

Global Agricultural Liberalization: An In-Depth Assessment of What Is At Stake

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Abstract

We use the global LINKAGE model to assess the impact of trade and support policies in agriculture on income, trade, and output patterns. We provide order-of-magnitude estimates of the impacts of policy changes rather than point estimates. Two sets of simulations are used to identify key drivers in the results. One set decomposes the aggregate results by looking at the impacts of partial reforms, regionally and across instruments, to identify the relative contribution to global gains of reforms in industrialized and developing countries and of border protection versus domestic support. The second set responds to critics of trade reform (inflated gains for developing countries, no transition costs for industrial country farmers, uncertain supply response in developing countries).

Reform of agriculture and food provides 70 percent of the global gains from merchandise trade reform of \$385 billion. The global gains are shared equally among industrial and developing countries. Developing countries gain more as a share of initial income, and income gains occur in developing country agriculture, reducing poverty. Both groups of countries gain more from their own reforms than from the other group's reforms. Productivity and supply assumptions affect impact assessment, but their influence is small and does not alter the main aggregate findings. Trade elasticities, however, are key in determining the overall level of the income gains. Higher elasticities dampen terms-of-trade effects and increase trade and real income gains more than proportionally and the converse is true for smaller elasticities. These effects can be very large for individual countries.

Keywords: agricultural trade liberalization, developing countries, Doha Round, farm policy, WTO.

GLOBAL AGRICULTURAL LIBERALIZATION: AN IN-DEPTH ASSESSMENT OF WHAT IS AT STAKE

This paper extends and elaborates on our previous work on global agricultural trade policy analysis (Beghin, Roland-Holst, and van der Mensbrugge 2003). This latest analysis uses a global dynamic applied general equilibrium model (LINKAGE) to assess how the multifarious trade and support policies in agriculture affect income, trade, and output patterns at the global level.¹ Such models have become a standard tool for assessing policy reforms because they capture linkages across sectors and regions (through trade) and because, by their nature, they have adding-up constraints so that supply and demand are in equilibrium in all markets. The analysis provides order-of-magnitude estimates of the potential consequences of policy changes, rather than a single point or “best” estimate. It also looks at the induced structural changes, including cross-regional patterns of output and trade, which tend to be much larger than the more familiar gains to real income. While income gains typically amount to 1 percent of base income or less, structural changes—for example, in sectoral output or trade—can be greater than 50 percent.

Two sets of simulations are used to create a deeper picture of what drives the key results. One set decomposes the aggregate results by looking at the impacts of partial reforms—both regionally and across instruments—to identify what share of the global gains derives from reform in industrial countries and from reform in developing countries, and what share is driven by border protection and by domestic support. The second set of simulations addresses issues raised by critics of trade reform, notably that the predicted gains for developing countries are too optimistic and that the transition costs for industrial country farmers are high and too often ignored. Concerns have also been raised about the ability of developing countries to respond to reforms and to achieve consistently high productivity gains. To answer the questions about the impacts on developing countries, three assumptions are explored: the consequences of assuming differential and

lower agricultural productivity in some developing countries, the impacts of constraining output supply response in selected low-income countries, and estimates of trade elasticities. The paper also assesses the impacts of slower exit by industrial-country farmers and how this would affect transition adjustments.

Some of the main findings are as follows.

- Reform of agriculture and food provides 70 percent of the global gains from merchandise trade reform—\$265 billion of a total of \$385 billion.
- The global gains are shared roughly equally between industrial and developing countries, but developing countries gain significantly more as a share of initial income. Significant income gains occur in developing-country agriculture, where poverty tends to be concentrated.
- Developing countries gain more from reforming their own support policies than from improved market access in industrial countries. Likewise, industrial countries also gain relatively more from their own reform.
- Notwithstanding the overall benefits from greater openness, structural changes are important, and transition adjustments need to be addressed.
- Productivity and supply assumptions affect impact assessment, but their influence is small, and they do not alter the main aggregate findings. Trade elasticities, however, are the key determinants in the overall level of the income gains. Higher elasticities dampen terms-of-trade effects and increase trade and real income gains more than proportionally, while the opposite is true for lower elasticities. These effects can be very large for individual countries.

The rest of the paper is organized as follows. We introduce the modeling framework in the next section, with a detailed description of the model baseline assumptions. Then, the following section looks at the impacts of agricultural reforms and provides a decomposition of impacts by policy instrument. In the third section, sensitivity analysis is discussed along with its implications. Conclusions are last. An extensive annex is available from the authors. It includes a longer description of the model and parameter values, and detailed tables of individual-country results for the policy analysis and sensitivity analysis.

The Modeling Framework

The LINKAGE model is based on a standard neoclassical general equilibrium model with firms maximizing profit in competitive markets and consumers maximizing well-being under a budget constraint. The model has added features related to its dynamic nature. It is global, with the world decomposed into 23 regions, and multisectoral, with economic activity aggregated into 22 sectors (Annex A, available from authors). Seven of the 23 regions are classified as high income (or industrial), including Canada, Western Europe (European Union-15 plus the European Free Trade Association countries), Japan, and the United States—the so-called Quad countries. The developing countries include some of the large countries that are important in agricultural markets as producers or as consumers (Argentina, Brazil, China, India, and Indonesia). The remaining developing countries are grouped into regional aggregations.² The sectoral decomposition is concentrated in the agricultural and food sectors (15 of the 22 sectors).

The LINKAGE model is dynamic, with scenarios spanning 1997 to 2015. The dynamics include exogenously given labor and land growth rates, savings-driven investment and capital accumulation, and exogenous productivity growth. Structural changes over time are driven by differential growth rates and supply and demand parameters.³ Trade is modeled using the Armington assumption. Goods are differentiated by region of origin using a two-nested structure (domestic absorption first allocated across domestic and aggregate import goods, then aggregate imports allocated across different regions of origin).

Overview of Baseline Simulation

Assessing the impacts of policy reforms requires two steps in the dynamic framework of the LINKAGE model, a baseline (or reference) simulation and a reform simulation. The baseline involves running the model forward from its 1997 base year to 2015, with exogenous assumptions about labor and population growth rates, productivity, and demand behavior parameters including savings, which determines the rate of capital accumulation (adjusted exogenously for depreciation).

The baseline simulation can also incorporate changes in base-year policies, to take into account known changes in policies (between 1997 and the present) or anticipated changes. However, the baseline described in what follows assumes no changes in base-year policies: they are held at their 1997 levels. Thus, the reform simulations reflect

changes from their 1997 levels, not changes that would be anticipated from 2004 levels.⁴ It is unclear in which direction some past and anticipated changes would affect the global trade reform results. Some changes clearly reflect further opening, for example, China's accession to the World Trade Organization (WTO) and some bilateral free trade agreements. Others would go in the opposite direction, for example, the changes to the U.S. farm support programs.

Agriculture and Food Trends in the Baseline Scenario

Trends in agriculture and food supply and demand across the globe as determined in the baseline scenario are driven in part by the macro environment (as described in Annex B, available from authors). But they are also driven by microeconomic assumptions about the mobility of factors, production technologies, income and price elasticities, and trade elasticities, among others.

For agriculture and food between 2000 and 2015, both demand and production grow at 1.0–1.2 percent a year in industrial countries, and at a much higher 2.9–3.4 percent in developing countries (Tables 1 and 2 summarize the results; tables in the annex, available from the authors, provide details for individual countries). On a per capita basis there is more demand growth in developing countries, largely because of higher income elasticities for food. Thus the baseline assumes that demand growth will be lower than output growth in industrial countries and higher than output growth in developing countries.

With higher output growth than demand, industrial countries will see an increase in their exportable surplus. In the aggregate, their net agricultural and food trade will improve dramatically, from a deficit of \$17 billion in 2000 to a surplus of \$50 billion in 2015 (at 1997 prices). The opposite occurs in developing countries, where a net positive balance in agriculture and food turns into a large deficit of \$50 billion, due mostly to a ballooning in processed food. Agriculture and food balances are positive for low-income countries in 2000 and 2015.

Developing a baseline of the future world economy requires nuanced analysis. The country and regional growth rates used here are in line with consensus views, given stronger demographic trends and income elasticities for agriculture and food in developing economies. World and regional totals may be skewed by several factors. The weights

TABLE 1. Trends in agriculture, 2000–15

	Average Annual Growth (percent)				Net Trade (billion 1997 US\$)	
	Output	Demand	Imports	Exports	2000	2015
	High-income countries	1.2	1.1	1.9	3.0	-24.3
Low-income countries	3.6	3.5	4.4	5.5	9.9	21.6
Middle-income countries	3.2	3.3	8.3	5.4	14.4	-18.5
Low-income countries, excluding India	3.7	3.4	3.6	6.6	7.2	22.4
Middle-income countries, including India	3.2	3.4	8.3	5.1	17.1	-19.3
Developing countries	3.3	3.4	7.8	5.4	24.3	3.1
World total	2.6	2.6	4.4	4.2	0.0	0.0

Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

Note: Net trade is measured at FOB prices (imports exclude international trade and transport margins).

TABLE 2. Trends in processed foods, 2000–15

	Average Annual Growth (percent)				Net Trade (billion 1997 US\$)	
	Output	Demand	Imports	Exports	2000	2015
	High-income countries	1.2	1.0	1.3	2.4	7.7
Low-income countries	3.3	3.4	3.9	2.2	3.6	1.8
Middle-income countries	2.9	3.1	4.5	2.0	-11.3	-55.3
Low-income countries, excluding India	3.1	3.3	3.8	2.2	1.8	-0.2
Middle-income countries, including India	2.9	3.1	4.5	2.0	-9.5	-53.4
Developing countries	2.9	3.2	4.5	2.1	-7.7	-53.5
World total	1.8	1.8	2.4	2.3	0.0	0.0

Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

Note: Net trade is measured at FOB prices (imports exclude international trade and transport margins).

are biased toward industrial countries because of the use of base-year (1997) value shares. Volume shares would yield different figures. Demand growth in developing countries may be overstated because income elasticities are held constant at their base-year levels. It is plausible to argue that income elasticities would converge toward those of high-income countries as developing countries grow. The growth numbers are also broadly consistent with Food and Agriculture Organization (FAO) historical trends. The discrepancy between agricultural growth and food processing originates in the growth in intermediate demand for agricultural products as food processing grows. A more meat-intensive future world will also exhibit a slight acceleration in agricultural growth relative to food because of the feed input in the livestock sector. So, while the baseline scenario is plausible, aggregate growth rates should be used with caution for all these reasons.

The biggest mover among developing countries is China, where the food deficit of \$8 billion in 1997 would swell to somewhere around \$120 billion by 2015. Demand is expected to outpace output by about 1 percentage point a year.⁵ In agriculture this provides new opportunities for sub-Saharan Africa and Latin America, with both seeing a large rise in agricultural surplus (on an aggregate basis). Sub-Saharan Africa will nonetheless see a slight deterioration in its processed food balance. The aggregate net trade balances may mask more detailed sectoral shifts. For example, sub-Saharan Africa will continue to be a net importer of grains through the baseline scenario time horizon; therefore, a trade reform-induced rise in world prices could lead to a negative terms-of-trade shock since the agricultural commodities sub-Saharan Africa tends to export—for example, coffee and cocoa—already have relatively free access.

With relatively low demand growth in industrial countries and relatively high output growth, the exportable agricultural surplus will increase substantially, particularly from North America and Oceania. Europe and Japan are the exceptions, with output growth expected to be anemic.

The Impacts of Agricultural Reform

The impacts of agricultural trade reform are examined first in the context of global merchandise trade reform, and then the results are decomposed by type of reform and re-

gion to assess the relative importance for developing countries of reforms in industrial countries and in developing countries.

Results of Global Merchandise Trade Reform

Global reform involves removing protection in all (nonservice) sectors, in all regions, and for all instruments of protection (leaving other taxes unchanged, though lump sum taxes [or transfers] on households adjust to maintain a fixed government fiscal balance). The model contains six instruments of protection:

- Import tariffs, eliminated only if they are positive.
- Export subsidies, eliminated only if they are negative.⁶
- Capital subsidies, with direct payments converted into subsidies on capital.
- Land subsidies, with some payments also converted to subsidies on land.
- Input subsidies.
- Output subsidies.

The overall measure of reform, referred to as real income, measures the extent to which households are better off in the post-reform scenario than in the baseline scenario in the year 2015.⁷ The world gain (measured in 1997 U.S. dollars) is \$385 billion, an increase from baseline income of some 0.9 percent (Table 3). The gains are relatively evenly divided between industrial countries (\$188 billion) and developing countries (\$197 billion), but developing countries are considerably better off as a share of reference income, with a gain of 1.7 percent compared with 0.6 percent for industrial countries.

Caveats. A few caveats about the basic global reform scenario are in order. First, there are known deficiencies in the base-year policies, which are taken from release 5.4 of the Global Trade Analysis Project (GTAP) database. Most preferential arrangements are not incorporated, including the Generalized System of Preferences and some regional trading agreements.⁸ Alternative scenarios could be undertaken to test their overall importance, especially regarding the utilization rates of the preferences. Second, the reference scenario assumes no changes in the base-year policies between the base and terminal years. Thus, changes in trading regimes since 1997, such as China's accession to

TABLE 3. Real income gains and losses from global merchandise trade reform: Change from 2015 baseline

	All Instruments	Tariffs Only	Export Subsidies Only	Capital Subsidies Only	Land Subsidies Only	Input Subsidies Only	Output Subsidies Only
<i>Change in value (billion 1997 US\$)</i>							
High-income countries	188.3	160.4	1.4	1.1	-4.8	-0.3	9.0
Low-income countries	31.9	34.6	-1.1	-0.1	-0.7	-0.3	0.2
Middle-income countries	164.7	187.7	-7.0	-1.2	-7.3	-3.8	-6.4
Low-income countries, excluding India	19.9	21.5	-0.9	-0.1	-0.6	-0.2	0.9
Middle-income countries, including India	176.7	200.8	-7.3	-1.2	-7.4	-3.9	-7.0
Developing countries	196.5	222.3	-8.2	-1.3	-8.1	-4.1	-6.2
World total	384.8	382.7	-6.8	-0.2	-12.8	-4.4	2.8
<i>Percentage change</i>							
High-income countries	0.6	0.5	0.0	0.0	0.0	0.0	0.0
Low-income countries	1.6	1.7	-0.1	0.0	0.0	0.0	0.0
Middle-income countries	1.8	2.0	-0.1	0.0	-0.1	0.0	-0.1
Low-income countries excl. India	1.9	2.1	-0.1	0.0	-0.1	0.0	0.1
Middle-income countries incl. India	1.7	1.9	-0.1	0.0	-0.1	0.0	-0.1
Developing countries	1.7	1.9	-0.1	0.0	-0.1	0.0	-0.1
World total	0.9	0.9	0.0	0.0	0.0	0.0	0.0

Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

the WTO, or anticipated changes, such as the elimination of the Multifibre Arrangement, are not taken into account.⁹

Third, changes to some key assumptions or specifications could generate higher benefits. For example, raising the trade elasticities—as some have argued—dampens the negative terms-of-trade effects. Increasing returns to scale can generate greater efficiency improvements, depending on the structure of product markets and scale economies to be achieved. Reform of services could have economywide impacts to the extent that cheaper and more efficient services can lower production costs as well as improve real incomes. Changes in investment flows—not modeled here—have proven to be as important (sometimes more) as lowering trade barriers in many regional agreements. In a global model, the net change would be zero. Therefore, any reallocation of capital would leave some countries better off, all else remaining the same, while leaving others worse off (abstracting from the benefits of future repatriated profits). Gross flows could have a greater impact than net capital flows to the extent that they raise productivity if they are associated with technology-laden capital goods. Finally, dynamic effects can also lead to a boost in the overall gains from reform.

The global scenario captures some of the inherent dynamic gains, notably changes from savings and investment behavior. These can sometimes have a substantial impact to the extent that imported capital goods are taxed. Assuming that savings rates are unchanged, a sharp fall in the price of capital goods can lead to a significant rise in investment (more bang per dollar invested). The scenario does not incorporate changes to productivity, however. The channels and magnitudes of trade-related changes to productivity are as yet poorly validated by solid empirical evidence, and attempts to incorporate these effects are largely simply illustrative of potential magnitudes. Recent World Bank reports suggest that these effects could be large, but the reports are really an appeal for more empirical research.¹⁰

Decomposition by Instrument. The key finding on instruments of protection is the predominant role of tariffs. Removal of tariffs accounts for virtually all of the gains. The other instruments have much smaller impacts on real income—slightly positive on average for industrial countries and negative for developing countries taken together. For example, elimination of export subsidies negatively affects Africa—both North and sub-

Saharan—and the Middle East, though it provides a positive benefit for Europe. Elimination of domestic protection also tends to be negative for developing countries and for industrial countries as well at times. The rest of sub-Saharan Africa is a notable exception, having an income gain of 0.6 percent. This could reflect the removal of significant output subsidies on cotton in some of the major producing countries (for example, China and the United States).

The ambiguity of the welfare impact is in part driven by the nature of partial reforms. Removal of one form of protection may exacerbate the negative impacts of other forms of protection. For example, removal of output subsidies may worsen the impact of tariffs if removal of the subsidy leads to a reduction in output and an increase in imports. There are no robust theoretical arguments to determine which is more harmful. There are also other general equilibrium effects inherent in multisectoral global models.

While the total measure of gain often garners the most attention—at least from policymakers and the media—more relevant for most players are the detailed structural results. By and large, it is the structural results that influence the political economy of reforms, particularly since the losers from reforms tend to be concentrated and a well-identified pressure group, whereas the gainers are typically diffuse and harder to identify. For example, a 10 percent decline in the price of wheat could have a major impact on a farmer's income but an almost imperceptible effect on the average consumer.

With reform, industrial country aggregate agricultural output declines—by more than 11 percent when all forms of protection are eliminated (Table 4). Removal of tariff protection generates the greatest change to production in industrial countries, but unlike the case with the welfare impacts, the other forms of protection have measurable, if smaller, impacts on output. Removal of output subsidies results in the next greatest change in agricultural output, driven largely by the nearly 5 percent output decline in the United States, though land and export subsidies have nearly the same aggregate impact. The detailed results for the Quad countries confirm several points of common wisdom regarding the patterns of protection. First, the United States makes more use of output subsidies than do Europe and Japan. Europe makes greater use of export subsidies and direct payments (capital and land subsidies). Japanese protection is mostly in the form of import barriers.

TABLE 4. Agricultural output gains and losses from global merchandise trade reform: Change from 2015 baseline

	All Instruments	Tariffs Only	Export Subsidies Only	Capital Subsidies Only	Land Subsidies Only	Input Subsidies Only	Output Subsidies Only
<i>Change in value (billion 1997 US\$)</i>							
High-income countries	-109.7	-56.2	-9.5	-1.6	-10.4	-7.4	-12.0
Low-income countries	14.8	11.5	1.1	0.0	0.7	0.4	2.0
Middle-income countries	41.8	18.1	8.2	-0.2	8.5	0.5	9.3
Low-income countries, excluding India	13.7	10.5	0.9	0.0	0.5	0.3	2.8
Middle-income countries, including India	42.9	19.2	8.4	-0.2	8.7	0.6	8.6
Developing countries	56.6	29.7	9.3	-0.1	9.2	0.9	11.3
World total	-53.1	-26.6	-0.2	-1.7	-1.2	-6.5	-0.7
<i>Percentage change</i>							
High-income countries	-11.1	-5.7	-1.0	-0.2	-1.1	-0.7	-1.2
Low-income countries	2.4	1.8	0.2	0.0	0.1	0.1	0.3
Middle-income countries	2.4	1.0	0.5	0.0	0.5	0.0	0.5
Low-income countries, excluding India	4.1	3.1	0.3	0.0	0.2	0.1	0.8
Middle-income countries, including India	2.1	0.9	0.4	0.0	0.4	0.0	0.4
Developing countries	2.4	1.2	0.4	0.0	0.4	0.0	0.5
World total	-1.6	-0.8	0.0	-0.1	0.0	-0.2	0.0

Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

Results of Agricultural Reform

Full merchandise trade reform provides a benchmark from which to judge the maximal effects from reform. This section focuses on the agricultural and food sectors.

Real Income Gains. If all regions remove all protection in agriculture and food, the global gains in 2015 amount to \$265 billion—nearly 70 percent of the gains from full merchandise trade reform (see Table 5). This is remarkable considering the small size of agriculture and food in global output (Figure 1).¹¹ Agriculture represents less than 2 percent of output for industrial countries and 10.5 percent for developing countries, while processed foods represent 4.5 percent for industrial countries and 7.5 percent for developing countries. Agriculture is still a relatively high 19 percent of output in the low-income developing countries. Clearly, protection tends to be higher in agriculture and food than in other sectors, particularly in industrial countries but in middle-income countries as well. Protection is more uniform in low-income countries.

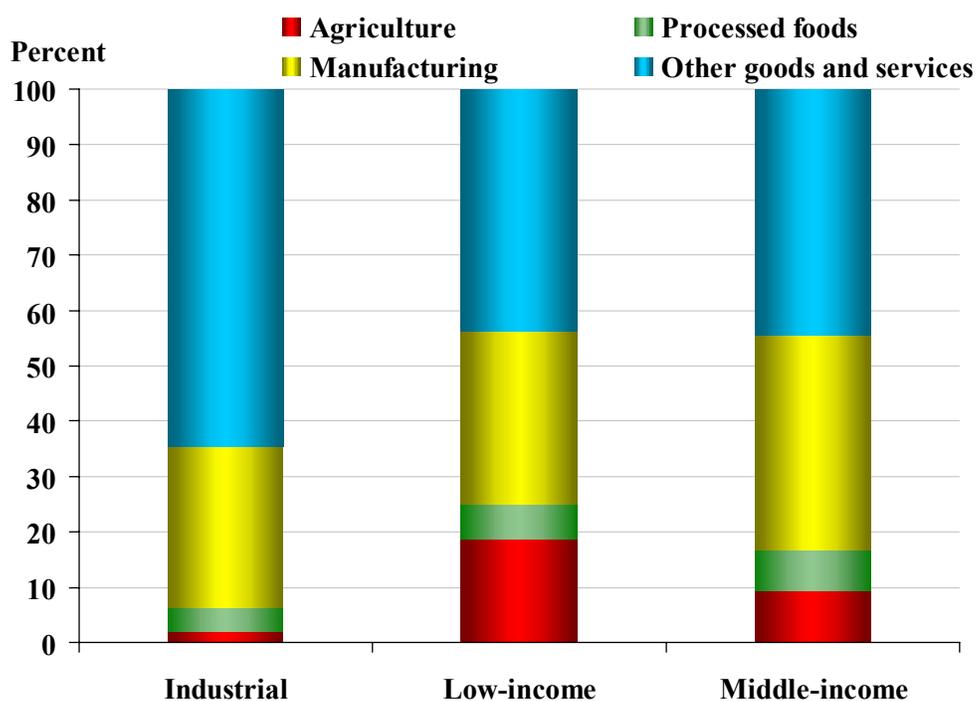
For low-income countries the gains from global free trade in agriculture and food amount to around one-third of the gains from global free trade in all merchandise. This is a consequence of their dependence on imports of the most protected food items—such as grains—while they are net exporters of commodities with little or no protection. The middle-income countries gain 71 percent from global free trade in agriculture and food, nearly as much as industrial countries, which gain 72 percent as compared with full merchandise trade reform

If reforms are limited to high-income countries—a super version of special and differential treatment—with perhaps an agreement by middle-income countries to bind at existing levels of protection, global gains drop to \$102 billion, indicating that a significant portion of the global gains is generated by removal of agricultural barriers in developing countries (see Table 5).¹² The drop in gains is particularly striking for middle-income countries, where the gains from their own agricultural and food reform would be quite substantial. On a percentage basis, this is less so for low-income countries. The industrial countries reap gains of \$92 billion, implying that agricultural reform in developing countries could generate gains of about \$45 billion for the industrial countries.

TABLE 5. Real income gains from agricultural and food trade reform: Change from 2015 baseline (billion 1997 US\$)

	Global Merchandise Trade Reforms	Agricultural and Food Trade Reform		Agricultural Trade Reform Only
	Global	Global	High-Income Countries	High-Income Countries
High-income countries	188.3	136.6	92.0	29.3
Low-income countries	31.9	10.3	3.0	1.1
Middle-income countries	164.7	118.2	6.9	-4.9
Low-income countries, excluding India	19.9	8.4	3.6	1.6
Middle-income countries, including India	176.7	120.1	6.4	-5.3
Developing countries	196.5	128.6	10.0	-3.8
World total	384.8	265.2	102.0	25.5

Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.



Source: GTAP release 5.4.

FIGURE 1. Output structure in base year, 1997

The final decomposition scenario is to assess the impacts of reform in agriculture alone in industrial countries, leaving protection unchanged for processed foods. This lowers the gains substantially for industrial countries—from \$92 billion to \$29 billion (see Table 5). Protection is high in both sectors, and the processed foods sector is more than twice as large as the agricultural sector. Furthermore, in a partial reform scenario, the efficiency gains in agriculture could be offset to some extent by further losses in processed foods. Output will expand in the processed food sector as resources are moved around, and the lower costs of inputs will also provide incentives to increase output. Middle-income countries could lose from an agriculture-only reform in industrial countries. They would benefit little from improved market access in agriculture, and in a partial reform scenario expansion of their protected domestic agriculture and food production leads to efficiency losses that are not compensated elsewhere.

To conclude, global agricultural trade reform generates a huge share of the gains to be made from merchandise trade reform. Market access into industrial countries provides

significant gains, but a greater share of the gains for developing countries comes from agricultural trade reform among developing countries. Finally, reform in agriculture alone provides few benefits. It needs to be linked to reform in the processed food sectors.

Structural Implications. Accelerating integration is one of the key goals of trade reform. Beyond the efficiency gains that come from allocating resources to their best uses, integration is expected to bring productivity increases—scale economies, greater competitiveness, ability to import technology-laden intermediate goods and capital, greater market awareness, and access to networks.

The potential changes in trade from global reform of agriculture and food are large. World trade in these two sectors could jump by more than a half a trillion dollars in 2015 (compared with the baseline), an increase of 74 percent (Table 6). Exports in agriculture and food from developing countries would jump \$300 billion, an increase of over 115 percent, with industrial country exports increasing \$220 billion, or 50 percent. On the flip side, imports from both industrial and developing countries would rise substantially. The net trade position of industrial countries would deteriorate marginally—from \$50 billion in the baseline in 2015 to \$48 billion after global reform of agriculture and food. The marginal improvement for developing countries decomposes into a boost of nearly \$12 billion for low-income countries and deterioration for middle-income countries of nearly \$10 billion.

If the reform is limited to industrial countries, the picture is modified significantly. First, the change in imports for industrial countries is almost identical under the two scenarios—\$223 billion with full reform and \$205 billion with industrial country reform only (see Table 6). Developing countries see a significant rise in exports but to industrial countries only, with little or no change in their own imports. Thus, industrial countries would witness a much sharper deterioration in their net food bill, with net imports registering a change of \$142 billion instead of \$2 billion, as under the global reform scenario. The United States and Europe bear the brunt of the adjustment, with Canada, Australia, and New Zealand seeing little difference between the global and partial reform scenarios. In other words, these three countries reap much of the trade benefits from greater market access within industrial countries. Opening up of markets in developing countries significantly dampens the adjustment process for the United

TABLE 6. Impact of global agricultural and food reform on agricultural and food trade: Change from 2015 baseline

	Exports		Imports		Net Trade		2015
	Global	Industrial	Global	Industrial	Global	Industrial	Baseline
<i>Change in value (billion 1997 US\$)</i>							
High-income countries	221.2	63.4	223.3	205.3	-2.1	-141.9	50.4
Low-income countries	41.0	20.9	29.2	-0.3	11.8	21.2	23.4
Middle-income countries	260.1	120.5	269.8	-0.2	-9.7	120.7	-73.8
Low-income countries, excluding India	33.8	17.5	21.9	0.1	11.8	17.5	22.2
Middle-income countries, including India	267.3	123.9	277.1	-0.5	-9.8	124.4	-72.7
Developing countries	301.1	141.4	299.0	-0.4	2.1	141.9	-50.4
World total	522.3	204.9	522.3	204.9	0.0	0.0	0
<i>Percentage change</i>							
High-income countries	50	14	57	52			
Low-income countries	74	38	92	-1			
Middle-income countries	125	58	96	0			
Low-income countries, excluding India	70	36	84	0			
Middle-income countries, including India	125	58	96	0			
Developing countries	115	54	95	0			
World total	74	29	74	29			

Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

Note: The columns labeled “Global” refer to the impacts from *global* agriculture and food reform. The columns labeled “Industrial” refer to industrial-country only reform of agricultural and food.

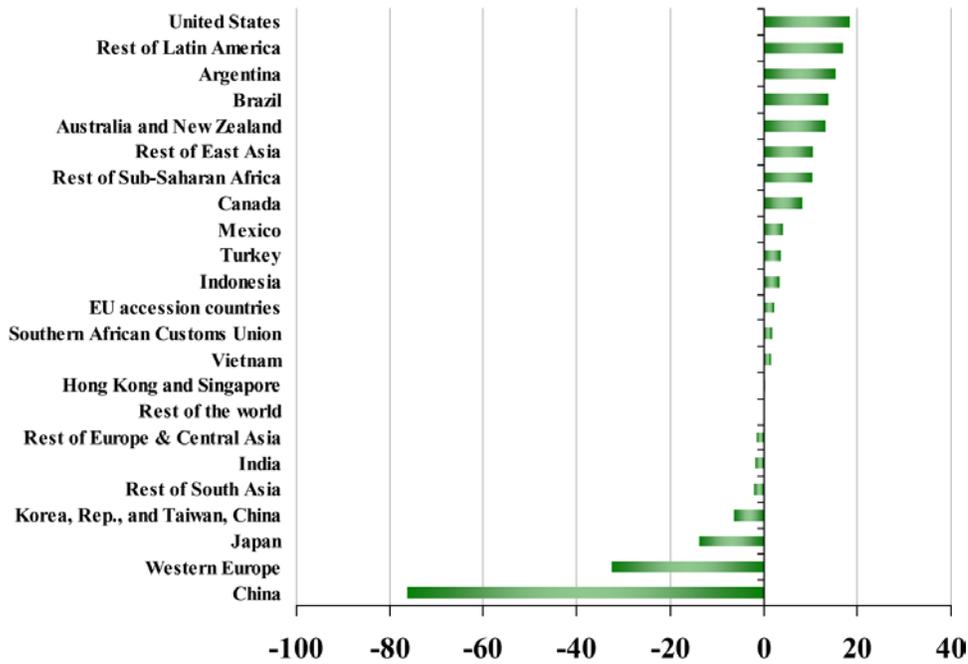
States and Europe, and the United States would reinforce its net exporting status significantly under a global reform scenario.

Most developing countries see a greater improvement in their net food trade with industrial-country-only reform than with global reform. However, Argentina, Brazil, and the rest of East Asia improve their net food trade more with global reform than with partial reform. They would gain additional market access from developing countries and reinforce their comparative advantage over more highly protected countries in East Asia. The biggest beneficiary on net terms would be China. While its (small) exports would not change much, removal of its own protection would induce a huge shift in imports. The lack of reform under the partial reform scenario means that instead of its net food position deteriorating by \$74 billion in the global reform scenario, it sees a small improvement of \$6 billion. Taken together for developing countries, the partial reform would generate an improvement in net trade of food of \$142 billion.

The structural impacts previously described are associated with global changes in the distribution of farm income. With global agriculture and food reform, farm incomes barely change at the global level (a loss of perhaps \$10 billion¹³ or 0.6 percent of baseline 2015 farm income). Changes are much more significant at the regional level (Figures 2 and 3). The largest absolute gains in farm income are in the Americas, Australia and New Zealand, and developing East Asia excluding China. Latin America would receive 40 percent of the total positive gains; Australia, Canada, and New Zealand, 18 percent; and the United States, 15 percent.

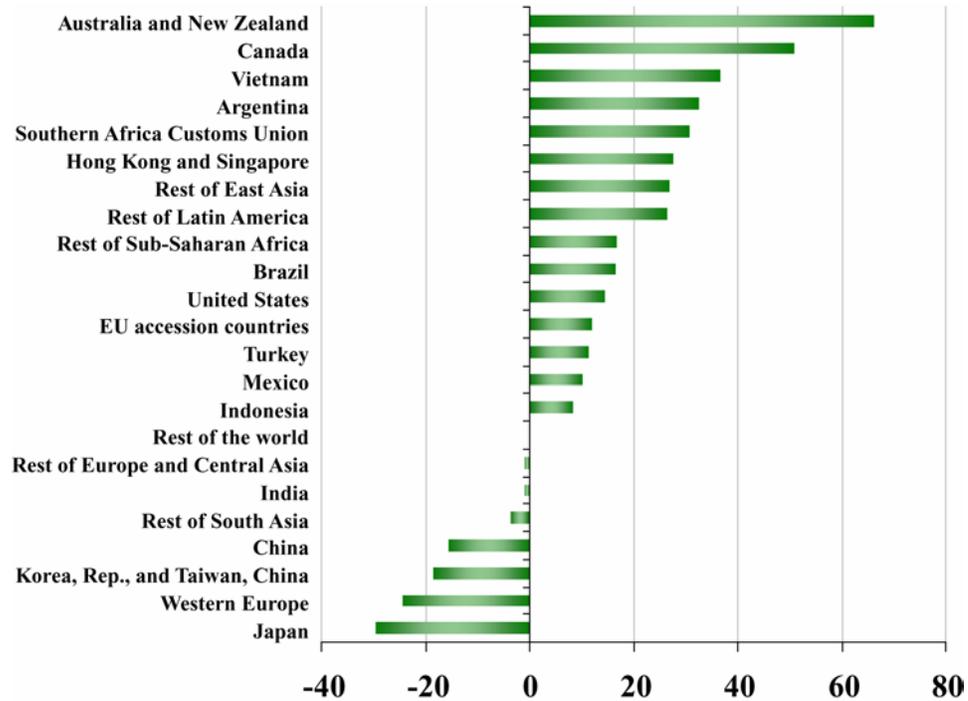
The relative position of regional gainers is somewhat different, however (see Figure 3). Farmers in Australia, Canada, and New Zealand gain the most from global free trade in agriculture and food, with income gains of 50–65 percent. Farmers in a number of developing regions have gains of more than 25 percent, including Vietnam, Argentina, countries of the Southern Africa Customs Union (SACU), the rest of East Asia (which includes Thailand, Malaysia, and the Philippines), and the rest of Latin America.

The farmers who lose most are in China, with potential losses of \$75 billion in 2015 compared with the baseline scenario.¹⁴ The next biggest losers are farmers in Western Europe and the developed East Asian economies—Japan; the Republic of Korea; and Taiwan, China. In percentage terms, the biggest losses occur in Japan (30 percent) and



Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

FIGURE 2. Change in rural value added from baseline in 2015 (billion 1997 US\$)



Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

FIGURE 3. Percentage change in rural value added from baseline in 2015

Western Europe (24 percent), with China's losses down to about 15 percent because of its huge rural economy.

Most of the impact on rural incomes is generated by volume changes, not factor returns. Both labor and capital returns are determined essentially on national markets.¹⁵ Thus, wage changes are modest overall, with generally greater impacts in developing countries, where more labor is employed in agriculture (Table 7). For example, unskilled wages increase 8 percent in Argentina and Vietnam, and 5–6 percent in the rest of Latin America and the rest of sub-Saharan Africa. Unskilled workers in Australia and New Zealand also benefit from these reforms. Unskilled workers in developing countries generally do better in relative terms than do skilled workers, largely as a result of their concentration in agricultural sectors. China is a significant exception. Removal of its agricultural protection lowers demand for unskilled workers, and their wages decline. The impact on wages in the European Union and Japan is negligible, as agriculture employs a very small share of the national labor force.

As in the labor markets, the returns in capital market are determined mainly at the national level (Table 8). Thus, changes to income will largely be reflected in volume changes, not in price changes. However, direct payments to farmers are implemented as an ad valorem subsidy on capital (and land), thus creating a wedge between the cost to farmers and the returns to owners. Removal of the capital subsidy has little effect on owners since the return is determined at the economywide level, but it raises the costs to farmers. For example, the cost of capital net of subsidies increases by almost 1 percent in the European Union, but the average cost to farmers increases by 22 percent—and even more for livestock producers (43 percent). Note that these capital subsidies are used mainly in industrial countries, so for most developing countries there is no difference between the owner return and the cost to farmers.

The changes in the contribution of land to agricultural incomes are driven largely by price movements—contrary to the case for labor and capital income (Table 9). Land is essentially a fixed factor in agriculture, with some allowance for movements up and down the supply curve and for cross-sectoral shifts in land usage.¹⁶ In Europe, the average return to land drops 66 percent, with the supply of land falling 9 percent. Farmers gain some benefit in lower unit costs because of falling land prices. But removal of the

TABLE 7. Impact of global agriculture and food reform on agricultural employment and wages: Change from 2015 baseline (percent)

	Total Agriculture			Cereals and Sugar			Livestock and Dairy		
	Employ- ment	Wages		Employ- ment	Wages		Employ- ment	Wages	
		Unskilled	Skilled		Unskilled	Skilled		Unskilled	Skilled
Canada	8.5	1.0	0.8	30.4	1.0	0.8	-15.5	1.0	0.8
United States	0.4	0.6	0.6	-12.4	0.6	0.6	3.3	0.6	0.6
European Union with EFTA	-23.7	-0.6	0.4	-57.7	-0.6	0.4	-28.0	-0.6	0.4
Australia and New Zealand	18.2	3.4	2.3	25.6	3.4	2.3	31.1	3.4	2.3
Japan	-26.8	-0.9	-0.1	-28.9	-0.9	-0.1	-46.2	-0.9	-0.1
Korea, Rep., and Taiwan, China	-13.8	-0.2	0.7	-3.9	-0.2	0.7	8.2	-0.2	0.7
Hong Kong (China) and Singapore	8.8	1.0	0.8	28.8	1.0	0.8	-2.0	1.0	0.8
Argentina	13.3	7.9	5.5	25.8	7.9	5.5	14.3	7.9	5.5
Brazil	12.5	3.4	3.0	25.8	3.4	3.0	11.7	3.4	3.0
China	-6.6	-3.1	0.0	-26.6	-3.1	0.0	8.6	-3.1	0.0
India	-0.3	0.0	0.2	0.7	0.0	0.2	1.1	0.0	0.2
Indonesia	4.3	1.4	-0.3	6.1	1.4	-0.3	-2.0	1.4	
Mexico	5.0	1.3	-0.2	1.3	1.3	-0.2	-4.8	1.3	-0.2
SACU	13.8	1.3	1.1	31.7	1.3	1.1	8.8	1.3	1.1
Turkey	5.2	3.0	0.5	-15.3	3.0	0.5	-18.7	3.0	0.5
Vietnam	17.0	7.8	3.0	63.1	7.8	3.0	-15.4	7.8	3.0
Rest of East Asia	11.6	2.7	0.9	72.0	2.7	0.9	-9.1	2.7	0.9
Rest of South Asia	-1.3	-0.2	0.0	1.1	-0.2	0.0	0.7	-0.2	0.0
EU accession countries	6.9	1.6	0.9	12.8	1.6	0.9	13.3	1.6	0.9
Rest of Europe and Central Asia	-0.4	-1.0	-0.3	0.3	-1.0	-0.3	-2.4	-1.0	-0.3
Rest of sub-Saharan Africa	6.2	6.0	1.9	17.9	6.0	1.9	1.2	6.0	1.9
Rest of Latin America	6.2	5.4	3.4	17.9	5.4	3.4	42.6	5.4	3.4
Rest of the World including Middle East and North Africa	-0.1	-0.3	0.9	2.6	-0.3	0.9	-4.2	-0.3	0.9

Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

TABLE 8. Impact of global agricultural and food trade reform on agricultural capital: Change from 2015 baseline (percent)

	Total Agriculture			Grains and Sugar			Livestock and Dairy		
	Volume	Owners' Return	Farmers' Cost	Volume	Owners' Return	Farmers' Cost	Volume	Owners' Return	Farmers' Cost
Canada	-4.9	-0.5	4.1	7.2	-0.5	3.1	-17.0	-0.5	7.1
United States	0.8	0.7	2.6	-19.2	0.7	2.6	4.5	0.7	6.5
European Union with EFTA	-32.9	0.7	21.8	-67.1	0.7	21.7	-29.2	0.8	43.1
Australia and New Zealand	40.2	0.6	1.2	3.0	0.7	1.3	123.5	0.6	1.7
Japan	-22.9	1.7	4.9	-25.0	1.7	7.6	-47.0	1.7	12.2
Korea, Rep., and Taiwan, China	-4.3	0.7	12.0	8.9	0.8	15.4	17.5	0.8	103.8
Hong Kong (China) and Singapore	9.8	0.7	0.7	75.4	0.7	0.7	-4.3	0.7	0.7
Argentina	6.0	4.2	4.2	9.0	4.2	4.2	17.9	4.2	4.2
Brazil	10.1	3.1	3.1	21.9	3.1	3.1	9.8	3.1	3.1
China	-2.7	3.2	3.2	-17.5	3.2	3.2	5.8	3.2	3.2
India	0.0	0.1	0.1	0.8	0.1	0.1	1.2	0.1	0.1
Indonesia	0.7	-0.2	-0.2	1.0	-0.2	-0.2	-0.9	-0.2	-0.2
Mexico	4.3	-0.1	3.7	2.3	-0.1	4.4	-7.5	-0.1	9.1
SACU	19.5	-0.6	-0.6	39.4	-0.6	-0.6	25.4	-0.6	-0.6
Turkey	0.2	-0.4	-0.2	-15.8	-0.4	0.5	-15.1	-0.4	-0.4
Vietnam	2.4	1.8	1.8	28.7	1.8	1.8	-13.3	1.8	1.8
Rest of East Asia	20.9	0.2	0.2	36.5	0.2	0.2	-8.6	0.2	0.2
Rest of South Asia	0.1	1.3	1.3	2.3	1.3	1.3	0.7	1.2	1.2
EU accession countries	-0.2	0.5	21.6	7.7	0.5	18.9	-6.3	0.5	67.6
Rest of Europe and Central Asia	-2.5	1.6	7.7	-1.9	1.6	8.3	-5.8	1.6	9.3
Rest of sub-Saharan Africa	0.5	-1.1	-1.1	5.6	-1.1	-1.1	4.0	-1.1	-1.1
Rest of Latin America	6.2	1.8	1.8	15.9	1.8	1.8	41.1	1.8	1.8
Rest of the World including Middle East and North Africa	0.3	-0.2	-0.2	2.9	-0.2	-0.2	-3.7	-0.2	-0.2

Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

TABLE 9. Impact of global agriculture and food reform on agricultural land: Change from 2015 baseline (percent)

	Total Agriculture			Cereals and Sugar			Livestock and Dairy		
	Land	Price		Land	Price		Land	Price	
		Owner	Farmer		Owner	Farmer		Owner	Farmer
Canada	-6.4	69.5	133.8	6.6	76.9	192.8	-25.2	56.8	83.5
United States	2.4	-5.1	22.1	-19.0	-12.5	42.1	12.3	-0.2	9.1
European Union with EFTA	-9.4	-66.3	-57.0	-58.9	-74.1	-4.7	-3.5	-65.0	-59.7
Australia and New Zealand	6.2	197.8	219.1	1.9	197.0	224.0	34.8	219.6	252.4
Japan	-21.0	-44.9	-41.5	-24.0	-45.5	-34.6	-34.1	-48.9	-48.9
Korea, Rep., and Taiwan, China	-11.4	-27.6	-27.1	-0.2	-25.3	-24.6	4.1	-23.0	-20.9
Hong Kong (China) and Singapore	11.1	64.2	64.2	-22.0	45.0	45.0	-2.3	58.0	58.0
Argentina	4.5	56.2	56.2	11.4	59.5	59.5	12.0	60.0	60.0
Brazil	9.9	18.0	18.0	23.8	22.9	22.9	8.6	17.6	17.6
China	-0.9	-25.7	-25.7	-21.1	-31.1	-31.1	7.6	-23.6	-23.6
India	0.0	-1.8	-1.8	0.8	-1.5	-1.5	1.4	-1.3	-1.3
Indonesia	0.7	10.9	10.9	2.1	11.4	11.4	-1.8	10.0	10.0
Mexico	2.7	0.6	13.1	-8.9	-3.6	52.1	-1.6	-0.6	0.8
Southern African Customs Union	8.0	86.4	86.4	26.4	95.2	95.2	4.5	84.9	84.9
Turkey	0.8	47.3	47.3	-14.9	39.0	39.0	-20.2	36.1	36.1
Vietnam	-0.3	44.6	44.6	33.2	60.3	60.3	-16.0	38.1	38.1
Rest of East Asia	-1.5	34.1	34.1	43.7	53.8	53.8	-9.6	32.7	32.7
Rest of South Asia	-0.1	-6.0	-6.0	3.2	-5.0	-5.0	1.3	-5.4	-5.4
EU accession countries	2.6	2.0	6.1	4.6	2.8	10.8	7.5	3.5	8.8
Rest of Europe and Central Asia	-1.5	-2.4	-2.4	-1.1	-2.3	-2.3	-1.2	-2.2	-2.2
Rest of sub-Saharan Africa	-0.3	62.8	62.8	9.0	67.9	67.9	-2.4	61.7	61.7
Rest of Latin America	1.0	55.4	55.4	5.0	58.6	58.6	40.3	74.9	74.9
Rest of the World including Middle East and North Africa	0.0	0.1	0.1	2.7	0.8	0.8	-4.3	-1.2	-1.2

Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

direct subsidy does not allow farmers to reap the full cost gains from falling land prices. The average cost for farmers drops 57 percent, lower than the drop in the rental price of land (66 percent). And the change in the cost structure is highly sector specific. Thus, cereal and grain farmers see a small drop in their net cost of land (5 percent); however, the drop in the price of land does not compensate for removal of the subsidies since the returns to owners fall by 74 percent. This is not the case in the livestock sector, where subsidy payments are linked to capital (the herds) and not to land. The impacts in the United States are muted, with the overall return to landowners changing slightly—a decline of 5 percent—but costs to farmers increasing substantially—22 percent on average and more than 42 percent for cereal and sugar producers.

In most developing countries, land prices increase substantially, except in China and in a few other regions. This may reduce to some extent the positive distributional impacts from relatively higher wages for unskilled labor since land ownership may not necessarily be congruent with the unskilled labor working the land. There are some interesting sectoral shifts. For example, China would see more land devoted to livestock and dairy, and less to cereals, which would be imported from lower-cost sources.

Sensitivity Analysis

This section uses sensitivity analysis to explore how results change when some of the basic assumptions of the model change. It focuses on four areas:

- The agricultural productivity assumptions of the standard baseline scenario. Agricultural productivity is cut by 1 percentage point in developing countries and the results from global agriculture and food reform are compared with the results using the default productivity assumptions. In a separate analysis, productivity is increased for middle-income developing countries.
- The impacts of the mobility of agricultural capital. Agricultural capital is more closely tied to the sector, making it more difficult to shed and leading to a different transition when reform is undertaken.
- Sensitivity of the results to supply rigidities in developing countries.
- Sensitivity of the results to the key trade elasticities.

Agricultural Productivity

Agricultural productivity is assumed to grow 2.5 percent a year globally in the standard baseline scenario based on existing evidence (Martin and Mitra 1996, 1999). This may be too optimistic for developing countries, particularly for low-income countries. This assumption may have an impact on long-term self-sufficiency rates, particularly of sensitive commodities. The more that trade reform raises the world price of food, the more net food importers will be adversely affected by negative terms-of-trade shocks. To test the sensitivity of the trade results to agricultural productivity, a different baseline was construed with agricultural productivity improving at a slower 1.5 percent for developing countries but remaining at 2.5 percent for industrial countries.

Trade Impact. Under the standard baseline, high-income countries go from a position of net food importers in 1997 to net food exporters in 2015 (Table 10). Low-income countries improve their position significantly, going from a positive food balance of \$12.5 billion in 1997 to \$23 billion in 2015. The position of middle-income countries deteriorates, however. Under the low-productivity baseline, the net food trade position of industrial countries increases substantially—jumping to \$151 billion in 2015 compared with only \$50 billion in the standard baseline. Low-income countries still maintain a positive balance but one that is much closer to zero than in the previous baseline. And the net food trade situation of middle-income countries shows a greater dependence on world markets.

Whereas reform in the standard baseline positions low-income countries as net food exporters and has only a mild negative effect on the food balance of high- and middle-income countries, under the low-productivity assumption the food trade balance of the high-income countries improves substantially—by \$30 billion—largely because of an increased dependence on food imports by middle-income countries. The low-income countries still see an improvement in their trade balance but by a more modest \$3.6 billion rather than the nearly \$12 billion using the standard productivity assumptions.

Output Impact. Average annual agricultural output growth in developing countries slows from 3.3 percent in the standard baseline to 2.6 percent in the low-productivity baseline (Table 11). In industrial countries, higher productivity provides an opportunity

TABLE 10. Net trade impacts assuming lower agricultural productivity in developing countries (billion 1997 US\$)

	Standard Productivity		Low Productivity		
	1997	Baseline 2015	Reform 2015	Baseline 2015	Reform 2015
High-income countries	-23.1	50.4	48.4	151.2	181.6
Low-income countries	12.5	23.4	35.2	0.9	4.5
Middle-income countries	10.5	-73.8	-83.6	-152.0	-186.1
Low-income countries, excluding India	7.4	22.2	34.1	8.5	17.2
Middle-income countries, including India	15.6	-72.7	-82.4	-159.7	-198.9
Developing countries	23.1	-50.4	-48.4	-151.2	-181.6

Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

TABLE 11. Impacts on output assuming lower agricultural productivity for developing countries

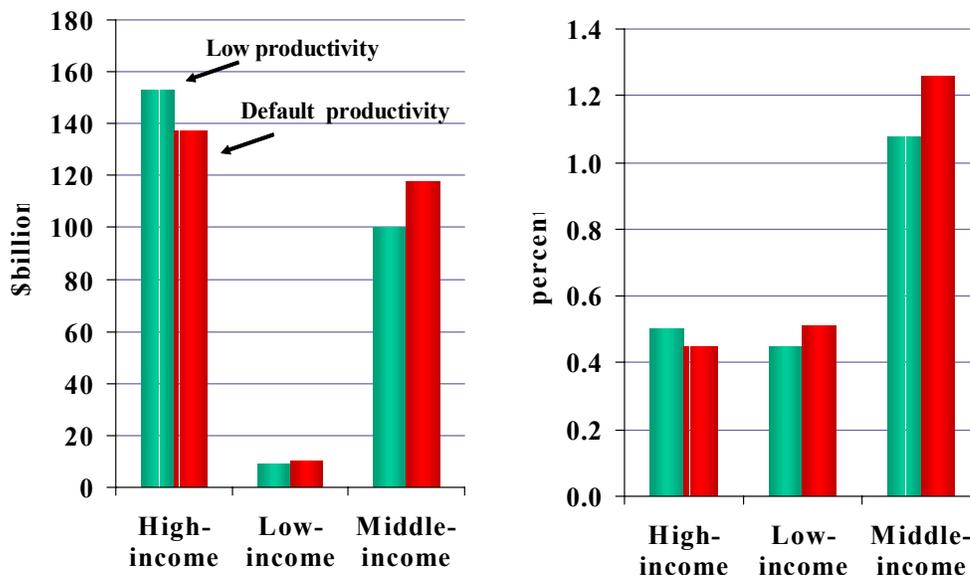
	Growth in 2000–15 (percent)		Baseline Difference in 2015		Difference Between Baseline and Reform Scenario in 2015			
	Low Baseline	Standard Baseline	Value (billion \$)	Percentage Change	Low (billion \$)	Standard (billion \$)	Low (percent)	Standard (percent)
High-income countries	1.9	1.2	122.6	12.4	-100.0	-107.7	-9.0	-10.9
Low-income countries	2.8	3.6	-71.6	-11.4	8.7	12.1	1.6	1.9
Middle-income countries	2.6	3.2	-166.2	-9.4	27.0	37.2	1.7	2.1
Low-income countries, excluding India	3.0	3.7	-39.4	-11.6	10.3	12.3	3.4	3.6
Middle-income countries, including India	2.6	3.2	-198.4	-9.7	25.4	37.0	1.4	1.8
Developing countries	2.6	3.3	-237.8	-10.0	35.7	49.4	1.7	2.1
World total	2.4	2.6	-115.2	-3.4	-64.3	-58.3	-2.0	-1.7

Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

to gain market share, and higher world prices relative to the original baseline provide greater incentives to produce. World output under the alternative scenario declines 3.4 percent (higher prices lead to reduced demand), with a reallocation between industrial and developing countries. Industrial countries benefit from a 12 percent increase in output in 2015 compared with the standard baseline, whereas developing-country output is reduced by some 10 percent.

With respect to output impacts following the trade reform scenario, the qualitative results of the different baseline assumptions of agricultural productivity are identical—trade reform of agriculture and food lead to a shift in agricultural production from industrial to developing countries. In the standard baseline, developing-country agricultural output increases more than 2 percent, whereas in the low-productivity baseline the increase is only 1.7 percent. The decline in industrial countries drops to 9 percent, from 11 percent in the standard baseline. The changes in output patterns across regions are identical, though the magnitudes differ.

Aggregate Welfare. The change in the agricultural productivity assumption translates into modest changes in aggregate welfare (Figure 4). Industrial countries see an improvement of \$18 billion in 2015, a jump in gains of about 0.05 percentage point.



Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

Figure 4. Welfare impacts of productivity changes

Developing countries see a reduction in their welfare gains, with low-income countries seeing a drop of \$1.4 billion (0.08 percentage point) and middle-income countries a drop of \$17.8 billion (0.19 percentage point).

A High Productivity Assumption. Many middle-income countries such as Argentina, Brazil, and Thailand have experienced rapid growth in agriculture, suggesting the potential for higher productivity growth than assumed in the standard baseline. To explore this, agricultural productivity growth was raised from 2.5 percent to 4.0 percent for middle-income countries (China, India, Indonesia, rest of East Asia, Vietnam, Argentina, Brazil, Mexico, rest of Latin America, the EU accession countries, rest of Europe and Central Asia, and Turkey).

Changes are as expected. Agricultural supply and exports expand for natural exporters such as Argentina and Brazil. China, the largest middle-income importer, reduces its deficit by about \$18 billion (Table 12). The middle-income group, including India, experiences a net surplus of \$30 billion in 2015, whereas under the standard baseline it has a deficit of \$19 billion. High-income countries experience a deterioration of their net agricultural trade of about \$50 billion, compared with \$3 billion in the standard baseline, and Europe's deficit increases to nearly \$60 billion. Results for the food sector are qualitatively similar but smaller in size, with an increase in competitiveness of food processing in middle-income countries and a decrease in net trade by high-income countries relative to the standard baseline (Table 13). These large changes show how sensitive baseline trajectories are to changes in assumptions about the future. They do not, however, affect the impact of the reform scenario measured in deviations from the baseline.

In conclusion, the baseline assumptions regarding productivity are important, though changes in the assumption would not yield substantially different results from agriculture and food trade reform for developing countries in terms of net benefits and agricultural output.¹⁷ However, lower productivity would reduce the level of food self-sufficiency among developing countries—particularly middle-income countries—and could lead to a different assessment of the direction of food self-sufficiency in the aftermath of reform.

TABLE 12. Baseline trends in agriculture with higher agricultural productivity in middle-income countries

	Average Annual Growth 2000-15 (percent)				Net Trade (billions of 1997 US\$)	
	Output	Demand	Imports	Exports	2000	2015
	High-income countries	0.6	1.0	2.7	0.9	-24.3
Low-income countries	3.9	3.8	4.0	6.2	9.9	25.2
Middle-income countries	3.7	3.6	7.5	7.2	14.4	24.9
Low-income countries, excluding India	3.8	3.5	4.0	6.2	7.2	19.1
Middle-income countries, including India	3.7	3.7	7.4	7.1	17.1	31.1
Developing countries	3.7	3.7	7.0	7.0	24.3	50.2

Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

Note: Net trade is measured at FOB prices (imports exclude international trade and transport margins).

TABLE 13. Baseline trends in food processing with higher agricultural productivity in middle-income countries

	Average Annual Growth 2000-15 (percent)				Net Trade (billions of 1997 US\$)	
	Output	Demand	Imports	Exports	2000	2015
	High-income countries	1.1	1.0	1.4	2.0	7.7
Low-income countries	3.5	3.5	3.6	3.2	3.6	4.4
Middle-income countries	3.1	3.3	4.1	2.6	-11.3	-40.6
Low-income countries, excluding India	3.2	3.3	3.7	2.2	1.8	-0.1
Middle-income countries, including India	3.1	3.3	4.1	2.8	-9.5	-36.2
Developing countries	3.2	3.3	4.1	2.7	-7.7	-36.2

Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

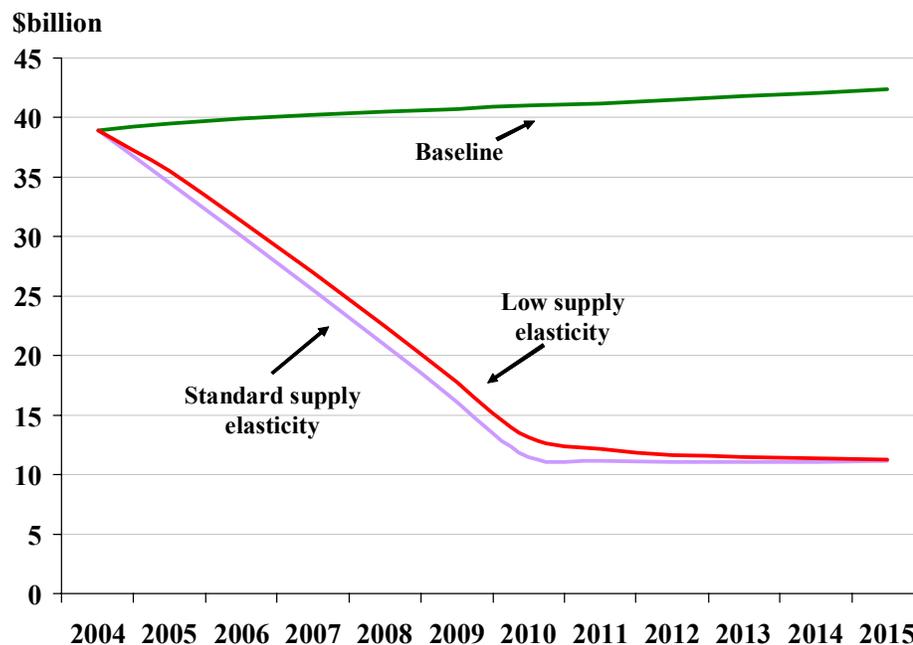
Note: Net trade is measured at FOB prices (imports exclude international trade and transport margins).

Mobility of Agricultural Capital and the Transition in Industrial Countries

The focus so far has been mainly on the long-term impact of the removal of protection, with little attention to the transitional impacts. A key mechanism of the model is the vintage structure of capital. Sectors in decline have excess capital that will not readily be used in other sectors. This is certainly the case with agricultural capital, although some could be used for nonagricultural purposes and other equipment could be used in nonprotected agricultural sectors.

Excess capital is released to other sectors following an upward-sloping supply curve. The value for the supply elasticity in the standard model is 4. To test the importance of this elasticity, the reform scenario is simulated again but with a supply elasticity of 0.5. This makes excess supply much less mobile and, all else equal, will tend to increase supply relative to the same simulation with a higher supply elasticity.

Consider the case for the sugar sector in Europe. The starting point is 2004, since the trade reform starts in 2005. Under the baseline, sugar output in Europe increases modestly between 2004 and 2015 (Figure 5). With the start of reform, output drops rapidly,



Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

FIGURE 5. Sugar output in Europe (billion US\$)

and by 2015 output has fallen from about \$42 billion to about \$11 billion. The supply elasticity has an impact on the rate of decline of sugar output, but the final level is identical. Thus, with a low supply elasticity, the transition is drawn out over a longer period. The rate of decline between 2004 and 2010 is 18.4 percent using the standard elasticity and 16.5 percent with the lower elasticity.

There are only a handful of sectors in industrial countries in which the supply elasticity has any noticeable impact: wheat and sugar in the United States; rice, wheat, other grains, oil seeds, and sugar in the European Union; and wheat and oil seeds in Japan. The aggregate impacts on agricultural production are negligible, at less than 1 percent over all industrial countries in any given year, and at most 0.3 percent for developing countries, but in the opposite direction. There are no discernible impacts on welfare.

In conclusion, lowering the supply elasticity will draw out the supply response during the transition phase but will have no discernible long-term impact on the results.

Supply Response in the Low-Income Countries

This section evaluates the impact of lowering the land supply response in three regions—the rest of South Asia, the SACU region, and the rest of sub-Saharan Africa—to examine whether low-income countries, with their potentially low supply response, will benefit from greater market access. This involves three parameters. First, the base-year land supply elasticity was reduced from 1 to 0.25. Second, the land supply asymptote was reduced from 20 percent of the initial land supply to 10 percent.¹⁸ These two parameters determine aggregate land supply. A third parameter moderates the degree of land mobility across sectors. The allocation of land across sectors is governed by a constant elasticity of transformation function.¹⁹ The standard transformation elasticity is 3, a relatively elastic value. In the sensitivity simulation, the transformation elasticity for the three regions is set to 0.5.

The lower land supply elasticities affect the baseline scenario. For the three regions where changes were made to supply elasticities, the overall rate of growth of agricultural output between 2000 and 2015 declines from 3.4 to 3.1 percent in the rest of South Asia and from 4.0 to 3.8 percent in rest of sub-Saharan Africa; it remains the same for SACU at 2.1 percent (Table 14). In all three regions, the most affected crop is plant-based fibers. These three regions have a sizable market share at the global level in 1997 of 1.4 percent

TABLE 14. Impact of lower land supply elasticities in rest of South Asia and sub-Saharan Africa (percent)

	Baseline Growth Rates 2000–15			Impact of Trade Reform	
	Standard Supply Elasticity	Low Supply Elasticity	Baseline Difference in 2015	Standard Supply Elasticity	Low Supply Elasticity
<i>Rest of South Asia</i>					
Rice	2.8	2.7	-2.1	3.4	2.4
Wheat	2.7	2.6	-3.8	34.4	19.6
Other grains	3.8	3.6	-3.6	-2.4	-1.5
Oil seeds	4.1	3.5	-9.1	-10.0	-6.8
Sugar	3.8	3.3	-8.9	-17.2	-12.4
Plant-based fibers	4.5	3.7	-13.2	19.2	6.2
Other crops	3.6	3.2	-7.3	-8.0	-5.4
Cattle	4.0	3.7	-4.9	1.7	1.5
Other meats	4.1	3.6	-8.3	-1.0	-1.8
Raw milk	3.9	3.5	-6.1	1.3	1.3
Total	3.4	3.1	-5.6	-0.2	-0.6
<i>Southern Africa Customs Union</i>					
Rice	2.3	2.4	-1.7	8.8	8.4
Wheat	1.9	1.9	-0.5	0.0	0.5
Other grains	1.1	1.3	0.8	29.5	19.9
Oil seeds	1.6	1.8	-1.8	9.2	8.6
Sugar	1.3	1.4	-0.2	87.7	50.6
Plant-based fibers	6.0	3.8	-35.9	3.4	3.6
Other crops	2.4	2.4	-8.7	7.2	4.3
Cattle	2.2	2.2	0.0	24.2	23.0
Other meats	2.2	2.2	0.1	5.0	5.1
Raw milk	2.2	2.2	0.0	-2.7	-2.6
Total	2.1	2.1	-2.9	18.4	14.0
<i>Rest of sub-Saharan Africa</i>					
Rice	3.2	3.2	-0.1	-1.2	-0.9
Wheat	3.4	3.5	0.4	0.3	3.0
Other grains	3.2	3.2	0.4	-0.1	3.0
Oil seeds	3.9	3.8	-0.8	51.0	37.7
Sugar	3.2	3.2	1.5	48.1	40.3
Plant-based fibers	8.1	6.5	-23.2	42.8	24.9
Other crops	4.5	4.2	-5.8	-3.6	0.0
Cattle	3.5	3.4	-1.4	4.6	3.5
Other meats	3.7	3.6	-1.9	-0.7	0.3
Raw milk	3.3	3.3	-1.1	1.7	1.2
Total	4.0	3.8	-4.1	5.6	4.9

Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data

for plant-based fibers and 15 percent for rice. However, the demand for rice is much less elastic than for plant-based fibers. The lower supply elasticity would make land relatively more costly, all else equal, and given the higher demand elasticities, the higher land prices will be reflected in lower demand from these three regions.

The impact of trade reform on agricultural output using both the standard and the lower land elasticities is broadly the same qualitatively though lower in magnitude in general. Considering again the case of sugar, output increases 88 percent in SACU and 48 percent in the rest of sub-Saharan Africa using the standard supply elasticity. Sugar output expansion drops to 51 percent in SACU and 40 percent in the rest of sub-Saharan Africa when lower land supply elasticity is assumed.

The welfare impacts are modest but measurable, and the results reflect only some of the possible supply constraints in low-income countries. For the three regions under question, aggregate welfare would decline \$1.1 billion compared with the standard assumption, and it would drop from 1.2 percent to 1.1 percent of baseline income.

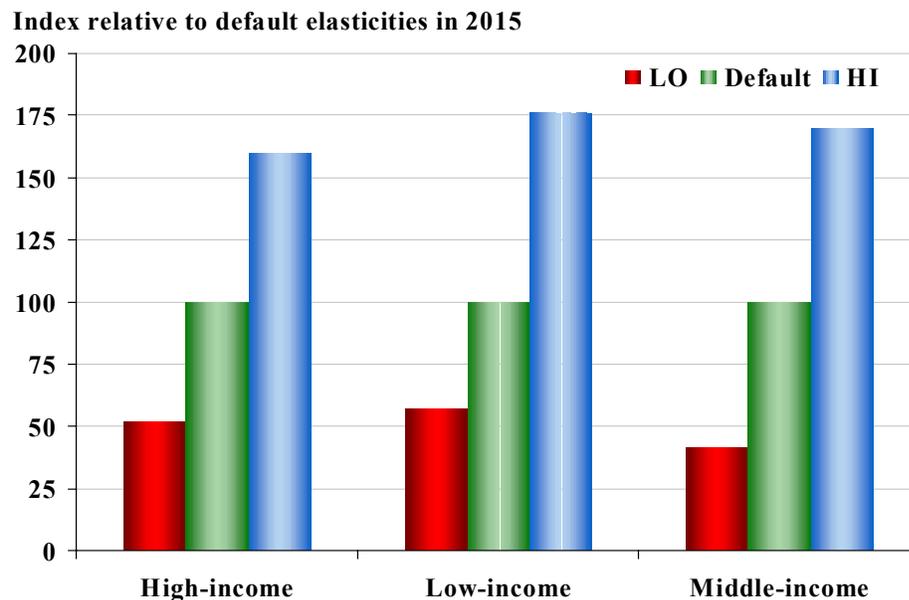
Trade Elasticities

The most critical parameter in trade reform scenarios is trade elasticities. There is ongoing debate about their size. Most econometric evidence suggests that the Armington elasticities (measuring the degree of substitutability between domestic and imported goods) are low, in the range of 1 to 2.²⁰ The studies are riddled with data problems, particularly the evaluation of unit values, and many trade economists downplay the empirical evidence, for two main reasons. First, low Armington elasticities lead to implausible terms-of-trade effects. And second, low elasticities would suggest high optimal tariffs. Trade studies fall into three groups: those with relatively low elasticities (1–3), those with middling elasticities (3–6), and those with very high elasticities (20–40). Examples of the first are the MONASH model (Dixon and Rimmer 2002) and the standard GTAP model (Hertel 1996). Recent World Bank work has been using the middling elasticities. High elasticities are mainly associated with the work of Harrison, Rutherford, and Tarr (see, for example, their 2003 article).

The impacts of the agriculture and food trade reform were reassessed using two alternative elasticities. A low scenario uses trade elasticities 50 percent lower than the standard, and a high scenario uses trade elasticities 50 percent higher than the standard

(the standard values used in this study are shown in Annex Table A.3, available from the authors). Each set of assumptions requires two simulation runs. A new baseline is constructed each time, with all assumptions identical except for the trade elasticities, and the reform scenario is simulated. Thus, the comparisons are between each individual baseline and each associated reform scenario.

Within this range of trade elasticities the model exhibits some modest nonlinearity, particularly on the upside (Figure 6). For all three regions the 50 percent higher elasticities lead to a greater than 50 percent rise in real income gains—particularly for developing regions, where the rise is almost 75 percent. On the downside, both high- and low-income regions see an equiproportionate fall in the real income gains relative to the elasticities, with a fall to 40 percent of the standard gains in the case of the middle-income countries. The higher elasticities dampen the adverse terms-of-trade shocks from reforms, leading to the higher income gains. The global gains vary from a low of \$126 billion to a high of \$438 billion, with the gains at \$265 billion using the standard elasticities.

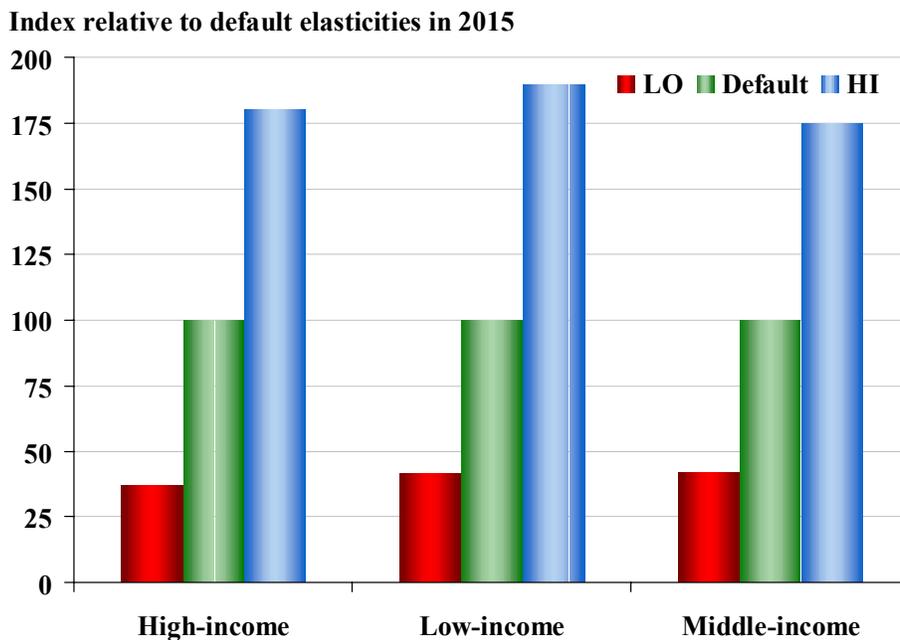


Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

FIGURE 6. Real income and trade elasticities

For some countries and regions the range of results is much broader than at the aggregate level. For example, Mexico would lose some \$1.2 billion with the low elasticities and gain \$3 billion with the high elasticities compared with a gain of 0.9 with the standard elasticities. Several other regions show similar variation. The standard deviation of the index across all developing countries is 130 in the case of the high elasticities, whereas the weighted average is 170.

The impacts on trade are similar to the impacts on income but exhibit more nonlinearity (Figure 7). At the global level, exports increase 80 percent using the high elasticities and decline 60 percent using the low elasticities (with export increases ranging from a low of \$216 billion to nearly \$1 trillion). There is also less variability across regions of the model than with the income results. In isolation, the trade elasticities appear to have the greatest impact in determining the overall outcomes of trade reform, although other model changes—both in specification and in elasticities—combined may be at least as important in determining overall outcomes. This is an area of active research for better determining the bounds on the possible ranges for these elasticities. Improved data



Source: World Bank simulations with LINKAGE model, based on release 5.4 of the GTAP data.

FIGURE 7. Exports and trade elasticities

would help, but there are still issues relating to model specification and aggregation that need to be thought through.

Conclusions

This quantitative assessment of the impact of agricultural and food market distortions on incomes, welfare, trade, and output shows that the changes in cross-regional patterns of output and trade tend to be much larger than are the more familiar gains to real income. A decomposition of the aggregate results across policy instruments and regions shows that reforms in agriculture and food account for a large share of the global gains of reforms of total merchandise trade. This result is driven by the relatively low protection levels in manufacturing sectors. Another major finding is that developing countries have more to gain from reforming their own support policies than from reforms in high-income countries. Symmetrically, high-income countries would experience larger welfare gains from their own reforms than from developing countries' reforms. These dimensions of the debate are often overlooked but are crucial. Global reform leads to additive results with aggregate gains close to the gains from reforms in each group. A third key finding is that agricultural reform alone in high-income countries would create moderate gains, about 10 times smaller than those of a combined reform of food and agricultural markets. Developing countries would be negatively affected as a group, because their own distortions would be exacerbated by the agricultural reforms in high-income countries.

The results are broadly robust to changing assumptions on future agricultural productivity in developing countries, supply constraints, and level of the trade elasticities, but the levels of the trade elasticities remain of foremost importance. The trade effects of reforms are also sensitive to assumptions about agricultural productivity gains in developing countries. Assuming low-productivity gains leads to a reversal in the estimated impact of global liberalization for industrial countries, increasing their net food trade surplus, as middle-income countries become much larger importers of food and agricultural products. Low-income countries experience an increase in net food trade surplus that is much smaller than under the higher productivity assumption. Hence, variations in productivity could lead to a different assessment of the direction of food self-sufficiency after reform. Supply constraints do not qualitatively affect the estimated im-

pact of trade reform on agricultural output, although estimated changes tend to be smaller. Higher trade elasticities dampen the adverse terms-of-trade shocks from reforms, leading to higher income gains. The global gains vary from a low of \$126 billion with low elasticities to a high of \$438 billion with high elasticities, with the gains at \$265 billion using the standard elasticities. There is also higher variation at the individual country level.

The changes in agricultural value added and factor prices are considerable in several cases. The estimated loss of rural value-added is large in Japan and the European Union, the Republic of Korea, Taiwan (China), and China. Thus, considerable adjustment and displacement of resources would take place to reflect these changes. Cairns Group countries and the United States experience sizable gains in rural value-added, as do SACU and the rest of sub-Saharan Africa. Wages for unskilled labor in developing countries are moderately influenced by major policy reforms, such as in China, where they decrease, but more significantly in Argentina, where they increase.

Endnotes

1. The model is based at the World Bank and uses the GTAP release 5.4 dataset (see van der Mensbrugghe 2003 for details).
2. East Asia is divided into four economies: China, Indonesia, Vietnam and the rest. South Asia has two components: India and the rest. Latin America has four economies: Argentina, Brazil, Mexico, and the rest. Europe and Central Asia are split into three components: the European Union accession countries, Turkey, and the rest. Sub-Saharan Africa has two components: the Southern Africa Customs Union (SACU) countries, and the rest. And the Rest of the World region has all other countries including the Middle East and North Africa.
3. See van der Mensbrugghe 2003 for a technical description of the model.
4. Agricultural policies derived from the Agricultural Market Access Database (AMAD) reflect 1998/99 levels of support, except for cotton, for which International Cotton Advisory Committee data were used (see Baffes 2004).
5. Income elasticities are held more or less constant over the time horizon. With China's rapid growth, one might anticipate a convergence of income elasticities toward levels in higher-income countries and thus a dampening of food growth over time relative to incomes.
6. Textile and apparel quotas that generate quota rents for exporters are converted to export taxes (for the country of origin). In the current simulations, these have not been eliminated.
7. Technically, it is a measure of the Hicksian equivalent variation. When comparing aggregate welfare measures across studies, it is important to convert them to similar scales. Thus, \$350 billion in 2015 is more or less equivalent to \$250 billion in 2004 and \$200 billion in 1997, assuming an average annual global GDP growth rate of 3 percent (all in 1997 US\$, the base year of release 5 of the GTAP data set). Assuming a world inflation rate of 2.5 percent over the entire period, the measured \$250 billion in 2004 in 1997 dollars becomes \$300 billion in 2004 dollars.
8. The Mercosur preferential agreement is not incorporated in the standard GTAP dataset but is included in the dataset used for these simulations. Efforts were made to minimize distortions to the original social accounting matrix while adjusting the original dataset.

9. There is also an issue regarding whether bound or applied tariffs are liberalized. Most developing countries have bound their tariffs at rates much higher than applied rates. Negotiations concern the bound tariffs; the reforms described here are relative to the applied tariffs. For a full reform scenario, it is not much of an issue, but for analyzing potential outcomes of a negotiation, it could be.
10. See the *Global Economic Prospects* publications for 2002 and 2004 (World Bank 2001, 2003). The 2002 report notes *dynamic* gains of \$830 billion compared with *static* gains of \$350 billion, with a range of up to \$1,340 billion depending on some key parameters (see Table 6.2, page 171).
11. Figure 1 shows output shares in the base year. One would assume that the agricultural and food shares are declining over time, as income elasticities for food tend to be lower than for other goods and services.
12. While the model is highly nonlinear, the results to a close approximation are relatively additive.
13. Nominal values are measured with respect to the model's *numéraire*—the average export price of manufactured exports from industrial countries.
14. This should be considered an upper bound on China's potential loss since the baseline scenario does not include the impacts of China's accession to the WTO. Thus, the reform scenario is capturing the combined gains from global reform and China's WTO accession, which include the gains to be had from reforming from 1998/99 base agricultural policies.
15. Sector-specific capital returns may be possible during the transition phase, as sectors in decline shed unwanted capital. The most mobile equipment will be shed first, and the return to the remaining capital may be priced lower than the national rate of return to capital.
16. In the default version of the model, cross-sectoral transformation elasticities are set to 3. Thus a 10 percent rise in the return in one sector (relative to the others) will lead to a 30 percent shift of land into that sector. Because of the finite transformation elasticity, land prices are sector specific.
17. Given the aggregate nature of the model, the impacts on vulnerable countries or sectors are harder to assess. In particular, sub-Saharan Africa is a heterogeneous subcontinent that is not reflected in the level of aggregation of this study.
18. The land supply function is governed by a logistic curve. It is calibrated in the base year to an exogenously given elasticity and the value of the asymptote relative to the base supply level. Thus, if the asymptote is set to 1.2, land supply can increase by at most 20 percent above its base level.
19. The elasticity measures the ease of shifting land from one activity to another when the relative price of these two activities changes.

20. More recent econometric work is resulting in higher estimates for the trade elasticities and these are now being reflected in the forthcoming release of the GTAP dataset.

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