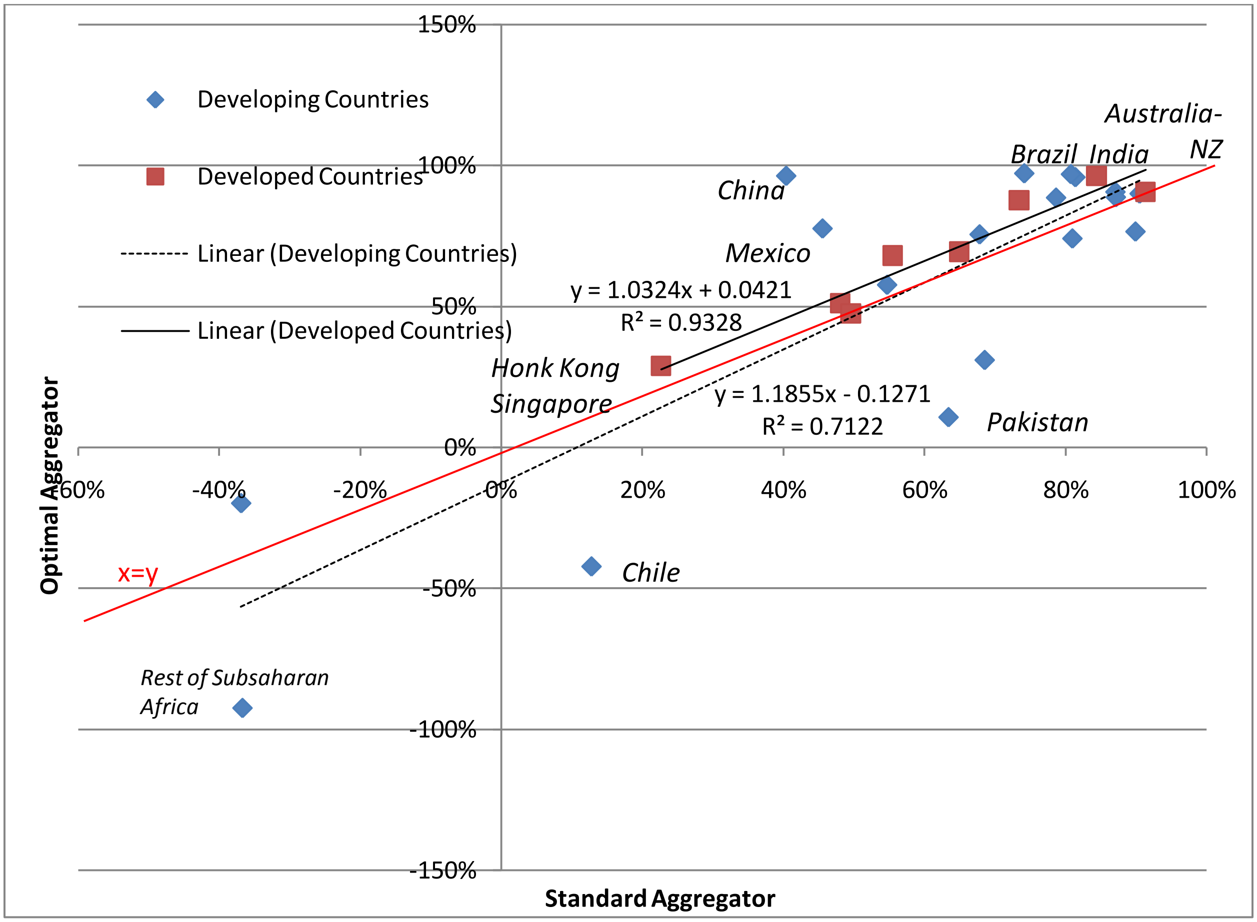
Source: Linkage model Simulations.

Going to the country/region level shows a similar picture. On Figure 4 we display the ratio of the agricultural liberalization welfare effects over the absolute value of welfare changes for both agricultural and non agricultural trade liberalization. For all developed countries/regions[5], except Japan, included in the analysis the role of agricultural trade liberalization is reinforced. Interestingly, for another highly protected and distorted region – rest of Western Europe (Norway, Iceland and Switzerland) – no changes take place. For the European Union, the share of agricultural liberalization

[5] Australia and New Zealand, United States of America, Canada, Japan, the European Union, South Korea and Taiwan, Hong Kong and Singapore, Rest of Western Europe.

increases from 73 to 88 percent. This comparison shows that even if we expect that for highly distorted regions the optimal aggregator will magnify welfare gains, this is not always the case and the use of a global CGE remains important. Indeed, positive effects on consumer welfare are counter balanced by terms-of-trade effects at the macro level (large volume increase of imports). However, for traditional exporters, such as Australia and New Zealand, or Canada the effects is unambiguous and both the domestic trade reform and the terms-of-trade effects of global liberalization move in the same direction.

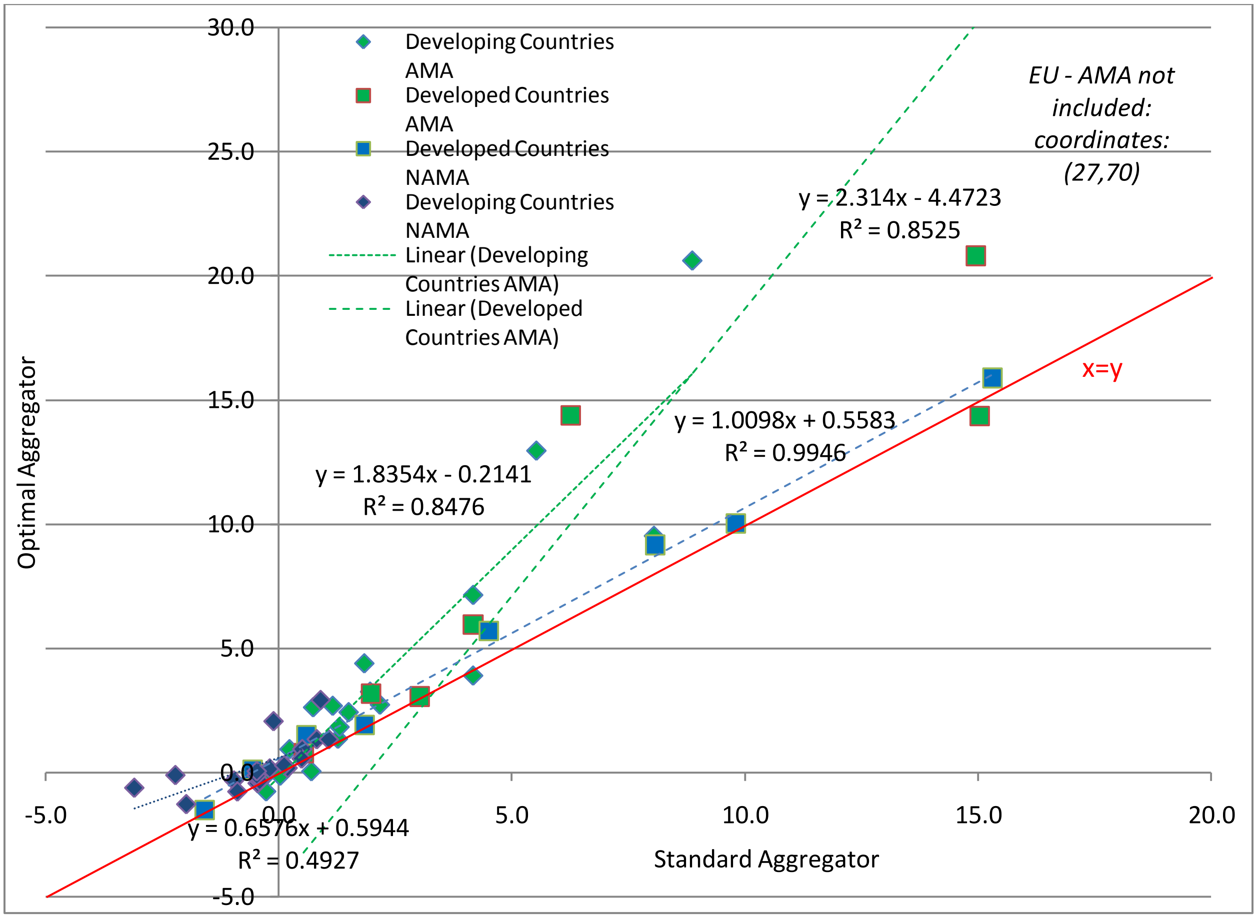
Figure 4 Role of AMA liberalization in total welfare changes



Note: The contribution of AMA liberalization is measured as the welfare changes in dollars driven by the agricultural liberalization divided by the sum of the absolute value of welfare change due to AMA and NAMA liberalization.
Source: Linkage model Simulations.

For developing countries, the picture is much more contrasted and if for exporters, such as Brazil or India, see the role of agricultural trade liberalization increased, some exporters, as Chile face a different situation. Indeed, in Figure 4, Chile is in the low-right quadrant, implying that the agricultural liberalization has moved to a positive contribution to a negative one. This effect is driven by a particular evolution of the terms of trade for this country. Indeed, even if it should have benefited from the removal of distorted foreign trade policies, but, it suffers mainly from preference erosion in major markets, such as Mercosur, the US and the EU, with which it has already has Free-Trade-Agreements. With the optimal aggregator approach, the exports of its competitors on these markets become much more attractive, due to the elimination of distorted tariffs when Chilean exports, facing no distortions, could not benefit from this effect. For another region, rest of sub Saharan Africa in the low right quadrant, in a similar situation and most effects play against this region: the negative contribution to welfare change of the agricultural liberalization is increased. Overall, we check that the effect of the optimal aggregator on the role of agricultural trade liberalization is stronger for developing countries (lower R^2 in the correlation between the results of the two aggregators for developing countries, with a steeper slope). This result is confirmed by Figure 5 (absolute gains in level) and Appendix 3 that looks at the regression in the change of results based on tariff distribution indicators.

Figure 5 Absolute gains (bn USD) in AMA and NAMA at the country/region level with alternative aggregators



Source: Linkage model Simulations.

5 Conclusions

Traditional approaches to aggregation of trade distortions ignore the variations in trade barriers within the broad sectors used in the analysis, and tend to underweight the importance of products subject to high trade barriers. Because of this, it seems likely that they will underestimate the benefits of agricultural trade reform given the high variation in agricultural trade barriers in many countries. The purpose of this paper is to apply a new approach to aggregating trade barriers in order to assess whether it is, indeed, the case that the potential contribution of agricultural trade reform to the potential benefits of national and global trade reform rises when the benefits of reform are correctly measured.

We use a new approach to aggregation that takes into account the importance of variations in trade barriers within the composite sectors used for analysis for the welfare implications of reform. It does this by identifying two different tariff aggregators for each sector—one that is optimal for representing the effects on expenditure of changes in disaggregated tariffs, and one that represents the effects of changes in tariffs on government revenues raised. This approach allows us to measure more accurately the impacts of changes in protection on the full welfare impacts—including those arising from changes in the terms of trade—of trade policy reforms.

With the database used, the share of the potential benefits of global trade reform coming from agriculture is already very high, at over three quarters. Our analysis finds that moving to optimal aggregators leads to small increases—in the order of two percentage points—in the share of the potential global welfare benefits from reform.

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Appendix 1

Commodity Aggregation Used in the Analysis

For the analysis in this paper, we aggregated the 57 commodities included in the GTAP v7 database into the following 26 commodities for use in the model. The tariff aggregators were estimated for each of these commodity groups prior to undertaking the analysis. For the reasons outlined in the text, the results of the analysis should be much less vulnerable to differences in the extent to which one sector has been arbitrarily disaggregated more than another.

ric	Rice
gro	Other grains
osd	Oil seeds
sug	Sugar
pfb	Plant-based fibers
v_f	Vegetables and fruits
ocr	Other crops
lvs	Livestock
onr	Other natural resources
ffl	Fossil fuels
pmt	Processed meats
vol	Vegetable oils and fats
mil	Dairy products
ofd	Other food
b_t	Beverages and tobacco
tex	Textile
wap	Wearing apparel
lea	Leather
crp	Chemicals rubber and plastics
i_s	Iron and steel
mvh	Motor vehicles and parts
cgd	Capital goods
omf	Other manufacturing
cns	Construction
svc	Utilities and services

Appendix 2

Country results

This appendix provides the detailed results at the country/region level used in and .

	Share in absolute variation(1)		**Welfare AMA - Bns USD**		**Welfare NAMA - Bns USD**	
	Standard Aggregator	*Optimal Aggregator*	*Standard Aggregator*	*Optimal Aggregator*	*Standard Aggregator*	*Optimal Aggregator*
World total	79%	81%	116.2	208.6	30.9	48.9
Bangladesh	-37%	-20%	-0.3	-0.1	-0.4	-0.4
Brazil	87%	91%	5.5	13.0	0.8	1.3
Chile	13%	-42%	0.0	-0.1	0.2	0.2
China	40%	96%	1.5	2.4	-2.2	-0.1
Egypt	69%	31%	0.2	0.9	-0.1	2.1
India	81%	96%	4.2	7.1	-1.0	-0.3
Indonesia	87%	89%	1.3	1.3	-0.2	0.2
Pakistan	63%	11%	0.7	0.0	-0.4	-0.3
Thailand	81%	74%	2.2	2.7	0.5	1.0
Mexico	46%	78%	0.7	2.6	-0.9	-0.8
Nigeria	55%	58%	1.3	1.8	1.1	1.3
Turkey	79%	89%	1.8	4.4	0.5	0.6
Rest of Asia	90%	76%	8.0	9.5	0.9	2.9
Rest of LAC	68%	75%	4.2	3.9	-2.0	-1.3
Morocco & Tunisia	81%	97%	2.0	3.2	-0.5	-0.1
SACU	90%	90%	1.2	2.7	0.1	0.3
Rest of Sub Saharan Africa	-37%	-93%	-0.3	-0.8	-0.5	0.1
Rest of the World	74%	97%	8.9	20.6	-3.1	-0.6
Australia and New Zealand	84%	96%	3.0	3.1	-0.6	0.1
Rest of Europe	91%	91%	6.3	14.4	0.6	1.5
EU 27	73%	88%	27.1	70.7	9.8	10.0
United States	48%	51%	4.2	6.0	4.5	5.7
Canada	56%	68%	2.0	3.2	-1.6	-1.5
Japan	50%	47%	15.0	14.4	15.3	15.9
Korea and Taiwan	65%	69%	15.0	20.8	8.1	9.2
Hong Kong and Singapore	23%	29%	0.5	0.8	1.8	1.9

Note: (1) The contribution of AMA liberalization is measured as the welfare changes in dollars driven by the agricultural liberalization divided by the sum of the absolute value of welfare change due to AMA and NAMA liberalization.

Source: Linkage Model Simulations

Appendix 3

Estimated contribution of the ex-ante within sector coefficient of variation of the power of tariff

In this section, we estimate the elasticities of welfare changes (percent) using the optimal aggregator vs the standard aggregator to the average of the within-sector coefficient of variation (CV) of the power of the tariff expressed as a percentage. This test aims to check if ex-ante information on the tariff distribution is sufficient to explain the changes in welfare impact computed with the standard or the optimal aggregator. If for NAMA liberalization, the initial coefficient of variation of applied tariffs appears to explain the changes observed for agricultural liberalization, this result holds only for Developing countries for which an increase in 1 point of the coefficient of variation raise the welfare gains by 0.05 percentage point. This result confirms our previous findings for which some countries (e.g. Japan, or Rest of Western Europe) were not positively affected by the use of the optimal aggregator despite large distortions.

	Impacts on AMA liberalization effects	**Impact on NAMA liberalization effects**
All countries	AMA applied Tariff CV: *ns*	NAMA applied Tariff CV: 0.04**
Developed countries	AMA applied Tariff CV:*ns*	NAMA applied Tariff CV: 0.008**
Developing countries	AMA applied Tariff CV:0.05**	NAMA applied Tariff CV: 0.07**

Note:
ns stands for non significant, * coefficient significant at 5 percent, ** coefficient significant at 2 percent.
Source: Linkage model Simulations.