Web Appendix

for: Distributional effects of WTO agricultural reforms in rich and poor countries

Thomas W. Hertel* & Roman Keeney*, Maros Ivanic**, L. Alan Winters**

*Purdue University, **The World Bank

Published in:

***Economic Policy* 50, April 2007**

1. Annex I: Development and Focus of the Macro-Modeling Framework

Francois et al. (2005), offer a thorough overview of the potential impacts of the Doha Development Agenda. Their analysis encompasses seven agricultural sectors and one for processed food, sixteen regions, estimates of trade barriers to services and increasing returns to scale and imperfect competition in industrial and service sectors. Our focus on agriculture and distributional effects leads us to use the GTAP-AGR model (Keeney and Hertel, 2005), a modified version of the widely used GTAP model. GTAP-AGR was specifically developed to incorporate greater detail and current econometric evidence on agricultural commodity and factor markets, with an eye towards improving the ability to simulate farm income changes arising from changes in factor rewards.

The GTAP database we apply the model to has ten agricultural and seven food sectors in 34 regions/countries including, the sixteen focus countries (15 developing plus the USA). The GTAP-AGR model maintains the assumptions of perfect competition and constant returns to scale in production. Abstracting from potential imperfect competition in manufacturing and services (which are not central to our analysis) makes our model more robust and facilitates systematic sensitivity analysis with respect to the trade elasticities. The latter are based on the econometric estimates reported in Table A.1.1, and we use the associated standard errors in our analysis of the sensitivity of key results to parametric uncertainty.

Factor market supply and demand elasticities are critical in our analysis of agricultural reforms. We draw on the OECD’s (2001) Policy Evaluation Matrix documentation which provides central parameter values, as well as upper and lower bounds on factor supply elasticities to agriculture for five regions (EU, Canada, Mexico, USA, Japan). Table A1.2 provides the central values and implied standard deviations from these five regions for labor and capital supply elasticities as well as the mapping to other regions in our model. Following the OECD we assume identical factor supply elasticity distributions for agricultural labor and capital in each region. The remaining primary factor, land, is specific to agriculture in the GTAP database, and a constant elasticity of transformation function is used here to reflect the limited mobility of farm land amongst agricultural uses. This is calibrated to reproduce the central value for acreage response in the OECD study using the same regional mapping and is reported in the second row of Table A1.2. In our systematic sensitivity analysis, we assess the robustness of our results with respect to the factor supply assumptions by sampling from the underlying distributions reported in this table. Thus, we generate a distribution of results (mean and standard deviation) that can be used to evaluate the robustness of our reported results.

In addition to factor supplies to agriculture, we have also modified the factor demand parameters in the GTAP model to better reflect the impact of input and output subsidies in rich country agriculture on factor returns. Specifically, we employ a nested-CES production function for agriculture that is calibrated to the three key elasticities of substitution available from the earlier referenced OECD report (see Keeney and Hertel, 2005, for details on the calibration approach). These parameters include: the elasticity of substitution amongst farm-owned inputs (land, labor and capital), the elasticity of substitution amongst purchased inputs, and the elasticity of substitution between these two composites. Central values and standard deviations are reported in rows three through five of Table A1.2. Once again, these standard deviations feed into our sensitivity analysis.

In the case of the livestock sectors, one additional modification is required to accurately reflect the inter-sectoral interactions generated by the use of feedstuffs in livestock production. The potential for alternative feedstuffs to substitute for one another in livestock rations constrains crop prices to move together, at least to some degree. Thus the demand for feedstuffs for livestock sectors is treated as a sub-nest of the purchased inputs aggregate. The elasticity of substitution amongst feedstuffs is based on the estimates by Surry (1990), from which we obtain a share-weighted average value of 0.9.

While it is appealing to base our analysis on these econometrically estimated parameters, there remains the question of how well the model captures reality when operating as a general equilibrium system. Fortunately, the GTAP-AGR model has recently been subjected to validation experiments using historical data on price variability in agricultural commodity markets (Valenzuela et al., 2005). Specifically, the authors subject the supply side of the model to random shocks, based on historically observed variation in wheat supplies. The resulting distributions of price outcomes in each region are compared to the observed variation in prices over this same period.

Overall, the model performs quite well. However, it does have a tendency to predict too much price volatility for net importing regions and too little for net exporters. Those authors show that this aspect of the model's predictive ability can be improved by incorporating additional estimates of market insulation for the major wheat importers. In short this framework seems to be well-suited for agricultural-focused analysis.

The standard deviations reported in Tables A.1.1. and A.1.2 emphasize the fact that the parameters driving results are uncertain. The large number of parameters embodying differing degrees of uncertainty and their interactions in the model solution clearly point to the need for a systematic sensitivity analysis of model results. Sensitivity analysis of simulation models is typically carried out using Monte Carlo approaches over empirical distributions, but this method requires a prohibitive number of model solutions for the scale of analysis conducted here. Fortunately, Arndt (1996) has developed the Gaussian Quadrature (GQ) method as an alternative requiring far fewer solutions yet maintaining much of the approximation accuracy of Monte Carlo sampling.

Gaussian Quadrature as applied in GTAP (and GTAP-AGR) is a numerical integration technique to approximate the distributional character of results by intelligent selection of replication points from the parameter distribution. The points are chosen to exactly match the integral over a third-order polynomial. Assuming that our CGE model relationships are well-approximated by a third-order polynomial our sensitivity results will be robust. Arndt (1996) tests this question using the GTAP model and concludes that the GTAP model is well approximated by a third-order polynomial as the results of Monte Carlo and GQ approximations are quite consistent. In order to implement GQ in our model, we assume that our parameter distributions are independent, and can be approximated by a finite symmetric triangular distribution.

Table A.1.1. Trade Elasticities

Sector	Domestic-Import Substitution Elasticity	Standard Deviation
Rice	5.05	2.00
Wheat	4.45	2.10
Coarse Grains	1.30	0.55
Oilseeds	2.45	0.40
Sugar	2.70	1.00
Cotton	2.50	1.20
Other Crops	2.31	0.20
Milk	3.65	0.40
Cattle	2.00	0.35
Non-Ruminant Animals	1.30	0.15
Fish	1.25	0.30
Forestry	2.50	0.35
Processed Dairy	3.65	0.40
Processed Beef	3.85	0.95
Other Meats	4.40	0.45
Processed Sugar	2.70	1.00
Processed Rice	2.60	1.30
Processed Oilseeds	3.30	0.35
Other Food	1.69	0.05
Textiles and Wearing Apparel	3.81	0.05
Automobiles	2.80	0.15
Heavy Manufactures	3.22	0.20
Electronics	4.40	0.10
Other Manufactures	3.99	0.10
Petrol	2.88	0.55

Table A.1.2. Factor Supply and Demand Elasticities in the Model

	Canada	EU	Japan	Mexico	USA
Factor Supplies					
Labor/Capital	0.40 (0.12)	0.50 (0.16)	0.50 (0.16)	0.50 (0.08)	0.40 (0.12)
Land	0.40 (0.08)	0.25 (0.06)	0.25 (0.06)	0.40 (0.08)	0.40 (0.08)
Factor Substitution					
On-farm and Purchased	0.90 (0.37)	0.90 (0.24)	0.40 (0.16)	0.50 (0.20)	0.80 (0.33)
On-farm	0.10 (0.04)	0.40 (0.20)	0.30 (0.24)	0.50 (0.20)	0.30 (0.20)
Purchased	0.10 (0.04)	0.50 (0.20)	0.30 (0.12)	0.15 (0.06)	0.15 (0.06)
Parameter Mapping					
Maps to:	CAN, AUSNZL	EUEFTA, XER, FmUSSR	JPN, DVDASIA	MEX, All Other Regions	USA

Source: OECD (2001)

Annex II: Micro-level Results from Macro-modeling Frameworks

Tracing the effects of macroeconomic shocks through to individual households or groups of households has attracted a lot of interest recently, especially among scholars interested in poverty. Winters (2002) and Winters et al. (2004) provide an analytical framework and survey of the somewhat patchy empirical literature relevant to trade liberalization and poverty, while Bourguignon and Pereira da Silva (2003) take a broader view. Hertel and Reimer (2005) also survey the trade-poverty field, but with much greater emphasis on CGE modeling methods and findings.

The most complete approach to modeling poverty impacts using CGE models embeds household behavior fully within the national CGE model, solving simultaneously (and hence consistently) for household and macro-level variables. Rutherford, Tarr and Shepotylo (2006) epitomize this approach, embedding 55,000 households endogenously into a CGE model of Russia. This level of detail comes at high computational cost. Jensen and Tarp (2005), in their study of Vietnam, compare two static CGE models with embedded households: the first depicts 5999 actual households from the national household survey, while the second aggregates these into 16 representative household types for computational efficiency. Unfortunately in this case, the results appear to differ by approach so it is unclear whether the 'short-cut' of multiple representative households is worthwhile.

At the other extreme is a first-order approximation approach to linking trade reform with poverty outcomes. This approach combines a national CGE model with detailed household survey data and a linear approximation to the welfare function for any given individual household in the survey. Implementation involves solving the CGE model in the first step and passing the resulting changes in commodity prices, factor prices and possibly quantities and employments to the latter from which welfare effects can be estimated.[1] Chen and Ravallion (2004) provide an informative example of this approach, focusing on Chinese accession to the WTO. They use a sample of over 80 thousand households which they analyze by region and income level. They conclude – along with other scholars – that WTO accession is likely to impose losses on many agricultural households in China because it opens up agricultural markets and reduces agricultural prices. For this reason, poverty is likely to increase. Chen and Ravallion also find, *inter alia*, that although overall income distribution is not changed much by accession, there is considerable 'churning,' whereby individual households face material changes in real income, essentially swapping places in the distribution.[2]

Hertel et al. (2004) adopt an approach that lies between these two extremes in their analysis of the impact of global trade reforms on household welfare in Indonesia. These authors distinguish seven classes of households according to their predominant source of income – e.g. wages, farm profits, transfers, etc. – and disaggregate each class into 20 vigintiles. Thus, their model is populated by 140 'representative' households. They estimate a general consumption model (the AIDADS, see subsequent annex), which is used both in the CGE model and in the micro-simulation model to model behavior of the 140 representative households. This approach permits them to predict continuously varying consumption bundles as income rises from the subsistence level to the top of the income distribution, based on a common set of national preferences. In so doing, they are able to identify the poverty level of utility, which becomes a parameter in the model and which permits an unambiguous assessment of changes in poverty headcounts as prices, incomes and the composition of the consumption bundle changes in the wake of trade liberalization. These authors do not permit the changes in income distribution to influence aggregate demand, arguing that such changes are very small and unlikely to play a significant role. However, they do emphasize the critical importance of reconciling national accounts and household survey data on incomes – particularly with regard to the imputation of wages associated with self-employed labor (see next Annex).

Hertel and Winters (2006) is conceptually similar in its estimates of the poverty implications of the DDA, but with up to three levels of sequential modeling. First, a detailed global CGE model is solved with representative households to calculate the effects of the DDA on each country's trading environment (world prices of imports and shifts in export demand). These are then passed to national CGE models for twelve country case studies to estimate the effects of the DDA changes on welfare allowing households and firms to respond to the new incentives. The models in the different case

[1] The problem with this is that the representative household model makes assumptions about aggregate household behavior that may not be precisely replicated by the household model so that there is in principle an inconsistency. If the shocks are small, however, and the CGE model appropriately calibrated, the inconsist9ency is probably quite small.
[2] A much earlier example of the approach is Adelman and Robinson (1978).

studies emphasize different national characteristics in order to capture locally critical dimensions of poverty and income-generation – for example, employment decisions in Brazil, internal transportation margins in Mexico, etc. Finally, all the national models produce estimates of the poverty impacts of the shock, some from household models embedded into the national models and some by passing prices, wages, etc to a separate household module as previously discussed.

The diversity of approaches in Hertel and Winters' national models reflects well the country and case-specificity of the poverty effects of trade liberalization (see Winters et al, 2004), but it does impede the calculation of global aggregates and comparisons across countries. Thus, a further simplification in the search for a computationally tractable approach to poverty estimates is sometimes used. This entails solving a CGE model with a single representative consumer, while considering the effects of a shock only on a few statistics such as unskilled wages, average incomes, food prices, the consumer price index, etc. 'Poverty elasticities' are then applied to the resulting change in average incomes generating an estimate of the implied change in poverty. (The poverty elasticity relates the proportionate change in poverty to the proportionate change in *per capita* GDP – see, for example, Ravallion, 1997). This is the approach in Cline (2004), who gets very high estimates for highly stylized global liberalizations – around 400 million pulled out of poverty.[3] World Bank (2001, 2003) and Anderson et al. (2006) use a similar approach, but base their poverty changes on poverty response to average unskilled wages deflated by the food price index rather than GDP per capita.

One issue that is prominent in the comparison between these two sets of estimates is the initial estimate of poverty. Cline applies his projected proportionate change to actual poverty numbers for 2001, while the World Bank applies them to an estimate of poverty for 2015, when the DDA transitional period is likely to end. Van der Mensbrugghe (2006) analyzes why the World Bank estimates of the poverty impacts of DDA have fallen and finds falling base-line poverty and falling estimated poverty elasticities important, as well as declines in estimated economic impacts of the DDA due to changes in the global base (China's accession etc.) and in estimates of protection.

[3] Crucially, Cline uses the GTAP 5 data base which abstracts from LDC preferences (i.e., assumes they do not exist so preference erosion is not present), and which applies a simple (unweighted) average tariff rule in agriculture. Its 1997 base also does not reflect the accession of China to the WTO, full implementation of the Uruguay Round. In addition, the stylized poverty elasticities in his study appear quite high relative to those computed based on actual household survey data.

A second issue concerns the provenance of the poverty elasticities applied. These are typically derived by characterizing the pre-shock income distribution in a very simple way and then assuming that every individual's income rises by the amount of the average increase. The income distribution is usually taken to have a simple parametric form and parameters derived from income distribution data. Thus, Cline (2004) assumes a lognormal income distribution, which may be fully parameterized using only information on the Gini coefficient and the ratio of poverty income to income per capita (i.e. two pieces of information). World Bank (2003) and Anderson et al. (2006), on the other hand, use a generalized quadratic distribution estimating the three parameters from the seven observations as reported for each country in *World Development Indicators* (Table 2.8). By contrast, the earnings/ stratum/country-specific elasticities (70 elasticities per country) used in our analysis are driven entirely by the survey data with no distributional assumptions imposed; we only seek to characterize behavior in the neighborhood of the poverty line.

Annex III: Reconciling the household survey data with GTAP

As noted previously in this paper, it is critically important to “get the factor shares right” for purposes of trade policy analysis. In their work on Brazil, Harrison, Rutherford, Tarr and Gurgel (2005) find that the question of whether or not trade reform in that country benefits the poor hinges largely on the factor intensity of agriculture. In the GTAP data base it is capital intensive (see Table A.3.1). However, this appears to be largely due to an incomplete imputation of the returns to self-employed labor, which are erroneously attributed to capital. When Harrison et al. estimate these factor shares directly, they find that Brazilian agriculture is unskilled labor intensive (see also Table A.3.1). This means that an expansion of agricultural activity under trade reform will raise unskilled wages, relative to other factor returns, thereby benefiting the poor, for whom this is the primary source of income.

For this study, we have imputed returns to self-employed skilled and unskilled labor, based on the wages of comparable workers in the commercially employed labor force. With these imputations, as well as estimated returns to capital and land, for the entire agriculture sector in each of the 15 focus countries, we compute the agriculture-wide factor intensity. The GTAP factor payment data are then adjusted by imposing these survey-based agriculture-wide factor intensities, while keeping total value-added constant. As can be seen from a comparison of the factor intensities in Table A.3.1, the survey-based estimates (used in this study) suggest that agriculture is much more unskilled labor intensive than implied by the GTAP estimates.

Table A.3.1. Comparison of Value Added Cost Shares in Agric.: GTAP and Survey Estimates

Region	GTAP 6.1 Cost Shares				HH Survey Cost Shares			
	Land	ULab	SkLab	Capital	Land	ULab	SkLab	Capital
Indonesia	0.51	0.42	0.00	0.07	0.13	0.78	0.01	0.09
Philippines	0.41	0.54	0.01	0.04	0.29	0.54	0.01	0.15
Thailand	0.51	0.42	0.00	0.07	0.04	0.93	0.02	0.02
Vietnam	0.51	0.42	0.00	0.07	0.19	0.73	0.00	0.08
Bangladesh	0.44	0.38	0.00	0.18	0.02	0.96	0.00	0.02
Mexico	0.28	0.46	0.01	0.25	0.09	0.78	0.00	0.13
Colombia	0.28	0.46	0.01	0.25	0.12	0.76	0.00	0.12
Peru	0.28	0.46	0.01	0.25	0.10	0.73	0.04	0.13
Venezuela	0.28	0.46	0.01	0.25	0.18	0.61	0.00	0.21
Brazil	0.16	0.23	0.01	0.60	0.04	0.78	0.03	0.15
Chile	0.28	0.46	0.01	0.25	0.07	0.82	0.00	0.10
Malawi	0.15	0.60	0.01	0.25	0.13	0.61	0.00	0.25
Mozambique	0.15	0.60	0.01	0.25	0.10	0.69	0.00	0.21
Zambia	0.15	0.60	0.01	0.25	0.14	0.50	0.00	0.35
Uganda	0.12	0.71	0.01	0.16	0.21	0.42	0.00	0.37

Source: GTAP Database 6.1 and Household Survey Data

Annex IV: Estimation and Calibration of the AIDADS Demand Systems

Given the emphasis in this paper on household welfare – in both rich and poor countries – it is important that we pay close attention to the specification of household preferences. The approach used here follows closely that of Hertel et al. (2004) insofar as we begin by estimating an international, cross-section demand system, which is then systematically adjusted (calibrated) to reproduce national per capita demands. These national preferences are then also used to predict demands across the income spectrum, within each country; in particular they are used to assess the impact of consumer price changes on households at the poverty line in our fifteen focus countries. In the USA, the national demand system is used to evaluate welfare for each of the farm household groups organized by production specialty and the distribution of wealth.

The specific functional form chosen for this task must be extremely flexible with respect to per capita income. Accordingly, we use the rank 3 AIDADS demand system (An Implicit Directly Additive Demand System) to represent consumer preferences in each of the 34 regions of our model. This demand system, originally developed by Rimmer and Powell (1996), has the following form:

$$\sum_k U_k(q_k, U) = 1, \qquad (1)$$

where U is the utility level, and U_k is twice-differentiable, monotonic,strictly quasi-concave in q_k, and has the following form:

$$U_k = \frac{(\alpha_k + \beta_k \exp(U))}{1 + \exp(U)} \ln\left(\frac{\alpha_k + \beta_k \exp(U)}{A \exp(U)} \left(\frac{I - p'\gamma}{p_k}\right) \right) \qquad (2)$$

In the AIDADS system, the predicted budget share is a sum of subsistence and discretionary budget shares:

$$s_{kn} = \frac{p_{kn}\gamma_k}{I_n} + \left(\frac{\alpha_k + \beta_k \exp(U_n)}{1 + \exp(U_n)} \right) \left(\frac{I_n - p_n{}'\gamma}{I_n} \right) \qquad (3)$$

where s_{kn} is the average budget share spent on good k in country n, p_{kn} is the price of good k in country n, I_n is total expenditures in country n, U_n is utility in country n, γ_k is estimated parameter reflecting the subsistence level of good k, and $p\gamma$ is minimally sustainable per-capita income in any country. Parameters α_k and β_k are, respectively, the estimated lower and upper bounds on marginal budget shares at very low (i.e., close to subsistence), and very high income levels.

Estimation of (3) follows the approach outlined in Cranfield et al. (2003). Unlike those authors, who estimate this demand system using International Comparisons Project data bases, we estimate AIDADS directly on the GTAP data base following Reimer and Hertel (2003). This offers several advantages. Firstly, the GTAP data is more recent (2001 for version 6.1) vs. 1993-95 for the latest (unpublished) ICP data, and 1985 for the most recent published ICP data. Secondly, by estimating AIDADS directly on the GTAP data, we circumvent the need to estimate a transition matrix from ICP to GTAP commodities – an undertaking which presents some thorny problems (Hertel et al., 2004). In the estimation, we follow the 10 commodity GTAP aggregation estimated by Reimer and Hertel (2003). Those authors show that their GTAP-based demand system is qualitatively very similar to the ICP-based systems, which is also reassuring.

Estimation of this demand system is undertaken using the 80 country, per capita consumption data set offered by GTAP, version 6.1.[4] The key behavioral relationships from our demand system estimates are reported in Table A.4.1. The first three columns pertain to our international estimation, while the last two columns report the adjustments required in the "calibration" stage for one of the focus countries. For each commodity, we have estimates of subsistence quantities of consumption, from which we may infer (given average prices in our sample), budget shares at the subsistence level of income. From the first column in Table A.4.1 we can see that the largest share by far (56.9%) is for staple grains and other food crops. This is followed by manufactures, other food and beverages, housing and transportation.

The next two columns in Table A.4.1 report the marginal budget shares for extremely poor households (MBS-poor) and for extremely rich households (MBS-rich). Based on the international estimates for MBS-poor, we see that, as households' income increases beyond the subsistence level, 18.9 cents of their first $1 of income is spent on grains and crops, whereas only 1.7 cents are spent on financial and business services. As income rises, these marginal shares change. Eventually, at very high levels of income, they approach MBS-rich. In the case of grains, this is zero, whereas for financial services, it approaches 0.096. In general, as per capita income increases, the marginal (and hence average as well) budget shares fall for food and clothing, while rising for other manufactured goods and electronics, utilities, housing and services.

Of course the estimates in the first three columns of Table A.4.1 are based on an international cross section of 80 countries. When it comes to assessing the incidence of trade reforms at the national level, we wish to account for national eccentricities in demand. Therefore, in a second stage, we calibrate the AIDADS model for each country in the model. This involves fixing the subsistence quantities (subsistence shares change slightly due to price differences), and rescaling the commodity-specific MBS-poor and –rich parameters in order to preserve their relative size, while permitting the demand system to replicate observed per capita consumption of that particular commodity composite (Golub, 2006). The last two columns of Table A.4.1 show the calibrated marginal budget shares for Peru. (The full set of calibrated parameters for the focus countries is provided in Tables A.4.2 and A.4.3.) A comparison with the estimated values in the previous two columns reveals that the aggregate food budget share is somewhat lower in Peru, with most of this due to lower expenditures on meat, dairy and fish. On the other hand, the expenditures on textiles and apparel have been increased in the calibration process, as have those for transport and communications.

[4] The authors thank Tasneem Mirza for able research assistance in the estimation and calibration of the AIDADS function.

Table A.4.1. Estimated Consumption Relationships

Commodity Group	International Estimates			Calibrated-Peru		
	Subsist Shr	MBS-Poor	MBS-Rich	Subsist Shr	MBS-Poor	MBS-Rich
Crops	0.57	0.19	0.00	0.57	0.19	0.00
Meat, Dairy, Fish	0.00	0.16	0.05	0.00	0.14	0.05
Food and Beverages	0.10	0.20	0.07	0.10	0.21	0.08
Textiles and Apparel	0.00	0.07	0.05	0.00	0.12	0.10
Utilities	0.00	0.05	0.06	0.00	0.03	0.05
Trade	0.04	0.07	0.20	0.04	0.05	0.15
Manufactures	0.17	0.07	0.15	0.17	0.07	0.18
Transportation and Communication	0.06	0.10	0.11	0.06	0.13	0.17
Financial Services	0.01	0.02	0.10	0.01	0.01	0.03
Housing and Public Services	0.05	0.08	0.21	0.05	0.07	0.19

Source: Authors' estimates, see AIDADS annex to this paper.

Table A.4.2 Calibrated Values for Marginal Budget Shares at Subsistence Income Levels

Region	Crops	MeatDairy	OthFoodBev	TextAppar	~HousUtils	WRTrade	Mnfcs	TransComm	FinService	HousOthServ
Aus. Nzl	0.23	0.09	0.21	0.04	0.04	0.10	0.05	0.09	0.01	0.14
China	0.17	0.22	0.18	0.10	0.02	0.07	0.09	0.06	0.02	0.06
Japan	0.48	0.04	0.17	0.03	0.03	0.07	0.03	0.06	0.00	0.10
DevAsia	0.42	0.08	0.13	0.03	0.04	0.05	0.05	0.07	0.01	0.11
Indon.	0.15	0.11	0.22	0.05	0.05	0.06	0.08	0.10	0.01	0.16
Philip.	0.20	0.23	0.25	0.03	0.04	0.06	0.03	0.06	0.01	0.09
Thailand	0.09	0.10	0.16	0.15	0.05	0.08	0.12	0.13	0.01	0.11
Vietnam	0.05	0.11	0.15	0.04	0.06	0.02	0.09	0.03	0.04	0.41
SE Asia	0.12	0.10	0.13	0.23	0.02	0.08	0.12	0.12	0.01	0.07
Banglad	0.29	0.13	0.09	0.10	0.01	0.01	0.04	0.17	0.01	0.16
India	0.26	0.16	0.09	0.09	0.03	0.09	0.04	0.13	0.01	0.12
Pakistan	0.02	0.34	0.16	0.08	0.05	0.02	0.04	0.15	0.01	0.13
S Asia	0.37	0.16	0.09	0.07	0.02	0.07	0.04	0.11	0.01	0.06
Canada	0.16	0.10	0.17	0.06	0.04	0.07	0.08	0.18	0.01	0.14
USA	0.23	0.07	0.16	0.05	0.05	0.09	0.06	0.08	0.02	0.19
Mexico	0.10	0.19	0.26	0.08	0.02	0.07	0.06	0.15	0.00	0.05
C Amer.	0.15	0.16	0.21	0.09	0.03	0.07	0.07	0.11	0.01	0.10
Colomb.	0.13	0.19	0.20	0.05	0.04	0.09	0.05	0.13	0.00	0.12
Peru	0.19	0.14	0.21	0.12	0.03	0.05	0.07	0.13	0.01	0.07
Venez.	0.13	0.15	0.29	0.06	0.03	0.07	0.06	0.15	0.00	0.07
Brazil	0.03	0.14	0.23	0.07	0.11	0.07	0.11	0.10	0.03	0.10
Chile	0.11	0.16	0.24	0.09	0.03	0.08	0.06	0.11	0.02	0.11
S Amer	0.11	0.17	0.23	0.06	0.03	0.09	0.06	0.12	0.01	0.13
EUEFTA	0.27	0.14	0.17	0.05	0.05	0.07	0.06	0.08	0.02	0.08
Oth Eur	0.16	0.24	0.17	0.06	0.11	0.05	0.08	0.09	0.03	0.02
FmUSSR	0.10	0.22	0.17	0.06	0.13	0.03	0.06	0.12	0.01	0.11
MENA	0.24	0.15	0.16	0.09	0.03	0.08	0.06	0.10	0.02	0.07
ZAF	0.04	0.16	0.26	0.07	0.05	0.13	0.10	0.12	0.02	0.07

Malawi	0.09	0.11	0.26	0.06	0.01	0.20	0.15	0.05	0.00	0.08
Mozambique	0.15	0.09	0.27	0.05	0.03	0.25	0.04	0.07	0.04	0.02
Tanzania	0.28	0.12	0.36	0.06	0.01	0.08	0.04	0.03	0.00	0.02
Zambia	0.18	0.09	0.31	0.07	0.04	0.07	0.08	0.10	0.01	0.04
Uganda	0.47	0.15	0.10	0.02	0.01	0.09	0.01	0.04	0.00	0.12
SSA	0.16	0.11	0.27	0.06	0.03	0.10	0.08	0.09	0.04	0.06

Source: Authors' calculations

Table A.4.3. Calibrated Values for the Marginal Budget Shares at Infinite Income Levels

Region	Crops	MeatDairy	OthFoodBev	TextAppar	~HousUtils	WRTrade	Mnfcs	TransComm	FinService	HousOthServ
Aus. Nzl	0.00	0.03	0.07	0.03	0.05	0.27	0.11	0.09	0.05	0.31
China	0.00	0.08	0.07	0.08	0.03	0.22	0.22	0.07	0.10	0.15
Japan	0.00	0.02	0.08	0.03	0.05	0.27	0.10	0.10	0.02	0.33
DevAsia	0.00	0.03	0.06	0.03	0.06	0.19	0.14	0.10	0.05	0.34
Indon.	0.00	0.03	0.07	0.03	0.06	0.15	0.16	0.10	0.07	0.35
Philip.	0.00	0.09	0.11	0.02	0.06	0.20	0.09	0.09	0.06	0.28
Thailand	0.00	0.03	0.05	0.09	0.05	0.19	0.22	0.12	0.04	0.23
Vietnam	0.00	0.02	0.03	0.02	0.05	0.04	0.11	0.02	0.13	0.59
SE Asia	0.00	0.03	0.04	0.16	0.03	0.20	0.23	0.12	0.03	0.16
Bang	0.00	0.05	0.03	0.08	0.01	0.03	0.09	0.20	0.07	0.43
India	0.00	0.05	0.03	0.06	0.03	0.25	0.08	0.14	0.07	0.29
Pakistan	0.00	0.11	0.06	0.06	0.06	0.07	0.10	0.18	0.03	0.34
S Asia	0.00	0.07	0.04	0.07	0.03	0.27	0.11	0.17	0.06	0.19
Canada	0.00	0.03	0.05	0.04	0.05	0.17	0.15	0.18	0.02	0.31
USA	0.00	0.02	0.04	0.03	0.05	0.21	0.10	0.07	0.11	0.37
Mexico	0.00	0.07	0.10	0.07	0.03	0.23	0.15	0.19	0.03	0.13
C Amer.	0.00	0.05	0.07	0.07	0.04	0.20	0.14	0.12	0.06	0.25
Colomb.	0.00	0.06	0.07	0.04	0.05	0.24	0.11	0.14	0.02	0.29
Peru	0.00	0.05	0.08	0.10	0.05	0.15	0.18	0.17	0.03	0.19
Venez.	0.00	0.05	0.11	0.05	0.04	0.22	0.15	0.18	0.02	0.18
Brazil	0.00	0.04	0.06	0.04	0.11	0.16	0.19	0.09	0.14	0.19
Chile	0.00	0.05	0.08	0.06	0.04	0.20	0.12	0.11	0.10	0.24
S Amer	0.00	0.05	0.07	0.04	0.04	0.22	0.11	0.12	0.06	0.30
EUEFTA	0.00	0.05	0.06	0.04	0.06	0.22	0.15	0.10	0.12	0.21
Oth Eur	0.00	0.08	0.06	0.05	0.14	0.16	0.19	0.10	0.17	0.05
FmUSSR	0.00	0.07	0.06	0.04	0.16	0.09	0.13	0.13	0.05	0.27
MENA	0.00	0.05	0.06	0.07	0.04	0.25	0.14	0.11	0.10	0.18
ZAF	0.00	0.04	0.08	0.04	0.05	0.30	0.17	0.11	0.07	0.14

Malawi	0.00	0.03	0.07	0.03	0.01	0.43	0.24	0.04	0.00	0.15
Mozambique	0.00	0.02	0.07	0.03	0.03	0.55	0.06	0.06	0.15	0.03
Tanzania	0.00	0.06	0.19	0.07	0.03	0.36	0.14	0.05	0.01	0.09
Zambia	0.00	0.03	0.12	0.06	0.06	0.22	0.19	0.12	0.09	0.12
Uganda	0.00	0.07	0.05	0.02	0.02	0.36	0.02	0.06	0.00	0.41
SSA	0.00	0.03	0.08	0.04	0.04	0.24	0.15	0.09	0.20	0.13

Source: Authors' calculations.

Annex V: Macro-economic Closure in the CGE Model

One of the key decisions in CGE modeling is the choice of macroeconomic closure for the model. This involves determining the split between exogenous and endogenous variables. The standard macroeconomic closure in the GTAP model allows current consumption, both private and public, and future consumption (savings) to be determined by a utility function governing preferences for the representative regional household. This is attractive when it comes to assessing aggregate national welfare, as it provides an unambiguous measure of regional well-being (utility of the representative household). It also permits one to completely decompose regional welfare.

However, in the present paper the focus is not on aggregate regional welfare, but rather on the welfare of individual households within the country. Here, the representative regional household approach is less insightful, in part because in this formulation changes in the price of capital goods (savings) and government consumption play a large role in regional household welfare. Mapping public consumption and savings to the disaggregate households is beyond the scope of this research. Therefore, we seek a closure that will place a clear emphasis on utility derived from private consumption – a macro-aggregate that we are able to meaningfully disaggregate.

It is common for CGE modelers to focus attention on private consumption as a measure of regional welfare. Typically these authors fix real government consumption as well as investment. In addition, they fix the trade balance, so savings is also effectively fixed (e.g., Harrison, Rutherford and Tarr, 2002). This closure gives rise to a singularity in a global model, since a global closure requires that global savings equals global investment. The other problem with this closure for our purposes is that any time the price of government services falls or the price of capital goods falls, real private consumption will rise. This may not be realistic, particularly in those cases where savings and government spending tend to command a sizable, and relatively constant share of net national income.

Dissatisfaction with these alternatives leads us to a third macro-economic closure for the trade poverty work reported in this paper. In particular, we exogenize the three key macroeconomic ratios: government spending, net national saving, and the trade balance, all relative to net national income. This has intuitive appeal. It also has some significant practical advantages which are important for this paper. We develop these implications here.

Begin with the following disposition of net national income:

$$Y = C + S + G \tag{A.4}$$

Where Y = net national income, C = private consumption expenditure, S = net national savings (public and private savings combined), and G = government spending. From this, we obtain the following expression for private consumption:

$$C = Y\left(1 - \frac{S}{Y} - \frac{G}{Y}\right) = \kappa Y \tag{A.5}$$

where κ = the marginal propensity for private consumption out of net national income which is fixed under this closure. In proportional change terms, this implies that real private consumption, $\hat{Q}^C$, will rise if either the price of private consumption falls ($\hat{P}^C < 0$) or net national income rises ($\hat{Y}^C > 0$). These variables are easily mapped to the disaggregated households, making distributional analysis clear-cut.

There is a further implication of this closure rule that is also advantageous. This may be seen by normalizing the external balance condition, dividing through by net national income to get:

$$\frac{(S-I)}{Y} = \frac{(X-M)}{Y} \qquad \text{(A.6)}$$

Note that the right hand side of this equation is fixed in our closure, and *S/Y* is fixed. Therefore, *I/Y* is also fixed. However, real investment, $\hat{Q}^I$, does vary in this closure. It rises when the price of capital goods falls, or when *Y* rises. This seems reasonable. Of course it does dilute some of the real consumption gains that would have occurred (the price of capital goods generally falls under trade liberalization) if we had left investment fixed in real terms, as done under the second closure option considered above.

There is yet a third important benefit associated with this closure option, the treatment of transfer payments. In a simplified view of the world, public transfer payments to private households can be viewed as the difference between taxes and government spending on real goods and services: $Trans = T - G$, or, dividing through by net national income, *Y*:

$$\frac{Trans}{Y} = \frac{T}{Y} - \frac{G}{Y} \qquad \text{(A.7)}$$

Since *T/Y* is fixed under our tax replacement closure, and *G/Y* is fixed, the left hand side of this equation is also fixed. Thus, even though *Trans* is not explicitly modeled, we know that it must implicitly change in proportion to *Y*. As a result, we can consistently index the transfer payments in the model to net national income, which is what we have done in our analysis of poverty impacts.

2. Annex VI: Additional Supporting Information

This annex is provided to present additional supporting information or model results that are alluded to but not discussed in detail or at length in the primary text due to space limitations. The first of these is Table A.6.1, which gives an overview the importance of farm income to OECD farm households. In particular, the low share of income from farming for US and Japanese farm households in contrast to the situation in Europe is important for determining representative welfare outcomes and compensation schemes to offset farm household welfare losses.

Table A.6.2 provides the information on agricultural support across the member countries of the OECD. As discussed in the paper, most countries rely on both market price support and domestic support. The OECD-wide average for market price support's share in the total PSE is 0.63, and from the table we see that most countries lie in the 0.40 to 0.63 range of reliance on MPS. Notable low-end exceptions occur in Australia and Hungary where nearly all support occurs through domestic support to farmers. On the other end, Japan and Korea rely very little on domestic support using border measures for over 90 percent of support to farmers.

Table A.6.3 reports the global trade volume changes, by commodity. In the case of the non-agricultural products and services, these trade volumes have been aggregated somewhat, due to the modest overall effects. The first two columns of Table A.6.3 report the global trade volume impacts of agricultural reforms in the rich countries. Complete liberalization of rich country farm policies generates some very large trade volume increases for rice, sugar and beef products where border protection is dominant. In the full liberalization scenario, coarse grains and cotton trade volumes actually fall, as domestic subsidies are eliminated and production, and therefore rich country exports, are reduced. Under the Doha scenario, which emphasizes export subsidy elimination (which reduces trade volume), as opposed to tariff reduction (which increases volume), the global trade volumes for wheat and dairy products also fall.

In the case of full liberalization, on a global basis, trade rises more than under RichAgr liberalization for all farm and food products. Overall tariffs are high in the developing countries – typically in both agriculture and non-agriculture. So eliminating these barriers serves to boost trade. For example, world rice trade rises by nearly twice as much when poor countries join in the liberalization. And the trade volumes for coarse grains and and cotton now rise in the wake of reforms. But the biggest difference is in the non-agriculture sectors, where liberalization in the rich and poor countries alike leads to substantial increases in trade in textiles and apparel, autos and other manufactured goods. Services trade rises, despite the absence of liberalization in these sectors, since more merchandise trade requires more transport and insurance services. Finally, note that the Global Doha scenario is quite similar to the Rich Agriculture Doha scenario for food products. This is due to the fact that large binding overhangs and relatively modest cuts in developing country bound tariffs (no cuts for LDCs) translate into little additional market access outside of the rich countries.

Table A.6.4 completes the results presented in Table 7 of the text, offering the terms of trade and welfare results for non-focus countries. The general pattern noted for the focus countries of Table 7 persists for these countries. Welfare results are in general a mixed bag, with agricultural exporters benefiting most and agricultural importers suffering the consequence of higher prices for those imports. As before these countries tend to enjoy greater welfare gains when developing countries participate more fully in reforming their own measures. These results are complemented by the price decomposition of the terms of trade effect given in Table A.6.5 (see discussion in text).

The next set of additional results are given in Table A.6.6 and support the conclusion that U.S. rice households realize welfare improvements derived from non-U.S. reforms. Here we see that for the wealth deciles making up the aggregate U.S. rice household, domestic reforms typically have significant and large welfare effects. These losses are however consistently offset by positive welfare aspects (roughly two times the U.S. domestic support impact) of reduced tariffs on exports into the Japanese market.

Additional insight on poverty impacts is given as Table A.6.7 and compares the change in the true cost of living for the two poverty thresholds in the developing focus countries. The first thing to note is that the true cost of living at the poverty line rises, relative to the numeraire (the world average factor return), indicating that, all else constant, things are becoming more expensive for the poor. For example, in Peru, the cost of living at the $1/day poverty line rises by nearly six percent. The increase is slightly less for the $2/day poverty line due to the lesser importance of food in the consumption bundle (recall

Figure 3), but it too rises in all cases excepting for Uganda, which is the only focus country to experience a real depreciation in the face of rich country agricultural liberalization. This table also shows that, country by country, the cost of living increases are higher at the one dollar per day level. This is a result of the increased importance of food and agricultural goods in the budget at this lower income level and the price increasing effects of reduced domestic support in the rich country experiments.

The final table of additional results is given in Table A.6.8, and provides information on disaggregate farm welfare losses under Global liberalization. These results are discussed in the main text and are strongly indicative of the dramatic dependency of these farmers on agricultural policies.

Table A.6.1. Shares of Farm Income in Household Total for OECD Countries

Region	Farm Income Share
Oceania	0.59
Japan	0.12
Korea	0.46
Taiwan	0.46
Canada	0.10
U.S.	0.05
EU (15)	0.60
EFTA	0.73
EU (10)	0.71

Source: OECD (2003).

Table A.6.2. Overview of Agricultural Support in the OECD

Region	Pct. PSE	Share MPS	Share Non-MPS
Australia	4	0.00	1.00
New Zealand	1	0.60	0.40
European Union	35	0.58	0.42
Iceland	59	0.43	0.57
Norway	67	0.40	0.60
Switzerland	69	0.54	0.46
Czech Rep.	17	0.40	0.60
Hungary	12	0.12	0.88
Poland	10	0.63	0.37
Turkey	15	0.70	0.30
Japan	59	0.90	0.10
Korea	64	0.93	0.07
Canada	17	0.47	0.53
Mexico	19	0.62	0.38
U.S.A.	21	0.40	0.60
All OECD	31	0.63	0.37

Source OECD (2002).

Table A.6.3. Changes in Trade Volumes by Scenario ($US 2001 mn)

Region	Rich Agriculture		Global (All countries and merchandise)	
Sector	Full	Doha	Full	Doha
Rice	128.5	22.5	212.6	26.8
Wheat	2.8	-0.2	13.5	1.0
Coarse Grains	-3.0	-2.2	4.5	-1.0
Oilseed Products	5.0	0.2	23.0	1.5
Sugar	56.2	18.6	76.5	21.1
Cotton	-6.7	-2.2	2.5	-0.2
Other Crops	1.8	0.3	10.4	1.2
Dairy Products	10.7	-4.9	19.6	-3.9
Beef Products	43.5	8.6	51.5	9.3
Other Meat	17.0	3.6	30.0	5.1
Other Food	3.1	0.7	10.5	1.7
Natural Resources	0.1	0.0	2.8	0.3
Textiles and Apparel	-0.4	-0.1	22.2	5.3
Automobiles	0.3	0.1	5.1	1.0
Heavy Manufactures	0.1	0.0	6.3	1.1
Electronics	-0.1	0.0	1.0	0.0
Other Manufactures	0.3	0.1	5.4	1.2
Services	0.2	0.0	0.8	0.3
Total Merchandise	0.77	0.15	6.14	1.12

Source: Authors' simulations.

Table A.6.4. Non-focus Countries ToT and Welfare Impacts

Country	Rich Agriculture				Global (All countries and merchandise)			
	Full		Doha		Full		Doha	
	ToT	Welfare	ToT	Welfare	ToT	Welfare	ToT	Welfare
China	0.17	-0.69	-0.03	-0.16	0.94	-0.57	0.22	-0.08
Dev'd. Asia	-0.09	-0.21	-0.05	-0.09	0.37	3.06	0.19	1.11
SE Asia	0.04	-0.10	0.01	0.00	0.77	1.16	0.26	0.24
India	0.66	-0.03	0.08	-0.04	-4.26	0.21	-0.44	0.08
Pakistan	0.00	-0.13	-0.15	-0.08	-2.80	0.08	-1.41	-0.45
South Asia	0.03	-0.12	-0.06	-0.05	0.80	0.35	0.50	0.10
Other Central America	1.45	0.42	0.55	0.14	-0.41	0.09	0.65	0.24
South America	3.33	0.53	1.04	0.16	1.89	0.38	1.13	0.18
Other Europe	0.19	-0.01	0.01	-0.13	-1.69	-0.22	-0.23	-0.17
Former USSR	0.00	-0.25	-0.12	-0.20	-0.78	0.77	-0.45	0.04
Mid-east North Africa	0.01	-0.24	-0.12	-0.17	-1.55	0.29	-0.29	-0.12
South Africa	0.39	0.04	0.03	-0.03	-0.31	0.65	0.07	0.10
Sub-Saharan Africa	0.63	0.06	0.07	-0.09	-1.92	-0.19	-0.09	-0.11

Source: Authors' simulations.

Table A.6.5. World, Export, and Import Price Contributions to Terms of Trade Changes under Full Rich Agricultural Liberalization

Region	ToT (total)	World Price	Export Price	Import Price
Austr. and N.Z.	2.79	1.22	1.71	-0.15
Japan	-1.32	-0.45	-0.65	-0.22
Canada	-0.07	0.14	-0.03	-0.18
USA	0.36	0.18	0.27	-0.1
Eur. and EFTA	-0.3	-0.09	-0.39	0.18
Bangladesh	-0.58	-0.52	0.01	-0.07
Brazil	5.48	1.55	4.09	-0.22
Chile	0.74	0.22	1.04	-0.52
Colombia	1.27	0.28	1.4	-0.41
Indonesia	-0.23	-0.18	0.07	-0.12
Malawi	2.67	2.4	0.41	-0.14
Mexico	-0.14	-0.26	0.36	-0.24
Mozambique	-0.39	0.01	-0.29	-0.12
Peru	3.47	0.49	3.5	-0.53
Philippines	0.01	-0.14	0.2	-0.05
Tanzania	0.04	1.1	-0.94	-0.12
Thailand	1.21	0.13	1.11	-0.03
Uganda	-0.5	1.61	-1.85	-0.22
Venezuela	-0.41	-0.01	0.1	-0.51
Vietnam	0.34	0.45	-0.04	-0.08
Zambia	-0.17	0.19	-0.19	-0.17
China	0.17	-0.13	0.32	-0.02
Dev'd Asia	-0.09	-0.16	0.1	-0.04
SE Asia	0.04	-0.1	0.12	0.02
India	0.66	0.21	0.51	-0.07
Pakistan	0	-0.01	0	0.01
South Asia	0.03	0.18	-0.04	-0.11
C. Europe	0.19	0.03	0.06	0.11
Frm. USSR	0	0.04	0.02	-0.06
Mid East N Afr.	0.01	-0.07	0.23	-0.15
South Africa	0.39	0.16	0.33	-0.1
Sub Sahar. Afr.	0.63	0.55	0.26	-0.18

Source: Authors' simulations.

Table A.6.6. Decomposed Welfare Impacts of Doha Reforms for US Rice Households

Income Group	Doha Total	U.S. Rice Reform	U.S. Other Ag. Reform	Japanese Rice Reform	ROW Ag. Reform
10%ile	1.36	-1.75	-1.11	3.44	0.78
20%ile	1.37	-1.76	-1.12	3.46	0.79
30%ile	1.89	-2.33	-1.44	4.56	1.10
40%ile	1.89	-2.34	-1.44	4.58	1.09
50%ile	6.32	-7.09	-2.30	13.92	1.79
60%ile	1.63	-2.38	-1.83	4.66	1.18
70%ile	4.64	-5.70	-2.45	11.19	1.60
80%ile	5.53	-6.67	-2.73	13.11	1.82
90%ile	5.60	-6.87	-2.74	13.51	1.70
95%ile	5.33	-6.92	-3.15	13.61	1.79
100%ile	5.31	-6.89	-3.13	13.55	1.78

Source: Authors' simulations.

Table A.6.7. Percent change in True Cost of Living at the Poverty Line

Country	$1/day	$2/day
Bangladesh	0.44	0.39
Brazil	5.67	5.12
Chile	2.11	1.84
Colombia	3.06	2.67
Indonesia	0.93	0.77
Malawi	2.88	2.83
Mexico	1.46	1.16
Mozambique	0.62	0.52
Peru	5.82	5.37
Philippines	1.44	1.32
Thailand	3.43	2.55
Uganda	-0.15	-0.15
Venezuela	0.65	0.56
Vietnam	1.07	0.85
Zambia	0.44	0.39

Source: Authors' simulations.

Note: All price changes are relative to the numeraire which is the global average primary factor price index.

Table A.6.8. Farm Household Impacts in the United States under Global Liberalization

Income Group	Rice	Sugar	Cotton	Dairy	Other
10%ile	-5.00	-0.74	-8.49	-1.99	0.10
20%ile	-5.03	-0.74	-8.49	-1.57	-0.04
30%ile	-6.28	-2.12	-6.92	-2.35	0.08
40%ile	-6.30	-4.33	-8.31	-1.62	0.14
50%ile	-16.83	-4.33	-7.49	-2.00	-0.20
60%ile	-7.61	-4.33	-4.67	-2.24	-0.17
70%ile	-15.15	-1.71	-6.61	-3.24	-0.50
80%ile	-17.46	-1.71	-4.86	-2.44	-0.57
90%ile	-18.31	-3.23	-8.90	-3.84	-1.02
95%ile	-19.56	-6.03	-6.48	-3.11	-0.99
100%ile	-19.48	-6.03	-13.01	-3.55	-1.80

Source: Authors' simulations.

Table A.6.9. Percentage change in the $1/day Head Count: Global Reforms Decomposed[a]

Country	Total	Rich Agricultural Reforms	Rich Non-agr. Reforms	Poor Agricultural Reforms	Poor Non-agr. Reforms
Bangladesh	0.29	-0.11	-0.05	-0.18	0.62
Brazil	-1.42	-1.79	-0.07	-0.15	0.60
Chile	-4.99	-3.89	0.00	-1.41	0.31
Colombia	0.10	-0.29	-0.04	-0.28	0.71
Indonesia	-1.45	-1.24	-0.46	-0.82	1.07
Malawi	-1.84	-0.74	0.02	-0.96	-0.16
Mexico	1.35	0.31	0.31	0.61	0.12
Mozambique	-0.69	0.07	0.04	-1.08	0.28
Peru	-0.80	-0.40	0.03	-0.23	-0.19
Philippines	-0.76	-0.76	-0.70	-0.56	1.27
Thailand	-8.87	-6.63	-0.53	-4.55	2.84
Uganda	0.07	0.04	0.00	-0.06	0.08
Venezuela	0.85	0.26	0.05	-0.15	0.70
Vietnam	-5.85	0.22	-1.84	-1.70	-2.53
Zambia	0.09	0.14	0.05	-0.29	0.19

Source: Authors' simulations.

[a] Sensitivity analysis not available for this decomposition.

Table A.6.10. Change in National Poverty due to Global Liberalization: Doha versus Full[a]

	Global Liberalization				Global Doha Liberalization			
	$1/day		$2/day		$1/day		$2/day	
Country	%	1000s	%	1000s	%	1000s	%	1000s
Bangladesh	0.29	130	0.13	133	-0.05	-22	0.01	10
Brazil	-1.42	-325	-1.73	-635	-0.79	-181	-1.09	-400
Chile	-4.99	-15	-3.26	-46	-1.28	-4	-0.76	-11
Colombia	0.10	4	1.20	105	-0.09	-4	-0.13	-11
Indonesia	-1.45	-218	-0.59	-619	-0.20	-30	-0.09	-94
Malawi	-1.84	-78	-0.77	-60	0.35	15	0.12	9
Mexico	1.35	125	0.67	166	0.13	12	0.03	7
Mozambique	-0.69	-42	-0.30	-38	0.02	1	0.01	1
Peru	-0.80	-35	-1.87	-172	0.06	3	-0.15	-14
Philippines	-0.76	-86	-0.19	-66	-0.25	-28	-0.12	-42
Thailand	-8.87	-105	-4.49	-872	-1.97	-23	-1.02	-198
Uganda	0.07	12	2.19	430	0.04	7	1.58	310
Venezuela	0.85	28	0.78	54	0.21	7	0.18	13
Vietnam	-5.85	-90	-4.84	-1242	0.89	14	0.70	180
Zambia	0.09	5	0.03	2	0.03	2	0.01	1

Source: Authors' simulations.

[a]No sensitivity analysis is conducted for global liberalization simulations.

Annex VII: Replacing Lost Tariff Revenue

Hertel and Winters (2006) highlight the fact that, for many of the developing countries, the poverty impacts depend critically on the assumptions made about tax replacement in those same developing countries. This follows from the fact that tariff revenue makes up a very large share of fiscal revenue in the poorest countries, and the resulting tax adjustments required to replace this lost revenue can have a very significant impact on consumer prices and after-tax earnings (Harrison, Rutherford and Tarr, 2002). The main options that have been explored in the literature are the income tax and value-added, or consumption taxes. Those authors using income tax replacement (e.g., Anderson, Martin and van der Mensbrugghe, 2006) often assume that these will not be collected on the poorest of the poor, as they are often not part of the formal economy. This assumption naturally favors poverty reduction, as the tax burden is shifted from the poor, who often consume imported food, to the rich, who bear the direct burden of higher income taxes.

The poverty impacts of replacing lost tariff revenue with a value-added or consumption tax depend heavily on the pattern of exemptions (Emini et al., 2006). Such exemptions can benefit the poor, who tend to consume more food – and which is often exempted from such indirect taxes. However, with a relatively narrow tax base and highly differentiated rates, sharp increases in such taxes can also greatly reduce economic efficiency, thereby having an adverse impact on the entire economy – and potentially raising poverty.

Given the importance of this issue to the global liberalization scenarios, we have rerun the full global liberalization scenario (including tariff cuts in the developing countries) with two alternative tax replacement assumptions, as suggested by the preceding discussion. Column one of Table A.7.1 repeats the poverty results ($1/day poverty line only) from our base case, as reported in the text of the paper. Here, we replace the lost tariff revenue with a uniform income tax on all factors of production. In column two, we contrast this with the assumption of Anderson, Martin and van der Mensbrugghe (2006) by which the poor are exempted from the income tax. Therefore, as tariffs fall, goods prices fall, and the poor are not asked to make up any of the lost tariff revenue. So the poverty reduction is much greater in this case. The third and final column of Table A.7.1 reports the poverty impacts when the value-added taxes are uniformly scaled up to replace the lost tariff revenue. This results in slightly more modest poverty reductions than in the base case used in the paper (income tax/poor pay).

Table A.7.1. Comparison of Poverty Impacts under Alternative Tax Replacements Schemes (percentage change in $1/day poverty headcount)

Region	Income Tax Poor Pay	Income Tax Poor Do Not Pay	Value Added Tax
Bangladesh	0.29	-4.27	0.02
Brazil	-1.42	-3.19	-0.76
Chile	-4.99	-7.14	-5.10
Colombia	0.10	-1.05	0.21
Indonesia	-1.45	-4.23	-1.40
Malawi	-1.84	-3.75	-1.26
Mexico	1.35	0.24	1.40
Mozambique	-0.69	-2.30	0.39
Peru	-0.80	-2.27	-0.67
Philippines	-0.76	-4.07	-1.73
Thailand	-8.87	-15.80	-4.58
Uganda	0.07	-0.16	0.07
Venezuela	0.85	-1.16	1.13
Vietnam	-5.85	-12.17	-7.08
Zambia	0.09	-1.62	1.23