Impacts of Trade Reform: Sensitivity of Model Results to Key Assumptions

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Abstract

The WTO's Doha Development Agenda has generated demand for estimates of the potential economic consequences of global trade reform. Recent improvements in the GTAP dataset have provided a much better representation of tariff restrictions as of 2001. However, despite its use by most global trade modelers, substantial differences in results emerge from different computable general equilibrium exercises. To help understand these differences, this paper examines the sensitivity of full global and regional trade liberalization results from the GTAP model, using the GTAP version 6.1 database, to different assumptions about factor mobility, fiscal neutrality, macro-economic closure, and trade (Armington) elasticities.

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1 Introduction

The WTO's Doha Development Agenda and various preferential trade negotiations have generated demand for estimates of the potential economic consequences of unilateral, preferential and especially MFN multilateral trade reforms. Recent improvements in the GTAP dataset have provided a much better representation, as of 2001, of bilateral tariff restrictions (including preferences). But despite its common use by most global trade modelers, there are nonetheless substantial differences in the output, value added, trade and economic welfare results emerging from different computable general equilibrium (CGE) exercises. The lack of uniformity in these estimates has confused policy makers and advisors and led to calls for clarification. In response, the global trade modeling community has begun to address in more detail such questions as: Why is there such a wide range of model predictions? And, more specifically: How sensitive are results to changes in key modeling assumptions?[1] The apparent suspension of the Doha negotiations in July 2006 provided economists with an opportunity to address this question away from the heat of the trade policy environment.

This paper contributes to this process of clarification by focusing heavily on results from complete global trade liberalization – including the elimination also of

[1] Each of the two most recent conferences on Global Economic Analysis have included organized sessions on model comparisons. For details and papers, see www.gtap.org.

agricultural subsidies – using the GTAP model (described in Hertel 1997) and the GTAP version 6.1 database (described in Dimaranan 2006). In addition, it explores the effects of incorporating recent developments in modeling and alternative parameters affecting agricultural markets (the GTAP-AGR model of Keeney and Hertel (2005)), and also examines one additional set of regional trade reform results for Sub-Saharan Africa. It shows the sensitivity of the estimated effects of reform on a range of variables including not only national economic welfare but also the volume of farm output, agricultural value added, and exports.

The reasons for focusing on agricultural results in particular are two-fold. One is that it is in agriculture and food that the greatest distortions to goods trade exist, despite the fact that this sector represents less than one-twelfth of world GDP and exports. Previous studies suggest that removing distortions to those goods would contribute 63 percent of the global gains from liberalizing all goods markets globally – and 78 percent of Sub-Saharan Africa's gains (Anderson, Martin and van der Mensbrugghe 2006a,b). The other reason for the agricultural focus is that more than two-thirds of the world's people living on less than $1 a day depend directly or indirectly on earnings from farming. Therefore, while acknowledging that many factors contribute to poverty, agricultural liberalization can play a key role in poverty alleviation (Hertel and Winters 2006, pp. 4-5).

Four variants on the core GTAP results are presented. The first highlights the effects of a different specification of factor demand and supply relations within the agriculture sector. This is important because some other widely referenced CGE models in the current WTO negotiations assume the presence of agricultural factor market

segmentation (e.g., the World Bank's Linkage model in van der Mensbrugghe 2006a) or segmentation across sectors in labor markets (e.g., the Carnegie model in Polaski 2006) and these different assumptions are often suggested to be a major source of discrepancy in the reported welfare results.

Second, since tariff revenue continues to represent a significant share of government revenue in many low-income countries, we explore a different fiscal closure from the standard GTAP one. The tax closure issue has been a focus of analyst's attention because it can affect the estimated poverty impacts of trade liberalization in poor countries where import tariff revenue is a large share of government taxes (Hertel and Winters 2006).

Third, we alter the standard GTAP model closure in which savings are driven by net national income and investment is based on equating expected rates of return. Specifically, we follow several other global trade models (e.g. the Linkage model, and the Carnegie model cited above) in employing the assumption that each region's trade balance is a fixed percentage of GDP.

Finally, we vary the assumption about the trade (or Armington) elasticities. The Armington specification is a source of considerable controversy in CGE modeling (see Lloyd and Zhang 2006, and Zhang 2006). We show how increasing these elasticities for some or all regions influences the results, so that the reader can evaluate better the implications of a given author applying larger Armington elasticities.

There are of course many other assumptions that could be varied. Perhaps the most obvious are the inclusion of services policy reform, and of the introduction of imperfect competition and increasing returns to scale in the manufacturing and services

sectors. These, however, are not considered here because they have been explored elsewhere.[2]

The paper begins in Sections 2 and 3 by summarizing the standard GTAP assumptions and then the variants to be sequentially introduced. Section 4 presents a comparison of key results. In Section 5 we assess how modeling assumptions affect price variability. Conclusions are then drawn in the final section.

2 The GTAP model's standard assumptions

The standard GTAP model is perhaps the most widely used CGE model for global trade policy analysis – in part due to its simple, yet robust assumptions. In its simplest form, the model assumes perfect competition and constant returns to scale in production. The functional forms are nested constant elasticities of substitution (CES) production functions. Land, labor (skilled and unskilled), and capital substitute for one another in a value added aggregate, and composite intermediates substitute for value-added at the next CES level (with fixed proportions applying in the standard model -- see Figure 1). Land is specific to agriculture in the GTAP database, and has imperfect mobility amongst

[2] Two examples of global trade liberalization analysis with services reform included and with imperfect competition and increasing returns to scale are Brown, Kiyota and Stern (2005) and Francois, van Meijl and van Tongeren (2005). One consequence of this specification is that any trade policy change that reduces the size of the agricultural sector, thereby shifting resources into the scale-economy-laden manufacturing and services sectors, increases welfare in the country in question. In light of the rather arbitrary decision about precisely which sectors exhibit scale economies and which do not, this may not be a robust prediction.

alternative agricultural uses. A Constant Elasticity of Transformation (CET) revenue function is employed to allow land to be transformed from one use to another. The closer the transformation elasticity is to zero, the more unresponsive is land supply to changing relative returns to land across agricultural uses. In the default GTAP closure, labor and capital are assumed to be mobile across all uses within a country and immobile internationally.

On the demand side there is a regional representative household whose expenditure is governed by Cobb-Douglas aggregate utility function which allocates net national expenditures across private, government, and savings. The greatest advantage of this regional household representation is the unambiguous indicator of welfare dictated by the regional utility function.[3] Government demand across composite goods is determined by a Cobb-Douglas assumption (fixed budget shares). Private household demand is represented by a Constant Difference of Elasticities (CDE) functional form, which has the virtue of capturing the non-homothetic nature of private household demands as well as permitting the user to calibrate the model to specific own-price elasticities of demand.

As noted previously, bilateral international trade flows are handled through the Armington specification by which products are differentiated by country of origin. These Armington elasticities are the same across regions but are sector-specific, and the import-

[3] In the GTAP model, government expenditures are not tied to tax revenues. Thus, reducing taxes in the GTAP model does not imply a reduction in government revenue and expenditure. Indeed, to the extent that tax reductions lead to a reduction in excess burden, regional real income will increase and real expenditure – including government expenditure -- may also rise.

import elasticities have been estimated at the disaggregated GTAP commodity level (Hertel et al. 2007).

The standard macro-economic closure assumes that the levels of each region's employment of each of the productive factors is fixed in aggregate, and that the regional balance of trade is determined by the relationship of regional investment and savings, where international capital mobility seeks to equalize *expected* (but not necessarily actual) rates of return across regions.

The full GTAP 6.1 database comprises 92 regions in addition to the 57 sectors/product groups, but to make the model more manageable we have aggregated it to 25 sectors/product groups and 27 regions (see Appendix Tables A1 and A2).

Two modifications have been made to the structure of protection in Version 6.1 of the GTAP database. One relates to cotton subsidies in the United States. The standard version reflects subsidy notifications to the WTO. It happens that the subsidies showing for the US in 2001 are much less than actually paid through its various and complex cotton programs: $1.0 billion as production subsidies and zero as export subsidies, compared with an average annual total payment of $3.0 billion for the 2000-2002 period according to official data from the USDA (Anderson and Valenzuela 2007).

The other modification to the GTAP protection database is to take account of the completion of the Uruguay Round Agreement implementation, including elimination of Textiles and Clothing quotas and enlargement of the EU to 25 members in 2004. These adjustments also include China’s commitments made in its accession to the WTO in late 2001.These changes are implemented, and the updated database is then used to conduct the following liberalization experiments. Since most of these adjustments reduce the level

of protection in the data base, we expect the subsequent estimates of global welfare gains from full liberalization to be smaller than in studies that simply use the 2001 data base. As is clear from the comparative results reported in van der Mensbrugghe (2006b), the latter would mistakenly count some of the Uruguay Round liberalization amongst the prospective gains from a Doha Development Agenda.

3 Modifications to the standard GTAP model assumptions

Before examining the findings based on the standard GTAP model, this section describes in greater detail the alternative assumptions we explore concerning factor mobility, fiscal neutrality, macro-economic closure, and trade (Armington) elasticities.

3.1 Sector-specific modifications: the GTAP-AGR model

To highlight the effects of a different specification of factor demand and supply relations within the agriculture sector, we compare results from the standard GTAP model with those from the GTAP-AGR model, which introduces segmentation of the farm and non-farm markets for labor and capital. The GTAP-AGR version is a variant of the GTAP model that is specifically oriented to analyzing agricultural markets (Keeney and Hertel 2005). This version introduces a number of modifications to the way agriculture is handled in the standard GTAP model, based on recent econometric studies – and it seeks to reflect the consensus reached by the OECD in its partial equilibrium agricultural modeling activities (OECD 2001). Firstly, GTAP-AGR incorporates a region-specific elasticity of land transformation amongst agricultural uses. While land is specific to agriculture in the GTAP model, the new parameters in GTAP-AGR make land less responsive within the agricultural sector to changes in relative land rents across uses.

Second, the GTAP-AGR model incorporates region-specific labor and capital supply elasticities in constant elasticity of transformation functions that allocate the aggregate endowments of labor and capital between agricultural and non-agricultural sectors. The limited mobility of labor allows for wage differentials between agriculture and non-agricultural sectors, and the same is true for capital. These factor supply elasticities are based on estimates from the OECD (2001).

Third, the GTAP-AGR model also allows for substitution among farm-owned and purchased inputs, and between the two, by calibrating each sector's constant elasticity of substitution cost function to the region-specific Allen elasticities of substitution provided by OECD estimates (OECD 2001).

Fourth, the livestock production function is modified to capture more realistic substitution possibilities in feed demand, by modeling the substitution possibilities for feedstuffs as an additional CES nest in the sector's cost function. This livestock production function is parameterized based on a three-stage model describing the behavior of European livestock producers, composite feed mixers, and grain producers (Surry 1990).

Finally, the consumer demand system in the GTAP-AGR model is re-specified, imposing separability of food from non-food commodities, and calibrating the agricultural and food demands to a recent set of price and income elasticities from a cross-country study of international food demand (Seale, Regmi and Bernstein 2003).

3.2 Adopting a fiscally-neutral closure

Since tariff revenue continues to represent a significant share of government revenue in many low-income countries, we examine how much difference it makes to adopt fiscal neutrality, by requiring tax replacement to compensate for lost revenue from import tariff collection when tariffs are eliminated. Specifically, we force consumption taxes to adjust to ensure that the share of net tax receipts in net national income remains unchanged in

the face of trade tax elimination. We do so by adjusting the power of the consumption tax (1 + tax rate) by a common factor on each and every good and service purchased by private households. The choice of whether and how to replace lost revenue can have important general equilibrium implications. The two most obvious tools for tax replacement are an income tax and a value-added tax. In developing countries, income taxes are generally difficult to implement due to the challenge of tracking earnings. Therefore, value-added taxes are the preferred tool for replacing border taxes, so this is what we focus on in our paper.[4] Assuming that the value-added tax is uniform across commodities, is applied to imports and domestic goods alike, and is rebated on exports, we can model this simply as a uniform consumption tax. This is the approach taken here, with the consumption tax being adjusted in order to ensure that tax revenues remain a constant share of national income.

3.3 Fixing the balance of trade

In the standard GTAP model closure, savings are driven by net national income, whereas investment is based on equating expected rates of return. Therefore, the trade balance is not constrained to be fixed. We modify that standard macro-economic closure of the GTAP model by fixing the ratio of the regional trade balance to net national income, at its benchmark level. Thus any change in domestic savings must be offset by a change in investment, with the latter no longer being determined by the equating of expected rates of return across regions.

[4] In addition, capital and labor are in fixed supply in our analysis, so an income tax has no allocative impact. This makes it rather uninteresting to consider.

3.4 Raising trade elasticities, including just for developing countries

The standard GTAP Armingtons elasticities are based on econometric estimates by Hertel et al. (2007) for imports from the world into seven countries including the United States, and the pooled estimates of these elasticities for each product category are assumed to apply to all countries in the world. Yet many practitioners argue that the terms of trade effects generated by models using those estimates are more pessimistic than seems warranted by casual observation, and these effects are in turn a direct consequence of the Armington elasticities employed in the model.[5] So we explore what happens if they are doubled for all countries, both between domestic goods and the imported composite, as well as among the import suppliers.[6]

While some argue that institutional rigidities will make these elasticities smaller in developing countries, others argue that poorer countries may well have higher

[5] Harrison et al. (2004), for example, use Armington elasticities several times higher than those employed in the GTAP model. They cite Reidel (1988) and Athukorala and Reidel (1994) who argue that when the econometric model is correctly specified to test the 'small country' hypothesis, the export demand elasticities are not statistically different from infinity (the 'small country' case) for Hong Kong manufactures.

[6] The domestic-import elasticities are simply set equal to one-half the import-import values, following Jomini et al. (1991). The latter parameters are notably difficult to estimate, in part due to the absence of data on consumption of domestic varieties. Hertel et al. (2007) provide systematic sensitivity analysis in the context of a specific regional reform, based on their econometrically estimated standard errors; but in the context of this paper we believe it is more useful to simply highlight how increasing these elasticities influences the results.

elasticities than the United States and other wealthy countries because they import less-differentiated products than richer ones. We therefore examine what happens to results if the Armington elasticities of substitution are doubled just for developing countries by modifying the standard GTAP model to incorporate region-specific trade elasticities.

Still other critics of GTAP results claim that primary products are more homogenous then industrial products, so we also explore what happens if the trade elasticities are doubled just for agricultural, forestry, minerals and energy raw materials globally.

4 Results

We begin by focusing solely on how the effects on national economic welfare of full global trade liberalization (including the elimination of agricultural subsidies) are affected by altering the various assumptions listed above. We then look at their effects on agricultural and food exports, and on primary agricultural value added. It turns out the results for developing countries are especially sensitive to the Armington elasticities. To explore that further, we also show how changing those elasticities can affect the estimated impact of trade liberalization by Sub-Saharan Africa alone.

4.1 Welfare effect of full global trade liberalization

The standard GTAP model suggests that the world would be better off by $86.3 billion per year with the removal of all tariffs and subsidies as of 2001 (amended as described at the end of Section 2 above), $29 billion of which would accrue to developing countries

(column 1 of Table 1). This is the point of reference against which other results are to be compared.[7]

The first comparison is with the GTAP-AGR model's results. Recall that the main difference between this model and standard GTAP is the treatment of factor markets. Column 2 of Table 1 shows this alternative model to generate a gain that is $7 billion smaller than the GTAP model's estimate, almost all of the difference being attributable to Japan ($5.2 billion) and the European Union ($1.6 billion).[8] This smaller gain using GTAP-AGR may be attributed to the more limited factor mobility between agriculture and non-agricultural sectors. In a general equilibrium model, the global efficiency gains come from reallocating factors of production away from inefficient uses and towards more efficient ones. In GTAP-AGR, the scope for moving labor and capital out of agriculture in the regions where it is heavily subsidized (i.e. Japan and the EU), and into agriculture in the regions where it is relatively more efficient, is more limited. Thus the efficiency gains are smaller. However, despite the very different factor market

[7] This $86.3 billion estimate is very close to the $88.1 billion generated by the World Bank's Linkage Model when it is scaled back to the same period and adopts GTAP trade elasticities and farm land flexibility assumptions (van der Mensbrugghe 2006).

[8] An earlier computation using the GTAP-AGR model (Hertel and Keeney 2006) estimated a difference of just $2 billion less than the standard model. The reason Hertel and Keeney's difference is smaller than ours in the present paper is that we have aggregated the primary and processing sectors for rice, and similarly for sugar, thereby reducing for those two commodities the extent of tariff peaks, which are extreme in Japan and the EU in particular. This comparison highlights yet another source of discrepancy between model results. Since welfare costs are related to the variance of protection rates, aggregation choice can matter.

assumptions in these two models, the key conclusion is that the overall economic welfare gain in the global economy is rather robust in this case.

We turn next to the tax replacement issue. When fiscal neutrality is imposed via adjustment to the tax on private household consumption of goods and services, the global welfare effect of full liberalization changes very little – but its cross-regional distribution alters significantly (column 3 of Table 1). Specifically, welfare rises in the EU and US by about $6 billion while falling about the same amount in developing countries. In order to explain this result, we distinguish between two drivers of welfare change: terms of trade changes and allocative efficiency changes. First consider the efficiency consequences of adjusting this tax. When costly farm export subsidies and domestic support payments are eliminated in the EU and US, this more than offsets the loss in import tariff revenue from reduction of the relatively low overall tariffs, so distorting consumption taxes are lowered under the revenue neutral closure. In other regions, by contrast, the loss of import tax revenue requires consumption taxes to go up. In high-income countries other than the EU and US that rise in the consumption tax rate is just a small fraction of one percentage point, but in developing countries it ranges from 1 to 7 percentage points, or, in the cases of Thailand and Vietnam, just over 10 percentage points. For this reason, the efficiency gains in the developed countries are higher, while in the developing countries they are lower, relative to the standard GTAP results. In the case of the terms of trade, since the consumption tax changes the mix of final demand this can have an impact on the terms of trade as well. In particular, when the tax rises, there is a stronger tendency to export goods and services, and therefore the terms of trade for the developing countries tend to deteriorate, relative to the base case. On the other hand, in the developed countries, where

the consumption tax is reduced, production is diverted from exports to domestic use and the terms of trade improve, relative to the base case.

The third model comparison is with respect to the scenario in which the trade balance is held fixed, rather than being allowed to change due to changes in the capital account induced by the requirement that changes in expected rates of return be equalized across countries. In this case, global efficiency gains and hence global welfare gains are almost unchanged, but the regional distribution is quite different. In particular, developing country welfare is reduced by 28 percent (column 4 of Table 1). The latter is due to a greater deterioration in the terms of trade for developing countries.

This effect is large enough to warrant further discussion. First, consider the fact that developing countries have higher overall tariffs, so when they cut them, imports expand relatively more than in the developed countries. This, in turn, forces exports to expand more, thereby leading to a deterioration in the terms of trade. In the standard case, the necessary export expansion is diminished somewhat by the increased foreign investment in developing countries. The increased share of global investment flowing to developing countries is driven by a rise in the rate of return on capital, relative to the rich countries. This, in turn, stems from the reduction in price of capital goods, which makes investment cheaper. Capital goods, and the inputs used to produce them, often face relatively high tariffs in developing countries. Lower priced capital goods boost the rate of return on investment and encourage increased investment inflows. In addition, there is a tendency for the rental rate on capital to rise due to improved allocative efficiency in these economies. Both of these factors raise expected returns on investment. Assuming net national savings in the developing countries are little changed, this excess in the

increment to investment relative to savings means exports need expand by less, so the terms of trade deteriorate less in developing countries (and therefore improve less in the developed countries which import these exports). Thus the terms of trade deterioration is less in the standard GTAP model as compared with this alternative case in which the trade balance is fixed and foreign investment does not respond to the higher rates of return (Table 2). In summary, capturing the impact of trade reforms on investment, and indirectly on the terms of trade for the developing economies, is important.

The fourth comparison focuses on the trade (Armington) elasticities. These are central to the welfare outcomes of trade liberalization exercises in CGE models, and they continue to be hotly debated. For the sake of illustration, consider what happens when the Armington elasticities for all countries are doubled: the estimated global welfare from full liberalization is also doubled: $176 billion instead of $86 billion. This is because the global efficiency gains are a function of the volume changes in the distorted markets. With doubled trade elasticities, the import volume change following global liberalization is roughly doubled, and so are the efficiency gains.

However, the distribution of global efficiency gains is not equally shared around the world. For developing countries the rise is proportionately greater ($63 billion instead of $29 billion), and for Sub-Saharan Africa the difference is especially large ($6.0 billion instead of $1.4 billion, or more than four times as large). That is, there is less likelihood that any developing country region would show losses from global trade reform assuming higher trade elasticities.

If it were only developing countries whose trade elasticities were twice the standard ones, developing countries' estimated welfare gain from global trade

liberalization would be 39 percent higher ($40 billion compared with $29 billion – see columns 1 and 6 of Table 1). The differences are smallest for large developing countries (China, Brazil), whose terms of trade deteriorate most, as their exports expand, and so suffer a greater offset to the larger gains from improved resource allocation (Table 2).[9] High-income countries would also benefit more if developing country trade elasticities were higher than estimated in the standard GTAP model, but only by 14 percent, with their greater gains in this case deriving largely from improved terms of trade.

We also explored the effect of doubling trade elasticities just for primary products. It raised the global welfare estimate from $86 billion to $112 billion, with less than $6 billion of that extra going to developing countries. This relatively smaller increment is a function of the relatively small share of primary products in world trade.

4.2 Effects on farm output volume, agricultural and food export value, and agricultural value added

The output effects of full global liberalization are summarized in Appendix Table A3 for all the key sectors by region and in Table 3 for primary agriculture for a more-detailed list of countries/country groups. The reason for the agricultural focus is because, as is clear from Appendix Table A3, this is where most of the reallocation of resources within and between countries occurs. In high-income countries agriculture shrinks by about one-tenth while in developing countries it expands by between 3 and 7 percent following a

[9] These effects of trade elasticities on the terms of trade versus resource re-allocative contributions to the welfare effect of liberalization are well known from trade theory (Lloyd and Zhang 2006).

move to free trade. The changes in processed food output are in the same directions but are somewhat more muted. When attention is turned to countries within each of those two country groups (Table 3), farm output expands in North America and Australia/NZ while it shrinks by about one-tenth in the EU, one-third in Korea and Taiwan, and one-half in Japan – with little variation between the 5 different sets of modeling assumptions. Similarly among developing countries, the farm output gains are largest for the agricultural exporters such as Thailand, Vietnam, South America and southern Africa. The changes are smallest when a fixed trade balance is imposed.

The export story is similar but even more accentuated for developing countries, while for high-income countries there is some growth in exports from all sectors because of intra-sectoral trade expansion through greater production specialization (Appendix Table A4). For agriculture, it is only the EU that would experience a reduction in farm exports following full liberalization, in part because its farm export subsidies would be removed (Table 4). Again the differences across the 5 different sets of modeling assumptions are modest with the exception of the scenario in which the Armington elasticities of substitution are doubled for developing countries – in which case the positive effects of reform on farm exports for those countries are more than 70% greater.

As for the effects of global trade reform on agricultural value added, they are roughly twice as large in the GTAP-AGR model as in the standard GTAP model (Table 5). This is not surprising because the GTAP-AGR model assumes less flexibility in farm land and labor use. So, with quantities of factors adjusting less, their prices change more – rising more in the case of expanding sectors and shrinking more in the case of contracting sectors. It suggests that analysts interested in short-run factor market and

value added effects within agriculture should consider using the GTAP-AGR rather than the GTAP standard model. When the Armington elasticities of substitution are doubled, developing countries' farmers are estimated to be made much better off from full reform than is the case with the standard GTAP model, with those in Sub-Saharan Africa enjoying a boost of one-eighth in their value added. Given that many of those farmers are self-employed and have little or no off-farm income (so their income would change by a similar proportion to agricultural value added), this has obvious significance for poverty alleviation.

4.3 Effects of African sub-regional liberalization with higher trade elasticities

One of the regions that has attracted special concern when it comes to the welfare effects of trade reform, as generated by the GTAP model, is Sub-Saharan Africa, because numerous studies have suggested they might lose from trade reforms. So to explore further the effects of doubling the trade elasticities, we compare the standard GTAP model results and those with doubled Armington elasticities for developing countries for full trade liberalization in Sub-Saharan Africa. That region has been divided into just three groups of countries in this and earlier simulations (see Appendix Table A2).

The results are summarized in Table 6 and 7. The standard GTAP model suggests Sub-Saharan Africa would lose slightly from its own regional liberalization, with its efficiency gains being fully offset by a deterioration in its terms of trade. But a doubling of the Armington elasticities of substitution effectively doubles the efficiency gains while diminishing the terms of trade losses, as the export demand elasticities also double in size. In this case, the region benefits by $2.0 billion instead of gaining nothing from own-

reform. So instead of all of the gains for Sub-Saharan Africa from global reform coming from other regions' reform, as suggested by the standard GTAP model, these results suggest fully one-third of them would come from own region's reform. This further underscores the importance of obtaining accurate estimates of the Armington elasticities of substitution for use in trade policy analyses.

However, because farmers in Sub-Saharan Africa are protected from import competition to a considerable extent, liberalization by them alone leads to a fall in farm output and agricultural value added, and more so in the case where the Armingtons elasticities have been doubled. If liberalization also occurs in other regions, by contrast, the gains in SSA farm output, exports and incomes are much larger when the doubled Armington elasticities of substitution are employed -- more than offsetting Sub-Saharan African farmers' losses from own-country cuts to their tariffs.

5 But which is the right model?

This paper so far has emphasized the sensitivity of results to a particular trade structure assumption (and associated parameters). Given those findings, more effort needs to be directed to the validation of these models against historical data. Unfortunately, these models are a composite of myriad assumptions in economic behavior, parameter choice, and closure. Unlike structural econometric models, there is not at present a well-developed set of tools for estimating and fitting these models to historical data.

Earlier attempts to validate results of computable general equilibrium models against historical data include Kehoe et al. (1995) and Gelhar (1997). More recently, Valenzuela et al. (2007) have introduced a systematic methodology for comparing the

results of multi-sector, static computable general equilibrium models with evidence on the standard deviations of market prices for particular commodities. They limit their validation exercise to a single agricultural commodity (wheat), and find that the model does not consistently under- or over-predict price variability (in opposition to a long standing presumption that these modes under predict price changes) but rather tends to under-predict price volatility for net exporters and over-predict price volatility for importing regions. This finding turns out to be very useful for understanding how to improve these types of models. By signaling where and how the model is presently falling short, this work points the way forward for future improvements. In particular those authors find that the model's performance can be enhanced by explicitly modeling importers' policies aimed at insulating domestic producers and consumers from international price volatility. To account for these policies in reduced form, the authors follow earlier work by in Tyers and Anderson (1992) and others by econometrically estimating regional price transmission elasticities and incorporating them into the model. They find that the modified model improves by one-third the matching of the observed volatility in wheat prices, and conclude that the inadequate representation of this aspect of government policies is an important limitation of the GTAP global CGE model – and likely other similar models.

As an illustrative example, here we followed Valenzuela et al.'s framework and assessed the market price-tracking ability of our model when the Armington elasticities are doubled globally. We find that, in the case of wheat, the model under these more-elastic conditions tends to dampen price variation, and thereby reduces the capacity of the

model to match observed data – by one-eighth. Of course, this is only for one commodity, and it applies to short-run (annual price) variation.

6 Conclusions

The key conclusion from our comparison of the standard GTAP model and the agriculture-specific GTAP-AGR model is that the effects of global trade reform on agricultural value added are roughly twice as large with the latter model in which factor markets in agriculture are assumed to be less flexible. The overall economic welfare effects are not very sensitive to the associated change in assumptions about the farm production parameters, *provided* sufficient disaggregation is permitted to capture the effects of key food tariff peaks.

Turning to the other three modeling assumptions considered, the first two (assuming fiscal neutrality, and fixing the trade balance) lead to greater gains from global trade reform for high-income countries but lesser gains for developing countries (or greater losses in the case of some Africa countries). The final one (doubling the Armington elasticities) brings greater gains to both groups of countries, but proportionately much more so for developing countries.

Effects of liberalization on farm output and exports differ little as the assumptions are varied except in case of higher trade elasticities, where doubling the trade elasticities causes agricultural exports of developing countries to be two-thirds greater, and developing country farmers there are expected to be made much better off.

Regional liberalization by Sub-Saharan Africa alone, which in the standard GTAP model typically generates a welfare loss for parts of the continent, is more

attractive when higher trade elasticities are assumed. Such a result strengthens the argument that Sub-Saharan Africa has much to gain from participating in the WTO's multilateral trade reform negotiations under the Doha Development Agenda. This is especially so if it would otherwise be liberalizing anyway, for by doing so under the WTO the region is in a position to extract more market access opportunities from its non-Sub-Saharan Africa trading partners in return for opening its own markets. However, liberalization by African countries alone, leads their farmers to be worse off following the removal of national agricultural protection, and this effect is even more pronounced when larger trade elasticities are assumed.

Given the sensitivity of model results to the specification of trade elasticities, more effort needs to be expended in the task of estimating trade elasticities for a much wider range of both developed and developing countries. Further research might also seek to distinguish import elasticities for products from different groups of countries, instead of assuming they are the same from all sources. Finally, independent estimates of the elasticity of substitution between imports and domestic goods are required. Presently these are simply assumed to be half as large as the import-import elasticities of substitution. However, changes in these elasticities will govern the extent of import penetration into the domestic market following trade reform, and this is a critical piece of the overall puzzle.

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Table 1: Impacts of full global trade liberalization and agricultural subsidy removal on national economic welfare under different modeling assumptions

(equivalent variation in income, 2001 US$m)

	Standard GTAP	AGR-model	Fiscal neutral closure	Fixed trade balance closure	Doubling Armington globally	Doubling Armington in devpg countries
High-income countries	**57350**	**50194**	**61886**	**65619**	**112623**	**79939**
Australia-New Zealand	3649	3447	3441	3468	5257	3581
European Union	11684	10094	15009	16015	32397	24783
USA	2363	2492	3998	5516	7607	4717
Canada	426	171	353	434	2724	513
Japan	26317	21160	26786	28059	40738	29650
Korea & Taiwan	9554	9391	8830	8708	19114	12743
Hong Kong & Singapore	3357	3439	3469	3419	4787	3952
Developing countries	**28950**	**29239**	**24061**	**20819**	**63303**	**40252**
Central Europe	***2285***	***2060***	***2101***	***1556***	***5184***	***4044***
Russia	1073	927	936	584	1991	1695
Turkey	1222	1199	1213	1133	2061	2015
Other Central Europe	-9	-66	-48	-162	1132	334
East Asia	***10986***	***11551***	***9042***	***9544***	***15978***	***13155***
China	4452	5061	3310	3963	6214	3957
Indonesia	857	811	775	741	953	973
Thailand	2774	2764	2396	2416	3415	3529
Vietnam	1219	1206	1193	955	2650	2348
Other East Asia	1684	1710	1369	1469	2746	2348
South Asia	***2223***	***2157***	***1883***	***1351***	***8161***	***5281***
Bangladesh	-25	-19	-53	-178	883	363
India	1714	1643	1481	1157	6228	4043
Other South Asia	534	534	455	372	1051	875
Latin America and Carib	***9048***	***9187***	***7926***	***5797***	***17563***	***8324***
Argentina	1528	1546	1396	1165	1778	1400
Brazil	7225	7228	6791	5366	9411	5470
Mexico	-441	-425	-504	-591	3349	1655
Other Latin Am. Carib	735	838	244	-143	3025	-201
Middle East North Africa	***958***	***759***	***79***	***-293***	***6580***	***4332***
Sub-Saharan Africa	***1408***	***1244***	***1059***	***487***	***5957***	***2092***
South Africa	763	751	675	389	1243	903
Selected SS Africa	696	614	680	653	1913	667
Other Sub-Saharan Africa	-50	-121	-295	-555	2802	523
Rest of the World	***2043***	***2280***	***1971***	***2377***	***3880***	***3024***
WORLD	**86301**	**79433**	**85947**	**86439**	**175927**	**120191**

Source: Authors' model simulations

Table 2: Decomposition of the welfare impacts of full global trade liberalization and agricultural subsidy removal on national economic welfare under different modeling assumptions

(equivalent variation in income, 2001 US$m)

	Standard GTAP			AGR-model			Fiscal neutral closure		
	Alloc. effect	*TOT effect*	*Total EV*	Alloc. effect	TOT effect	Total EV	Alloc. effect	TOT effect	Total EV
High-income count.	***59991***	***-2133***	***57350***	**51884**	**-1233**	**50194**	**61774**	**784**	**61886**
Australia-N. Zealand	*773*	*2914*	*3649*	825	2641	3447	724	2763	3441
European Union	*19924*	*-9254*	*11684*	16361	-7195	10094	21926	-7698	15009
USA	*2654*	*1726*	*2363*	2964	1454	2492	2791	2977	3998
Canada	*1171*	*-1068*	*426*	1226	-1387	171	1178	-1110	353
Japan	*27025*	*-948*	*26317*	22313	-1448	21160	26961	-258	26786
Korea & Taiwan	*8426*	*1429*	*9554*	8170	1567	9391	8165	937	8830
Hong Kong & Singap	*18*	*3068*	*3357*	25	3134	3439	29	3174	3469
Developing countries	***26757***	***1695***	***28950***	**27978**	**815**	**29239**	**24720**	**-1326**	**24061**
Central Europe	***2466***	***-766***	***2285***	***2514***	***-1030***	***2060***	***2435***	***-940***	***2101***
Russia	*1229*	*-816*	*1073*	1233	-959	927	1226	-971	936
Turkey	*561*	*664*	*1222*	563	639	1199	563	655	1213
Other Central Europe	*675*	*-614*	*-9*	718	-709	-66	646	-624	-48
East Asia	***4291***	***6807***	***10986***	***4936***	***6716***	***11551***	***3855***	***5162***	***9042***
China	*1227*	*3785*	*4452*	1813	3773	5061	984	2824	3310
Indonesia	*166*	*834*	*857*	161	810	811	164	738	775
Thailand	*607*	*1968*	*2774*	662	1898	2764	510	1658	2396
Vietnam	*1045*	*141*	*1219*	1050	110	1206	1038	126	1193
Other East Asia	*1246*	*79*	*1684*	1250	125	1710	1159	-182	1369
South Asia	***5422***	***-3118***	***2223***	***5418***	***-3188***	***2157***	***5246***	***-3286***	***1883***
Bangladesh	*516*	*-488*	*-25*	517	-484	-19	495	-491	-53
India	*4399*	*-2688*	*1714*	4383	-2749	1643	4290	-2818	1481
Other South Asia	*507*	*58*	*534*	519	46	534	461	24	455
Latin America and Carib	***6351***	***2520***	***9048***	***6740***	***2309***	***9187***	***5698***	***2088***	***7926***
Argentina	*518*	*988*	*1528*	576	947	1546	456	915	1396
Brazil	*1804*	*5189*	*7225*	2084	4910	7228	1529	5051	6791
Mexico	*2382*	*-3226*	*-441*	2323	-3143	-425	2379	-3269	-504
Other LatAm. Carib	*1647*	*-430*	*735*	1757	-404	838	1333	-610	244
M. E. N. A.	***4386***	***-3695***	***958***	***4450***	***-3959***	***759***	***3932***	***-4153***	***79***
Sub-Saharan Africa	***2143***	***-375***	***1408***	***2198***	***-566***	***1244***	***1884***	***-485***	***1059***
South Africa	*492*	*45*	*763*	496	30	751	432	17	675
Selected SS Africa	*93*	*596*	*696*	105	507	614	96	578	680
Other SS Africa	*1558*	*-1015*	*-50*	1598	-1103	-121	1355	-1080	-295
Rest of the World	***1699***	***321***	***2043***	***1721***	***533***	***2280***	***1670***	***287***	***1971***
WORLD	***86749***	***-438***	***86301***	**79862**	**-418**	**79433**	**86493**	**-542**	**85947**

… continued

Table 2 (cont.): Decomposition of the welfare impacts of full global trade liberalization and agricultural subsidy removal on national economic welfare under different modeling assumptions

(equivalent variation in income, 2001 US$m)

	Fixed trade balance closure			Doubling Armington globally			Doubling Armington in developing countries		
	Alloc. effect	*TOT effect*	*Total EV*	Alloc. effect	TOT effect	Total EV	Alloc. effect	TOT effect	Total EV
High-income count.	**62290**	**4192**	**65619**	**117008**	**-3573**	**112623**	**66185**	**14998**	**79939**
Australia-N. Zealand	757	2763	3468	1129	4175	5257	753	2866	3581
European Union	21867	-6468	16015	47222	-15689	32397	23003	971	24783
USA	2845	4173	5516	5048	4170	7607	3088	3500	4717
Canada	1222	-1031	434	3394	-943	2724	1211	-1000	513
Japan	27318	880	28059	39578	1266	40738	27661	2080	29650
Korea & Taiwan	8252	752	8708	20693	-1016	19114	10445	2955	12743
Hong Kong & Singap	28	3123	3419	-58	4463	4787	24	3625	3952
Developing countries	**24540**	**-4589**	**20819**	**59374**	**3123**	**63303**	**54486**	**-15464**	**40252**
Central Europe	***2245***	***-1479***	***1556***	***5580***	***-1081***	***5184***	***5469***	***-2256***	***4044***
Russia	1052	-1333	584	2226	-1001	1991	2172	-1393	1695
Turkey	553	585	1133	1465	599	2061	1568	445	2015
Other Central Europe	640	-731	-162	1890	-679	1132	1730	-1308	334
East Asia	***4288***	***5415***	***9544***	***11085***	***4615***	***15978***	***10176***	***2205***	***13155***
China	1283	3296	3963	4242	2306	6214	4242	-479	3957
Indonesia	167	693	741	397	633	953	386	644	973
Thailand	570	1571	2416	1515	1675	3415	1396	1892	3529
Vietnam	1019	-1	955	2246	300	2650	1960	376	2348
Other East Asia	1249	-143	1469	2686	-298	2746	2192	-229	2348
South Asia	***5213***	***-3835***	***1351***	***11793***	***-3597***	***8161***	***10442***	***-5043***	***5281***
Bangladesh	482	-577	-178	1375	-502	883	1088	-643	363
India	4270	-3192	1157	9430	-3194	6228	8420	-4379	4043
Other South Asia	461	-67	372	989	99	1051	935	-22	875
Latin America and Carib	***5231***	***569***	***5797***	***13388***	***4206***	***17563***	***12168***	***-3763***	***8324***
Argentina	339	754	1165	748	953	1778	682	611	1400
Brazil	1079	4267	5366	2693	6712	9411	2345	3180	5470
Mexico	2449	-3446	-591	6561	-3638	3349	6371	-5296	1655
Other LatAm. Carib	1364	-1005	-143	3386	179	3025	2769	-2258	-201
M. E. N. A.	***4089***	***-4788***	***-293***	***9868***	***-3529***	***6580***	***9223***	***-5207***	***4332***
Sub-Saharan Africa	***1718***	***-993***	***487***	***4455***	***1826***	***5957***	***4012***	***-1481***	***2092***
South Africa	297	-196	389	857	152	1243	748	-122	903
Selected SS Africa	85	569	653	304	1587	1913	317	357	667
Other SS Africa	1337	-1366	-555	3294	86	2802	2947	-1716	523
Rest of the World	***1754***	***522***	***2377***	***3205***	***682***	***3880***	***2996***	***81***	***3024***
WORLD	**86829**	**-397**	**86439**	**176382**	**-450**	**175927**	**120671**	**-467**	**120191**

Source: Authors' model simulations

Table 3: Impacts of full global trade liberalization and agricultural subsidy removal on agricultural output volume under different modeling assumptions

(percent difference from benchmark in 2001)

	Standard GTAP	AGR-model	Fiscal neutral closure	Fixed trade balance closure	Doubling Armington globally	Doubling Armington in devpg countries
High-income countries	**-10.1**	**-12.0**	**-10.4**	**-12.0**	**-16.8**	**-10.2**
Australia-New Zealand	22.7	18.5	22.0	11.9	35.9	20.5
European Union	-10.1	-11.9	-10.4	-13.0	-25.7	-11.6
USA	5.8	4.3	5.4	-0.2	4.6	5.0
Canada	11.8	8.3	11.2	5.7	16.3	11.8
Japan	-48.6	-51.9	-48.7	-43.5	-57.6	-47.7
Korea & Taiwan	-33.3	-31.8	-33.9	-16.8	-25.2	-22.9
Hong Kong & Singapore	7.0	5.4	6.3	2.9	9.1	8.9
Developing countries	**6.7**	**5.7**	**5.4**	**3.0**	**9.0**	**4.5**
Central Europe	***1.8***	***0.8***	***1.3***	***1.3***	***2.2***	***0.2***
Russia	-1.4	-2.3	-2.8	-0.3	-3.3	-5.1
Turkey	3.7	2.4	3.3	0.2	3.4	0.9
Other Central Europe	2.1	1.1	1.7	1.8	3.0	1.0
East Asia	***9.5***	***9.5***	***7.5***	***3.6***	***10.7***	***8.1***
China	9.6	9.9	7.5	4.0	12.3	8.9
Indonesia	3.6	2.7	2.7	-0.4	0.8	0.9
Thailand	27.3	23.6	26.0	10.1	18.1	21.2
Vietnam	11.5	11.7	10.2	1.2	4.1	7.4
Other East Asia	2.1	1.3	-0.5	-0.5	-0.6	-2.0
South Asia	***0.0***	***-1.2***	***-1.1***	***-0.6***	***-0.5***	***-2.5***
Bangladesh	-1.4	-2.4	-2.1	-0.3	1.4	-0.7
India	-0.3	-1.6	-1.4	-0.8	-1.4	-3.4
Other South Asia	2.2	1.2	1.0	0.1	2.3	1.0
Latin America and Carib	***17.6***	***15.8***	***17.0***	***8.4***	***26.5***	***14.7***
Argentina	14.9	13.8	14.3	5.9	19.0	14.9
Brazil	37.6	33.5	36.9	17.1	56.1	35.6
Mexico	2.8	1.5	2.4	-0.4	-0.4	-4.5
Other Latin America Carib	14.7	13.6	14.0	8.7	25.7	12.6
Middle East North Africa	***0.6***	***-0.4***	***-0.7***	***1.0***	***2.0***	***-2.5***
Sub-Saharan Africa	***7.8***	***6.6***	***6.9***	***4.9***	***17.4***	***4.9***
South Africa	6.5	4.8	5.6	5.0	27.0	4.8
Selected SS Africa	12.9	11.4	12.2	4.9	15.2	8.6
Other Sub-Saharan Africa	6.2	5.2	5.1	5.0	11.2	3.5
Rest of the World	***10.2***	***4.9***	***9.3***	***4.8***	***13.2***	***6.4***
WORLD	**0.3**	**-1.0**	**-0.6**	**-2.7**	**-0.8**	**-1.1**

Source: Authors' model simulations

Table 4: Impacts of full global trade liberalization and agricultural subsidy removal on value of agricultural and food exports (at FOB prices) under different modeling assumptions

(percent difference from benchmark in 2001)

	Standard GTAP	AGR-model	Fiscal neutral closure	Fixed trade balance closure	Doubling Armington globally	Doubling Armington in devpg countries
High-income countries	**7.9**	**7.7**	**7.1**	**7.2**	**27.3**	**12.4**
Australia-New Zealand	36.6	30.2	36.1	36.6	71.9	35.9
European Union	-9.3	-7.3	-9.8	-9.9	-16.6	-10.8
USA	30.8	25.6	29.3	29.5	54.0	35.3
Canada	32.4	27.8	31.7	31.8	75.0	34.3
Japan	35.9	61.7	33.8	34.3	129.0	67.1
Korea & Taiwan	108.7	118.6	108.5	109.2	812.6	360.8
Hong Kong & Singapore	69.8	66.5	68.0	69.0	280.1	104.6
Developing countries	**46.1**	**40.4**	**46.2**	**47.3**	**100.5**	**65.8**
Central Europe	***52.8***	***47.2***	***51.8***	***53.0***	***127.5***	***88.2***
Russia	17.2	14.0	17.7	18.8	48.9	30.1
Turkey	56.4	52.8	55.1	56.3	152.0	90.0
Other Central Europe	71.0	62.9	69.4	70.7	157.9	120.2
East Asia	***42.9***	***38.4***	***43.8***	***43.0***	***64.0***	***55.2***
China	77.3	67.5	79.1	77.0	129.6	101.4
Indonesia	19.6	18.4	19.2	19.3	24.6	27.6
Thailand	19.6	15.7	20.2	20.2	18.0	13.4
Vietnam	5.9	8.2	5.3	7.6	-1.9	11.1
Other East Asia	43.6	43.1	44.6	43.3	62.1	65.6
South Asia	***27.6***	***26.9***	***27.7***	***29.0***	***109.2***	***97.0***
Bangladesh	20.3	20.9	20.6	23.2	872.4	843.9
India	25.3	24.8	25.5	26.9	59.4	45.6
Other South Asia	35.0	33.7	35.0	35.5	92.8	88.0
Latin America and Carib	***48.5***	***41.2***	***48.5***	***50.7***	***94.5***	***61.1***
Argentina	20.0	17.9	19.5	21.6	29.9	23.7
Brazil	97.8	80.4	97.9	103.9	171.4	109.6
Mexico	31.9	29.4	31.5	31.9	94.0	65.5
Other Latin America Carib	37.1	31.9	37.1	37.7	78.8	47.9
Middle East North Africa	***47.2***	***43.8***	***47.5***	***48.7***	***177.6***	***68.2***
Sub-Saharan Africa	***45.8***	***39.5***	***45.8***	***47.9***	***135.7***	***63.3***
South Africa	25.4	21.1	24.6	26.1	55.3	37.1
Selected SS Africa	81.0	70.5	80.8	82.6	258.5	104.1
Other Sub-Saharan Africa	41.5	36.0	41.9	44.4	124.8	59.6
Rest of the World	***77.3***	***66.3***	***77.1***	***71.4***	***180.9***	***132.6***
WORLD	**21.1**	**19.0**	**20.6**	**21.0**	**52.6**	**30.9**

Source: Authors' model simulations

Table 5: Impacts of full global trade liberalization and agricultural subsidy removal on agricultural value added (net farm income) under different modeling assumptions

(percent difference from benchmark in 2001)

	Standard GTAP	AGR-model	Fiscal neutral closure	Fixed trade balance closure	Doubling Armington globally	Doubling Armington in devpg countries
High-income countries	**-12.2**	**-23.8**	**-12.4**	**-12.4**	**-18.0**	**-12.3**
Australia-New Zealand	13.2	17.8	12.8	13.0	19.1	12.0
European Union	-14.5	-25.6	-14.7	-14.8	-26.6	-15.5
USA	-2.7	-13.5	-2.9	-2.8	-4.1	-3.4
Canada	5.6	-2.2	5.2	5.3	8.6	5.7
Japan	-40.1	-58.2	-40.3	-40.1	-48.2	-39.2
Korea & Taiwan	-12.4	-32.6	-12.9	-12.6	-5.9	-5.6
Hong Kong & Singapore	4.2	5.9	4.0	4.1	6.1	5.4
Developing countries	**4.4**	**6.3**	**3.7**	**4.1**	**5.7**	**3.0**
Central Europe	***1.3***	***0.2***	***0.9***	***1.0***	***1.2***	***-0.1***
Russia	0.1	-2.0	-0.6	-0.3	-0.8	-1.9
Turkey	1.4	-0.1	1.1	1.1	0.6	-1.1
Other Central Europe	1.7	1.3	1.6	1.5	2.4	1.2
East Asia	***6.0***	***10.2***	***5.0***	***5.8***	***6.7***	***5.4***
China	6.3	10.9	5.3	6.2	7.6	6.0
Indonesia	2.1	3.2	1.8	1.9	1.1	1.0
Thailand	11.8	23.1	11.3	11.6	10.2	10.1
Vietnam	9.0	12.3	8.5	8.3	9.0	9.0
Other East Asia	1.9	1.5	0.8	1.6	-0.2	-0.6
South Asia	***-0.6***	***-4.0***	***-1.0***	***-1.0***	***-0.7***	***-1.8***
Bangladesh	0.7	-2.3	0.2	0.0	2.6	0.6
India	-1.1	-5.4	-1.6	-1.6	-1.3	-2.5
Other South Asia	2.0	2.4	1.5	1.5	1.6	1.2
Latin America and Carib	***9.9***	***18.7***	***9.6***	***9.6***	***13.2***	***7.9***
Argentina	7.5	17.2	7.2	7.0	8.5	6.9
Brazil	27.3	49.4	26.8	27.1	32.6	24.8
Mexico	-0.9	-1.1	-1.1	-1.1	-2.1	-4.3
Other Latin America Carib	8.5	15.9	8.2	8.2	14.1	7.1
Middle East North Africa	***1.4***	***0.2***	***0.3***	***0.9***	***2.6***	***-1.1***
Sub-Saharan Africa	***7.0***	***7.7***	***6.2***	***6.5***	***12.8***	***4.6***
South Africa	7.1	8.0	6.3	6.7	10.7	5.9
Selected SS Africa	10.6	12.4	10.1	10.3	17.5	7.2
Other Sub-Saharan Africa	5.6	5.9	4.8	5.1	11.4	3.5
Rest of the World	***7.3***	***6.6***	***7.0***	***7.5***	***11.0***	***5.8***
WORLD	**-1.5**	**-4.4**	**-2.0**	**-1.8**	**-2.7**	**-2.4**

Source: Authors' model simulations

Table 6: Impacts of full regional liberalization by Sub-Saharan Africa, and by rest of the world, on welfare without and with trade elasticities doubled

(equivalent variation in income, 2001 US$m)

	Standard GTAP model				Doubling Armingtons globally			
	TOTAL		That due to terms of trade		TOTAL		That due to terms of trade	
	Own Regional Lib.	Other countries' Lib.	Own Regional Lib.	Other countries' Lib.	Own Regional Lib.	Other countries' Lib.	Own Regional Lib.	Other countries' Lib.
South Africa	260	503	-453	498	498	745	-549	701
Selected Sub-Saharan Africa[a]	4	692	-95	691	185	1728	-146	1733
Other Sub-Saharan Africa	-268	218	-1264	249	1273	1529	-1429	1515
Sub-Saharan Africa	***-4***	***1412***	***-1811***	***1436***	***1956***	***4001***	***-2125***	***3951***
Other developing countries	549	26993	529	1541	657	56689	607	690
High-income countries	1501	55849	1244	-3377	1497	111126	1470	-5043
World	**2047**	**84254**	**-38**	**-400**	**4110**	**171817**	**-48**	**-402**

[a] Selected Sub-Saharan Africa includes: Botswana, Madagascar, Malawi, Mozambique, Tanzania, Uganda, Zambia, Zimbabwe

Source: Authors' model simulations

Table 7: Impacts of full regional liberalization by Sub-Saharan Africa, and by rest of the world, on agricultural output, the value of food and agricultural exports, and agricultural value added without and with trade elasticities doubled

Agricultural output volume(percent difference from benchmark in 2001)

	Standard GTAP model		Doubling Armingtons globally	
	Own Regional Lib.	Other countries' Lib.	Own Regional Lib.	Other countries' Lib.
South Africa	-3.1	9.6	-6.5	33.5
Selected Sub-Saharan Africa[a]	-1.7	14.6	-3.5	18.5
Other Sub-Saharan Africa	-4.5	10.7	-6.1	17.3

Agricultural and food exports value (percent difference from benchmark in 2001)

	Standard GTAP model		Doubling Armingtons globally	
	Own Regional Lib.	Other countries' Lib.	Own Regional Lib.	Other countries' Lib.
South Africa	4.7	20.7	15.1	40.2
Selected Sub-Saharan Africa[a]	5.2	75.8	18.5	240.0
Other Sub-Saharan Africa	8.7	32.8	22.4	102.4

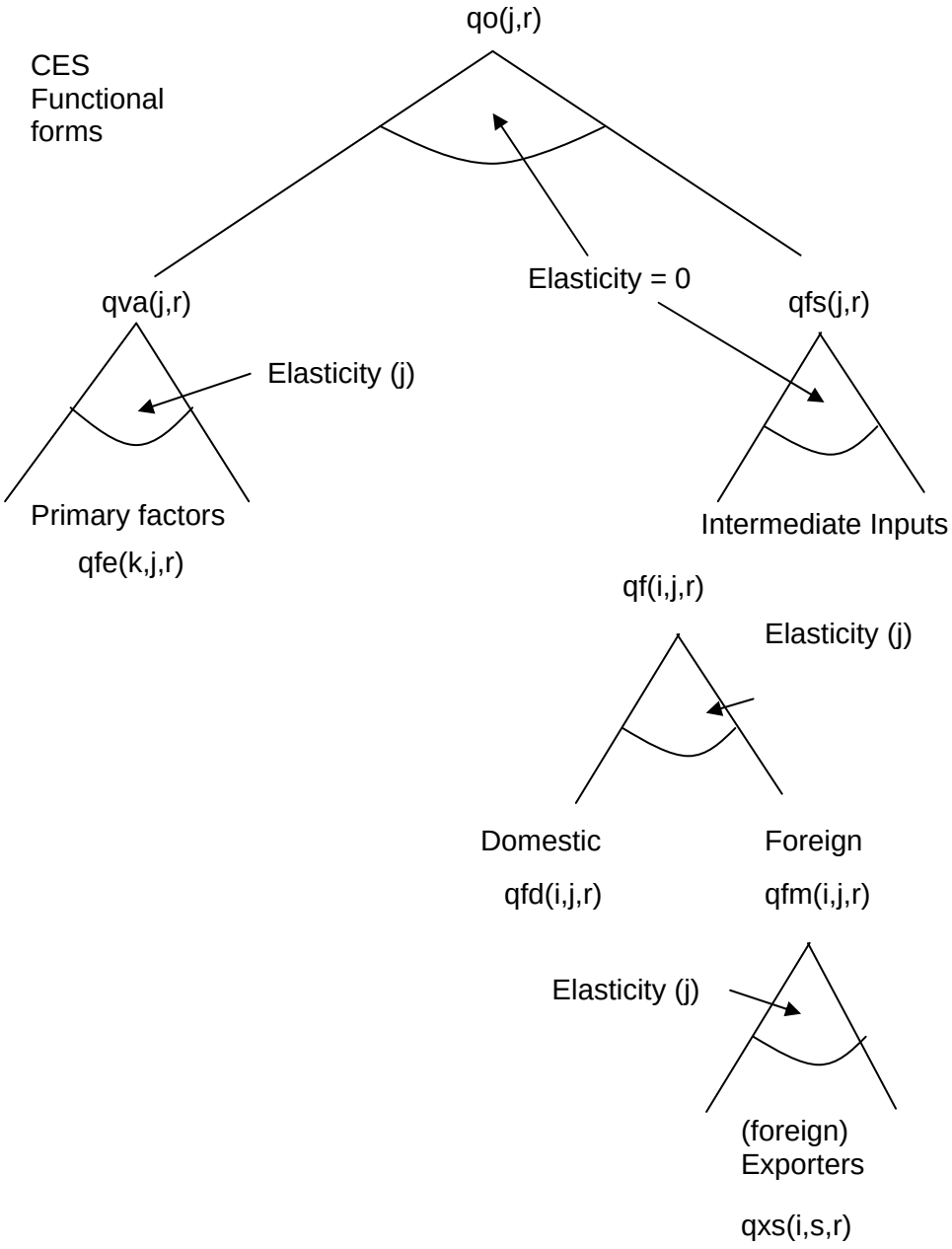
Agricultural value added (percent difference from benchmark in 2001)

	Standard GTAP model		Doubling Armingtons globally	
	Own Regional Lib.	Other countries' Lib.	Own Regional Lib.	Other countries' Lib.
South Africa	-1.4	8.5	-4.0	14.7
Selected Sub-Saharan Africa[a]	-0.5	11.1	-1.7	19.2
Other Sub-Saharan Africa	-2.0	7.6	-2.9	14.3

[a] Selected Sub-Saharan Africa includes: Botswana, Madagascar, Malawi, Mozambique, Tanzania, Uganda, Zambia, Zimbabwe

Source: Authors' model simulations

Figure 1: Production structure in the GTAP Model



where j = set of commodities (ouput); i = set of commodities (input to processing); k = set of endowments commodities; r = region (importer); s = region (exporter). Changes in quantities are in percentages: qo = change in output quantity; qva = change in composite quantity of endowments; qfe = change in quantity of endowments; qfs = change in composite quantity of intermediate inputs; qf = change in quantity of intermediate inputs; qfd = change in quantity demanded of domestically produced commodity; qfm = change in quantity demanded of composite foreign produced commodity; qxs = change in quantity demanded of foreign produced commodity.

Source: Hertel (1997) and www.gtap.org

Appendix Table A1: Sectoral aggregation of the GTAP database for this study

	New sector	GTAP 6.1 sector	Description
1	ric	pdr, pcr	Paddy rice; Processed rice
2	wht	wht	Wheat
3	gro	gro	Cereal grains nec
4	v_f	v_f	Vegetables, fruit, nuts
5	osd	osd	Oil seeds
6	sug	c_b, sgr	Sugar cane, sugar beet; Sugar
7	pfb	pfb	Plant-based fibers
8	ocr	ocr	Crops nec
9	lvs	ctl, oap, rmk,wol	Cattle,sheep,goats,horses; Animal products nec; Raw milk; Wool, silk-worm cocoons
10	onr	frs, omn omn	Forestry; Minerals nec
11	ffl	coa, oil, gas, p_c	Coal; Oil; Gas; Petroleum, coal products
12	pmt	cmt, omt	Meat: cattle,sheep,goats,horse; Meat products nec
13	vol	vol	Vegetable oils and fats
14	mil	mil	Dairy products
15	ofd	fsh, ofd, b_t	Fishing; Food products nec; Beverages and tobacco products
16	tex	tex	Textiles
17	wap	wap	Wearing apparel
18	lea	lea	Leather products
19	crp	crp	Chemical,rubber,plastic prods
20	i_s	i_s	Ferrous metals
21	mvh	mvh	Motor vehicles and parts
22	cgd	otn, ele, ome	Transport equipment nec; Electronic equipment; Machinery and equipment nec
23	omf	lum, ppp,nmm, nfm, fmp, omf	Wood products; Paper products, publishing; Mineral products nec; Metals nec; Metal products; Manufactures nec
24	cns	cns	Construction
25	svc	ely, gdt, wtr, trd, otp, wtp, atp, cmn, ofi, isr, obs, ros, osg, dwe	Electricity; Gas manufacture, distribution; Water; Trade; Transport nec; Sea transport; Air transport; Communication; Financial services nec; Insurance, Business services nec; Recreation and other services; PubAdmin/Defence/Health/Educat; Dwellings

Appendix Table A2: Regional aggregation of the GTAP database for this study

	New Region	Comprising Regions GTAP version 6.1
1	Australia-New Zealand	AUS NZL
2	European Union	AUT BEL DNK FIN FRA DEU GBR GRC IRL ITA LUX NLD PRT ESP SWE CHE XEF XER CYP CZE HUN MLT POL SVK SVN EST LVA LTU
3	USA	USA
4	Canada	CAN
5	Japan	JPN
6	Korea & Taiwan	KOR TWN
7	Hong Kong & Singapore	HKG SGP
8	Argentina	ARG
9	Bangladesh	BGD
10	Brazil	BRA
11	China	CHN
12	India	IND
13	Indonesia	IDN
14	Thailand	THA
15	VietNam	VNM
16	Russia	RUS
17	Mexico	MEX
18	South Africa	ZAF
19	Turkey	TUR
20	Other South Asia	PAK LKA XSA
21	Other East Asia	MYS PHL
22	Other Latin America and Carib	BOL COL ECU PER VEN CHL URY XSM XCA XFA XCB
23	Other Central Europe	ALB BGR HRV ROM XSU
24	Middle East North Africa	IRN XME MAR TUN XNF
25	Selected Sub-Saharan Africa	BWA MWI MOZ TZA ZMB ZWE MDG UGA
26	Other Sub-Saharan Africa	XSC MUS XSD NGA XSS
27	Rest of the World	XOC XEA XSE XNA

Appendix Table A3: Impacts of full global trade liberalization on sectoral output volume under different modeling assumptions

(percent difference from benchmark in 2001)

Assumption:	**Standard GTAP model**					
	Agriculture	Other Primary	Proc. Food	Other Manuf	Svc	Total
High-income countries	-10.1	0.4	-2.4	-0.1	-0.2	-0.4
Developing countries	6.7	-1.7	3.9	-1.2	0.6	0.5
Central Europe	1.8	0.0	-0.3	-2.7	-0.3	-0.8
East Asia	9.5	-3.2	4.4	0.8	1.5	1.8
South Asia	0.0	-8.2	-9.0	-2.5	-1.3	-2.1
Latin America and Carib	17.6	-2.0	8.2	-3.0	1.3	1.3
Middle East North Africa	0.6	-0.5	0.4	-2.1	-0.6	-0.8
Sub-Saharan Africa	7.8	-0.7	6.2	-5.2	0.4	0.2
WORLD	0.3	-0.8	-0.5	-0.4	-0.1	-0.2

Assumption:	**AGR-model**					
	Agriculture	Other Primary	Proc. Food	Other Manuf	Svc	Total
High-income countries	-12.0	0.1	-2.6	-0.2	-0.3	-0.6
Developing countries	5.7	-1.7	3.3	-0.8	0.6	0.6
Central Europe	0.8	-0.2	-0.6	-2.3	-0.2	-0.8
East Asia	9.5	-2.8	4.4	1.1	1.7	2.1
South Asia	-1.2	-8.3	-9.2	-2.5	-1.4	-2.3
Latin America and Carib	15.8	-1.8	7.1	-2.5	1.3	1.3
Middle East North Africa	-0.4	-0.7	-0.1	-1.9	-0.6	-0.9
Sub-Saharan Africa	6.6	-0.7	4.8	-4.4	0.3	0.1
WORLD	-1.0	-0.9	-0.8	-0.4	-0.2	-0.3

Assumption:	**Fiscal neutral closure**					
	Agriculture	Other Primary	Proc. Food	Other Manuf	Svc	Total
High-income countries	-10.4	0.2	-2.4	0.0	-0.2	-0.4
Developing countries	5.4	-1.9	2.9	-1.0	0.5	0.4
Central Europe	1.3	-0.2	-0.7	-2.6	-0.3	-0.9
East Asia	7.5	-3.4	2.6	1.0	1.3	1.6
South Asia	-1.1	-8.5	-9.9	-2.3	-1.5	-2.3
Latin America and Carib	17.0	-2.2	7.8	-3.0	1.2	1.2
Middle East North Africa	-0.7	-0.7	-0.8	-2.1	-0.8	-1.0
Sub-Saharan Africa	6.9	-1.0	5.1	-5.1	0.5	0.0
WORLD	-0.6	-1.0	-0.8	-0.2	-0.1	-0.2

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Appendix Table A3 (cont.): Impacts of full global trade liberalization on sectoral output volume under different modeling assumptions

(percent difference from benchmark in 2001)

Assumption:	**Fixed trade balance closure**					
	Agriculture	Other Primary	Proc. Food	Other Manuf	Svc	Total
High-income countries	-12.0	0.7	-1.7	0.4	0.2	0.0
Developing countries	3.0	-0.8	2.2	-0.9	-0.2	-0.1
Central Europe	1.3	0.5	1.1	-1.7	0.2	-0.2
East Asia	3.6	-3.3	1.1	0.0	-1.1	-0.1
South Asia	-0.6	-0.9	-7.6	1.3	0.2	0.0
Latin America and Carib	8.4	-1.0	5.0	-2.8	-0.1	-0.1
Middle East North Africa	1.0	0.2	1.8	-0.5	-0.1	0.0
Sub-Saharan Africa	4.9	0.2	5.7	-4.4	-0.2	-0.1
WORLD	-2.7	-0.1	-0.5	0.1	0.1	0.0

Assumption:	**Doubling Armingtons globally**					
	Agriculture	Other Primary	Proc. Food	Other Manuf	Svc	Total
High-income countries	-16.8	0.6	-6.0	-0.3	-0.1	-0.7
Developing countries	9.0	-3.0	6.5	-2.4	0.4	0.3
Central Europe	2.2	-0.9	-1.5	-4.7	-0.2	-1.6
East Asia	10.7	-5.6	2.5	1.0	0.6	1.6
South Asia	-0.5	-7.2	-0.2	-2.6	-0.3	-1.4
Latin America and Carib	26.5	-3.3	11.1	-6.2	0.5	0.6
Middle East North Africa	2.0	-1.8	9.4	-3.7	0.2	-0.5
Sub-Saharan Africa	17.4	-1.4	29.0	-11.5	0.7	1.9
WORLD	-0.8	-1.3	-2.2	-0.8	0.0	-0.5

Assumption:	**Doubling Armingtons in developing countries**					
	Agriculture	Other Primary	Proc. Food	Other Manuf	Svc	Total
High-income countries	-10.2	-0.1	-1.6	0.0	0.1	-0.2
Developing countries	4.5	-2.7	0.0	-2.4	-0.2	-0.8
Central Europe	0.2	-0.4	-5.3	-3.9	-0.4	-1.9
East Asia	8.1	-4.9	1.3	0.5	0.9	1.1
South Asia	-2.5	-12.0	-4.4	-4.4	-1.8	-3.3
Latin America and Carib	14.7	-3.1	4.2	-5.6	-0.5	-1.0
Middle East North Africa	-2.5	-1.1	-6.6	-3.5	-0.5	-1.8
Sub-Saharan Africa	4.9	-1.0	0.5	-8.0	0.0	-1.6
WORLD	-1.1	-1.5	-1.1	-0.6	0.1	-0.3

Source: Authors' model simulations

Appendix Table A4: Impacts of full global trade liberalization on value of exports under different modeling assumptions

(percent difference from benchmark in 2001)

Assumption:	**Standard GTAP model**				
	Agriculture and Food	Other Primary	Other Manuf	Services	Total
High-income countries	7.9	4.3	4.1	2.2	4.0
Developing countries	46.1	1.6	9.4	-0.8	10.1
Central Europe	52.8	1.6	3.5	2.1	6.1
East Asia	42.9	-3.5	10.1	-5.9	10.4
South Asia	27.6	73.9	34.5	4.3	29.1
Latin America and Carib	48.5	0.9	3.5	-1.3	9.5
Middle East North Africa	47.2	0.2	13.8	2.3	6.2
Sub-Saharan Africa	45.8	3.4	2.4	0.7	9.3
WORLD	21.1	2.4	5.4	1.6	5.6

Assumption:	**GTAP-AGR model**				
	Agriculture and Food	Other Primary	Other Manuf	Services	Total
High-income countries	7.7	3.7	4.0	2.0	3.8
Developing countries	40.4	1.5	9.8	-0.5	9.8
Central Europe	47.2	1.0	4.1	2.2	5.9
East Asia	38.4	-2.5	10.3	-5.8	10.3
South Asia	26.9	73.7	34.7	4.4	29.1
Latin America and Carib	41.2	1.0	4.0	-0.8	8.8
Middle East North Africa	43.8	-0.1	14.5	2.6	6.1
Sub-Saharan Africa	39.5	3.2	4.3	1.8	9.2
WORLD	19.0	2.1	5.4	1.6	5.5

Assumption:	**Fiscal neutral closure**				
	Agriculture and Food	Other Primary	Other Manuf	Services	Total
High-income countries	7.1	3.7	4.0	2.0	3.8
Developing countries	46.2	1.5	10.2	-0.4	10.6
Central Europe	51.8	1.5	3.8	2.2	6.2
East Asia	43.8	-3.4	11.3	-5.3	11.4
South Asia	27.7	74.2	35.6	4.8	29.9
Latin America and Carib	48.5	0.7	3.8	-1.1	9.7
Middle East North Africa	47.5	0.1	14.8	2.9	6.5
Sub-Saharan Africa	45.8	3.2	2.9	0.9	9.5
WORLD	20.6	2.2	5.5	1.6	5.7

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Appendix Table A4 (cont.): Impacts of full global trade liberalization on value of exports under different modeling assumptions

(percent difference from benchmark in 2001)

Assumption:	**Fixed trade balance closure**				
	Agriculture and Food	Other Primary	Other Manuf	Services	Total
High-income countries	7.2	3.4	3.5	1.8	3.4
Developing countries	47.3	1.6	11.1	0.4	11.4
Central Europe	53.0	1.5	5.0	2.8	7.0
East Asia	43.0	-3.8	11.1	-5.2	11.2
South Asia	29.0	74.4	39.2	6.5	32.8
Latin America and Carib	50.7	1.1	6.2	0.6	11.8
Middle East North Africa	48.7	0.2	16.4	3.8	7.1
Sub-Saharan Africa	47.9	3.7	5.9	2.8	11.5
WORLD	21.0	2.1	5.3	1.6	5.5

Assumption:	**Doubling Armingtons globally**				
	Agriculture and Food	Other Primary	Other Manuf	Services	Total
High-income countries	27.3	8.9	7.4	5.1	8.2
Developing countries	100.5	4.0	25.2	-1.1	25.1
Central Europe	127.5	0.4	11.7	6.4	15.7
East Asia	64.0	-1.2	24.9	-11.6	23.4
South Asia	109.2	236.9	85.0	6.4	77.3
Latin America and Carib	94.5	4.7	17.5	0.9	25.7
Middle East North Africa	177.6	-0.6	31.2	3.4	15.8
Sub-Saharan Africa	135.7	8.8	7.3	-2.4	26.8
WORLD	52.6	5.5	11.7	4.0	12.7

Assumption:	**Doubling Armingtons in developing countries**				
	Agriculture and Food	Other Primary	Other Manuf	Services	Total
High-income countries	12.4	4.4	4.3	3.0	4.6
Developing countries	65.8	3.5	23.6	3.6	21.4
Central Europe	88.2	1.6	13.2	6.3	14.1
East Asia	55.2	-0.2	22.0	-5.1	21.0
South Asia	97.0	118.4	74.0	10.7	65.7
Latin America and Carib	61.1	4.0	17.7	6.1	21.2
Middle East North Africa	68.2	0.4	30.8	6.5	12.5
Sub-Saharan Africa	63.3	8.3	16.3	7.0	20.1
WORLD	30.9	3.8	9.0	3.1	9.1

Source: Authors' model simulations