**Global Merchandise Trade Reform:**
**Comparing results with the LINKAGE Model**

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# Global Merchandise Trade Reform:
# Comparing results with the LINKAGE Model

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**Abstract:** This paper summarizes the key findings from simulating the full removal of all remaining trade barriers and domestic support using the World Bank's global trade model, known as LINKAGE. In its default configuration, the Linkage model is dynamic recursive with the measured gains assessed in 2015 relative to a baseline for the global economy. The gains from this scenario are substantial, particularly for developing countries. The scenario also highlights the importance of agriculture as a source of the gains—for both developed and developing countries—and the importance of developing country reform as a source of their own gains.

A second part of the paper looks at some of the key underlying assumptions of the standard LINKAGE model. First, the paper shows the relative importance of using a dynamic framework as opposed to a simple comparative static framework. Second, the paper shows how the trade reform results are impacted by changes in specific assumptions—the level of the trade elasticities, known to be important in assessing trade reform, the role of land supply—both its relative mobility across sectors and its aggregate responsiveness to changes in its underlying rental value—, and labor market closure—fixed versus flexible wages. There is no doubt that the aggregate income results are sensitive to these underlying assumptions. However, conclusions regarding the structural impacts are more robust, and they also tend to be much greater than the average income impact.

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# Introduction

The results from global trade modeling exercises have become a standard feature of the multilateral trade discussions—taking off in particular towards the end of the Uruguay Round as the combination of improved computer power and data provided trade economists with the ability to undertake relatively rapid analysis of proposed reforms to the global trading system. There have been steady improvements since the early 1990s, particularly in the base data itself, and more recently with the trade data base that now more comprehensively incorporates preferential arrangements, applied and bound tariffs, specific tariffs, and to a lesser extent non-tariff barriers. Along with these improvements has been a rapid increase in the number of applications of global trade models—if not in their number, as many analysts use existing models albeit providing perhaps some particular twists. The plethora of studies has led to sometimes sharply divergent views of the impacts of trade reform on the global economy—and those involved in the negotiations—the negotiators, trade analysts (including journalists) and other policy makers both often misunderstand the results and/or 'cherry-pick' those that best match their own priors and positions.

This paper will shed some light on the robustness of the results coming from a specific model—the World Bank's LINKAGE model—that has been at the center of the World Bank's analysis of the Doha Round and its implications for developing countries and widely cited. The paper is part of a broader exercise meant to compare the results from three global trade models—LINKAGE, GTAP (Purdue University, USA) and Mirage (CEPII, France). The exercise is intended to assess model differences for a single specific reform, i.e. global trade reform—since any other type of reform could lead to issues about the design of the reform and model differences could then be because of design differences as well as model differences. Setting all tariffs to zero (as well as domestic support), albeit an unlikely scenario at the moment, at least provides from the modeling perspective a 'clean' experiment' for the purposes of model comparison.

The first part of the paper lays out the standard impacts from the LINKAGE model from full global merchandise trade reform and the removal of all domestic distortions. These results have been circulated widely already—see for example Anderson, Martin and van der Mensbrugghe (2006)—and are replicated herein for readers not familiar with them. They also provide a partial basis for comparison with other models. One of the key differences of the Linkage model with many other models (though not all), is its dynamic component, i.e. the impacts of the reforms are compared in some later year, 2015, rather than in a static world, often the base year of the model, currently 2001. As this paper shows, this has relatively important impacts for the assessment itself. Even in the simple dynamics of the LINKAGE model, without forward looking behavior and given technology change—trade reform leads to additional gains because of higher savings and investment and the structural changes inherent in the baseline scenario with countries/regions, trade and output growing at different rates, so that the projected economy of 2015 is no longer the static economy of 2001. However, to make the model comparison independent of the forecast horizon, the second part of the paper focuses on a comparative static version of the model.

The remainder of the paper is divided into four sections. The next section provides a brief overview of the LINKAGE model. This is followed by a description of the impacts from global merchandise trade reform using the standard dynamic version of the model including some of the key findings:

- as a percentage of base income, gains to developing countries are higher than the gains to high-income countries
- agricultural reform accounts for a disproportionate share of the gains (relative to its global output or trade share)
- developing countries have as much to gain from South/South trade reform as from greater market access to developed countries' markets
- market access, i.e. a lowering of trade barriers provides, is vastly more important than removal of domestic support or export subsidies in terms of global welfare improvement
- developing countries' negative terms of trade impacts results more from balance of payments constraint than from a significant rise in the cost of imported food

The subsequent section—based on the comparative static version of the model—focuses on the robustness of the model results to some key assumptions. Three are tested: 1) the trade (or Armington) elasticities, obviously of key importance in trade simulations; 2) the supply and flexibility of land, key as well given the importance of agricultural distortions; and 3) the flexibility of labor, particularly as regards the apparent high-level of unemployment in many parts of the world.

The final section will draw some conclusions from the various simulations and what they imply in terms of a research agenda, if not in terms of the negotiations themselves.

## The global LINKAGE model for assessing effects of future trade reform

The model used for this analysis is the World Bank's global dynamic computable general equilibrium (CGE) model, known as LINKAGE (van der Mensbrugghe 2005). This section describes its default configuration. It is a relatively straightforward CGE model but with some characteristics that distinguish it from standard comparative static models such as the GTAP model. A key difference is that it is recursive dynamic, so while it starts with 2001 as its base year it can be solved annually through to 2015. The dynamics are driven by exogenous population and labor supply growth, savings-driven capital accumulation, and labor-augmenting technological progress (as assumed for the World Bank's Global Economic Prospects exercise in 2004). In any given year, factor stocks are fixed. Producers minimize costs subject to constant returns to scale production technology, consumers maximize utility, and all markets – including for labor – are cleared with flexible prices. There are three types of production structures. Crop sectors reflect the substitution possibility between extensive and intensive farming. Livestock sectors reflect the substitution possibility between ranch- versus range-feeding. And all other sectors reflect the standard capital/labor substitution (with two types of labor: skilled and unskilled).[1] There is a single representative household per modeled region, allocating income to consumption using the extended linear expenditure system. Trade is modeled using a nested Armington structure in which aggregate import demand is the outcome of allocating domestic absorption between domestic goods and aggregate imports, and then aggregate import demand is allocated across source countries to determine bilateral trade flows.

There are six sources of protection in the model. The most important involves the bilateral tariffs. There are also bilateral export subsidies. Domestically, there are subsidies only in agriculture, where they apply to intermediate goods, outputs, and payments to capital and land.

Three closure rules are used. First, government fiscal balances are fixed in any given year. The fiscal objective is met by changing the level of lump sum taxes on households. This implies that losses of tariff revenues are replaced by higher direct taxes on households. Second, the current account balance is fixed. Given that other external financial flows are fixed, this implies that *ex ante* changes to the trade balance are reflected in *ex post* changes to the real exchange rate. For example, if import tariffs are reduced, the propensity to import increases. Additional imports are financed by increasing export revenues and this is typically achieved by a real exchange rate depreciation. Finally, investment is savings driven. With fixed public and foreign saving, investment will be driven by two factors: changes in the savings behavior of households, and changes in the unit cost of investment. The latter can play an important role in a dynamic model if imported capital goods are taxed. Because the capital account is exogenous, rates of return across countries can differ over time and across simulations. The model only solves for relative prices. The

[1] In its standard configuration, unskilled and skilled labor are combined together in a single labor composite factor and this latter is substitutable with capital. In an alternative configuration, skilled labor is combined with capital—with zero or low substitution—and this latter factor is substitutable with unskilled labor.

numéraire, or price anchor, in the model is given by the export price index of manufactured exports from high-income countries. This price is fixed at unity in the base year and throughout time.

The newest version of the LINKAGE model, Version 6.0, is based on the latest release of the GTAP dataset, Release 6.05.[2] Compared with Version 5 of the GTAP dataset, Version 6 has a 2001 base year instead of 1997, updated national and trade data and, importantly, a new source for the protection data. The new protection data come from a joint CEPII (Paris)/ITC (Geneva) project. The product of this joint effort, known as MAcMap[3], is a tariff level detailed database on bilateral protection that integrates trade preferences, specific tariffs and a partial evaluation of non-tariff barriers (NTBs), for example tariff rate quotas (TRQs). In summary, the new GTAP database has lower tariffs than the previous database because of the inclusion of bilateral trade preferences and of major reforms between 1997 and 2001 such as continued implementation of the Uruguay Round Agreement, especially the elimination of quotas on textile and clothing trade, and China's progress towards WTO accession (which contributed to the ratio of global exports plus imports to GDP rising from 44 to 46 percent over those four years).[4]

The version of the LINKAGE model used for this study is comprised of a 27-region, 25-sector aggregation of the GTAP data set (see Annex Table). There is a heavy emphasis on agriculture and food, comprising 13 of the 25 sectors, and a focus on the largest commodity exporters and importers.

## Impacts of global merchandise trade reform—the standard model

This section describes the key impacts from global merchandise trade reform using the standard dynamic version of the LINKAGE model. These are the results that have been described in earlier papers and also provide a benchmark from which to assess the gains from partial reform—such as those to be obtained from a conclusion to the Doha Round of negotiations.[5] In a first step, a baseline is constructed that describes the evolution of the global economy from the base year, 2001, through to 2015. Some known policy changes are integrated into the baseline and are phased in between 2001 and 2005—the most prominent are the WTO accession commitments of China and Taiwan (China), EU expansion to EU-25,

[2] The GTAP database is a product of an international consortium of universities, research think tanks, and national and international agencies hosted at the Global Trade Analysis Program (GTAP), Purdue University. The GTAP program also supports a global trade model, known as GTAP, which in many respects is similar to the LINKAGE model. For more information, see Hertel (1997) and www.gtap.org.
[3] Bouët et al (2004).
[4] In a pre-simulation experiment, the U.S. cotton subsidy, not part of the standard GTAP dataset is incorporated in the database using a method that is intended to minimize the distortions to the original database (see Malcolm 1998). The subsidy is modeled as an output price subsidy equivalent to 36 percent of unit cost in the cotton sector.
[5] See for example Anderson, Martin and van der Mensbrugghe 2006.

and the end of the textile and clothing quotas. No policy changes are assumed to occur after 2005. The deviations from full merchandise trade reform are then compared to the baseline situation in 2015.

Table 1 reports the distribution of the standard economic welfare or real income (equivalent variation) effects of removing all merchandise trade barriers and agricultural subsidies globally. Of the $287 billion gain in income that reform would generate for the global economy in 2015, two-thirds would accrue to the high-income countries. However, as a share of income, developing countries do somewhat better than high-income countries, with an average increase of 0.8 percent compared to 0.6 percent for high-income countries.[6] The results vary widely across developing countries, ranging from little impact in the case of Bangladesh and Mexico to 4 or 5 percent increases in parts of East Asia. The second column of numbers in that table show the amount of that welfare gain due to changes in the international terms of trade for each country. For developing countries as a group the terms of trade effect is negative, reducing somewhat the gains from improved efficiency of domestic resource use (especially in China and India). That effect would dissipate over time, however, as developing countries diversify their exports in the course of their continuing economic growth and industrialization.

The final two columns of Table 1 split the total effect into that due to liberalizing markets for agricultural and processed food products versus for other merchandise. It shows that nearly two-thirds of the welfare gain for both developing and high-income countries comes from freeing up markets for agricultural and food products. For Sub-Saharan Africa that ratio is four-fifths, and for Latin America (and Australia/New Zealand) it is more than 90 percent. By contrast, for the more densely-populated developing countries that are already into export-oriented manufacturing, it is the reform of non-agricultural markets that boost their welfare most.

These gains from global merchandise reform are significantly lower than previous estimates with the LINKAGE mode—see World Bank (2002, 2004). The later of those two sources (2004) shows an estimated gain of $413 billion at the global level in 2015, and much larger relative and absolute gains for developing countries. Three main reasons explain the roughly $125 billion decline in the estimated global welfare impact (described in greater detail in van der Mensbrugghe 2006). Two of the reasons are linked

[6] There is an ongoing debate regarding adjusting the gains for purchasing power (PPP) differences across countries. PPP adjustments would have no impact on the gains accruing to an individual country in percentage terms, but it would shed a somewhat different picture on the allocation of the absolute gains between developed and developing countries. If the real income gains are adjusted for their purchasing power (using 2001 PPP weights), the gains to high-income countries rise to $246 bn (from $202 bn), and those to developing countries rise to $257 bn from $96 bn (with an implicit weighted average PPP of around 3). The global gains therefore are $503 bn and are almost evenly divided between developed and developing countries. As a percent of baseline income (expressed in PPP terms), the PPP adjustment makes almost no difference even for the aggregate gains (the global gains are 0.72 percent versus 0.67 percent).

and have to do with the new GTAP database. A new base year, 2001, instead of 1997, captures trade liberalization of the intervening four years from unilateral, regional and multilateral reforms (for example continuing implementation of the Uruguay Round agreement). Also, the new database has a more comprehensive incorporation of preferences, both reciprocal and non-reciprocal. The third reason relates to the baseline policy changes as described above, i.e. those phased-in between 2001 and 2005. In rough terms the change in database accounts for about 25 percent of the decline, preferences for about 32 percent, and the remaining 43 percent is determined by the baseline policy changes.[7]

There are several ways to decompose the real income gains from global trade reform so as to better understand the sources of the gains. One way is to assess the impacts of developing versus high-income country liberalization in different economic sectors; another is to decompose by policy instrument. The next two sections describe the main findings from these decompositions.

### *Decomposition of global gains by broad sector and liberalizing region*

The results when decomposed by sector and liberalizing region are provided in Table 2. They suggest global liberalization of agriculture and food yields 63 percent of the total global gains.[8] This is consistent with the high tariffs in agriculture and food (17 percent global average) versus other sectors, but is nonetheless remarkable given the low shares of agriculture in global GDP (4 percent) and global merchandise trade (9 percent). Three-quarters of those gains are accounted for by the farm policies of high-income countries. Notice too that as much of that gain from farm reform is due to South-South agricultural liberalization as would come from developing countries' unrestricted access to high-income country markets. That is almost equally true in manufacturing in aggregate, despite the big gains from textiles and clothing reform ($15 billion from market access in high-income countries compared with $9 billion due to South-South textiles trade growth). In other words, reform by developing countries is nearly as important in terms of economic welfare gains to the South as reform by high-income countries. It is clear that reforming agricultural policies in both sets of countries is crucial for developing countries, with high-income reform of textiles only half as important as agricultural reform.

[7] The exact decomposition is not straightforward. First, the two databases will differ because of price and exchange rate adjustments (for example, the dollar was particularly strong in 2001 compared with 1997 giving greater weight to dollar-based economies). Second, release 5 included some preferential arrangements (for example NAFTA), whereas the release 6 version of the database without preferences excludes all preferential arrangements with the exception of the EU.
[8] This is similar to Hertel and Keeney's 66 per cent (see Hertel and Keeney).

### *Decomposition of global gains with respect to the three pillars*[9]

A result that has raised considerable discussion is that market access provides 93 percent of the overall gains, with domestic support accounting for 5 percent and export subsidies the residual 2 percent.[10] The results are very similar to those reported in Hertel and Keeney (2006, Table 2.7), and to those in Hoekman, Ng and Olarreaga (2004, Table 4) even though the latter study used a partial equilibrium framework and only halved all agricultural distortions.

The discussion of the relative importance of market access compared with subsidies is in part due to the widely cited estimates of support produced by the OECD known as the producer support estimate (PSE). Direct producer subsidies are only one element of the PSE. The main additional element is that provided by market price-supporting trade measures. The latter are calculated by comparing domestic and border prices of like products so as to capture the total domestic market price effect of all trade distortions, including tariff and non-tariff import barriers as well as export subsidies. The domestic support in OECD countries totaled $89 billion in 2001, according to the OECD To that needs to be added domestic support to primary agriculture in non-OECD countries, which is another $7 billion in 2001 according to the GTAP database (Dimaranan and McDougall 2005, Ch.16b).

For market price support provided through trade measures, the GTAP database relies on applied tariff rates including preferential rates where applicable, plus export subsidy notifications by members to the WTO Secretariat (Dimaranan and McDougall 2005, Chs.16d and 16e). By contrast, the OECD relies on domestic-to-border price comparisons to capture the combined effect of all trade measures. It estimates that for primary agriculture in OECD countries, this amounted to $139 billion in 2001, whereas the GTAP database suggests it is $118 billion.[11] But it is necessary to go beyond primary agriculture when evaluating the consequences of reforms under WTO, because the WTO negotiations on agriculture involve potential liberalization of a wide range of processed agricultural products as well. In OECD countries domestic subsidies are not paid to processed agricultural products, but the extent of border protection to processing activities is substantial: according to the GTAP database, in 2001 that assistance

[9] The discussion in this section is largely based on Anderson, Martin and Valenzuela (2005).

[10] The decomposition is path dependent but as suggested in the rest of the section, the findings are nonetheless robust. See Harrison, Horridge and Pearson (2000) for a path independent decomposition technique.

[11] One reason for that difference is that by using only tariffs, the GTAP method does not capture the protective effect of non-tariff barriers (NTBs) such as Sanitary and Phyto-Sanitary (SPS) measures or other technical barriers to imports that may provide additional economic protection. The OECD measure based on price comparisons, by contrast, captures the domestic price-raising effects of all trade distortions, including any NTBs. The other key difference between the OECD and GTAP measures has to do with the weighting procedures used to aggregate across product categories: the GTAP method uses import weights that understate the importance of highly-protected commodities, while the OECD uses production weights that overstate the importance of highly-protected commodities.

amounted to $343 billion, which is greater than the estimated total support to primary agriculture for that year. The remaining important element to consider is the market price support provided to the agricultural and food sectors of non-OECD countries. At $96 billion for primary agriculture plus $110 billion for food processing, this support is a substantial addition to the support through import barriers of $118 billion provided to OECD agriculture and $285 billion to OECD processed food. But there are almost no export subsidies in non-OECD countries, further increasing the prominence of market access.

In summary, the OECD and GTAP databases are very similar in their estimates of the extent of direct support to farmers in OECD member countries; but the GTAP database also includes support via the food processing sector in those countries plus the support to both sets of activities in non-OECD countries. In total, the GTAP database suggests less than 14 percent of the dollar value of the transfers to those producers from taxpayers and consumers is in the form of domestic support and only 4 percent comes via export subsidies.

These numbers are laid out in Anderson, Martin and Valenzuela (2005), where several other important observations also are made. One is that domestic support only impacts the production side of the market, whereas the tariff distorts both production and consumption and thereby has a larger welfare impact. Another is that the welfare cost of distortions increase with their variability, in other words the cost of a uniform set of tariffs is lower than the cost of a set of variable tariffs with the same average rate.[12] They show that there is more variability in the tariff structure than in domestic support, thereby increasing the relative importance of the weight of market access. And thirdly, since tariffs are a trade tax and are dominant globally, export subsidies can be globally welfare enhancing insofar as they offset the anti-trade effects of tariffs, even though they are usually welfare-reducing for the country imposing them. The offsetting element thus reduces the contribution of export subsidies to the global welfare cost of farm support programs.

### *Decomposition of terms of trade impacts*

An important feature of almost all global GE models is the terms of trade impacts. These are generated by the so-called Armington assumption, i.e. exporters from each country, no matter how small, have some market power because their products are differentiated from those of other countries. This implies that each country could potentially have an optimal tariff above zero, below which countries would suffer welfare losses.[13] Of particular concern to many is that net food-importing countries could lose when

[12] This is because the cost of a tariff distortion increases with the square of the tariff.
[13] For recent reviews of the Armington assumption, see Lloyd and Zhang (2006) and Zhang (2006).

agricultural protection is removed, as international food prices under most circumstances would tend to rise.

As already shown in Table 1, the overall negative terms of trade impacts for developing countries amounts to roughly $30 billion—a not insignificant cost compared to the net welfare gain of roughly $90 billion.

Table 3 shows how these terms of trade impacts are allocated between export and import price effects and across broad categories of goods and services. Focusing first on the aggregate impact for all developing countries, the first thing to notice that almost all of the net effect comes from the export side, i.e. it is declining export prices that explain the terms of trade impacts, rather than rising import prices. There is nonetheless an impact of rising food import prices that raises the cost of imports by $9 billion, which is only partially offset by rising export prices that raise revenues by $5 billion.[14] The regions with the largest increase in their food import bill are those with the largest import volume (for example East Asia and Pacific) and/or those with the highest import distortions (for example Middle East and North Africa, and South Asia).

The terms of trade decomposition also suggests that the source of the terms of trade loss for developing countries is perhaps not so much due directly to the Armington assumption, but is more linked to the specific external closure rule of the model, i.e. the fixity of the trade balance. As tariffs fall (to zero), the desire to import increases. With the given closure rule, only an increase in export supply can balance the ex ante increase in import demand and this implies a real depreciation that gets reflected in a decline in export prices. This is the most obvious case since it is manufacturing prices that decline the most, and manufacturing is the largest component of trade for developing countries taken in aggregate. Given that on average tariffs are higher in developing countries than in developed countries, it is logical that the terms of trade impacts works against developing countries.

Clearly, the assumption of fixed trade balances could be relaxed (or equivalently relax the capital mobility constraint).[15] This would be consistent with the model results since the returns to capital increase more rapidly in developing countries than in developed countries as a consequence of the trade reform. This relative price change would typically induce international capital movement that could compensate for the real exchange rate’s effect on the terms of trade.

[14] A negative in the import columns implies rising import costs.

[15] There is a version of the LINKAGE model with international capital mobility. It was most recently used to look at demographics, savings and investment (World Bank 2003). The standard GTAP model has limited international capital mobility—similar to LINKAGE—in a myopic framework. The G-Cubed model has fully integrated capital markets and forward looking behavior (McKibbin and Wilcoxen 1992).

## Factor market assumptions and comparisons with other models

This section of the paper focuses on the robustness of some of the key model assumptions and provides an insight into how the standard results compare with the GTAP model, one of the most widely used for global trade analysis, and other models such as that used recently by the Carnegie Endowment for International Peace.[16] The first section shows a comparison of the standard dynamic version of the model with the comparative static version. This comparison allows for an assessment of the relative importance of the simple dynamics of the LINKAGE model and it also allows for more transparent comparison with other comparative static models, such as GTAP in its standard version.

In subsequent sections two key sets of elasticities are modified as well as the impacts of changing labor market closure. The first set of elasticities concerns land flexibility—both in aggregate volume as well as its flexibility across agricultural sectors. The second concerns the Armington trade elasticities.

### *Dynamic versus static*

The comparative static version of LINKAGE has model parameters that are intended to reflect some medium- or long-term horizon to line up approximately with the recursive dynamic version. In production this implies that the higher substitution elasticities[17] are imposed and land, labor and capital are mobile across sectors (though not across regions). A pre-simulation shock is imposed with the baseline policy changes and the impacts of global merchandise trade reform are compared with the model results from the pre-simulation shock. One immediate result of the comparative static exercise is that the dollar amounts for the real income gains will be significantly smaller because they reflect the size of the global economy in 2001, not that of (projected) 2015[18], though the percentage changes will be in the same ballpark depending on the differences induced by the dynamics.

The gain of $287 billion in 2015—from the standard dynamic scenario—is equivalent to $176 billion relative to the 2001 economy (tables 4a and 4b).[19] The second column of table 4 shows the impact of global merchandise trade reform in a pure comparative static framework, but using the standard LINKAGE elasticities. A comparison of columns 1 and 2 provides an assessment of the static dynamic gains. Essentially, these come from two sources. The first is the increase in savings and investment generated by

[16] See Polaski (2006).
[17] The dynamic version of the model has a vintage structure for capital distinguishing between installed or *old* capital and *new* capital with typically lower substitution elasticities for *old* capital than for *new*.
[18] The global economy is about 55 percent larger in 2015 than in 2001 (evaluated at 2001 market exchange rates).
[19] There can be confusion about terminology since sometimes the dynamic gains are called 'static' gains. The term 'static' gain to refers to the gains in 2015 under the assumption of **no** trade-reform induced changes to productivity. These 'static' gains are different from the comparative static gains that compare two different equilibrium conditions in the same model year.

higher growth and a reduction in the price of capital goods (from the elimination of tariffs), which combine to raise the capital stock and therefore contribute to the dynamic gains. The second effect comes from the nature of the dynamic baseline itself. The baseline has countries growing at different rates, assumes an increase in the trade-to-GDP ratio, and incorporates other structural changes that would tend to increase the gains from trade reform over time, particularly for developing countries, where the comparative static gains are considerably lower than the dynamic gains, i.e. only $23 billion versus $45 billion, or 0.4 percent of baseline income versus 0.8 percent in the dynamic simulation. There are also some potential losers, for example India.

### *Land flexibility and sensitivity to trade elasticities*

The next column in Table 4 (column 3) shows the impact of restraining land flexibility. In the standard version of the model, there is perfect mobility of land across sectors, i.e. land will be allocated such that its return is uniform in all agricultural sectors.[20] There is also an upward sloping land supply curve (that determines the aggregate supply of land) with varying elasticities depending on the land constraints in individual countries.[21] In the constrained version, the land supply elasticity is set to 0 in all countries and the land mobility parameter is set to 1 (consistent with the standard GTAP mobility parameter).[22] The gains for high-income countries do not vary much from the default land mobility assumption. In part, this is due to the fact that the land supply elasticity in the EU, Japan and NIEs is set to a low initial level due to their limited land expansion possibilities. The gains to developing countries drop by (another) half, from $23 billion to $12 billion. The largest losses occur for some of the key agricultural exporters, particularly in Latin America. Agricultural production in the high-income countries will decrease less than in the case of high land flexibility. This implies that market access (in agriculture) will be more difficult for the developing countries all else equal and they will therefore require a greater real depreciation that will be reflected in a greater terms of trade impact.

The next two simulations are intended to line up the LINKAGE model with the standard GTAP model to facilitate model comparison. The first imposes the GTAP Armington elasticities. The standard LINKAGE model uses its own set of Armington trade elasticities that have evolved over time based on previous studies, but that have been more or less constant over the last few years (and in recent World Bank

[20] In some countries and for some sectors there can be agro-ecological constraints to the degree of land mobility—for example the availability of water. Implementing these constraints would require more detailed knowledge at the local level than is currently feasible to implement.

[21] The supply elasticities are not differentiated depending on whether land is expanding or contracting—one would expect the latter to be higher than the former. It is also costless to increase land supply, thus the measured gains may be over-estimating the overall gains by ignoring the investment cost of increasing productive land.

[22] Inter-sectoral land supply allocation is driven by a CET supply function. In GTAP the transformation elasticity is 1. The default in LINKAGE is a transformation elasticity of infinity.

estimates). Those elasticities are in the mid-to-high range of those used in global models—between 4 and 6.[23] GTAP has revised its Armington elasticities upward—they had been in the 2–4 range. The new estimates are based on more recent econometric evidence and are closer to the LINKAGE elasticities.[24] The LINKAGE elasticities are still higher—an average of 35 percent overall, though 75 percent higher in primary agriculture and 23 percent higher in processed foods. All else equal, this will raise the gains from global reform relative to the GTAP model.

The impact of using the GTAP trade elasticities is shown in the fourth column of table 4. Given that these are lower than the standard LINKAGE elasticities, one would anticipate a decline in the gains from global trade reform. The global gains are about 30 percent lower, but the gains to developing countries are lower by 55 percent, with a number of country/regions exhibiting negative gains—for example China, India, the rest of Sub-Saharan Africa.

The final column shows the joint impact of using the GTAP Armington elasticities and land flexibility assumptions. The gains to developing countries are eviscerated, with three of the six regional aggregates showing losses. Reducing land flexibility lowers the ability of some of the developing regions to respond to new agricultural market opportunities—particularly Sub-Saharan Africa and Latin America.

Clearly, these various assumptions can have large potential impacts on the welfare gains. The headline numbers tend to be the welfare gains—and they do measure to some extent the payoffs across countries in the 'trade' game. However, they are not necessarily driving the negotiating process itself that may be more influenced by sector-specific actors, notably those that have the most to lose from reform, or the most to gain. Moreover, the global gains abstract from potentially large distributional issues—not simply across sectors—for example skilled versus unskilled labor, land owners versus renters, etc. How large are the potential output changes? and how robust are these changes with respect to the above mentioned elasticities?

Selective output changes can be seen in Table 5. The table has four panels—all reflective of the percent change in output relative to global merchandise trade reform using the comparative static version of

[23] Both models use the so-called rule-of-two. The top-level CES elasticity measures the degree of substitution between domestic goods and the aggregate import bundle. The second-level CES elasticity measures the degree of substitution of imports by individual trading partner—and the rule-of-two is that the second level elasticity is twice the top-level elasticity. Hence, if the latter is 4, the elasticity across trading partners is 8.

[24] In our trade work at the World Bank we have been reluctant to convert to the GTAP elasticities for essentially two reasons. One is to ensure consistency of results overtime by minimizing changes to model specification and elasticities. The second is that the level of some of GTAP's econometrically estimated elasticities appear questionable and contrary to intuition to the extent the elasticities reflect the degree of homogeneity of goods. For example, GTAP's elasticity for sugar is 2.7, somewhat lower than for motor vehicles and parts (2.8) and chemicals, rubber and plastics (3.3).

LINKAGE under four different assumptions. The top-left panel reflects the standard LINKAGE assumptions for both the trade elasticities and the land supply elasticities. The top-right panel uses GTAP's land supply assumptions combined with the LINKAGE Armington elasticities. The bottom-left panel uses GTAP's trade elasticities combined with LINKAGE's land supply elasticities. And the final panel (bottom-right) shows the output changes when using both GTAP's Armington and land assumptions. The table could be much larger given the number of sectors, but the table reflects a combination of single (model) sectors, for example cotton or dairy products, combined with aggregate output changes. Most of the single sectors correspond to those with some of the very highest trade distortions on a global basis.

A few main findings emerge from these tables. First, unlike the welfare impacts, the changes to output can be substantial. If one takes a look at simply the first column, the aggregate change in agricultural output, the values range from a decline of 27 percent in Japan to a high of 44 percent in Brazil.[25] These percentages are vastly greater than the real income increases and represent potentially very large structural changes in the domestic economies. Second, not very surprisingly, the numbers indicate a rather sharp change in the allocation of agricultural output between high-income and developing countries with the former seeing agricultural output decline by 13 percent, despite high increases in Australia, Canada and New Zealand and essentially the status quo for the United States, and the latter seeing a rise of 4.8 percent led largely by Argentina, Brazil and the rest of South America, but with significant increases in parts of Sub-Saharan Africa as well. Third, as with the comparison between real income changes and output changes, the detailed the sector, the greater are the changes. For example, in the case of cotton, the output changes range from a decline of 65 percent in Europe (EU-25+EFTA) to a rise of 336 percent in the case of Canada—with other very significant increases in other parts, for example a rise of 57 percent in Sub-Saharan Africa. It should be noted that these output changes in cotton essentially reflect the removal of domestic support and not trade barriers. This underscores the fact that welfare measures are poor indicators of underlying structural changes that can be important even if the overall welfare impact is small (or even negative). Fourth, developing countries gain market share in all sectors save the last—an aggregate sector of all other manufacturing with substantial gains in meat and dairy products and cotton, and significant gains in textile and apparel.

Turning now to comparing the output changes under the various assumptions, it is relatively obvious that these changes are relatively robust under all four alternative assumptions. The large output changes, whether positive or negative, remain large. For example in the case of changes in agricultural output, the

[25] When reading this table, it is important to keep in mind that though the percentage change can be very high, the actual change may not be numerically or economically significant. For example, the 300+ percent increase of cotton production in Canada is off a very low and insignificant base. (Cotton is worth only $30 million in Canada, or about 0.1 percent of its agricultural production by value.)

range for Latin America is an increase of 16 to 26 percent depending on the various assumptions and is clearly the large agricultural winner under any assumption, even one with relatively rigid land flexibility. At the same time, the impact on the output change is more or less the same be it via a lowering of the trade elasticities or a reduction in land flexibility—either individually could subtract between 6 and 7 percentage points from the increase in agricultural output. There are interaction effects between the two assumptions since combined together, the decline is only 10 percentage points and not the 13-14 percentage points were the change in assumptions linear. There are also clear differences across countries that reflect their initial positions and endowments. Brazil, for example, is significantly more impacted by restricting land flexibility, than is Argentina, and is positively impacted by a reduction in the trade elasticities (with an output gain of 44.0 percent in the case of the latter, marginally better than 43.6 percent under the default assumptions).

In overall terms, it appears the high-income agricultural output is more sensitive to changes in standard trade and land assumptions than developing country agriculture. Whereas under the default assumptions, output would decline by about 13 percent on average, lower trade elasticities would dampen that lost by almost 50 percent, to a decline of 7 percent, with the land mobility assumptions playing a more modest role. For developing countries, the change in the Armington elasticity leads to a much smaller change in both absolute and relative terms, with again the land assumptions playing a more modest role than the trade elasticities. Neither set of assumptions have dramatic impacts on changes in manufactured output, even in the case of textile and clothing.

### *Flexible versus rigid wages*

Labor market imperfections could potentially have an important impact on the welfare gains. While most global trade models have assumed fixed employment (or market-clearing wages), this assumption has been questioned by some.[26] One (perhaps extreme) alternative is to assume fixed (real or nominal) wages with an unlimited supply of labor (at least within some limit). The issue is quite complex. In most developing countries the only safety net is typically the family and thus not working is often not an alternative and the issue is really the choice of finding work in the formal sector versus the informal sector and there is sufficient evidence to show wage flexibility in the latter. In developed countries the situation is also complex and not readily amenable to easy modeling solutions—with sometimes rigid labor market regulations, varying safety nets, and also informal employment that is oft-times poorly

[26] See for example Ackerman

measured.[27] Another potential labor market imperfection is the degree of labor mobility across sectors—particularly between rural and urban (or in the case of the LINKAGE model, between agriculture and non-agriculture). Limiting labor flexibility across sectors could lower gains to specific regions and globally—similar to limiting land mobility. If the highly distorted agricultural sectors in certain OECD regions are not allowed to shed excess labor to more efficient uses in industry and services, the allocative efficiency gains will be reduced, and it will also reduce the gains to those regions that have less opportunity to gain market share.

The final set of simulations tests the role of flexibility of labor markets using the comparative static version of the model with the standard Armington trade elasticities and assumptions on land flexibility. Two polar cases are discussed. The first is the standard case with fully flexible wages and a fixed supply of labor. The second assumes fixed real wages and unlimited labor supply (at least within the range of changes in labor demand implied by the reform simulation).[28] These assumptions only affect unskilled workers. Skilled workers are assumed to have fully flexible wages in both simulations. Additionally, labor is perfectly mobile across all sectors, i.e. there is no rural to urban migration function.[29]

The main results are in Table 6. At the global level, real income increases by 0.8 percent with fixed real wages of unskilled workers instead of 0.5 percent in the case of full employment, i.e. a comparative static gain of $220 billion instead of $127 billion. The increase for developed countries is only 0.1 percentage point—from 0.5 to 0.6 percent relative to baseline income (an increase worth around $30 billion). The increase for developing countries is much more significant—from 0.4 percent to 1.6 percent—a near quadrupling of their comparative static gain with flexible wages. The main reason is that all economies are operating under their production possibility frontier, hence any reform that leads to an increase in the demand for labor will have greater impact than simply a movement along the frontier. The multipliers can also be substantial. In the case of Sub-Saharan Africa the gains jump to 2.6 percent of baseline income

[27] See the recent debate in the EU on the low VAT rate in some sectors—notably construction—where the proponents argued this would reduce informal employment (*Wall Street Journal Europe*, January 25, 2006, "EU at stalemate over VAT—Deal proves elusive on cuts in some rates; test of French clout").

[28] The modeling of less than full employment is somewhat more complicated than described above. In the case of unemployed labor, a minimum wage function is assumed. The minimum wage depends on two factors—the overall price index and the level of unemployment. With full indexation, the elasticity of the minimum wage with respect to the price level is 1. In the simulations described herein, the elasticity of the minimum wage with respect to unemployment is 0. If it were less than zero, a rise in unemployment would tend to put downward pressure on the minimum wage and move it nearer the market equilibrium wage. The model has endogenous regime switching such that should the labor market clear, the minimum wage function is no longer binding (see van der Mensbrugghe 2006). For the purposes of this simulation, the initial level of unemployment is (arbitrarily) set to 10 percent in each region so as to insure that there is no regime switching, i.e. to make sure that the minimum wage is binding (and fully indexed to prices).

[29] The new Carnegie study assumes partial market segmentation of the rural and urban labor markets modeled using a Harris-Todaro type migration function that depends on relative expected wages (Polaski 2006).

from 0.3 percent under the standard assumptions. This reflects the relative unskilled intensity of the SSA economies as well as the unskilled intensity of their consumption.

Comparing the wage impacts from the standard simulation to the volume impacts from assuming fixed wages illustrates the duality of one assumption over the other. In most regions the wage impact is almost identical to the demand impact. For example in the case of Canada the real (unskilled) wage increases by 0.6 percent in the standard closure and labor demand rises by 0.6 percent under the assumption of fixed real wage. In developing countries, there tends to be additional multiplier effects, as already noted above. But this will depend on the relative intensity of unskilled labor in production and consumption and the impacts of trade reforms on individual sectors, i.e. whether unskilled sectors have been protected or not.

The final column in Table 5 also shows the potential impacts on the increased volume of unskilled workers.[30] According to these results, global merchandise trade reform would create some 84 million unskilled jobs world-wide, almost all of them in developing countries with the exception of the NIEs.[31] In percentage terms, the highest increase is in Sub-Saharan Africa—an increase of 6.4 percent, presumably enough to put a significant dent in the rate of unemployment.

## Concluding remarks

The first part of the paper summarizes the key findings from the World Bank's recent work on global merchandise trade reform, concentrating on the impacts from full global merchandise trade reform, using the standard version of the LINKAGE model in its recursive dynamic formulation with the gains attributed to a change in 2015 incomes relative to a baseline scenario. The gains even in this relatively standard version—with no productivity enhancing effects, scale economies, variety effects and increase in cross-border investment—are substantial, particularly for developing countries.[32] The results also highlight the importance of agricultural barriers and the rising role of developing countries as a source of the gains.

The second half of the paper highlights the importance of model structure and the need for more empirical validation. The gains for developing countries are crucially dependent on the future structure of the global economy as illustrated by the difference between the dynamic and comparative static impacts. More econometric work needs to be undertaken to improve estimates of the Armington trade elasticities, particularly for developing countries, and of the flexibility of land supply in aggregate and across sectors.

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[30] These data should be treated with additional caution since they the volume data in the GTAP data is based on some strong assumptions, but they nonetheless provide some orders of magnitude.

[31] These are in the *Other high-income countries* aggregate region.

[32] Moreover, most global trade models have ignored the significant gains that could potentially be generated in the service sectors, including Mode 4 liberalization, i.e. increasing the international movement of workers.

The sensitivity analysis illustrates that the real income impacts are only the tip of the iceberg in terms of providing a full picture of the impacts of trade reform. Output (and employment) impacts will be much more significant with percent changes in the double, if not triple digits, as compared with aggregate real income gains of typically 1 percent or less. The sensitivity analysis shows that the real income gains are substantially affected by the underlying assumptions on the trade elasticities and land supply. However, output changes, at least in terms of sign and overall economic relevance, are much more robust to these different specifications. Under a full trade reform scenario, global agriculture will see some very important structural shifts with developing countries gaining significant output shares at the overall expense of developed countries—and this under a broad range of assumptions regarding the trade elasticities and land flexibility.

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**Table 1: Impacts on real income from full liberalization of global merchandise trade, by country/region, 2015**

(Impacts in 2015 relative to the baseline, in 2001 dollars first two columns, percent of baseline income last three columns)

| | **Total** ($billion) | **That due to change in terms of trade** ($billion) | **Total as percent of baseline income** (percent) | **That due to liberalization of agriculture & food** (percent) | **That due to liberalization of all other merchandise** (percent) |
|---|---|---|---|---|---|
| Australia and New Zealand | 6.1 | 3.5 | 1.04 | 1.00 | 0.04 |
| EU 25 plus EFTA | 65.2 | 0.5 | 0.65 | 0.38 | 0.26 |
| United States | 16.2 | 10.7 | 0.11 | 0.05 | 0.07 |
| Canada | 3.8 | -0.3 | 0.41 | 0.63 | -0.22 |
| Japan | 54.6 | 7.5 | 1.10 | 0.72 | 0.37 |
| Korea and Taiwan | 44.6 | 0.4 | 3.52 | 2.62 | 0.90 |
| Hong Kong and Singapore | 11.2 | 7.9 | 2.60 | 0.46 | 2.13 |
| Argentina | 4.9 | 1.2 | 1.15 | 0.96 | 0.19 |
| Bangladesh | 0.1 | -1.1 | 0.19 | 0.21 | -0.03 |
| Brazil | 9.9 | 4.6 | 1.52 | 1.51 | 0.02 |
| China | 5.6 | -8.3 | 0.21 | 0.05 | 0.15 |
| India | 3.4 | -9.4 | 0.37 | -0.25 | 0.62 |
| Indonesia | 1.9 | 0.2 | 0.71 | 0.31 | 0.41 |
| Thailand | 7.7 | 0.7 | 3.91 | 2.09 | 1.82 |
| Vietnam | 3.0 | -0.2 | 5.25 | 2.49 | 2.76 |
| Russia | 2.7 | -2.7 | 0.54 | 0.23 | 0.31 |
| Mexico | 3.6 | -3.6 | 0.41 | 0.22 | 0.20 |
| South Africa | 1.3 | 0.0 | 0.87 | 0.35 | 0.52 |
| Turkey | 3.3 | 0.2 | 1.32 | 0.81 | 0.51 |
| Rest of South Asia | 1.0 | -0.8 | 0.51 | 0.27 | 0.23 |
| Rest of East Asia | 5.3 | -0.9 | 1.85 | 1.63 | 0.22 |
| Rest of LAC | 10.3 | 0.0 | 1.21 | 1.24 | -0.04 |
| Rest of ECA | 1.0 | -1.6 | 0.30 | 0.67 | -0.37 |
| Middle East and North Africa | 14.0 | -6.4 | 1.16 | 0.27 | 0.89 |
| Selected SSA countries | 1.0 | 0.5 | 1.53 | 1.64 | -0.11 |
| Rest of Sub Saharan Africa | 2.5 | -2.3 | 1.12 | 0.97 | 0.15 |
| Rest of the World | 3.4 | 0.1 | 1.53 | 1.23 | 0.30 |
| **High-income countries** | **201.6** | **30.3** | **0.62** | **0.40** | **0.23** |
| **Developing countries** | **85.7** | **-29.7** | **0.83** | **0.52** | **0.31** |
| Middle-income countries | 69.5 | -16.7 | 0.84 | 0.56 | 0.28 |
| Low-income countries | 16.2 | -12.9 | 0.81 | 0.38 | 0.43 |
| East Asia and Pacific | 23.5 | -8.5 | 0.69 | 0.37 | 0.32 |
| South Asia | 4.5 | -11.2 | 0.38 | -0.14 | 0.52 |
| Europe and Central Asia | 7.0 | -4.0 | 0.67 | 0.51 | 0.16 |
| Middle East and North Africa | 14.0 | -6.4 | 1.16 | 0.27 | 0.89 |
| Sub Saharan Africa | 4.8 | -1.8 | 1.09 | 0.85 | 0.24 |
| Latin America & the Caribbean | 28.7 | 2.2 | 1.02 | 0.94 | 0.08 |
| **World total** | **287.3** | **0.6** | **0.67** | **0.43** | **0.25** |

**Table 2. Regional and sectoral source of gains from full liberalization of global merchandise trade, developing and high-income countries, 2015**

Change in real income in 2015 relative to the baseline scenario

| | Gains by region in billions of dollars | | | Share of global gain (percent) | | |
|---|---|---|---|---|---|---|
| | Developing | High-income | World | Developing | High-income | World |
| **Developing countries liberalize:** | | | | | | |
| Agriculture and food | 28 | 19 | 47 | 33 | 9 | 17 |
| Textile and wearing apparel | 9 | 14 | 23 | 10 | 7 | 8 |
| Other merchandise | 6 | 52 | 58 | 7 | 26 | 20 |
| All sectors | 43 | 85 | 128 | 50 | 42 | 45 |
| **High-income countries liberalize:** | | | | | | |
| Agriculture and food | 26 | 109 | 135 | 30 | 54 | 47 |
| Textile and wearing apparel | 13 | 2 | 15 | 15 | 1 | 5 |
| Other merchandise | 4 | 5 | 9 | 3 | 2 | 3 |
| All sectors | 43 | 116 | 159 | 50 | 57 | 55 |
| **All countries liberalize:** | | | | | | |
| Agriculture and food | 54 | 128 | 182 | 63 | 64 | 63 |
| Textile and wearing apparel | 22 | 16 | 38 | 25 | 8 | 14 |
| Other merchandise | 10 | 57 | 67 | 12 | 28 | 23 |
| All sectors | 86 | 201 | 287 | 100 | 100 | 100 |

*Note*: Small interaction effects are distributed proportionately and numbers are rounded to sum to 100 percent.

## Table 3: Decomposition of the terms of trade impacts, 2015

(Revenue impacts of terms of trade changes in 2015, $billion)

| | Impact of changes in export prices | | | | Impact of changes in import prices | | | | Sum of |
|---|---|---|---|---|---|---|---|---|---|
| | Agricul-ture and food | Other merch. | Non trade-ables | Total | Agricul-ture and food | Other merch. | Non trade-ables | Total | all changes in terms of trade |
| Australia and New Zealand | 2.1 | 0.7 | 0.5 | 3.4 | -0.1 | 0.1 | 0.0 | 0.1 | 3.5 |
| EU 25 plus EFTA | 1.3 | -6.4 | -7.3 | -12.3 | -0.9 | 12.0 | 1.7 | 12.8 | 0.5 |
| United States | 7.2 | -4.1 | -0.9 | 2.1 | -0.1 | 8.4 | 0.3 | 8.6 | 10.7 |
| Canada | 1.0 | -1.8 | -0.2 | -1.0 | -0.5 | 1.1 | 0.1 | 0.7 | -0.3 |
| Japan | -0.4 | 5.4 | 0.6 | 5.6 | 0.2 | 1.4 | 0.2 | 1.9 | 7.5 |
| Korea and Taiwan | -5.8 | 4.8 | 1.4 | 0.5 | -0.9 | 0.8 | 0.1 | 0.0 | 0.4 |
| Hong Kong and Singapore | 0.1 | 4.0 | 3.4 | 7.5 | -0.1 | 0.2 | 0.2 | 0.3 | 7.9 |
| Argentina | 0.8 | 0.3 | 0.0 | 1.2 | -0.1 | 0.0 | 0.0 | 0.0 | 1.2 |
| Bangladesh | -0.1 | -0.8 | -0.2 | -1.1 | -0.1 | 0.1 | 0.0 | 0.0 | -1.1 |
| Brazil | 2.7 | 1.0 | 0.5 | 4.2 | -0.1 | 0.5 | 0.1 | 0.4 | 4.6 |
| China | 0.0 | -2.9 | 0.3 | -2.7 | -3.9 | -1.1 | -0.6 | -5.6 | -8.3 |
| India | -0.5 | -7.7 | -1.4 | -9.7 | -0.3 | 0.7 | 0.0 | 0.3 | -9.4 |
| Indonesia | 0.2 | 0.4 | 0.1 | 0.8 | -0.4 | -0.2 | 0.0 | -0.6 | 0.2 |
| Thailand | 0.5 | -0.7 | 0.7 | 0.5 | 0.0 | 0.2 | 0.0 | 0.2 | 0.7 |
| Vietnam | 0.3 | -0.9 | 0.3 | -0.2 | -0.1 | 0.1 | 0.1 | 0.0 | -0.2 |
| Russia | -0.2 | -2.7 | -0.2 | -3.2 | -0.4 | 0.8 | 0.1 | 0.5 | -2.7 |
| Mexico | 0.6 | -3.8 | -0.2 | -3.4 | -0.9 | 0.6 | 0.1 | -0.3 | -3.6 |
| South Africa | 0.0 | -0.1 | 0.0 | -0.2 | -0.1 | 0.2 | 0.0 | 0.2 | 0.0 |
| Turkey | 0.0 | -0.2 | 0.2 | 0.0 | -0.3 | 0.5 | 0.0 | 0.2 | 0.2 |
| Rest of South Asia | 0.0 | -0.8 | -0.2 | -1.0 | -0.1 | 0.3 | 0.0 | 0.2 | -0.8 |
| Rest of East Asia | 0.1 | -0.8 | 0.8 | 0.1 | -0.5 | -0.6 | 0.1 | -1.0 | -0.9 |
| Rest of LAC | 1.5 | -1.6 | 0.0 | -0.1 | -0.7 | 0.7 | 0.1 | 0.1 | 0.0 |
| Rest of ECA | -0.4 | -2.5 | -0.6 | -3.5 | 0.3 | 1.4 | 0.1 | 1.9 | -1.6 |
| Middle East and North Africa | -0.3 | -6.7 | -0.4 | -7.4 | -1.5 | 2.3 | 0.2 | 1.0 | -6.4 |
| Selected SSA countries | 0.2 | 0.0 | 0.0 | 0.3 | 0.0 | 0.2 | 0.0 | 0.2 | 0.5 |
| Rest of Sub Saharan Africa | -0.4 | -2.2 | -0.4 | -2.9 | 0.0 | 0.6 | 0.0 | 0.7 | -2.3 |
| Rest of the World | 0.0 | -0.1 | 0.0 | -0.1 | 0.2 | 0.1 | 0.0 | 0.3 | 0.1 |
| **High-income countries** | **5.7** | **2.7** | **-2.5** | **5.9** | **-2.4** | **24.0** | **2.8** | **24.4** | **30.3** |
| **Developing countries** | **5.0** | **-32.9** | **-0.5** | **-28.4** | **-9.0** | **7.5** | **0.3** | **-1.3** | **-29.7** |
| Middle-income countries | 5.2 | -20.7 | 1.1 | -14.4 | -8.1 | 5.6 | 0.1 | -2.4 | -16.7 |
| Low-income countries | -0.2 | -12.2 | -1.6 | -14.0 | -0.9 | 1.8 | 0.1 | 1.1 | -12.9 |
| East Asia and Pacific | 1.1 | -4.9 | 2.2 | -1.6 | -4.8 | -1.7 | -0.4 | -6.9 | -8.5 |
| South Asia | -0.6 | -9.4 | -1.7 | -11.8 | -0.6 | 1.1 | 0.0 | 0.6 | -11.2 |
| Europe and Central Asia | -0.6 | -5.4 | -0.7 | -6.7 | -0.5 | 2.8 | 0.3 | 2.6 | -4.0 |
| Middle East and North Africa | -0.3 | -6.7 | -0.4 | -7.4 | -1.5 | 2.3 | 0.2 | 1.0 | -6.4 |
| Sub Saharan Africa | -0.2 | -2.3 | -0.3 | -2.8 | -0.1 | 1.0 | 0.1 | 1.0 | -1.8 |
| Latin America & the Caribbean | 5.5 | -4.0 | 0.4 | 1.9 | -1.8 | 1.8 | 0.2 | 0.2 | 2.2 |
| **World total** | **10.7** | **-30.1** | **-3.0** | **-22.4** | **-11.4** | **31.4** | **3.0** | **23.1** | **0.6** |

**Table 4a: Dynamics, land mobility and trade elasticities—impacts on real income**

(change in real income in $2001 billion, relative to base year income)

| | Scaled dynamics | Comparative static | | | |
|---|---|---|---|---|---|
| | | **LINKAGE trade elasticities** | | **GTAP trade elasticities** | |
| | | *Flexible land* | *Fixed land* | *Flexible land* | *Fixed land* |
| **World total** | **176.0** | **126.8** | **111.8** | **88.1** | **77.3** |
| **High-income countries** | **129.1** | **103.6** | **99.8** | **77.8** | **75.7** |
| Australia and New Zealand | 3.5 | 2.2 | 1.9 | 1.8 | 1.7 |
| EU 25 plus EFTA | 45.3 | 44.0 | 39.9 | 32.9 | 30.2 |
| United States | 9.8 | 4.1 | 5.8 | 4.5 | 5.1 |
| Canada | 2.4 | 2.1 | 1.5 | 1.0 | 0.8 |
| Japan | 37.9 | 30.8 | 30.4 | 25.1 | 25.3 |
| Other high-income countries | 27.9 | 20.4 | 20.4 | 12.6 | 12.7 |
| **Developing countries** | **44.8** | **23.2** | **12.0** | **10.3** | **1.6** |
| *East Asia and Pacific* | 9.8 | 6.8 | 2.6 | 3.7 | 0.6 |
| China | 2.2 | 0.5 | -2.9 | -0.5 | -2.6 |
| *South Asia* | 2.2 | -1.2 | -0.3 | -2.2 | -1.6 |
| India | 1.6 | -0.8 | 0.2 | -1.5 | -0.9 |
| *Europe and Central Asia* | 3.8 | 3.8 | 3.3 | 2.2 | 1.8 |
| *Middle East and North Africa* | 8.2 | 3.8 | 3.3 | 2.1 | 1.6 |
| *Sub Saharan Africa* | 3.0 | 0.7 | 0.4 | 0.2 | -0.1 |
| Selected SSA countries | 0.6 | 0.3 | 0.2 | 0.4 | 0.3 |
| South Africa | 0.8 | 0.7 | 0.6 | 0.5 | 0.4 |
| Rest of Sub Saharan Africa | 1.6 | -0.3 | -0.4 | -0.6 | -0.8 |
| *Latin America & the Caribbean* | 17.9 | 7.9 | 2.0 | 3.9 | -0.7 |
| Argentina | 2.9 | 1.6 | 1.0 | 1.0 | 0.7 |
| Brazil | 6.1 | 4.7 | 2.3 | 5.0 | 2.2 |

**Table 4b: Dynamics, land mobility and trade elasticities—impacts on real income**

(percent change in real income relative to base line income)

| | Scaled dynamics | Comparative static | | | |
|---|---|---|---|---|---|
| | | LINKAGE trade elasticities | | GTAP trade elasticities | |
| | | *Flexible land* | *Fixed land* | *Flexible land* | *Fixed land* |
| **World total** | **0.7** | **0.5** | **0.4** | **0.3** | **0.3** |
| **High-income countries** | **0.6** | **0.5** | **0.5** | **0.4** | **0.4** |
| Australia and New Zealand | 1.0 | 0.7 | 0.6 | 0.5 | 0.5 |
| EU 25 plus EFTA | 0.6 | 0.6 | 0.6 | 0.5 | 0.4 |
| United States | 0.1 | 0.0 | 0.1 | 0.1 | 0.1 |
| Canada | 0.4 | 0.4 | 0.3 | 0.2 | 0.1 |
| Japan | 1.1 | 0.9 | 0.9 | 0.7 | 0.7 |
| Other high-income countries | 3.3 | 2.4 | 2.4 | 1.5 | 1.5 |
| **Developing countries** | **0.8** | **0.4** | **0.2** | **0.2** | **0.0** |
| *East Asia and Pacific* | 0.7 | 0.5 | 0.2 | 0.3 | 0.0 |
| China | 0.2 | 0.0 | -0.3 | -0.1 | -0.3 |
| *South Asia* | 0.4 | -0.2 | -0.1 | -0.4 | -0.3 |
| India | 0.4 | -0.2 | 0.0 | -0.4 | -0.2 |
| *Europe and Central Asia* | 0.7 | 0.7 | 0.6 | 0.4 | 0.3 |
| *Middle East and North Africa* | 1.2 | 0.5 | 0.5 | 0.3 | 0.2 |
| *Sub Saharan Africa* | 1.1 | 0.3 | 0.2 | 0.1 | 0.0 |
| Selected SSA countries | 1.5 | 0.7 | 0.5 | 1.0 | 0.8 |
| South Africa | 0.9 | 0.8 | 0.7 | 0.5 | 0.5 |
| Rest of Sub Saharan Africa | 1.1 | -0.2 | -0.3 | -0.4 | -0.6 |
| *Latin America & the Caribbean* | 1.0 | 0.5 | 0.1 | 0.2 | 0.0 |
| Argentina | 1.2 | 0.7 | 0.4 | 0.4 | 0.3 |
| Brazil | 1.5 | 1.2 | 0.6 | 1.3 | 0.5 |

**Table 5: Sectoral output impacts under various assumptions using the comparative static version of Linkage, percent change from baseline[33]**

| | LINKAGE Armington and land elasticities | | | | | | | LINKAGE Armington elasticities—GTAP land assumptions | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | agr | pfb | lvs | pmt | mil | twp | omx | agr | pfb | lvs | pmt | mil | twp | omx |
| **World total** | **-1.9** | **10.2** | **0.7** | **-2.0** | **-1.2** | **-0.1** | **-0.1** | **-1.3** | **11.0** | **1.1** | **-1.5** | **-1.1** | **-0.1** | **-0.2** |
| **High-income countries** | **-13.0** | **-6.5** | **-4.1** | **-9.4** | **-3.3** | **-5.6** | **0.7** | **-10.6** | **-6.6** | **-3.0** | **-7.3** | **-3.2** | **-5.5** | **0.5** |
| Australia and New Zealand | 26.1 | 23.3 | 26.3 | 5.4 | 108.7 | -21.7 | -5.8 | 19.9 | 18.6 | 20.9 | 2.6 | 97.5 | -21.1 | -4.1 |
| EU 25 plus EFTA | -22.9 | -64.4 | -13.1 | -22.0 | -11.5 | -5.7 | 0.4 | -18.9 | -56.5 | -10.8 | -18.2 | -10.8 | -5.7 | 0.2 |
| United States | -0.8 | -7.0 | 7.9 | 9.3 | 1.3 | -13.0 | 0.1 | 3.0 | -7.1 | 8.9 | 10.2 | 1.5 | -13.0 | -0.2 |
| Canada | 26.7 | 335.8 | -0.8 | 6.0 | -24.6 | -21.0 | -1.5 | 13.5 | 300.8 | -2.4 | 4.9 | -23.6 | -20.5 | -0.7 |
| Japan | -26.9 | 26.0 | -31.0 | -53.9 | -27.7 | -3.2 | 3.5 | -25.7 | 34.5 | -30.6 | -52.9 | -27.4 | -3.0 | 3.3 |
| Other high-income countries | -24.4 | 109.6 | -1.3 | -10.6 | 49.8 | 14.8 | 1.1 | -22.2 | 60.2 | -0.1 | -9.8 | 51.2 | 14.8 | 0.9 |
| **Developing countries** | **4.8** | **15.7** | **4.4** | **15.8** | **8.0** | **5.1** | **-2.5** | **4.3** | **16.8** | **4.2** | **12.6** | **8.2** | **5.0** | **-2.2** |
| *East Asia and Pacific* | 4.3 | 10.1 | 2.6 | 4.8 | 12.1 | 12.9 | -2.0 | 5.0 | 10.8 | 3.0 | 5.9 | 14.4 | 12.6 | -2.0 |
| China | 4.1 | 8.9 | 2.6 | 5.0 | 2.1 | 10.6 | -2.6 | 5.2 | 9.9 | 2.8 | 6.1 | 3.7 | 10.2 | -2.6 |
| *South Asia* | -3.9 | 16.4 | -5.0 | 15.9 | -4.3 | 17.9 | -8.8 | -3.4 | 17.3 | -4.6 | 20.9 | -3.8 | 16.2 | -9.1 |
| India | -4.2 | 14.6 | -5.8 | 33.5 | -3.3 | 19.2 | -8.6 | -3.6 | 15.9 | -5.3 | 46.8 | -2.7 | 17.5 | -9.0 |
| *Europe and Central Asia* | -0.6 | 12.3 | -0.7 | -6.5 | 17.6 | -11.5 | -0.6 | 0.2 | 15.8 | -0.4 | -5.8 | 18.1 | -11.6 | -0.8 |
| *Middle East & North Africa* | -2.4 | 9.2 | -2.4 | -0.3 | 14.6 | -12.3 | 1.7 | -1.5 | 13.7 | -1.6 | 1.3 | 15.6 | -12.2 | 1.5 |
| *Sub Saharan Africa* | 1.1 | 55.6 | 5.5 | 45.2 | 1.1 | -20.8 | -1.0 | 3.0 | 48.3 | 7.2 | 49.5 | 1.8 | -21.1 | -1.1 |
| Selected SSA countries | 7.8 | 18.3 | 40.4 | 225.9 | -12.6 | -16.4 | -11.6 | 8.6 | 21.3 | 43.1 | 233.7 | -11.5 | -16.2 | -10.9 |
| South Africa | 8.6 | 37.7 | 0.6 | -0.7 | 0.5 | -21.0 | -0.1 | 7.4 | 35.3 | 1.5 | 0.4 | 0.9 | -20.6 | 0.1 |
| Rest of Sub Saharan Africa | -2.6 | 67.2 | -0.9 | 32.2 | 16.6 | -21.9 | -0.1 | 0.4 | 56.7 | 0.9 | 38.5 | 17.0 | -22.8 | -0.7 |
| *Latin America & the Caribbean* | 26.1 | 21.6 | 26.7 | 30.6 | 2.9 | -11.5 | -4.9 | 20.0 | 20.4 | 23.0 | 21.6 | 2.4 | -10.7 | -3.4 |
| Argentina | 24.7 | 8.9 | 8.3 | 4.6 | 15.9 | -12.0 | -7.2 | 18.5 | 17.5 | 11.4 | 5.8 | 15.8 | -11.5 | -6.2 |
| Brazil | 43.6 | 1.5 | 99.4 | 152.0 | 4.7 | -10.5 | -9.7 | 31.9 | -1.8 | 77.9 | 104.1 | 3.8 | -9.2 | -5.7 |

| | GTAP Armington elasticities— LINKAGE land assumptions | | | | | | | GTAP Armington and land assumptions | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | agr | pfb | lvs | pmt | mil | twp | omx | agr | pfb | lvs | pmt | mil | twp | omx |
| **World total** | **-0.2** | **10.9** | **1.1** | **-2.0** | **-0.9** | **0.0** | **-0.1** | **0.2** | **11.6** | **1.5** | **-1.4** | **-0.8** | **0.0** | **-0.1** |
| **High-income countries** | **-7.0** | **5.2** | **-4.0** | **-10.3** | **-2.8** | **-5.1** | **0.7** | **-5.9** | **4.8** | **-2.8** | **-7.8** | **-2.7** | **-5.0** | **0.5** |
| Australia and New Zealand | 19.8 | 35.6 | 27.8 | 6.9 | 99.7 | -19.7 | -4.2 | 17.3 | 27.7 | 23.8 | 2.8 | 88.1 | -19.4 | -3.2 |
| EU 25 plus EFTA | -14.6 | -41.2 | -13.6 | -24.1 | -10.3 | -5.3 | 0.5 | -12.3 | -34.7 | -11.2 | -19.4 | -9.5 | -5.3 | 0.2 |
| United States | 3.8 | 5.0 | 8.8 | 9.8 | 1.4 | -12.1 | 0.0 | 5.4 | 5.0 | 9.6 | 10.8 | 1.5 | -12.0 | -0.1 |
| Canada | 11.7 | 158.7 | 3.8 | 9.0 | -21.1 | -19.5 | -0.8 | 8.9 | 146.9 | 3.7 | 8.0 | -20.0 | -19.2 | -0.6 |
| Japan | -18.4 | 19.6 | -31.0 | -57.2 | -23.1 | -2.8 | 2.7 | -18.7 | 25.0 | -31.1 | -56.1 | -22.8 | -2.7 | 2.6 |
| Other high-income countries | -13.9 | 57.2 | -6.0 | -13.2 | 38.6 | 15.0 | 1.5 | -13.7 | 45.8 | -5.2 | -12.0 | 40.0 | 15.2 | 1.4 |
| **Developing countries** | **4.0** | **12.8** | **5.1** | **17.9** | **7.1** | **4.8** | **-2.2** | **3.8** | **13.9** | **4.7** | **13.9** | **7.3** | **4.7** | **-2.0** |
| *East Asia and Pacific* | 4.2 | 9.6 | 2.8 | 4.9 | 10.1 | 12.2 | -1.6 | 4.6 | 10.3 | 3.3 | 6.5 | 12.6 | 12.0 | -1.6 |
| China | 3.8 | 8.6 | 2.8 | 5.1 | 1.9 | 10.2 | -2.0 | 4.3 | 9.5 | 3.2 | 6.9 | 4.0 | 10.0 | -2.0 |
| *South Asia* | -2.9 | 14.1 | -4.8 | 18.1 | -4.6 | 15.7 | -8.7 | -2.8 | 15.5 | -4.7 | 24.6 | -4.1 | 14.5 | -8.8 |
| India | -3.1 | 14.2 | -5.5 | 39.4 | -3.6 | 16.9 | -8.6 | -3.0 | 15.7 | -5.3 | 57.0 | -3.3 | 15.6 | -8.7 |
| *Europe and Central Asia* | -0.1 | 9.6 | -0.9 | -7.0 | 15.6 | -10.5 | -0.9 | 0.3 | 11.3 | -0.6 | -6.2 | 16.0 | -10.5 | -1.0 |
| *Middle East & North Africa* | -1.2 | 7.3 | -1.3 | -0.1 | 12.6 | -13.0 | 1.4 | -0.5 | 9.7 | -0.5 | 1.8 | 13.5 | -12.8 | 1.2 |
| *Sub Saharan Africa* | 3.3 | 34.2 | 7.9 | 49.8 | 0.2 | -19.8 | -1.9 | 4.4 | 33.5 | 9.8 | 55.5 | 0.9 | -19.9 | -1.9 |
| Selected SSA countries | 10.3 | 13.5 | 46.3 | 246.4 | -13.8 | -17.2 | -12.8 | 11.3 | 15.5 | 50.0 | 254.9 | -12.6 | -16.8 | -12.1 |
| South Africa | 5.3 | 33.1 | 0.3 | -0.3 | 0.8 | -18.2 | -0.3 | 5.6 | 32.5 | 1.5 | 1.1 | 1.3 | -18.0 | -0.2 |
| Rest of Sub Saharan Africa | 0.6 | 40.4 | 1.7 | 35.9 | 14.0 | -21.4 | -1.6 | 1.9 | 38.9 | 3.5 | 44.8 | 14.5 | -21.8 | -1.8 |
| *Latin America & the Caribbean* | 19.1 | 19.2 | 29.3 | 34.7 | 3.0 | -9.6 | -4.0 | 16.0 | 18.2 | 24.6 | 23.5 | 2.6 | -9.2 | -2.9 |
| Argentina | 16.2 | 9.8 | 8.0 | 5.1 | 14.8 | -9.7 | -5.8 | 15.0 | 13.8 | 11.2 | 6.5 | 14.6 | -9.8 | -5.6 |
| Brazil | 44.0 | 3.9 | 111.4 | 170.2 | 5.0 | -9.5 | -9.8 | 33.3 | 2.3 | 84.6 | 109.8 | 3.8 | -8.2 | -5.8 |

33 Abbreviations are primary agriculture (agr), cotton (or plant-based fibers, pfb), livestock (lvs), meat products (pmt), dairy products (mil), textile and apparel (twp), all other manufacturing (omx).

**Table 6: Impact of labor market closure on real income, wages and labor demand**

(change in real income, wages and labor demand in 2001, comparative static)

| | Real income | | | | Labor market | | |
|---|---|---|---|---|---|---|---|
| | | | | | Real wage | Demand for unskilled workers | |
| | $billion | | percent | | percent | percent | million |
| | Flex-wage | Fix-wage | Flex-wage | Fix-wage | Flex-wage | Fix-wage | Fix-wage |
| **World total** | 126.8 | 220.4 | 0.5 | 0.8 | 0.8 | 3.0 | 84.2 |
| **High-income countries** | 103.6 | 132.5 | 0.5 | 0.6 | 0.3 | 0.5 | 1.9 |
| Australia and New Zealand | 2.2 | 5.2 | 0.7 | 1.5 | 2.5 | 2.3 | 0.2 |
| EU 25 plus EFTA | 44.0 | 42.0 | 0.6 | 0.6 | -0.1 | -0.1 | -0.2 |
| United States | 4.1 | 4.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Canada | 2.1 | 3.6 | 0.4 | 0.6 | 0.6 | 0.6 | 0.1 |
| Japan | 30.8 | 45.7 | 0.9 | 1.3 | 0.9 | 0.9 | 0.5 |
| Other high-income countries | 20.4 | 31.7 | 2.4 | 3.7 | 3.8 | 3.9 | 1.4 |
| **Developing countries** | 23.2 | 87.9 | 0.4 | 1.6 | 2.9 | 3.4 | 82.3 |
| *East Asia and Pacific* | 6.8 | 31.9 | 0.5 | 2.2 | 3.6 | 3.8 | 37.3 |
| China | 0.5 | 18.2 | 0.0 | 1.8 | 2.5 | 3.4 | 26.4 |
| *South Asia* | -1.2 | 3.3 | -0.2 | 0.6 | 1.8 | 2.0 | 12.1 |
| India | -0.8 | 2.5 | -0.2 | 0.6 | 1.8 | 2.0 | 9.1 |
| *Europe and Central Asia* | 3.8 | 9.2 | 0.7 | 1.7 | 1.9 | 2.5 | 4.0 |
| *Middle East & North Africa* | 3.8 | 12.2 | 0.5 | 1.7 | 2.9 | 3.1 | 3.4 |
| *Sub Saharan Africa* | 0.7 | 7.1 | 0.3 | 2.6 | 3.9 | 6.4 | 18.4 |
| Selected SSA countries | 0.3 | 1.2 | 0.7 | 3.2 | 3.9 | 5.3 | 3.3 |
| South Africa | 0.7 | 1.8 | 0.8 | 1.9 | 2.1 | 2.4 | 0.4 |
| Rest of Sub Saharan Africa | -0.3 | 4.1 | -0.2 | 3.0 | 5.0 | 7.0 | 14.7 |
| *Latin America & the Caribbean* | 7.9 | 21.3 | 0.5 | 1.2 | 2.3 | 2.5 | 4.9 |
| Argentina | 1.6 | 3.2 | 0.7 | 1.3 | 1.3 | 1.6 | 0.2 |
| Brazil | 4.7 | 7.3 | 1.2 | 1.8 | 1.4 | 1.4 | 1.0 |

## Annex Table: Model aggregation of regions and sectors

| Regions | Sectors |
|---|---|
| **High-income** | **Primary agriculture** |
| Australia and New Zealand | Rice |
| EU 25 plus EFTA | Wheat |
| United States | Other grains |
| Canada | Oil seeds |
| Japan | Sugar |
| Korea and Taiwan | Plant-based fibers |
| Hong Kong and Singapore | Vegetables and fruits |
| | Other crops |
| **Developing countries** | Livestock |
| Argentina | |
| Bangladesh | **Processed foods** |
| Brazil | Processed meats |
| China | Vegetable oils and fats |
| India | Dairy products |
| Indonesia | Other food, beverages and tobacco |
| Thailand | |
| Vietnam | **Textile, clothing and footwear** |
| Russia | Textile |
| Mexico | Wearing apparel |
| South Africa | Leather |
| Turkey | |
| | **Natural resources and other manufacturing** |
| **Developing regions** | Other natural resources |
| Rest of South Asia | Fossil fuels |
| Rest of East Asia | Chemicals rubber and plastics |
| Rest of LAC | Iron and steel |
| Rest of ECA | Motor vehicles and parts |
| Middle East and North Africa | Capital goods |
| Selected SSA countries | Other manufacturing |
| Rest of Sub Saharan Africa | |
| Rest of the World | **Non-tradables** |
| | Construction |
| **Output aggregations** | Utilities and services |
| High-income countries | |
| Other high-income countries (NIEs) | |
| Developing countries | |
| Middle-income countries | |
| Low-income countries | |
| East Asia and Pacific | |
| South Asia | |
| Europe and Central Asia | |
| Middle East and North Africa | |
| Sub Saharan Africa | |
| Latin America and the Caribbean | |
| World total | |