# Climate Change and Food Security to 2050:

# A Global Economy-wide Perspective

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**Abstract**

Recent analyses of the possible adverse effects of climate change on agriculture in developing countries have raised food security concerns, especially for farm households whose crop productivity is expected to fall. The present study uses the GTAP global economy-wide model to capture at the same time the expected positive effects on temperate zone crop productivity, which will more or less offset the upward pressure on farm product prices from yield falls in developing countries. Also modelled is an expected adverse effect of higher temperatures and humidity on the productivity of unskilled workers in the tropics, but since they work in nonfarm as well as farm activities the net effect of that shock on agriculture's competitiveness is an empirical matter. The results suggest there may be less cause for concern over food security than some earlier studies indicated, but the degrees of uncertainty involved in such modelling are sufficient to warrant a precautionary approach.

**Keywords:** Climate change, crop and labour productivity growth, global computable general equilibrium model projections

**JEL codes:** D58, F17, Q17, Q24, Q54

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# Climate Change and Food Security to 2050: A Global Economy-wide Perspective

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Following the upward spike in international prices of many primary commodities in 2008, and in light of on-going climate changes, policy makers and the general public have once again become concerned about global food security. While prices in international markets for food and energy raw materials have come down from their mid-2008 peak, they rose again for grains in mid-2010 and they remain high by historical standards. More than that, the trend in food prices has been noticeably upward over the past decade, in contrast to its trend over the 20th century; and, since the introduction of biofuel subsidies and mandates in the US and EU a few years ago, food prices seem to be closely tracking fossil fuel prices – again in contrast to the second half of the 20th century (Figure 1).

Affluent people in high-income countries can cope with higher prices of farm products, but the poorest households of those countries, and a far higher proportion of non-farm households in developing countries, suffer when food prices are high. Even some farm households can be worse off, for example those who produce predominantly cash crops whose prices have not risen with those for staple food crops. Food crises can erupt into urban riots, as happened in numerous food-deficit developing countries in 2008, and can even bring down governments. When followed by natural disasters (as with the earthquake in Haiti in 2010), the outcome can be catastrophic.

Climate change is expected to have a non-trivial influence on food security for several decades even if global mitigation strategies were to be introduced immediately. It is showing up not only in warmer temperatures but also in more-frequent extreme weather events and in altered precipitation patterns and thus water availability. The associated crop productivity changes may be beneficial in cooler temperate regions in the higher latitudes, but it is widely expected to reduce farm land and labour productivity in the tropics – and globally, notwithstanding some expected improvements in high latitudes (see, e.g., Cline 2007, Mendelsohn 2009, Nelson et al. 2009).

What would be the market and economic welfare effects of these expected changes in productivity of global agricultural resources? If they were progressively to lower world food output, the international food price trend would move onto a higher trajectory, depending on how each country and commodity market responded to climate change. Thus it is not necessarily the case that most farm families in developing countries are going to be losers economically from climate change: it is always possible that the change in the price of their output more than compensates for any fall in their farm productivity.

This paper seeks to provide a sense of how climate change might impact on the world's markets for farm products if there is no mitigation or adaptation other than in response to price changes. We make use of the global GTAP model (Hertel 1997) to first provide projections of the world economy to 2030 and 2050 without any climate or policy changes, and then to compare those baseline numbers with projections which incorporate assumed impacts of climate change over the next four decades on farm productivity (based on damage function analyses reported in recent studies). Only the two most direct biophysical changes are modelled. The first is in crop land productivity, drawing on the interpretation of damage functions by Hertel, Burke and Lobell (2010). The second relates to the impact of higher temperatures and humidity on the productivity of unskilled labour in the already hot and humid tropics, drawing on the interpretation of its debilitating effects by van der Mensbrugghe and Rosen (2010). The paper concludes by mentioning some caveats and areas for further empirical analysis.

National and global economic welfare effects also are estimated in the GTAP model. Their magnitudes are shown to be very small, suggesting that there must be other costs of climate change not examined here to warrant the sorts of major policy responses being called for (such as carbon emission taxes and border tax adjustments). However, it needs to be kept in mind from the outset that we are imposing only a small subset of the shocks expected to come from climate change, and we are using a comparative static model that – unlike a dynamic stochastic model – cannot capture the sporadic additional costs to farmers and others of more-frequent extreme weather events, such as floods, droughts, frosts, hail and wind.

**Projecting a baseline to 2030 and 2050 with the GTAP model**

The standard GTAP model (Hertel 1997) is perhaps the most widely used CGE model for economy-wide global market analysis, in part due to its robust and explicit assumptions. In its simplest form, the model assumes perfect competition and constant returns to scale in production. The functional forms are nested constant elasticities of substitution (CES) production functions. Land and other natural resources, labour (skilled and unskilled), and produced physical capital substitute for one another in a value added aggregate, and composite intermediates substitute for value-added at the next CES level in fixed proportions. Land is specific to agriculture in the GTAP database, and is allowed to be highly mobile amongst alternative agricultural uses over this four-decade projection period. A Constant Elasticity of Transformation (CET) revenue function transforms land from one use to another. The closer the transformation elasticity is to zero, the more unresponsive is land supply to changing relative returns to land across agricultural uses. There is also a very low elasticity of transformation between alternative uses of natural resources. In the default GTAP closure, labour and capital are assumed to be mobile across all uses within a country but immobile internationally.

On the demand side there is a regional representative household whose expenditure is governed by Cobb-Douglas aggregate utility function which allocates net national expenditures across private, government, and saving activities. The greatest advantage of this regional household representation is the unambiguous indicator of economic welfare dictated by the regional utility function.[1] Government demand across composite goods is determined by a Cobb-Douglas assumption (fixed budget shares). Private household demand is represented by a Constant Difference of Elasticities (CDE) functional form, which has the virtue of capturing the non-homothetic nature of private household demands as well as permitting the user to calibrate the model to specific own-price elasticities of demand.

Bilateral international trade flows are handled through the Armington (1969) specification by which products are differentiated by country of origin. These Armington elasticities are the same across regions but are sector-specific, and the import-import elasticities have been estimated at the disaggregated GTAP commodity level (Hertel et al. 2007). For present purposes, where we are dealing with very long-term changes, we have doubled the usual short-to-medium term Armington elasticities for non-primary products and, for primary products, we have set them all at the level of the highest one (which was for natural gas, at nearly 70). The justification for the latter specification is that over such a long

[1] Altering taxes in the GTAP model does not imply a reduction in government revenue and expenditure, as government expenditures are not tied to tax revenues. A tax reduction, for example, leads to a reduction in excess burden, so regional real income increases and real expenditure – including government expenditure – may also rise.

period as four decades, primary products will be highly substitutable among different countries of origin.

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

The full GTAP 7.0 database comprises 113 regions in addition to the 57 sectors/product groups, but to make the model more manageable we have aggregated it to 23 sectors/product groups and 23 regions (see Appendix Tables A1 and A2). It is initially calibrated to the year 2004. The standard GTAP protection database (see Narayanan and Walmsley 2008) has been altered to include a more-complete set of estimates of distortions to agricultural prices in developing countries, based on Valenzuela and Anderson (2008).[2] Those distortion estimates suggest that, despite reforms of the past 25 years, there was still a considerable range of industry assistance rates across commodities and countries in 2004, including a strong anti-trade bias in national agricultural and trade policies for many developing countries. Furthermore, non-agricultural protectionism is still rife in some developing countries, and agricultural price supports in some high-income countries remain high.

To project the world economy to 2030 and 2050, we assume policies as of 2004 and the stock of agricultural land do not change in each region but that population, labour, capital and real GDP grow at the rates shown in Appendix Tables A3 and A4, from which the implied rates of total factor productivity and GDP per capita growth are derived as shown in the final two columns of each of those two tables. The exogenous growth rates are based on World Bank and OECD projections (see, e.g., Duval and de la Maisonneuve 2009). The rate of total factor productivity growth is assumed to be the same in each of the non-primary sectors, and to be somewhat higher in the primary sectors as detailed in the footnotes to Appendix Tables A3 and A4. Those higher rates are set so as to ensure the price of primary products in 2030 and 2050 (relative to the aggregate change for all products, shown in

[2] That distortions database is documented fully in Anderson and Valenzuela (2008) and is based on the methodology summarized in Anderson et al. (2008).

Appendix Table A5) are little different from those in 2004, and to be consistent with World Bank projections over the next four decades. Agricultural prices could have been made to fall by assuming faster productivity growth in the farm sector than in other sectors – as occurred in the past half century (Martin and Mitra 2001), and as projected in GTAP-based projection studies in the late 20th century (e.g., Anderson et al. 1997) – but that is considered less likely for the next four decades given the slowdown in agricultural R&D investment and its consequent slowing of farm productivity growth since 1990 (Alston, Babcock and Pardey 2010).

Given the differences across regions in those growth rates, and the fact that sectors differ in their relative factor intensities, the structures of production, consumption and trade across sectors within countries and also between countries is going to be different in 2030 and 2050 than in 2004. In particular, the developing countries (especially those of Asia) will become a considerably larger share of the projected global economy over the next four decades. In the baseline projection the developing countries' share of world GDP rises from 22 percent in 2004 to 26 percent in 2030 and 47 percent in 2050—with China's share alone growing from 4 to 17 percent (Appendix Table A6). The developing countries will also see the share of agriculture in their GDP decline, from 10 to 6 percent for that grouping as a whole (Appendix Table A7). As a consequence of these two changes, the developing countries' share of global agricultural GDP rises slightly, from 50 percent in 2004 to a projected 56 percent by 2050 (Appendix Table A8).

## Alternative scenarios for 2030 and 2050

Given the baseline projections summarized above, we then use the GTAP model to simulate the market and welfare effects first of the direct impact of climate change on crop yields in different parts of the world, and then also of the projected impacts of climate change on unskilled labour productivity in developing countries.

### *Crop productivity effects*

The direct impacts of climate change on crop productivity have been examined by many analysts, and there still remains considerable uncertainty as to even their sign let alone their magnitude. Nonetheless, for present purposes we adopt the same rates for the period from 2004 to 2030 as the medial rates used by Hertel, Burke and Lobell (2010),[3] with a few minor adjustments, such as for Australia so as to be more consistent with the 2008 Garnaut Review (see also Gunasekera et al. 2007). Those yield shocks are summarized in Table 1. Given that climate change is expected to accelerate after the first one-third of this decade, we then assume those impacts on crop yields in the first 26 years will be twice as large two decades later, in 2050.

Two points are worth noting about those shocks. First, those shock are generally positive for high-income temperate countries except for rice, coarse grains (i.e. maize) and cotton (and, in Australia's case, for fruits and vegetables whose yields are expected to suffer because of a shrinkage in water availability), while they are generally negative for developing countries (with China and the Middle East/North Africa region being the main exceptions). And second, those yield shocks are very small over a period as long as four decades, when compared with the annual productivity growth rates reported in Appendix Tables A3 and A4. More than that, farm land is projected to account throughout the next four decades for less than one-tenth of GDP in even the most agrarian of developing economies and to be below 1 percent in some high-income countries (Appendix Table A9). Hence the net economic effects of these direct crop yield impacts of climate change will necessarily be small in proportional terms – even though they may have large impacts on very seriously affected regions within some countries, such as the hot irrigated horticultural and rice- and cotton-growing regions of Australia and the United States.

The effects of those climate changed-induced direct crop productivity impacts on national agricultural self sufficiency for the sector as a whole in 2030 and 2050, as compared with the baseline in those years, are very small (barely 1 percent, see Table 2. Some of the effects on the production, consumption and trade components of those self sufficiency ratios, summarized in percentage terms in Tables 3 and 4 for 2030 and 2050, are somewhat larger than the effects on self sufficiency, but are still small overall. The projected volume of agricultural output would shrink by no more than 5 percent in any of the developing countries shown in those tables (but would rise in very few of them).

Typically the farmgate price of products is projected to move in the opposite direction to farm production in response to these yield shocks though. Hence agricultural value added

[3] Hertel, Burke and Lobell (2010) acknowledge the wide confidence band around that median effect by also noting the 5 and 95 percentile effects, and showing the wide difference that makes to the economic and poverty effects generated by their economywide model.

(which also takes account of changes in input prices such as animal feedstuffs) sometimes shows the opposite sign to the volume of farm output (column 4 of Tables 3(a) and 3(b)). In particular, agricultural value added rises in all but a few developing countries.

Note from the top of Tables 3(a) and 3(b) that the aggregate price of agricultural products in international markets in 2030 and 2050 changes hardly at all as a result of the productivity shocks (less than 0.3 percent). It even happens to be slightly negative, rather than positive as predicted by numerous commentators, which means the mainly adverse effects on farm supplies in developing countries is slightly offset by the mainly positive effects on farm output in high-income countries.

Consumption volumes are affected little by this one impact of climate change, but typically in the same direction as the production change. As a result, the value of agricultural trade changes very little. In the case of high-income countries, exports would be just 1.2 percent higher and those countries' farm imports would be 0.8 percent less in 2030 because of the assumed crop productivity impacts of climate change. The percentage changes for developing countries as a group would be slightly larger and of the opposite signs to those for high-income countries (bottom two rows of Table 3). Thus the developing country share of global exports (imports) of farm products would fall (rise).

The impact of those price and quantity changes on overall national economic welfare is summarized in Table 4. For the world as a whole, the negative impact seems very small, at around $4 billion per year by 2030 and just $3 billion by 2050 – a small fraction of 1 percent of projected real income. That aggregate conceals larger proportional changes at the country level, especially for developing countries, but even so they appear to be very minor (final column of Table 4). Those national economic welfare effects are shown in that table to come not only from (a) the factor productivity shocks themselves but also from (b) the impact of producer and consumer responses to them on the welfare costs of distortionary policies such as tariffs and subsidies and (c) the change in the country's international terms of trade. Note that the latter two indirect effects are non-trivial, and in some countries they are larger than the direct productivity effect. Also, the third effect (via changes in the terms of trade) in some cases is quite different by 2050 than in 2030. This is partly because the international prices for the myriad products, and their traded quantities, are affected to different extents by the productivity shocks. Particularly striking examples are China and India: in 2030 the terms of trade changes reduce slightly their national welfare, whereas by 2050 their welfare is enhanced considerably by the terms of trade changes (c.f. Tables 3(a) and 3(b)).

These projected changes from the assumed crop productivity effects of climate change are but one of the influences expected from temperature and humidity changes over coming decades. We turn now to an additional expected influence, namely via its debilitating impact on unskilled workers in developing countries which van der Mensbrugghe and Rosen (2010) indicated could be far more important.

***Effects also on unskilled labour productivity***

Almost all unskilled labourers in tropical developing countries have no access to air conditioning in their workplace, especially as most work outside on farms. Since temperatures and humidity are expected to rise from already very high levels in most of those countries, the productivity of such workers is sure to fall in the absence of counter measures. By contrast, in high-income countries the temperature rises generally will be from cool or at most moderate rather than high current levels, and in any case many unskilled workers there work inside with air conditioning.

We follow van der Mensbrugghe and Rosen (2010) in attempting to simulate the effect of climate change on all unskilled workers in tropical and desertified developing countries, by adding to the crop yield shock a shock to unskilled labour productivity in both agricultural and non-farm sectors. There are no precise predictions of the likely magnitude of that shock, so we simply adopt the modest assumption that it involves a 3 percent decline in unskilled labour productivity by 2030 and another 3 percent by 2050 in all developing countries other than the relatively temperate ones of Argentina, Korea, South Africa and Taiwan and the most affluent ones (Hong Kong and Singapore).

The effects of adding this additional shock on agricultural markets is summarized in Table 5. For developing countries as a group the generally negative impact of the two shocks on the volume of agricultural production is roughly double or more the effect of the crop productivity shock alone. But there is an even larger difference in the decline in consumption of farm products, so the impact on trade is muted. The developing country share of global exports (imports) of farm products would still be higher (lower) by 2050 than in the absence of the productivity shocks, but the change would be less than if only crop productivity was affected (c.f. the bottom right-hand corners of Tables 3 and 5). The main exception is China, whose value of agricultural exports diminishes by nearly twice as much with this pair of shocks as with just the crop shock. This is because most of its unskilled labour is employed in agriculture by 2050, so most of the brunt of the labour productivity shock is borne by farming which makes the non-farm sector more competitive.

The welfare affects are now far bigger than in the previous scenario, because the shock to unskilled labour applies to all sectors of developing countries, not just to agriculture. Even so they amount to no more than one-quarter of one percent of real income globally and up to one percent of welfare in some developing countries by 2050 (Table 6).

**Caveats**

The above analysis is very partial in nature, in several respects. First, it examines the effects of just two of the many impacts that climate changes are expected to have on the global economy. van der Mensbrugghe and Rosen (2010), for example, also take into account the effects on energy demand, water availability, tourism and sea level rise. Not surprisingly, therefore, they get a much higher impact of climate change on global economic welfare – indeed twice as big, and of opposite sign, as the welfare effect of freeing trade policies globally in 2050 (-1.8 percent, compared with 0.9 percent from freeing trade).

Second, we have only analysed the effects to 2050. The effects of climate change are expected to increase exponentially, however, so in the absence of mitigation they would be much larger in the second half of the 21$^{st}$ century. This is supported by the dynamic simulations to 2100 generated by Rosen and van der Mensbrugghe (2010).

Third, the nature of each simulated shock obviously determines the size of its effects. The crop productivity shocks we adopt, like most other analysts', help farm output in higher latitudes and hurt it in many parts of the tropics. The net effect in our case is virtually no aggregate global agricultural output change (see last row of Table 3). By contrast, van der Mensbrugghe and Rosen (2010) assume larger positive shocks in temperate regions and smaller negative shocks in the tropics and so project a small net global economic welfare gain from the changes in crop productivity. They also adopt a damage function approach to the effect of temperature rise on labour productivity (based on such studies as Kjellstrom et al. 2009), in contrast to our simple exogenous labour shock. More sophisticated damage functions with respect to crop productivity also could be adopted, especially now that the GTAP database is being enhanced to enable better modelling of land use changes (see Hertel 2010) and the impact of changes in water availability in irrigated versus non-irrigated areas (see Calzadilla et al. 2010). Given the great uncertainty associated with the magnitude – and in some cases even the sign of – potential shocks, analytical results ideally should include confidence bands around them or at least high and low alternatives to the median case presented.

Fourth, the standard version of the GTAP model used in the present study does not capture the complexity of energy markets. In particular, there are no biofuels markets, so the linkage that has recently emerged between biofuel crops and fossil fuels is not built into the projections. Modellers have certainly begun incorporating elements of that linkage, but even then there will be the challenge of anticipating how governments might alter biofuel subsidies and mandates over the next 40 years (given the newness of many of those policies and the uncertainty still surrounding the net environmental benefits of such supports to biofuel producers).

Fifth, as mentioned at the outset of this paper, the debilitating impact on welfare and food security from extreme weather events is not captured by the comparative static model we have employed. More-frequent extreme weather events such as floods, droughts, frosts, hail and wind can affect all sectors but are especially damaging to farm incomes whenever they strike. Analysis of the welfare effects of climate change ought to recognise these income distributional consequences, particularly on the poor. Economy-wide modellers are only now beginning to focus on those possible poverty consequences (see, e.g., Hertel, Burke and Lobell 2010).

And finally, we have assumed throughout that policies are unchanged through the projection period, and in particular that no new mitigation strategies or technologies are adopted to slow climate change, nor are trade, subsidy or tax policies changed. This is an obvious area for extending the analysis. If a carbon tax was gradually phased in by all countries, for example, climate change presumably would eventually slow down. However, it probably would not before 2050, and meanwhile that set of carbon taxes would alter the international competitiveness of various industries around the world. Carbon-intensive industrial sectors such as China's would be likely to lose comparative advantage, thereby making China's farmers more competitive. And China might not be able to avoid that outcome simply by not adopting a carbon tax, because in that case other countries that have adopted such a tax may impose border tax adjustments on goods imported from China (Mattoo, Subramanian, van der Mensbrugghe and He 2009a,b) .

**Conclusions**

Given the above caveats, it would of course be premature to draw implications for agricultural, trade and climate change policies from the empirical results presented in this paper. They are presented simply to illustrate some of the ways in which one or two of the shocks expected from on-going climate change can affect agricultural markets directly or indirectly, and thereby also economic welfare. When those effects are expected to be positive in some countries and negative in others, as in the case of farm products, the net impact on world food prices and hence real incomes of both farm and nonfarm households in the decades ahead can only be determined with the use of a global economy-wide model projected forward.

For what it is worth, in terms of global food security the results from the present analysis are less pessimistic than some earlier studies. One of the more widely cited is by Cline (2007), who predicts that by the 2080s, even with carbon fertilization, agricultural output will be 8 percent lower in developing countries, 8 percent higher in high-income countries, and 3 percent lower globally. Projections in a more recent study by Nelson et al. (2009) suggest that by 2050 climate change will have had, assuming no carbon fertilization, only a little downward impact on coarse grain production but will have reduced global rice production by one-eighth and wheat by one-quarter globally and nearly one-third in developing countries. Nelson et al. (2009) expect real international prices of grain and livestock in 2050 would be between 35 and 70 percent higher than in 2000 without climate change and more than 10 percentage points higher again with climate change, even with carbon fertilization. If those rather than the present study's results turn out to be closer to reality, food security concerns and associated policy responses such as expanding agricultural R&D investments will be vindicated.

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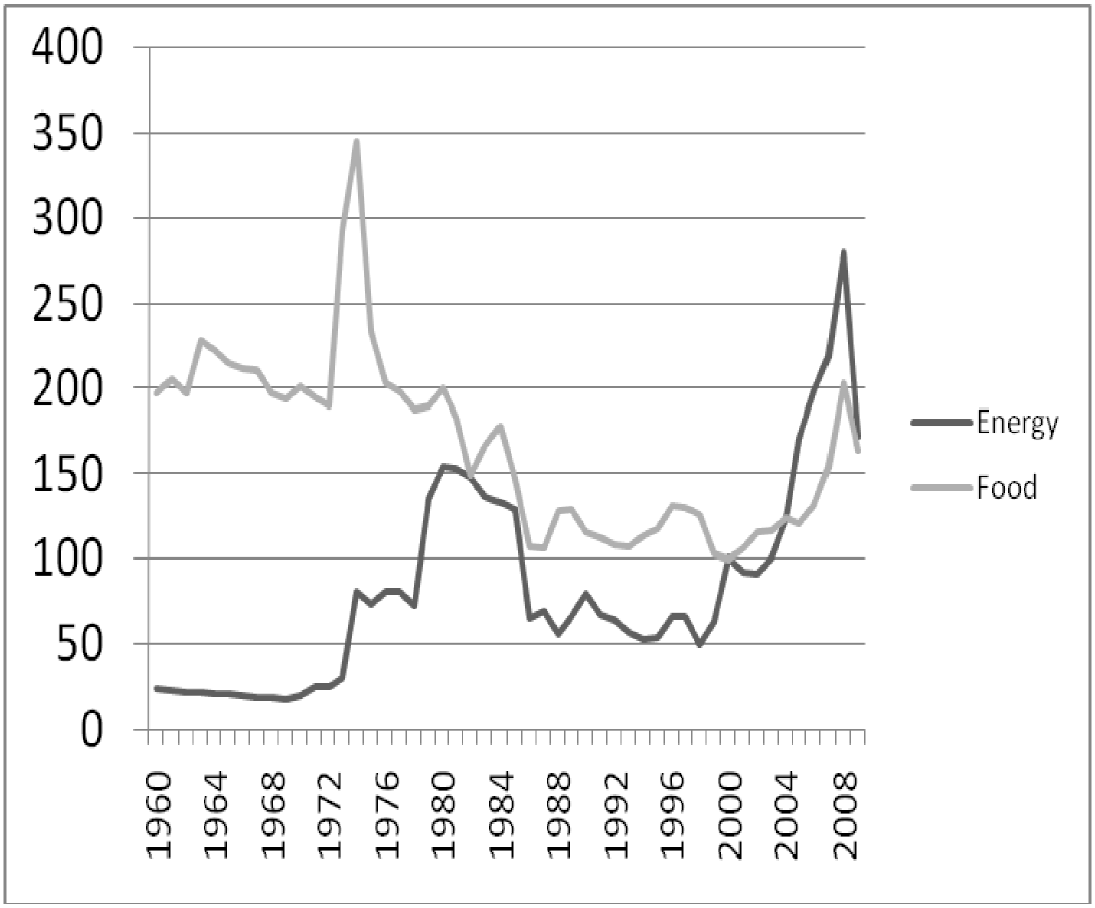
Figure 1: International price indexes for food and fossil fuel energy raw materials, 1960 to 2009

(2000 = 100)




Source: World Bank, Commodity Price Data (Pink Sheets, see http://go.worldbank.org/5AT3JHWYU0)

Table 1: Exogenous Yield Shocks (%) attributed to Climate Change in 2030, by region and sector

| Regions | Rice | Wheat | Coarse grains | Fruits Veg | Oil seeds | Cotton | Other crops |
|---|---|---|---|---|---|---|---|
| USA | -3 | 2 | 3 | 2 | 2 | -3 | 2 |
| Canada | -3 | 7 | -10 | 2 | 10 | -3 | 2 |
| EU27 and EFTA | 7 | 7 | -5 | 7 | 7 | 7 | 7 |
| Russia | 7 | 7 | -5 | 7 | 7 | 7 | 7 |
| Rest of Europe/C. Asia | 7 | 7 | -5 | 7 | 7 | 7 | 7 |
| Australia | -3 | 7 | -5 | -3 | 2 | -3 | 7 |
| New Zealand | 7 | 7 | -5 | 7 | 2 | 7 | 7 |
| Japan | 9 | 4 | 0 | 4 | 9 | 9 | 4 |
| Korea | 12 | 12 | 5 | 12 | 12 | 12 | 12 |
| HongKong/Sing/Taiwan | 12 | 12 | 5 | -3 | 12 | 12 | 12 |
| China | 0 | 2 | -10 | -8 | 0 | 0 | -8 |
| Indonesia | -3 | -3 | -10 | 7 | -3 | -3 | -3 |
| Malaysia | -3 | -3 | -10 | -3 | -3 | -3 | -3 |
| Thailand | -3 | -3 | -10 | -3 | -3 | -3 | -3 |
| Rest of East Asia | -3 | -3 | -10 | -3 | -3 | -3 | -3 |
| India | -5 | -3 | -10 | -3 | -3 | -3 | -3 |
| Rest of South Asia | -5 | -3 | -10 | -3 | -3 | -3 | -3 |
| Argentina | -3 | -3 | -10 | -3 | -3 | -3 | -3 |
| Brazil | -3 | -3 | -10 | -3 | 2 | -3 | -3 |
| Rest of Latin America | -3 | -3 | -5 | -3 | -3 | -3 | -3 |
| Middle East/Nth Africa | 2 | 2 | -5 | 2 | 2 | 2 | 2 |
| South Africa | -8 | -8 | -20 | -8 | -8 | -8 | -8 |
| Rest Sub-Saharan Africa | -3 | -3 | -10 | -3 | -3 | -3 | -3 |

Source: Hertel, Burke and Lobell (2010)

Table 2: Effects of economic growth, and of crop yield changes due to climate change, on agricultural self sufficiency, from 2004 to 2030 and 2050

(percent)

| Regions | Base-2004 | Base-2030 | CC-2030 | CC-2030 Yield +Labor | Base-2050 | CC-2050 Yield | CC-2050 Yield + Labor |
|---|---|---|---|---|---|---|---|
| USA | 103.4 | 130.2 | 130.3 | 130.2 | 152.3 | 152.2 | 152.3 |
| Canada | 108.3 | 125.4 | 125.1 | 125.0 | 125.3 | 125.2 | 125.3 |
| EU27 and EFTA | 94.0 | 114.4 | 115.6 | 115.6 | 123.5 | 124.3 | 124.3 |
| Russia | 89.2 | 94.5 | 94.8 | 94.9 | 94.6 | 95.0 | 95.3 |
| Rest of EE/C Asia | 100.2 | 106.6 | 107.7 | 107.6 | 120.7 | 121.7 | 121.7 |
| Australia | 137.9 | 164.3 | 164.3 | 164.5 | 186.2 | 186.7 | 187.2 |
| New Zealand | 161.2 | 187.4 | 189.0 | 188.9 | 207.5 | 206.0 | 206.3 |
| Japan | 82.5 | 96.8 | 97.7 | 97.6 | 114.0 | 114.2 | 114.5 |
| Korea | 81.4 | 83.6 | 86.6 | 86.5 | 88.9 | 91.0 | 90.9 |
| HK/Sing/Taiwan | 65.9 | 67.4 | 67.9 | 67.9 | 59.2 | 59.4 | 59.4 |
| China | 97.2 | 46.3 | 45.5 | 45.3 | 26.2 | 25.9 | 25.5 |
| Indonesia | 94.7 | 74.1 | 73.8 | 73.8 | 63.6 | 63.2 | 63.1 |
| Malaysia | 60.3 | 37.3 | 37.0 | 37.0 | 26.9 | 26.7 | 26.7 |
| Thailand | 111.9 | 98.0 | 97.0 | 96.9 | 97.4 | 97.0 | 96.7 |
| Rest of East Asia | 99.5 | 82.3 | 81.4 | 81.4 | 75.4 | 74.5 | 74.6 |
| India | 101.2 | 89.4 | 88.5 | 88.4 | 94.5 | 94.1 | 94.0 |
| Rest of Sth. Asia | 95.7 | 81.8 | 81.2 | 81.3 | 74.9 | 74.4 | 74.4 |
| Argentina | 142 | 153.2 | 150.0 | 149.6 | 171.5 | 168.3 | 167.6 |
| Brazil | 122.5 | 141.6 | 141.1 | 141.4 | 157.6 | 157.0 | 157.4 |
| Rest of L America | 101.7 | 93.2 | 92.5 | 92.5 | 90.5 | 89.5 | 89.6 |
| M. East/N. Africa | 83.6 | 86.7 | 86.8 | 86.6 | 92.2 | 92.3 | 92.0 |
| South Africa | 106.9 | 140.8 | 136.2 | 136.2 | 166.9 | 161.9 | 162.0 |
| Rest of SS Africa | 102.2 | 96.0 | 94.9 | 94.7 | 104.2 | 103.3 | 103.1 |
| **High-income countries** | **96.1** | **118.3** | **116.8** | **116.8** | **261.4** | **131.3** | **131.4** |
| **Developing countries** | **99.8** | **77.1** | **76.3** | **76.2** | **69.9** | **69.1** | **68.8** |

Source: Authors' simulations, assuming the crop productivity shocks of climate change are those shown in Table 1 by 2030 and twice those by 2050.

Table 3: Effects of crop productivity shocks due to climate change on agricultural production, consumption and trade, 2030 and 2050

(percent deviation from baseline in projected year)

(a) 2030: Average difference in world agric prices in 2030 = -0.25%

| Regions | Farmer price | Agricultural production volume | Agricultural consumption volume | Agricultural value added | Agricultural value of exports | Agricultural value of imports |
|---|---|---|---|---|---|---|
| USA | 0.0 | 0.0 | -0.1 | 0.0 | 0.1 | -0.7 |
| Canada | 0.4 | -0.5 | -0.2 | -0.4 | -0.1 | 0.0 |
| EU27 and EFTA | -0.9 | 1.4 | 0.3 | 0.7 | 2.0 | -1.0 |
| Russia | -0.3 | 0.5 | 0.2 | -0.1 | 1.3 | -1.0 |
| Rest of Europe/C. Asia | -1.0 | 1.4 | 0.3 | 0.4 | 3.2 | -1.0 |
| Australia | 0.3 | -0.1 | 0.0 | -0.5 | 0.4 | 0.4 |
| New Zealand | -0.4 | 1.0 | 0.1 | -0.2 | 1.0 | -0.9 |
| Japan | -1.1 | 1.1 | 0.2 | 0.8 | 2.8 | -0.7 |
| Korea | -2.6 | 4.6 | 1.0 | -1.4 | 7.2 | -2.9 |
| HongKong/Sing/Taiwan | -0.2 | 1.0 | 0.2 | -0.4 | 2.1 | -0.1 |
| China | 1.6 | -1.8 | -0.1 | -0.5 | -0.7 | 0.9 |
| Indonesia | 0.9 | -0.7 | -0.2 | -0.3 | -1.6 | 0.8 |
| Malaysia | 0.5 | -0.9 | -0.1 | 0.6 | -2.5 | 0.2 |
| Thailand | 0.9 | -1.1 | -0.1 | 0.2 | -1.5 | 1.1 |
| Rest of East Asia | 0.6 | -1.3 | -0.2 | 0.8 | -2.7 | 0.8 |
| India | 2.3 | -1.5 | -0.5 | -1.5 | -1.0 | 2.5 |
| Rest of South Asia | 1.1 | -1.0 | -0.2 | -0.5 | -1.0 | 2.5 |
| Argentina | 1.1 | -1.9 | 0.2 | 0.2 | -3.3 | 1.0 |
| Brazil | 0.3 | -0.7 | -0.3 | 0.2 | -1.4 | 1.5 |
| Rest of Latin America | 0.6 | -1.0 | -0.2 | 0.2 | -3.6 | 1.0 |
| Middle East/Nth Africa | -0.6 | 0.3 | 0.1 | 0.8 | -0.4 | -0.4 |
| South Africa | 1.8 | -3.5 | -0.2 | -0.1 | -5.9 | 0.9 |
| Rest Sub-Saharan Africa | 1.9 | -1.5 | -0.4 | -0.8 | -4.1 | 2.0 |
| **High-income countries** | **-0.5** | **0.7** | **0.2** | **0.3** | **1.2** | **-0.8** |
| **Developing countries** | **1.1** | **-1.0** | **-0.2** | **-0.5** | **-1.5** | **0.9** |
| **World** | **0.2** | **0.0** | **0.0** | **-0.1** | **0.4** | **0.4** |

Table 3 (continued): Effects of crop productivity shocks due to climate change on agricultural production, consumption and trade, 2030 and 2050
(percent deviation from baseline in projected year)

(b) 2050: Average difference in world agric prices in 2050 = -0.10%

| Regions | Farmer price | Agricultural production volume | Agricultural consumption volume | Agricultural value added | Agricultural value of exports | Agricultural value of imports |
|---|---|---|---|---|---|---|
| USA | -0.2 | 0.0 | 0.1 | 0.5 | -0.3 | -1.1 |
| Canada | 0.9 | -1.7 | -1.6 | -0.5 | -1.2 | -0.4 |
| EU27 and EFTA | -1.7 | 2.3 | 1.6 | 1.3 | 1.6 | -0.9 |
| Russia | -0.6 | 0.8 | 0.3 | 0.0 | 1.1 | -0.6 |
| Rest of Europe/C. Asia | -1.9 | 2.3 | 1.4 | 1.2 | 1.7 | -1.1 |
| Australia | 0.2 | -0.1 | -0.4 | 0.1 | 0.1 | -0.1 |
| New Zealand | -0.9 | 1.3 | 2.0 | 0.7 | 0.4 | -0.9 |
| Japan | -1.9 | 1.7 | 1.5 | 1.5 | 0.2 | -0.7 |
| Korea | -2.2 | 3.9 | 1.5 | -1.5 | 4.2 | -1.0 |
| HongKong/Sing/Taiwan | -0.7 | 0.7 | 0.3 | 1.4 | -0.4 | -0.3 |
| China | 1.1 | -1.9 | -0.5 | 0.7 | -7.3 | 0.0 |
| Indonesia | 0.9 | -0.9 | -0.3 | 0.0 | -4.2 | 0.5 |
| Malasya | -0.1 | -0.9 | -0.4 | 1.9 | -4.9 | -0.5 |
| Thailand | 0.1 | -0.8 | -0.3 | 1.5 | -1.2 | 0.0 |
| Rest of East Asia | -0.2 | -1.3 | -0.1 | 2.4 | -4.4 | -0.2 |
| India | 1.6 | -1.2 | -0.8 | -1.0 | -0.3 | 0.7 |
| Rest of South Asia | 1.1 | -1.3 | -0.6 | -0.1 | -1.5 | 0.3 |
| Argentina | 1.0 | -2.5 | -0.7 | 1.1 | -4.1 | 0.1 |
| Brazil | 0.4 | -0.9 | -0.5 | 0.4 | -1.0 | 3.2 |
| Rest of Latin America | 0.2 | -1.3 | -0.2 | 1.4 | -4.9 | 0.3 |
| Middle East/Nth Africa | -1.3 | 0.6 | 0.5 | 2.0 | -1.2 | -1.1 |
| South Africa | 2.1 | -5.5 | -2.6 | 1.9 | -7.6 | 0.0 |
| Rest Sub-Saharan Africa | 1.6 | -1.5 | -0.6 | -0.4 | -1.3 | 2.1 |
| **High-income countries** | **-0.9** | **0.7** | **0.8** | **0.9** | **0.6** | **-0.9** |
| **Developing countries** | **0.7** | **-1.0** | **-0.4** | **0.3** | **-1.3** | **0.1** |
| **World** | **-0.1** | **0.0** | **0.0** | **0.5** | **-0.1** | **-0.1** |

Source: Authors' simulations, assuming that climate change involves twice the crop productivity shocks shown in Table 1 by 2030 or 2050 relative to the baseline in that year.

Table 4: Effects on national economic welfare of crop productivity losses, 2030 and 2050

(2004 US$ million, deviation from baseline in projected year)

(a) 2030

| | Due to changes in: | | | | |
|---|---|---|---|---|---|
| Regions | Factor productivity | Terms of trade | Resource use efficiency | Total economic welfare | Total economic welfare as % of Income |
| USA | 245 | 697 | 226 | 1166 | 0.01 |
| Canada | 30 | 229 | -81 | 178 | 0.01 |
| EU27 and EFTA | 3270 | -1091 | -363 | 1815 | 0.01 |
| Russia | 194 | 71 | 46 | 310 | 0.03 |
| Rest of Europe/C. Asia | 839 | -31 | 310 | 1119 | 0.09 |
| Australia | -86 | 356 | 36 | 306 | 0.03 |
| New Zealand | 89 | -94 | 2 | -4 | 0.00 |
| Japan | 675 | -97 | -265 | 313 | 0.01 |
| Korea | 1110 | -226 | -989 | -106 | -0.01 |
| HongKong/Sing/Taiwan | 46 | 67 | -9 | 104 | 0.01 |
| China | -2954 | -885 | 1372 | -2467 | -0.04 |
| Indonesia | -220 | 45 | 12 | -163 | -0.03 |
| Malaysia | -36 | 10 | 26 | 0 | 0.00 |
| Thailand | -241 | 33 | 64 | -144 | -0.04 |
| Rest of East Asia | -311 | 64 | 2 | -246 | -0.06 |
| India | -4076 | -225 | 479 | -3821 | -0.23 |
| Rest of South Asia | -690 | 153 | 51 | -486 | -0.11 |
| Argentina | -229 | 277 | -197 | -149 | -0.06 |
| Brazil | -354 | -105 | -35 | -494 | -0.05 |
| Rest of Latin America | -1055 | 37 | 379 | -639 | -0.02 |
| Middle East/Nth Africa | 248 | 265 | 62 | 573 | 0.03 |
| South Africa | -360 | 325 | -20 | -54 | -0.02 |
| Rest Sub-Saharan Africa | -1267 | 128 | 21 | -1118 | -0.17 |
| **High-income countries** | **5256** | **40** | **-89** | **5203** | 0.01 |
| **Developing countries** | **-10389** | **-37** | **1218** | **-9210** | -0.05 |
| **World** | **-5134** | **1** | **1127** | **-4006** | -0.01 |

Table 4 (continued): Effects on national economic welfare of crop productivity losses, 2030 and 2050

(2004 US$ million, deviation from baseline in projected year)

(b) 2050

| | Due to changes in: | | | | |
|---|---|---|---|---|---|
| | Factor productivity | Terms of trade | Resource use efficiency | Total economic welfare | Total economic welfare as % of Income |
| USA | 582 | -1818 | 95 | -1141 | -0.01 |
| Canada | -141 | 940 | -212 | 586 | 0.03 |
| EU27 and EFTA | 7854 | -7626 | -1720 | -1493 | -0.01 |
| Russia | 303 | 241 | 108 | 652 | 0.04 |
| Rest of Europe/C. Asia | 2067 | -1716 | 686 | 1037 | 0.05 |
| Australia | -269 | 489 | 43 | 262 | 0.02 |
| New Zealand | 220 | -404 | -17 | -202 | -0.09 |
| Japan | 1222 | -2009 | -637 | -1423 | -0.03 |
| Korea | 1791 | -1062 | -1092 | -364 | -0.01 |
| HongKong/Sing/Taiwan | 46 | -123 | 5 | -73 | 0.00 |
| China | -2239 | 6547 | 1648 | 5957 | 0.05 |
| Indonesia | -421 | 134 | -3 | -290 | -0.03 |
| Malaysia | -58 | 107 | 44 | 93 | 0.02 |
| Thailand | -299 | 23 | 182 | -95 | -0.01 |
| Rest of East Asia | -487 | 20 | -19 | -486 | -0.07 |
| India | -6609 | 2929 | 923 | -2757 | -0.09 |
| Rest of South Asia | -1228 | 1034 | 109 | -84 | -0.01 |
| Argentina | -494 | 495 | -421 | -420 | -0.11 |
| Brazil | -842 | -28 | -79 | -949 | -0.06 |
| Rest of Latin America | -1941 | 109 | 643 | -1189 | -0.03 |
| Middle East/Nth Africa | 666 | 436 | 180 | 1282 | 0.04 |
| South Africa | -976 | 598 | -90 | -468 | -0.09 |
| Rest Sub-Saharan Africa | -2470 | 692 | 245 | -1533 | -0.13 |
| **High-income countries** | **11838** | **-11903** | **-1654** | **-1722** | 0.00 |
| **Developing countries** | **-15561** | **11911** | **2275** | **-1376** | 0.00 |
| **World** | **-3723** | **7** | **621** | **-3095** | 0.00 |

Source: authors' simulations

Table 5: Effects on agricultural production, consumption and trade of crop productivity losses **and** decreases in unskilled labour productivity, 2030 and 2050

(percent deviation from baseline in projected year)

(a) 2030: average difference in world agric prices = -0.07%

| | Farmer price | Agricultural production volume | Agricultural consumption volume | Agricultural value added | Agricultural value of exports | Agricultural value of imports |
|---|---|---|---|---|---|---|
| USA | 0.1 | -0.1 | -0.1 | 0.1 | -0.1 | -0.7 |
| Canada | 0.5 | -0.7 | -0.4 | -0.2 | -0.4 | 0.0 |
| EU27 and EFTA | -0.8 | 1.3 | 0.3 | 0.6 | 1.9 | -1.0 |
| Russia | -0.3 | 0.5 | 0.0 | -0.2 | 1.7 | -1.2 |
| Rest of Europe/C. Asia | -0.9 | 1.2 | 0.2 | 0.4 | 2.7 | -0.9 |
| Australia | 0.3 | 0.2 | 0.1 | -0.6 | 0.8 | 0.1 |
| New Zealand | -0.3 | 0.9 | 0.1 | -0.1 | 0.9 | -0.8 |
| Japan | -1.0 | 1.0 | 0.2 | 0.8 | 2.5 | -0.6 |
| Korea | -2.4 | 4.5 | 1.1 | -1.5 | 6.9 | -2.8 |
| HongKong/Sing/Taiwan | -0.1 | 0.9 | 0.3 | -0.4 | 2.0 | 0.0 |
| China | 2.4 | -3.0 | -1.0 | -0.2 | -3.1 | 0.6 |
| Indonesia | 1.1 | -1.5 | -1.0 | 0.4 | -2.4 | 0.1 |
| Malaysia | 0.5 | -1.7 | -1.0 | 1.4 | -2.1 | -0.6 |
| Thailand | 1.0 | -1.3 | -0.2 | 0.2 | -1.9 | 1.2 |
| Rest of East Asia | 0.8 | -2.1 | -0.9 | 1.3 | -3.0 | 0.4 |
| India | 2.6 | -2.4 | -1.2 | -1.0 | -2.6 | 1.8 |
| Rest of South Asia | 1.4 | -1.6 | -1.0 | -0.1 | -1.2 | 0.3 |
| Argentina | 1.0 | -2.0 | 0.4 | 0.4 | -3.9 | 0.9 |
| Brazil | 0.3 | -0.9 | -0.8 | 0.7 | -1.2 | 0.6 |
| Rest of Latin America | 0.9 | -1.8 | -1.0 | 0.7 | -4.0 | 0.5 |
| Middle East/Nth Africa | -0.2 | -0.8 | -0.6 | 1.2 | -1.7 | -0.5 |
| South Africa | 1.9 | -3.5 | -0.3 | -0.1 | -6.0 | 0.7 |
| Rest Sub-Saharan Africa | 2.3 | -2.7 | -1.4 | -0.1 | -5.8 | 1.7 |
| **High-income countries** | **-0.5** | **0.7** | **0.1** | **0.3** | **1.1** | **-0.9** |
| **Developing countries** | **1.1** | **-1.8** | **-0.9** | **-0.1** | **-2.2** | **0.5** |
| **World** | **0.2** | **-0.4** | **-0.4** | **0.1** | **0.2** | **0.1** |

Table 5 (continued): Effects of on agricultural production, consumption and trade of crop productivity losses and decreases in unskilled labour productivity, 2030 and 2050

(percent deviation from baseline in projected year)

(b) 2050: average difference in world agric prices = -0.28%

| Regions | Farmer price | Agricultural production volume | Agricultural consumption volume | Agricultural value added | Agricultural value of exports | Agricultural value of imports |
|---|---|---|---|---|---|---|
| USA | -0.1 | 0.2 | 0.1 | 0.3 | 0.0 | -1.4 |
| Canada | 1.1 | -1.7 | -1.7 | -0.7 | -1.1 | -0.5 |
| EU27 and EFTA | -1.6 | 2.4 | 1.7 | 1.3 | 1.6 | -1.0 |
| Russia | -0.7 | 1.2 | 0.4 | -0.3 | 1.9 | -0.7 |
| Rest of Europe/C. Asia | -1.7 | 2.3 | 1.4 | 1.1 | 1.6 | -1.2 |
| Australia | 0.0 | 0.6 | 0.1 | -0.4 | 1.0 | -0.9 |
| New Zealand | -0.8 | 1.2 | 1.8 | 0.6 | 0.5 | -1.0 |
| Japan | -1.9 | 2.0 | 1.5 | 1.1 | 0.6 | -1.0 |
| Korea | -1.9 | 3.8 | 1.5 | -1.7 | 4.3 | -0.8 |
| HongKong/Sing/Taiwan | -0.5 | 0.6 | 0.3 | 1.3 | -0.3 | -0.2 |
| China | 2.6 | -3.6 | -0.8 | 0.5 | -13.6 | 0.2 |
| Indonesia | 1.0 | -1.7 | -1.0 | 0.6 | -4.5 | -0.1 |
| Malaysia | 0.1 | -1.6 | -1.1 | 2.7 | -4.6 | -1.1 |
| Thailand | 0.4 | -1.3 | -0.6 | 1.7 | -1.8 | 0.1 |
| Rest of East Asia | 0.1 | -2.0 | -0.9 | 2.7 | -4.3 | -0.7 |
| India | 2.3 | -2.3 | -1.7 | -0.9 | -1.1 | 0.2 |
| Rest of South Asia | 1.5 | -1.9 | -1.2 | 0.2 | -1.6 | -0.1 |
| Argentina | 1.0 | -2.5 | -0.3 | 1.2 | -4.6 | 0.2 |
| Brazil | 0.4 | -1.1 | -1.0 | 0.7 | -0.9 | 2.4 |
| Rest of Latin America | 0.5 | -1.9 | -1.0 | 1.8 | -4.9 | -0.2 |
| Middle East/Nth Africa | -0.9 | -0.4 | -0.2 | 2.5 | -2.2 | -1.4 |
| South Africa | 2.0 | -5.5 | -2.6 | 1.9 | -7.6 | -0.6 |
| Rest Sub-Saharan Africa | 1.9 | -2.7 | -1.7 | 0.5 | -2.7 | 1.4 |
| **High-income countries** | **-0.5** | **0.6** | **0.8** | **0.7** | **0.8** | **-1.1** |
| **Developing countries** | **1.1** | **-2.9** | **-0.9** | **0.5** | **-1.9** | **0.1** |
| **World** | **0.2** | **-0.5** | **-0.3** | **0.6** | **-0.2** | **-0.2** |

Source: authors' simulations

Table 6: Effects on national economic welfare of crop productivity losses **and** decreases in unskilled labour productivity, 2030 and 2050

(2004 US$ million, deviation from baseline in projected year)

(a) 2030

| | Factor productivity | Terms of trade | Resource use efficiency | Total economic welfare | Total economic welfare as % of Income |
|---|---|---|---|---|---|
| USA | 244 | -1227 | -45 | -1028 | -0.01 |
| Canada | 30 | -439 | -130 | -539 | -0.04 |
| EU27 and EFTA | 3262 | -3387 | -784 | -910 | -0.01 |
| Russia | 194 | -2443 | -441 | -2690 | -0.26 |
| Rest of Europe/C. Asia | 836 | -994 | 255 | 97 | 0.01 |
| Australia | -86 | -1170 | -92 | -1347 | -0.12 |
| New Zealand | 89 | -116 | -7 | -34 | -0.02 |
| Japan | 674 | 109 | -300 | 482 | 0.01 |
| Korea | 1108 | 578 | -1029 | 657 | 0.04 |
| HongKong/Sing/Taiwan | 45 | 165 | 14 | 224 | 0.02 |
| China | -42915 | 12165 | -7571 | -38321 | -0.69 |
| Indonesia | -5029 | -298 | -231 | -5558 | -0.93 |
| Malaysia | -2912 | 347 | -117 | -2682 | -0.87 |
| Thailand | -240 | 337 | 76 | 174 | 0.05 |
| Rest of East Asia | -3139 | -30 | -385 | -3554 | -0.89 |
| India | -17432 | 2232 | -928 | -16127 | -0.96 |
| Rest of South Asia | -4410 | 591 | -322 | -4142 | -0.95 |
| Argentina | -228 | 115 | -212 | -325 | -0.13 |
| Brazil | -9560 | -314 | -1412 | -11286 | -1.04 |
| Rest of Latin America | -15544 | -921 | -6728 | -23192 | -0.90 |
| Middle East/Nth Africa | -10224 | -3966 | -1335 | -15524 | -0.77 |
| South Africa | -359 | -102 | -63 | -524 | -0.15 |
| Rest Sub-Saharan Africa | -6292 | -1247 | -610 | -8150 | -1.23 |
| **High-income countries** | **5243** | **-9667** | **-1544** | **-5969** | -0.01 |
| **Developing countries** | **-117131** | **9652** | **-20853** | **-128330** | -0.67 |
| **World** | **-111888** | **-16** | **-22395** | **-134298** | -0.22 |

Source: authors’ simulations

Table 6 (continued): Effects on national economic welfare of crop productivity losses **and** decreases in unskilled labour productivity, 2030 and 2050

(2004 US$ million, deviation from baseline in projected year)

(b) 2050

| | Factor productivity | Terms of trade | Resource use efficiency | Total economic welfare | Total economic welfare as % of Income |
|---|---|---|---|---|---|
| USA | 583 | -21726 | -2153 | -23296 | -0.11 |
| Canada | -143 | -1939 | -654 | -2736 | -0.15 |
| EU27 and EFTA | 7831 | -22858 | -5836 | -20863 | -0.12 |
| Russia | 305 | -6438 | -746 | -6879 | -0.46 |
| Rest of Europe/C. Asia | 2060 | -4961 | 469 | -2432 | -0.13 |
| Australia | -272 | -5708 | -637 | -6617 | -0.39 |
| New Zealand | 220 | -509 | -61 | -350 | -0.15 |
| Japan | 1230 | -7574 | -1275 | -7618 | -0.14 |
| Korea | 1787 | 1718 | -1154 | 2351 | 0.09 |
| HongKong/Sing/Taiwan | 45 | 365 | 46 | 456 | 0.02 |
| China | -66560 | 69422 | -12935 | -10073 | -0.09 |
| Indonesia | -8242 | -1101 | -431 | -9775 | -0.89 |
| Malaysia | -4893 | 1041 | -229 | -4080 | -0.72 |
| Thailand | -298 | 764 | 227 | 692 | 0.11 |
| Rest of East Asia | -4920 | -391 | -668 | -5979 | -0.86 |
| India | -28586 | 11354 | -779 | -18011 | -0.58 |
| Rest of South Asia | -7295 | 2025 | -525 | -5795 | -0.74 |
| Argentina | -493 | 125 | -476 | -845 | -0.22 |
| Brazil | -14365 | -679 | -2053 | -17097 | -1.00 |
| Rest of Latin America | -22981 | -2410 | -10037 | -35427 | -0.88 |
| Middle East/Nth Africa | -15376 | -7564 | -2043 | -24983 | -0.73 |
| South Africa | -975 | -1082 | -267 | -2323 | -0.44 |
| Rest Sub-Saharan Africa | -10365 | -2123 | -831 | -13318 | -1.17 |
| **High-income countries** | **11814** | **-71713** | **-10893** | **-70791** | -0.14 |
| **Developing countries** | **-183517** | **71464** | **-32155** | **-144207** | -0.42 |
| **World** | **-171704** | **-245** | **-43049** | **-214998** | -0.25 |

Source: authors’ simulations

Appendix Table A1: Aggregations of regions in the GTAP model

| | Regions-Aggregation | Comprising GTAP regions |
|---|---|---|
| 1 | USA | United States of America; Rest of North America |
| 2 | Canada | Canada |
| 3 | EU27 and EFTA | Austria; Belgium; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Latvia; Lithuania; Luxembourg; Malta; Netherlands; Poland; Portugal; Slovakia; Slovenia; Spain; Sweden; United Kingdom; Switzerland; Norway; Rest of EFTA; Bulgaria; Romania |
| 4 | Russia | Russian Federation |
| 5 | Rest of E. Europe/C. Asia | Albania; Belarus; Croatia; Ukraine; Rest of Eastern Europe; Rest of Europe; Kazakhstan; Kyrgyztan; Rest of Former Soviet Union; Armenia; Azerbaijan; Georgia; Iran Islamic Republic of; Turkey |
| 6 | Australia | Australia |
| 7 | New Zealand | New Zealand |
| 8 | Japan | Japan |
| 9 | Korea | Korea |
| 10 | Hong Kong, Singapore, Taiwan | Hong Kong; Taiwan; Singapore |
| 11 | China | China |
| 12 | Indonesia | Indonesia |
| 13 | Malaysia | Malaysia |
| 14 | Thailand | Thailand |
| 15 | Rest of East Asia | Cambodia; Lao People's Democratic Republ; Myanmar; Philippines; Viet Nam; Rest of Southeast Asia, Rest of Oceania; Rest of East Asia |
| 16 | India | India |
| 17 | Rest of South Asia | Bangladesh; Pakistan; Sri Lanka; Rest of South Asia |
| 18 | Argentina | Argentina |
| 19 | Brazil | Brazil |
| 20 | Rest of Latin America | Mexico; Bolivia; Chile; Colombia; Ecuador; Paraguay; Peru; Uruguay; Venezuela; Rest of South America; Costa Rica; Guatemala; Nicaragua; Panama; Rest of Central America; Caribbean |
| 21 | Middle East/North Africa | Rest of Western Asia; Egypt; Morocco; Tunisia; Rest of North Africa |
| 22 | South Africa | South Africa |
| 23 | Rest Sub-Saharan Africa | Nigeria; Senegal; Rest of Western Africa; Central Africa; South Central Africa; Ethiopia; Madagascar; Malawi; Mauritius; Mozambique; Tanzania; Uganda; Zambia; Zimbabwe; Rest of Eastern Africa; Botswana;; Rest of South African Customs |

Source: Authors' compilation from www.gtap.org

Appendix Table A2: Aggregations of sectors in the GTAP model

| | Sectors-Aggregation | Comprising GTAP sectors |
|---|---|---|
| 1 | Rice | Paddy rice; Processed rice |
| 2 | Wheat | Wheat |
| 3 | Coarse grains | Cereal grains nec |
| 4 | Fruit & veg | Vegetables, fruit, nuts |
| 5 | Oilseeds | Oil seeds, Vegetable oils and fats |
| 6 | Sugar | Sugar cane, sugar beet; Sugar |
| 7 | Cotton | Plant-based fibers |
| 8 | Other crops | Crops nec |
| 9 | Beef/sheep | Cattle,sheep,goats,horses; Meat of cattle, sheep, goats, horses; Wool, silk-worm cocoons |
| 10 | Pork/chicken | Animal products nec; Meat products nec |
| 11 | Dairy | Raw milk; Dairy products |
| 12 | Forestry | Forestry |
| 13 | Coal | Coal |
| 14 | Oil | Oil |
| 15 | Gas | Gas |
| 16 | Minerals nec | Minerals nec |
| 17 | Fish and processed food | Fishing; Food products nec; Beverages and tobacco products |
| 18 | Light manufacturing | Textiles; Wearing apparel; Leather products, Wood products; Paper products, publishing; Metal products; Motor vehicles and parts; Transport equipment nec; Manufactures nec |
| 19 | Heavy manufacturing | Petroleum, coal products; Chemical,rubber,plastic prods; Mineral products nec; Ferrous metals; Metals nec; Electronic equipment; Machinery and equipment nec |
| 20 | Utilities & Construction | Water; Construction; Trade |
| 21 | Electricity Gas dist. | Electricity; Gas manufacture, distribution |
| 22 | Transport | Transport nec; Sea transport; Air transport |
| 23 | Other Services | Communication; Financial services nec; Insurance; Business services nec; Recreation and other services; PubAdmin/Defence/Health/Education; Dwellings |

Source: Authors' compilation from www.gtap.org

Appendix Table A3: Assumed annual rates of growth in factor endowments and real GDP, and implied total factor productivity and real GDP per capita growth rates, from 2004 to 2030 (% per year)

| Regions | Popul-ation | Unskilled labor | Skilled labor | Capital | Real GDP | Implied TFP[a] | Implied realGDP per capita |
|---|---|---|---|---|---|---|---|
| USA | 0.7 | 0.8 | -0.2 | 3.2 | 2.6 | 1.4 | 1.9 |
| Canada | 0.4 | 0.4 | -0.6 | 3.1 | 2.6 | 1.2 | 2.3 |
| EU27 and EFTA | -0.1 | 0.0 | -0.7 | 1.9 | 1.9 | 1.2 | 2.0 |
| Russia | -0.6 | -0.7 | -1.0 | 3.2 | 3.2 | 1.2 | 3.8 |
| Rest E. Europe/C. Asia | 0.6 | 0.7 | 1.4 | 3.9 | 4.0 | 1.2 | 3.5 |
| Australia | 0.6 | 0.8 | -0.2 | 3.7 | 3.4 | 1.5 | 2.8 |
| New Zealand | 0.7 | 1.0 | 0.0 | 3.6 | 3.4 | 1.2 | 2.7 |
| Japan | -0.3 | -0.7 | -1.4 | 2.3 | 1.4 | 1.0 | 1.7 |
| Korea | 0.3 | -0.4 | 2.0 | 4.9 | 4.7 | 1.9 | 4.4 |
| HongKong/Sing/Taiwan | 0.4 | 0.2 | 0.6 | 4.9 | 4.5 | 1.8 | 4.1 |
| China | 0.6 | 0.5 | 5.0 | 9.5 | 6.9 | 1.2 | 6.3 |
| Indonesia | 1.1 | 1.3 | 3.7 | 4.8 | 5.1 | 1.6 | 4.0 |
| Malaysia | 1.3 | 1.5 | 5.0 | 5.7 | 5.7 | 1.6 | 4.4 |
| Thailand | 0.5 | 0.1 | 2.0 | 4.0 | 4.7 | 1.7 | 4.2 |
| Rest of East Asia | 1.2 | 1.5 | 2.9 | 4.1 | 4.4 | 1.2 | 3.2 |
| India | 1.1 | 1.5 | 3.0 | 5.9 | 5.7 | 1.8 | 4.6 |
| Rest of South Asia | 1.7 | 2.2 | 3.1 | 5.0 | 5.1 | 1.4 | 3.4 |
| Argentina | 0.9 | 0.3 | 2.9 | 2.7 | 3.4 | 1.5 | 2.5 |
| Brazil | 1.0 | 0.9 | 2.3 | 3.3 | 3.6 | 1.3 | 2.6 |
| Rest of Latin America | 1.3 | 1.6 | 2.9 | 3.5 | 3.9 | 1.0 | 2.6 |
| Middle East/Nth Africa | 1.6 | 2.0 | 2.4 | 4.1 | 4.6 | 1.0 | 2.9 |
| South Africa | 0.4 | 0.7 | 0.5 | 1.9 | 3.3 | 1.8 | 2.9 |
| Rest Sub-Saharan Africa | 2.0 | 2.5 | 2.4 | 3.8 | 4.5 | 1.0 | 2.5 |
| **High-income countries** | **0.2** | **0.2** | **-0.5** | **2.6** | **2.2** | **1.2** | **2.0** |
| **Developing countries** | **1.2** | **1.4** | **2.9** | **5.9** | **5.1** | **1.3** | **3.9** |
| **World** | **1.0** | **1.2** | **1.1** | **3.5** | **3.0** | **1.3** | **2.0** |

Additional primary sectoral TFP shocks (% per year): coal 2.7, oil 2.1, gas 1.7, mineral resources 1.0, agriculture and food 1.0, forestry 1.0.

Source: Authors’ compilation drawing on World Bank and OECD projections.

Appendix Table A4: Assumed annual rates of growth in factor endowments and real GDP, and implied total factor productivity and real GDP per capita growth rates, from 2030 to 2050 (% per year)

| Regions | Popul-ation | Unskilled labor | Skilled labor | Capital | Real GDP | Implied TFP[a] | Implied realGDP per capita |
|---|---|---|---|---|---|---|---|
| USA | 0.7 | 0.4 | -0.1 | 2.9 | 2.7 | 1.5 | 2.0 |
| Canada | 0.3 | -0.1 | -0.6 | 2.7 | 2.6 | 1.4 | 2.3 |
| EU27 and EFTA | -0.1 | -0.2 | -0.6 | 2.0 | 2.0 | 1.1 | 2.0 |
| Russia | -0.6 | -1.0 | -1.6 | 2.8 | 3.2 | 1.2 | 3.8 |
| Rest E. Europe/C. Asia | 0.7 | 0.8 | 0.6 | 3.1 | 3.5 | 1.0 | 2.8 |
| Australia | 0.6 | 0.3 | -0.1 | 3.4 | 3.5 | 1.7 | 3.0 |
| New Zealand | 0.6 | 0.5 | 0.1 | 3.4 | 3.6 | 1.5 | 3.0 |
| Japan | -0.3 | -0.7 | -1.7 | 1.7 | 1.6 | 1.3 | 1.9 |
| Korea | 0.2 | 0.3 | 0.3 | 4.7 | 4.7 | 1.8 | 4.4 |
| HongKong/Sing/Taiwan | 0.3 | 0.1 | -0.5 | 4.5 | 4.4 | 1.9 | 4.1 |
| China | 0.5 | 0.3 | 3.0 | 7.0 | 5.5 | 0.8 | 5.0 |
| Indonesia | 1.0 | 1.4 | 1.4 | 4.8 | 5.0 | 1.5 | 4.0 |
| Malaysia | 1.2 | 1.6 | 1.6 | 5.0 | 4.9 | 1.4 | 3.6 |
| Thailand | 0.5 | 0.2 | 0.2 | 4.4 | 4.9 | 1.6 | 4.4 |
| Rest of East Asia | 1.2 | 1.6 | 1.7 | 4.2 | 4.6 | 1.3 | 3.4 |
| India | 1.0 | 1.5 | 1.5 | 5.4 | 5.0 | 1.2 | 4.0 |
| Rest of South Asia | 1.6 | 2.2 | 2.1 | 5.0 | 4.9 | 1.2 | 3.3 |
| Argentina | 0.9 | 1.1 | 1.1 | 3.3 | 3.7 | 1.5 | 2.9 |
| Brazil | 1.0 | 0.9 | 0.9 | 3.5 | 3.7 | 1.5 | 2.8 |
| Rest of Latin America | 1.3 | 1.7 | 1.6 | 3.6 | 3.9 | 1.0 | 2.6 |
| Middle East/Nth Africa | 1.6 | 2.0 | 1.7 | 4.2 | 4.5 | 1.0 | 2.8 |
| South Africa | 0.5 | 0.9 | 0.2 | 3.1 | 3.5 | 1.4 | 3.1 |
| Rest Sub-Saharan Africa | 2.0 | 2.6 | 2.0 | 3.6 | 4.4 | 1.0 | 2.4 |
| **High-income countries** | **0.2** | **0.1** | **-0.4** | **2.4** | **2.4** | **1.3** | **2.6** |
| **Developing countries** | **1.2** | **1.5** | **1.7** | **5.7** | **4.8** | **1.1** | **4.0** |
| **World** | **1.0** | **1.3** | **0.9** | **3.9** | **3.4** | **1.3** | **2.6** |

Additional primary sectoral TFP shocks (% per year):: coal 3.1, oil 2.8, gas 2.2, mineral resources 1.7, agriculture and food 1.3, forestry 2.0.

Source: Authors’ compilation drawing on World Bank and OECD projections.

Appendix Table A5: Endogenous international commodity price changes resulting from updating the baseline data from 2004 to 2030 and 2050

(total percentage change relative to the aggregate for all products)

| | 2030/2004 | 2050/2004 |
|---|---|---|
| Rice | 0.0 | -1.9 |
| Wheat | 5.7 | 5.4 |
| Coarse grains | 5.4 | 5.4 |
| Fruit & veg | 5.5 | 5.2 |
| Oilseeds | 4.9 | 5.0 |
| Sugar | -2.7 | -4.4 |
| Cotton | 4.6 | 3.9 |
| Other crops | 5.2 | 4.8 |
| Beef/sheep | 0.2 | -1.1 |
| Pork/chicken | 0.4 | -0.1 |
| Dairy | -2.4 | -4.9 |
| **Agriculture & food** | **2.5** | **1.6** |
| **Forestry** | **0.3** | -1.4 |
| Coal | -5.6 | 0.5 |
| Oil | -1.9 | -2.2 |
| Gas | -2.7 | -3.0 |
| **Energy** | **-2.4** | **-2.0** |
| Minerals nec | -1.3 | 3.0 |
| Fish and processed food | 1.4 | 2.0 |
| Light manufacturing | -1.1 | -1.3 |
| Heavy manufacturing | -1.5 | -1.6 |
| **Manufacturing** | **-1.0** | **-1.1** |
| Utilities & construction | -0.8 | -1.3 |
| Electricity, gas distribution | -3.0 | -1.5 |
| Transport | -1.8 | -2.6 |
| Other services | 1.0 | 1.2 |
| **Services** | **0.2** | **0.2** |

Source: Authors' simulations

Appendix Table A6: Regional shares of global GDP

(percent)

| Regions | 2004 | 2030 | 2050 |
|---|---|---|---|
| USA | 32.5 | 29.1 | 25.3 |
| Canada | 2.3 | 2.0 | 1.8 |
| EU27 and EFTA | 27.0 | 20.2 | 15.4 |
| Russia | 1.1 | 1.2 | 1.1 |
| Rest E. Europe/C. Asia | 1.0 | 1.3 | 1.3 |
| Australia | 1.2 | 1.3 | 1.3 |
| New Zealand | 0.2 | 0.2 | 0.2 |
| Japan | 13.1 | 8.7 | 6.1 |
| Korea | 1.5 | 2.2 | 2.8 |
| HongKong/Sing/Taiwan | 1.8 | 2.5 | 3.1 |
| China | 4.4 | 11.3 | 17.2 |
| Indonesia | 0.5 | 0.8 | 1.1 |
| Malaysia | 0.3 | 0.6 | 0.8 |
| Thailand | 0.4 | 0.6 | 0.8 |
| Rest of East Asia | 0.6 | 0.8 | 1.0 |
| India | 1.7 | 3.3 | 4.5 |
| Rest of South Asia | 0.5 | 0.8 | 1.1 |
| Argentina | 0.8 | 0.9 | 1.0 |
| Brazil | 1.6 | 1.8 | 1.9 |
| Rest of Latin America | 3.8 | 4.8 | 5.2 |
| Middle East/Nth Africa | 2.9 | 4.2 | 5.2 |
| South Africa | 0.4 | 0.4 | 0.4 |
| Rest Sub-Saharan Africa | 0.7 | 1.0 | 1.2 |
| **High-income countries** | 78.3 | 63.9 | 52.6 |
| **Developing countries** | 21.7 | 36.1 | 47.4 |

Appendix Table A7: Sectoral shares of national GDP, 2004, 2030 and 2050 (percent)

(a) 2004

| | Agric | Other primary | Manuf | Services | Total |
|---|---|---|---|---|---|
| USA | 2 | 1 | 16 | 82 | 100 |
| Canada | 2 | 5 | 18 | 75 | 100 |
| EU27 and EFTA | 3 | 1 | 19 | 78 | 100 |
| Russia | 8 | 16 | 15 | 62 | 100 |
| Rest E. Europe/C. Asia | 10 | 12 | 17 | 62 | 100 |
| Australia | 4 | 5 | 14 | 78 | 100 |
| New Zealand | 8 | 2 | 16 | 74 | 100 |
| Japan | 2 | 0 | 19 | 79 | 100 |
| Korea | 3 | 0 | 28 | 68 | 100 |
| HongKong/Sing/Taiwan | 1 | 1 | 25 | 73 | 100 |
| China | 12 | 7 | 33 | 48 | 100 |
| Indonesia | 12 | 13 | 25 | 50 | 100 |
| Malaysia | 2 | 15 | 49 | 33 | 100 |
| Thailand | 10 | 3 | 32 | 55 | 100 |
| Rest of East Asia | 12 | 7 | 29 | 51 | 100 |
| India | 24 | 4 | 18 | 54 | 100 |
| Rest of South Asia | 20 | 3 | 14 | 63 | 100 |
| Argentina | 9 | 6 | 15 | 71 | 100 |
| Brazil | 8 | 2 | 18 | 71 | 100 |
| Rest of Latin America | 9 | 6 | 28 | 56 | 100 |
| Middle East/Nth Africa | 6 | 26 | 12 | 56 | 100 |
| South Africa | 3 | 3 | 21 | 73 | 100 |
| Rest Sub-Saharan Africa | 22 | 23 | 11 | 44 | 100 |
| **High-income countries** | 2 | 2 | 17 | 79 | 100 |
| **Developing countries** | 10 | 8 | 24 | 57 | 100 |
| **World** | 4 | 3 | 19 | 75 | 100 |

(b) 2030

| | Agric | Other primary | Manuf | Services | Total |
|---|---|---|---|---|---|
| USA | 2 | 2 | 14 | 83 | 100 |
| Canada | 2 | 8 | 14 | 76 | 100 |
| EU27 and EFTA | 3 | 2 | 16 | 79 | 100 |
| Russia | 6 | 22 | 12 | 61 | 100 |
| Rest E. Europe/C. Asia | 8 | 13 | 16 | 63 | 100 |
| Australia | 4 | 7 | 11 | 77 | 100 |
| New Zealand | 9 | 3 | 14 | 74 | 100 |
| Japan | 2 | 1 | 16 | 82 | 100 |
| Korea | 2 | 1 | 28 | 69 | 100 |
| HongKong/Sing/Taiwan | 1 | 1 | 25 | 73 | 100 |

| | | | | | |
|---|---|---|---|---|---|
| China | 6 | 5 | 44 | 45 | 100 |
| Indonesia | 8 | 13 | 25 | 53 | 100 |
| Malaysia | 1 | 13 | 51 | 35 | 100 |
| Thailand | 8 | 4 | 32 | 57 | 100 |
| Rest of East Asia | 9 | 9 | 30 | 53 | 100 |
| India | 19 | 5 | 18 | 58 | 100 |
| Rest of South Asia | 16 | 3 | 15 | 66 | 100 |
| Argentina | 9 | 8 | 13 | 70 | 100 |
| Brazil | 9 | 4 | 16 | 72 | 100 |
| Rest of Latin America | 8 | 8 | 27 | 57 | 100 |
| Middle East/Nth Africa | 5 | 25 | 13 | 56 | 100 |
| South Africa | 4 | 6 | 17 | 73 | 100 |
| Rest Sub-Saharan Africa | 19 | 23 | 12 | 45 | 100 |
| **High-income countries** | 3 | 3 | 15 | 80 | 100 |
| **Developing countries** | 8 | 8 | 28 | 56 | 100 |
| **World** | 4 | 4 | 19 | 73 | 100 |

(c) 2050

| | Agric | Other primary | Manuf | Services | Total |
|---|---|---|---|---|---|
| USA | 2 | 2 | 11 | 84 | 100 |
| Canada | 2 | 11 | 11 | 77 | 100 |
| EU27 and EFTA | 3 | 4 | 14 | 80 | 100 |
| Russia | 5 | 28 | 8 | 59 | 100 |
| Rest E. Europe/C. Asia | 8 | 14 | 14 | 64 | 100 |
| Australia | 4 | 9 | 9 | 77 | 100 |
| New Zealand | 9 | 4 | 13 | 74 | 100 |
| Japan | 2 | 1 | 11 | 86 | 100 |
| Korea | 2 | 1 | 27 | 70 | 100 |
| HongKong/Sing/Taiwan | 1 | 2 | 24 | 74 | 100 |
| China | 3 | 5 | 47 | 45 | 100 |
| Indonesia | 6 | 13 | 25 | 56 | 100 |
| Malaysia | 1 | 13 | 52 | 35 | 100 |
| Thailand | 7 | 4 | 31 | 59 | 100 |
| Rest of East Asia | 7 | 10 | 30 | 54 | 100 |
| India | 17 | 5 | 18 | 61 | 100 |
| Rest of South Asia | 13 | 4 | 15 | 68 | 100 |
| Argentina | 8 | 10 | 12 | 70 | 100 |
| Brazil | 11 | 5 | 13 | 72 | 100 |
| Rest of Latin America | 7 | 9 | 26 | 59 | 100 |
| Middle East/Nth Africa | 5 | 25 | 13 | 57 | 100 |
| South Africa | 4 | 8 | 15 | 73 | 100 |
| Rest Sub-Saharan Africa | 19 | 23 | 12 | 46 | 100 |
| **High-income countries** | 3 | 4 | 12 | 81 | 100 |
| **Developing countries** | 6 | 8 | 29 | 57 | 100 |
| **World** | 4 | 6 | 18 | 72 | 100 |

Appendix Table A8: National share of world agricultural GDP

(percent)

| Regions | 2004 | 2030 | 2050 |
|---|---|---|---|
| USA | 12.7 | 13.9 | 15.0 |
| Canada | 1.3 | 1.3 | 1.1 |
| EU27 and EFTA | 21.2 | 18.0 | 15.7 |
| Russia | 2.9 | 2.3 | 1.8 |
| Rest E. Europe/C. Asia | 4.4 | 4.4 | 4.2 |
| Australia | 1.6 | 1.9 | 2.1 |
| New Zealand | 0.5 | 0.5 | 0.6 |
| Japan | 5.0 | 3.6 | 3.2 |
| Korea | 1.2 | 1.2 | 1.4 |
| HongKong/Sing/Taiwan | 0.5 | 0.5 | 0.5 |
| China | 12.2 | 11.5 | 8.9 |
| Indonesia | 2.2 | 2.1 | 2.1 |
| Malaysia | 0.2 | 0.2 | 0.2 |
| Thailand | 0.9 | 1.0 | 1.1 |
| Rest of East Asia | 1.5 | 1.3 | 1.3 |
| India | 10.0 | 12.8 | 14.9 |
| Rest of South Asia | 2.5 | 2.9 | 3.0 |
| Argentina | 0.8 | 0.8 | 0.8 |
| Brazil | 3.2 | 4.0 | 5.1 |
| Rest of Latin America | 6.4 | 5.8 | 5.7 |
| Middle East/Nth Africa | 3.7 | 4.1 | 4.4 |
| South Africa | 0.4 | 0.6 | 0.6 |
| Rest Sub-Saharan Africa | 4.5 | 5.1 | 6.1 |
| **High-income countries** | 49.7 | 46.0 | 43.7 |
| **Developing countries** | 50.3 | 54.0 | 56.3 |

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Appendix Table A9: Primary factor shares of total GDP, 2004, 2030 and 2050

(%)

(a) 2004

| Regions | Unskilled labor | Skilled labor | Capital | Land | Other natural resources |
|---|---|---|---|---|---|
| USA | 40.7 | 31.4 | 27.3 | 0.3 | 0.3 |
| Canada | 38.4 | 23.3 | 36.3 | 0.2 | 1.8 |
| EU27 and EFTA | 34.1 | 24.4 | 40.9 | 0.3 | 0.4 |
| Russia | 28.6 | 12.8 | 51.1 | 1.8 | 5.7 |
| Rest E. Europe/C. Asia | 29.5 | 12.2 | 53.2 | 1.5 | 3.7 |
| Australia | 34.9 | 24.9 | 38.2 | 0.6 | 1.4 |
| New Zealand | 33.5 | 17.8 | 47.4 | 0.7 | 0.6 |
| Japan | 36.7 | 22.5 | 40.5 | 0.2 | 0.1 |
| Korea | 35.3 | 15.8 | 47.3 | 1.4 | 0.2 |
| HongKong/Sing/Taiwan | 31.1 | 21.8 | 46.4 | 0.4 | 0.3 |
| China | 39.7 | 11.1 | 43.4 | 3.3 | 2.5 |
| Indonesia | 32.0 | 8.0 | 50.5 | 5.7 | 3.8 |
| Malaysia | 36.8 | 11.8 | 45.8 | 1.1 | 4.6 |
| Thailand | 21.7 | 8.9 | 63.9 | 4.1 | 1.3 |
| Rest of East Asia | 30.4 | 11.5 | 50.4 | 4.7 | 2.9 |
| India | 34.8 | 10.8 | 44.2 | 9.0 | 1.2 |
| Rest of South Asia | 35.5 | 12.2 | 43.5 | 7.6 | 1.1 |
| Argentina | 38.0 | 17.1 | 40.6 | 2.3 | 2.0 |
| Brazil | 35.5 | 20.0 | 42.5 | 1.1 | 0.9 |
| Rest of Latin America | 30.7 | 15.1 | 49.8 | 2.2 | 2.2 |
| Middle East/Nth Africa | 22.4 | 11.1 | 56.7 | 0.6 | 9.2 |
| South Africa | 31.5 | 17.8 | 49.4 | 0.4 | 1.0 |
| Rest SubSaharan Africa | 31.9 | 9.0 | 49.5 | 2.6 | 7.0 |
| **High-income countries** | 36.9 | 26.2 | 36.0 | 0.3 | 0.5 |
| **Developing countries** | 32.9 | 13.7 | 47.7 | 2.8 | 2.8 |
| **World** | 36.1 | 23.8 | 38.2 | 0.8 | 1.0 |

Source: Authors' compilation drawing on World Bank and OECD projections.

Appendix Table A9 (continued): Primary factor shares of total GDP, 2004, 2030 and 2050

(%)

(b) 2030

| Regions | Unskilled labor | Skilled labor | Capital | Land | Other natural resources |
|---|---|---|---|---|---|
| USA | 39.6 | 28.8 | 30.1 | 0.6 | 1.0 |
| Canada | 36.2 | 20.7 | 38.1 | 0.5 | 4.6 |
| EU27 and EFTA | 32.2 | 22.3 | 43.7 | 0.6 | 1.2 |
| Russia | 23.5 | 11.6 | 49.3 | 1.3 | 14.3 |
| Rest E. Europe/C. Asia | 25.6 | 11.7 | 53.0 | 1.7 | 7.9 |
| Australia | 32.3 | 21.8 | 40.9 | 0.9 | 4.0 |
| New Zealand | 30.8 | 15.5 | 50.2 | 1.6 | 1.8 |
| Japan | 34.7 | 20.2 | 44.5 | 0.3 | 0.2 |
| Korea | 29.1 | 15.4 | 54.2 | 0.9 | 0.4 |
| HongKong/Sing/Taiwan | 26.1 | 19.1 | 53.5 | 0.3 | 0.9 |
| China | 29.5 | 10.7 | 54.8 | 1.4 | 3.6 |
| Indonesia | 27.8 | 8.4 | 51.8 | 4.1 | 8.0 |
| Malaysia | 32.2 | 12.7 | 46.1 | 0.7 | 8.3 |
| Thailand | 18.5 | 9.1 | 66.8 | 3.2 | 2.4 |
| Rest of East Asia | 26.6 | 11.7 | 52.1 | 3.7 | 5.8 |
| India | 29.5 | 11.2 | 48.4 | 8.3 | 2.6 |
| Rest of South Asia | 31.2 | 12.5 | 46.6 | 7.3 | 2.5 |
| Argentina | 34.2 | 18.0 | 40.4 | 3.0 | 4.4 |
| Brazil | 32 | 20.0 | 42.9 | 2.7 | 2.3 |
| Rest of Latin America | 27.7 | 15.6 | 49.5 | 2.4 | 4.8 |
| Middle East/Nth Africa | 19.5 | 10.8 | 51.3 | 1.2 | 17.2 |
| South Africa | 29.1 | 17.1 | 49.3 | 1.2 | 3.4 |
| Rest SubSaharan Africa | 27.9 | 9.0 | 44.0 | 5.3 | 13.8 |
| **High-income countries** | 35.2 | 24.0 | 38.5 | 0.6 | 1.7 |
| **Developing countries** | 27.8 | 13.0 | 51.4 | 2.6 | 5.3 |
| **World** | 33.0 | 20.8 | 42.3 | 1.2 | 2.7 |

Source: Authors’ compilation drawing on World Bank and OECD projections.

Appendix Table A9 (continued): Primary factor shares of total GDP, 2004, 2030 and 2050

(%)

(c) 2050

| Regions | Unskilled labor | Skilled labor | Capital | Land | Other natural resources |
|---|---|---|---|---|---|
| USA | 38.1 | 27.0 | 32.3 | 0.8 | 1.8 |
| Canada | 33.5 | 18.8 | 39.1 | 0.6 | 7.9 |
| EU27 and EFTA | 29.9 | 20.7 | 45.7 | 1.0 | 2.6 |
| Russia | 20.2 | 10.6 | 47.2 | 0.9 | 21.2 |
| Rest E. Europe/C. Asia | 23.3 | 11.2 | 52.3 | 2.3 | 11.0 |
| Australia | 29.5 | 19.8 | 42.7 | 1.2 | 6.8 |
| New Zealand | 28.2 | 14.2 | 52.1 | 2.5 | 3.1 |
| Japan | 33.2 | 18.2 | 47.3 | 0.6 | 0.6 |
| Korea | 25.7 | 13.9 | 59.1 | 0.8 | 0.6 |
| HongKong/Sing/Taiwan | 22.7 | 16.5 | 58.9 | 0.3 | 1.6 |
| China | 24.2 | 10.0 | 61.5 | 0.6 | 3.7 |
| Indonesia | 24.6 | 7.8 | 54.1 | 3.5 | 10.0 |
| Malaysia | 29.5 | 11.8 | 48.2 | 0.6 | 9.9 |
| Thailand | 16.4 | 8.6 | 69.3 | 2.6 | 3.1 |
| Rest of East Asia | 23.8 | 11.4 | 53.5 | 3.5 | 7.8 |
| India | 26.3 | 10.7 | 52.6 | 7.2 | 3.2 |
| Rest of South Asia | 28.3 | 12.2 | 49.6 | 6.7 | 3.2 |
| Argentina | 31.8 | 17.4 | 40.1 | 4.0 | 6.7 |
| Brazil | 29.6 | 19.2 | 43.6 | 4.0 | 3.6 |
| Rest of Latin America | 25.7 | 15.2 | 49.7 | 2.8 | 6.6 |
| Middle East/Nth Africa | 17.5 | 10.2 | 50.0 | 1.7 | 20.6 |
| South Africa | 26.4 | 15.9 | 49.5 | 2.0 | 6.1 |
| Rest SubSaharan Africa | 25.6 | 8.8 | 41.5 | 6.9 | 17.2 |
| **High-income countries** | 33.4 | 22.4 | 40.1 | 0.9 | 3.1 |
| **Developing countries** | 24.4 | 12.0 | 54.9 | 2.4 | 6.3 |
| **World** | 30.0 | 18.5 | 45.7 | 1.5 | 4.3 |

Source: Authors’ compilation drawing on World Bank and OECD projections.

Appendix Table A10: Unskilled labour share of agricultural and non-agricultural GDP, 2004, 2030 and 2050

(%)

| | Agricultural GDP | | | Non-agricultural GDP | | |
|---|---|---|---|---|---|---|
| | 2004 | 2030 | 2050 | 2004 | 2030 | 2050 |
| USA | 45.0 | 44.5 | 43.2 | 40.6 | 39.5 | 37.9 |
| Canada | 42.3 | 42.1 | 39.8 | 38.3 | 36.0 | 33.4 |
| EU27 and EFTA | 55.0 | 53.4 | 49.1 | 33.6 | 31.5 | 29.3 |
| Russia | 51.4 | 57.5 | 65.4 | 26.7 | 21.3 | 17.9 |
| Rest E. Europe/C. Asia | 52.5 | 54.3 | 51.7 | 27.0 | 23.0 | 20.9 |
| Australia | 48.0 | 45.3 | 43.3 | 34.3 | 31.8 | 28.9 |
| New Zealand | 56.2 | 55.1 | 52.5 | 31.6 | 28.5 | 25.7 |
| Japan | 44.7 | 49.8 | 49.9 | 36.6 | 34.4 | 32.9 |
| Korea | 39.9 | 46.2 | 45.4 | 35.2 | 28.8 | 25.3 |
| HongKong/Sing/Taiwan | 49.4 | 51.5 | 50.7 | 30.9 | 25.8 | 22.5 |
| China | 57.1 | 68.4 | 77.5 | 37.3 | 27.2 | 22.4 |
| Indonesia | 42.5 | 42.6 | 39.8 | 30.5 | 26.4 | 23.6 |
| Malaysia | 40.7 | 42.0 | 38.7 | 36.7 | 32.0 | 29.5 |
| Thailand | 39.3 | 41.9 | 43.6 | 19.8 | 16.6 | 14.5 |
| Rest of East Asia | 44.9 | 43.1 | 39.2 | 28.4 | 25.0 | 22.7 |
| India | 40.3 | 38.7 | 38.3 | 33.0 | 27.3 | 23.8 |
| Rest of South Asia | 35.3 | 32.0 | 29.5 | 35.6 | 31.0 | 28.1 |
| Argentina | 46.9 | 46.0 | 39.6 | 37.1 | 33.1 | 31.1 |
| Brazil | 25.3 | 25.1 | 24.7 | 36.5 | 32.8 | 30.2 |
| Rest of Latin America | 45.7 | 42.8 | 38.2 | 29.1 | 26.5 | 24.8 |
| Middle East/Nth Africa | 55.1 | 51.9 | 45.7 | 20.2 | 17.7 | 16.2 |
| South Africa | 35.2 | 30.3 | 25.2 | 31.3 | 29.0 | 26.5 |
| Rest SubSaharan Africa | 68.0 | 57.3 | 49.9 | 22.0 | 21.0 | 19.9 |
| **High-income countries** | | | | | | |
| **Developing countries** | | | | | | |
| **World** | | | | | | |

Source: Authors' compilation from GTAP model projections

Appendix Table A11: Agriculture's share of total employment of unskilled labour, 2004, 2030 and 2050

(%)

| | 2004 | 2030 | 2050 |
|---|---|---|---|
| USA | 1.8 | 2.2 | 2.7 |
| Canada | 2.4 | 2.8 | 2.5 |
| EU27 and EFTA | 4.1 | 4.9 | 5.4 |
| Russia | 13.6 | 14.8 | 15.7 |
| Rest E. Europe/C. Asia | 17.8 | 17.6 | 17.1 |
| Australia | 5.4 | 6.0 | 6.2 |
| New Zealand | 13.1 | 15.6 | 17.5 |
| Japan | 1.9 | 2.4 | 2.9 |
| Korea | 3.3 | 3.4 | 3.3 |
| HongKong/Sing/Taiwan | 2.0 | 2.0 | 1.9 |
| China | 17.4 | 13.3 | 10.4 |
| Indonesia | 16.5 | 12.6 | 10.3 |
| Malaysia | 2.5 | 1.7 | 1.3 |
| Thailand | 17.7 | 17.3 | 17.7 |
| Rest of East Asia | 18.1 | 13.8 | 11.2 |
| India | 28.0 | 25.0 | 24.9 |
| Rest of South Asia | 20.3 | 16.6 | 13.8 |
| Argentina | 11.3 | 11.5 | 10.5 |
| Brazil | 5.9 | 7.3 | 8.8 |
| Rest of Latin America | 14.0 | 11.6 | 9.8 |
| Middle East/Nth Africa | 15.0 | 13.9 | 12.1 |
| South Africa | 3.6 | 4.2 | 4.0 |
| Rest SubSaharan Africa | 46.0 | 39.0 | 36.9 |
| **High-income countries** | **3.2** | **3.8** | **4.2** |
| **Developing countries** | **14.8** | **12.9** | **11.6** |
| **World** | **5.2** | **6.1** | **6.5** |

Source: Authors' compilation from GTAP model projections

Table 1: Exogenous Yield Shocks (%) attributed to Climate Change in 2030, by region and sector

| Regions | Rice | Wheat | Coarse grains | Fruits Veg | Oil seeds | Cotton | Other crops |
|---|---|---|---|---|---|---|---|
| USA | -3 | 2 | 3 | 2 | 2 | -3 | 2 |
| Canada | -3 | 7 | -10 | 2 | 10 | -3 | 2 |
| EU27 and EFTA | 7 | 7 | -5 | 7 | 7 | 7 | 7 |
| Russia | 7 | 7 | -5 | 7 | 7 | 7 | 7 |
| Rest of Europe/C. Asia | 7 | 7 | -5 | 7 | 7 | 7 | 7 |
| Australia | -3 | 7 | -5 | -3 | 2 | -3 | 7 |
| New Zealand | 7 | 7 | -5 | 7 | 2 | 7 | 7 |
| Japan | 9 | 4 | 0 | 4 | 9 | 9 | 4 |
| Korea | 12 | 12 | 5 | 12 | 12 | 12 | 12 |
| HongKong/Sing/Taiwan | 12 | 12 | 5 | -3 | 12 | 12 | 12 |
| China | 0 | 2 | -10 | -8 | 0 | 0 | -8 |
| Indonesia | -3 | -3 | -10 | 7 | -3 | -3 | -3 |
| Malaysia | -3 | -3 | -10 | -3 | -3 | -3 | -3 |
| Thailand | -3 | -3 | -10 | -3 | -3 | -3 | -3 |
| Rest of East Asia | -3 | -3 | -10 | -3 | -3 | -3 | -3 |
| India | -5 | -3 | -10 | -3 | -3 | -3 | -3 |
| Rest of South Asia | -5 | -3 | -10 | -3 | -3 | -3 | -3 |
| Argentina | -3 | -3 | -10 | -3 | -3 | -3 | -3 |
| Brazil | -3 | -3 | -10 | -3 | 2 | -3 | -3 |
| Rest of Latin America | -3 | -3 | -5 | -3 | -3 | -3 | -3 |
| Middle East/Nth Africa | 2 | 2 | -5 | 2 | 2 | 2 | 2 |
| South Africa | -8 | -8 | -20 | -8 | -8 | -8 | -8 |
| Rest Sub-Saharan Africa | -3 | -3 | -10 | -3 | -3 | -3 | -3 |

Source: Hertel, Burke and Lobell (2010)

Table 2: Effects of economic growth, and of crop yield changes due to climate change, on agricultural self sufficiency, from 2004 to 2030 and 2050
(percent)

| Regions | Base-2004 | Base-2030 | Yield shock-2030 | Yield +Labor shock 2030 | Base-2050 | Yield shock-2050 | Yield +Labor shock 2050 |
|---|---|---|---|---|---|---|---|
| USA | 103.4 | 111.8 | 112.3 | 112.3 | 122.4 | 123.4 | 123.3 |
| Canada | 108.3 | 119.0 | 120.1 | 120.0 | 130.0 | 133.8 | 133.6 |
| EU27 and EFTA | 94.0 | 100.9 | 101.7 | 101.7 | 111.1 | 115.2 | 115.0 |
| Russia | 89.2 | 89.6 | 90.0 | 90.0 | 90.5 | 92.0 | 92.0 |
| Rest of EE/C Asia | 100.2 | 100.0 | 101.2 | 101.1 | 106.6 | 111.6 | 111.1 |
| Australia | 137.9 | 152.1 | 153.4 | 153.7 | 167.0 | 172.5 | 173.1 |
| New Zealand | 161.2 | 171.9 | 173.2 | 173.5 | 186.3 | 191.9 | 192.3 |
| Japan | 82.5 | 83.3 | 83.7 | 83.7 | 84.6 | 85.8 | 85.8 |
| Korea | 81.4 | 79.5 | 81.8 | 81.7 | 78.3 | 82.7 | 82.6 |
| HK/Sing/Taiwan | 65.9 | 65.2 | 65.7 | 65.4 | 65.5 | 64.7 | 64.6 |
| China | 97.2 | 90.3 | 89.4 | 89.3 | 85.8 | 82.8 | 82.6 |
| Indonesia | 94.7 | 84.2 | 83.9 | 84.0 | 79.0 | 82.7 | 82.8 |
| Malaysia | 60.3 | 45.3 | 44.7 | 44.8 | 39.1 | 37.7 | 38.0 |
| Thailand | 111.9 | 97.5 | 96.8 | 96.8 | 88.5 | 86.7 | 86.6 |
| Rest of East Asia | 99.5 | 89.5 | 88.8 | 88.8 | 86.0 | 84.2 | 84.1 |
| India | 101.2 | 95.1 | 94.3 | 94.3 | 87.5 | 85.3 | 85.5 |
| Rest of Sth. Asia | 95.7 | 86.1 | 85.4 | 85.5 | 78.8 | 77.3 | 77.5 |
| Argentina | 142 | 145.8 | 144.1 | 143.9 | 154.9 | 153.1 | 151.9 |
| Brazil | 122.5 | 132.0 | 131.5 | 131.8 | 144.1 | 143.9 | 144.3 |
| Rest of L America | 101.7 | 94.9 | 94.3 | 94.2 | 93.7 | 91.5 | 91.4 |
| M. East/N. Africa | 83.6 | 82.8 | 83.1 | 82.7 | 83.1 | 83.9 | 83.3 |
| South Africa | 106.9 | 115.4 | 114.5 | 114.6 | 129.0 | 125.8 | 125.7 |
| Rest of SS Africa | 102.2 | 97.2 | 96.1 | 95.8 | 96.7 | 93.5 | 93.1 |
| **High-income countries** | **96.1** | **111.8** | 112.4 | 112.3 | 126.9 | 129.7 | 129.3 |
| **Developing countries** | **99.8** | **92.5** | 91.9 | 91.9 | 88.6 | 86.8 | 86.8 |

Source: Authors' simulations, assuming the crop productivity shocks of climate change are those shown in Table 1 by 2030 and twice those by 2050.

Table 3: Effects of crop productivity shocks due to climate change on agricultural production, consumption and trade, 2030 and 2050
(percent deviation from baseline in projected year)

(c) 2030: Average difference in world agric prices in 2030 = 0.23%

| Regions | Farmer price | Agricultural production volume | Agricultural consumption volume | Agricultural value added | Agricultural value of exports | Agricultural value of imports |
|---|---|---|---|---|---|---|
| USA | 0.3 | 0.4 | -0.1 | -1.2 | 2.5 | -0.6 |
| Canada | 0.2 | 1.1 | 0.2 | -1.8 | 3.5 | 0.5 |
| EU27 and EFTA | -0.3 | 1.1 | 0.3 | -0.5 | 3.3 | -0.7 |
| Russia | -0.2 | 0.7 | 0.2 | -0.6 | 9.1 | -1.5 |
| Rest of Europe/C. Asia | -0.6 | 1.6 | 0.3 | -0.7 | 12.1 | -1.8 |
| Australia | 0.5 | 0.7 | -0.1 | -1.7 | 2.2 | 1.0 |
| New Zealand | 0.1 | 1.2 | 0.4 | -1.5 | 2.1 | -0.4 |
| Japan | -0.4 | 0.7 | 0.2 | 0.1 | 13.6 | -0.9 |
| Korea | -3.5 | 4.3 | 1.4 | 0.1 | 43.8 | -5.8 |
| HongKong/Sing/Taiwan | 0.3 | 1.2 | 0.4 | -1.9 | 10.9 | 0.7 |
| China | 4.3 | -1.8 | -0.8 | -4.4 | -21.1 | 6.2 |
| Indonesia | 1.2 | -0.6 | -0.2 | -0.7 | 8.3 | 1.7 |
| Malaysia | 1.0 | -1.1 | 0.4 | -0.1 | -1.1 | 1.6 |
| Thailand | 2.2 | -1.5 | -0.7 | -1.8 | -1.6 | 3.7 |
| Rest of East Asia | 1.6 | -1.3 | -0.5 | -0.7 | -2.9 | 3.3 |
| India | 3.2 | -1.7 | -0.9 | -2.0 | -6.7 | 12.7 |
| Rest of South Asia | 1.2 | -1.1 | -0.3 | -0.4 | -3.7 | 4.1 |
| Argentina | 0.9 | -1.8 | -0.6 | 0.4 | -3.9 | 1.5 |
| Brazil | 0.5 | -0.7 | -0.4 | 0.0 | -1.7 | 0.6 |
| Rest of Latin America | 0.9 | -0.9 | -0.3 | -0.4 | -4.5 | 2.2 |
| Middle East/Nth Africa | -0.1 | 0.6 | 0.2 | -0.4 | 5.1 | -0.3 |
| South Africa | 0.9 | -1.2 | -0.4 | -1.1 | -3.1 | 1.7 |
| Rest Sub-Saharan Africa | 2.5 | -1.7 | -0.6 | -1.3 | -6.6 | 2.6 |
| **High-income countries** | **-0.1** | **0.8** | **0.4** | **-0.8** | **1.8** | **-0.8** |
| **Developing countries** | **2.3** | **-1.1** | **-0.5** | **-2.1** | **-2.6** | **3.4** |
| **World** | **1.2** | **-0.2** | **-0.1** | **-1.6** | **0.9** | **1.5** |

Table 3 (continued): Effects of crop productivity shocks due to climate change on agricultural production, consumption and trade, 2030 and 2050
(percent deviation from baseline in projected year)

(d) 2050: Average difference in world agric prices in 2050 = 1.69%

| Regions | Farmer price | Agricultural production volume | Agricultural consumption volume | Agricultural value added | Agricultural value of exports | Agricultural value of imports |
|---|---|---|---|---|---|---|
| USA | 3.0 | -0.8 | -1.6 | -5.6 | 2.8 | 3.6 |
| Canada | 1.6 | 3.0 | 0.2 | -7.2 | 9.5 | 2.8 |
| EU27 and EFTA | 0.0 | 4.8 | 1.0 | -5.3 | 14.2 | -0.4 |
| Russia | 0.4 | 2.2 | 0.5 | -3.8 | 31.9 | -0.9 |
| Rest of Europe/C. Asia | 0.2 | 4.9 | 0.2 | -5.7 | 30.5 | 0.0 |
| Australia | 1.8 | 3.1 | -0.2 | -6.5 | 7.8 | 3.4 |
| New Zealand | 1.1 | 3.8 | 0.8 | -6.2 | 7.1 | 0.9 |
| Japan | -0.2 | 2.6 | 1.1 | -3.0 | 30.1 | 0.5 |
| Korea | -4.1 | 8.7 | 2.9 | -5.5 | 101.5 | -5.2 |
| HongKong/Sing/Taiwan | 1.4 | -0.5 | 0.7 | -2.2 | 1.4 | 2.7 |
| China | 12.9 | -5.2 | -1.8 | -11.1 | -40.3 | 17.1 |
| Indonesia | -5.3 | 7.3 | 2.4 | -1.3 | 116.3 | -14.5 |
| Malasya | 2.5 | -2.0 | 1.8 | -0.7 | 0.5 | 4.2 |
| Thailand | 4.9 | -2.9 | -0.9 | -3.4 | 2.9 | 10.1 |
| Rest of East Asia | 4.0 | -2.9 | -0.8 | -1.9 | -3.4 | 7.9 |
| India | 6.0 | -4.1 | -1.7 | -2.5 | -4.2 | 14.8 |
| Rest of South Asia | 2.8 | -2.4 | -0.5 | -0.7 | -7.1 | 6.2 |
| Argentina | 3.7 | -4.1 | -3.0 | -1.6 | -5.7 | 4.9 |
| Brazil | 2.1 | -1.5 | -1.3 | -1.6 | -1.7 | 2.4 |
| Rest of Latin America | 5.3 | -3.5 | -1.1 | -4.8 | -10.6 | 11.1 |
| Middle East/Nth Africa | 0.5 | 1.5 | 0.5 | -2.5 | 12.4 | 0.3 |
| South Africa | 5.1 | -5.5 | -3.2 | -9.2 | -8.7 | 6.5 |
| Rest Sub-Saharan Africa | 9.2 | -5.1 | -1.8 | -5.4 | -16.4 | 10.2 |
| **High-income countries** | **1.2** | **2.6** | **0.4** | **-5.4** | **7.2** | **0.4** |
| **Developing countries** | **6.6** | **-3.0** | **-1.1** | **-5.6** | **-3.2** | **9.0** |
| **World** | **4.5** | **-0.8** | **-0.6** | **-5.5** | **5.1** | **6.6** |

Source: Authors' simulations, assuming that climate change involves twice the crop productivity shocks shown in Table 1 by 2030 or 2050 relative to the baseline in that year.

Table 4: Effects on national economic welfare of crop productivity losses, 2030 and 2050

(2004 US$ million, deviation from baseline in projected year)

(c) 2030

| | Due to changes in: | | | | |
|---|---|---|---|---|---|
| Regions | Factor productivity | Terms of trade | Resource use efficiency | Total economic welfare | Total economic welfare as % of Income |
| USA | 86 | 912 | -265 | 732 | 0.00 |
| Canada | 114 | 43 | -97 | 61 | 0.00 |
| EU27 and EFTA | 804 | 505 | -1639 | -330 | 0.00 |
| Russia | 183 | -186 | -65 | -67 | -0.01 |
| Rest of Europe/C. Asia | 612 | 84 | 194 | 889 | 0.07 |
| Australia | 8 | 341 | -30 | 319 | 0.03 |
| New Zealand | 17 | 49 | 1 | 68 | 0.04 |
| Japan | 189 | -94 | -265 | -171 | 0.00 |
| Korea | 857 | 115 | -909 | 63 | 0.00 |
| HongKong/Sing/Taiwan | 33 | 46 | -5 | 75 | 0.01 |
| China | -7656 | -1805 | -175 | -9636 | -0.21 |
| Indonesia | -280 | -5 | 13 | -272 | -0.05 |
| Malaysia | -62 | -34 | 20 | -76 | -0.02 |
| Thailand | -354 | 180 | -99 | -274 | -0.08 |
| Rest of East Asia | -418 | -38 | -1 | -456 | -0.12 |
| India | -5894 | -294 | 425 | -5764 | -0.34 |
| Rest of South Asia | -946 | -167 | 93 | -1021 | -0.24 |
| Argentina | -173 | 200 | -132 | -106 | -0.04 |
| Brazil | -304 | 226 | 17 | -61 | -0.01 |
| Rest of Latin America | -952 | 18 | 221 | -713 | -0.03 |
| Middle East/Nth Africa | 201 | -282 | 22 | -59 | 0.00 |
| South Africa | -84 | 116 | -12 | 20 | 0.01 |
| Rest Sub-Saharan Africa | -1468 | 74 | 25 | -1370 | -0.21 |
| **High-income countries** | 2013 | 1654 | -2166 | 1501 | 0.00 |
| **Developing countries** | -17500 | -1652 | -497 | -19649 | -0.11 |
| **World** | -15487 | 2 | -2663 | -18148 | -0.03 |

Table 4 (continued): Effects on national economic welfare of crop productivity losses, 2030 and 2050

(2004 US$ million, deviation from baseline in projected year)

(d) 2050

| | Due to changes in: | | | | |
|---|---|---|---|---|---|
| | Factor productivity | Terms of trade | Resource use efficiency | Total economic welfare | Total economic welfare as % of Income |
| USA | -4838 | 9300 | 1125 | 5587 | 0.03 |
| Canada | 434 | 800 | -552 | 682 | 0.04 |
| EU27 and EFTA | 1723 | 5146 | -8512 | -1643 | -0.01 |
| Russia | 239 | -1110 | -184 | -1055 | -0.08 |
| Rest of Europe/C. Asia | 2104 | 885 | 1302 | 4292 | 0.24 |
| Australia | 226 | 2961 | -75 | 3112 | 0.19 |
| New Zealand | 66 | 455 | 21 | 543 | 0.24 |
| Japan | 199 | -588 | -1116 | -1505 | -0.03 |
| Korea | 2170 | 590 | -2577 | 183 | 0.01 |
| HongKong/Sing/Taiwan | -129 | 344 | -65 | 150 | 0.01 |
| China | -39341 | -16630 | -569 | -56540 | -0.68 |
| Indonesia | 6143 | 172 | -464 | 5851 | 0.56 |
| Malaysia | -226 | 32 | 149 | -45 | -0.01 |
| Thailand | -1417 | 663 | -379 | -1133 | -0.19 |
| Rest of East Asia | -1445 | -417 | -28 | -1890 | -0.28 |
| India | -23668 | -2305 | 1309 | -24664 | -0.82 |
| Rest of South Asia | -3487 | -973 | 467 | -3993 | -0.53 |
| Argentina | -716 | 1186 | -454 | 17 | 0.00 |
| Brazil | -1346 | 1929 | 1 | 585 | 0.04 |
| Rest of Latin America | -5424 | -1213 | 612 | -6026 | -0.15 |
| Middle East/Nth Africa | 841 | -2010 | 219 | -951 | -0.03 |
| South Africa | -624 | 1248 | -74 | 551 | 0.11 |
| Rest Sub-Saharan Africa | -7854 | -431 | 207 | -8078 | -0.75 |
| **High-income countries** | 153 | 17849 | -7990 | 10012 | 0.02 |
| **Developing countries** | -76523 | -17815 | -1647 | -95986 | -0.32 |
| **World** | -76370 | 34 | -9638 | -85974 | -0.11 |

Source: authors' simulations

Table 5: Effects on agricultural production, consumption and trade of crop productivity losses **and** decreases in unskilled labour productivity, 2030 and 2050

(percent deviation from baseline in projected year)

(c) 2030: average difference in world agric prices = 0.44%

| | Farmer price | Agricultural production volume | Agricultural consumption volume | Agricultural value added | Agricultural value of exports | Agricultural value of imports |
|---|---|---|---|---|---|---|
| USA | 0.4 | 0.4 | 0.0 | -1.2 | 2.4 | -0.7 |
| Canada | 0.3 | 1.0 | 0.2 | -1.8 | 3.4 | 0.7 |
| EU27 and EFTA | -0.1 | 1.1 | 0.3 | -0.7 | 3.5 | -0.6 |
| Russia | 0.0 | 0.6 | 0.1 | -0.7 | 9.0 | -1.6 |
| Rest of Europe/C. Asia | -0.4 | 1.4 | 0.3 | -0.8 | 10.9 | -1.7 |
| Australia | 0.6 | 0.9 | -0.1 | -2.0 | 2.7 | 0.9 |
| New Zealand | 0.4 | 1.2 | 0.3 | -1.8 | 2.4 | -0.1 |
| Japan | -0.3 | 0.7 | 0.3 | -0.1 | 13.6 | -0.8 |
| Korea | -3.0 | 3.5 | 0.8 | 0.3 | 41.7 | -5.9 |
| HongKong/Sing/Taiwan | 0.6 | 0.2 | -0.2 | -1.5 | 9.3 | 0.5 |
| China | 4.8 | -2.8 | -1.7 | -4.0 | -23.2 | 6.1 |
| Indonesia | 1.3 | -1.2 | -1.0 | 0.0 | 8.4 | 0.7 |
| Malaysia | 1.0 | -1.6 | -0.3 | 0.6 | 0.2 | 0.7 |
| Thailand | 2.5 | -1.5 | -0.7 | -2.0 | -1.6 | 4.0 |
| Rest of East Asia | 1.9 | -2.0 | -1.2 | -0.3 | -3.1 | 3.0 |
| India | 3.3 | -2.3 | -1.5 | -1.5 | -8.7 | 10.3 |
| Rest of South Asia | 1.4 | -1.7 | -1.0 | 0.1 | -2.8 | 2.7 |
| Argentina | 1.1 | -1.8 | -0.5 | 0.3 | -4.3 | 1.6 |
| Brazil | 0.7 | -1.2 | -1.1 | 0.5 | -1.6 | -0.1 |
| Rest of Latin America | 1.2 | -1.7 | -1.0 | 0.1 | -5.4 | 2.1 |
| Middle East/Nth Africa | 0.4 | -0.6 | -0.5 | 0.0 | 2.5 | 0.2 |
| South Africa | 1.1 | -1.2 | -0.5 | -1.3 | -3.1 | 1.5 |
| Rest Sub-Saharan Africa | 3.0 | -2.9 | -1.5 | -0.6 | -8.7 | 2.9 |
| **High-income countries** | **0.1** | **0.8** | **0.4** | **-0.9** | **1.6** | **-0.7** |
| **Developing countries** | **2.6** | **-1.9** | **-1.2** | **-1.6** | **-3.5** | **3.0** |
| **World** | **1.4** | **-0.6** | **-0.5** | **-1.4** | **0.6** | **1.4** |

Table 5 (continued): Effects of on agricultural production, consumption and trade of crop productivity losses and decreases in unskilled labour productivity, 2030 and 2050

(percent deviation from baseline in projected year)

(d) 2050: average difference in world agric prices = 1.90%

| Regions | Farmer price | Agricultural production volume | Agricultural consumption volume | Agricultural value added | Agricultural value of exports | Agricultural value of imports |
|---|---|---|---|---|---|---|
| USA | 3.1 | -0.6 | -1.3 | -5.1 | 2.5 | 2.9 |
| Canada | 1.7 | 3.0 | 0.2 | -6.8 | 9.2 | 2.8 |
| EU27 and EFTA | 0.2 | 4.5 | 1.0 | -4.9 | 13.5 | -0.3 |
| Russia | 0.6 | 1.9 | 0.3 | -3.7 | 29.9 | -1.5 |
| Rest of Europe/C. Asia | 0.4 | 4.5 | 0.3 | -5.3 | 27.0 | -0.4 |
| Australia | 1.8 | 3.8 | 0.2 | -6.8 | 9.0 | 2.9 |
| New Zealand | 1.4 | 3.8 | 0.5 | -6.4 | 7.3 | 1.6 |
| Japan | -0.1 | 2.5 | 1.2 | -2.9 | 28.1 | 0.5 |
| Korea | -3.9 | 8.6 | 3.0 | -5.5 | 98.8 | -4.9 |
| HongKong/Sing/Taiwan | 1.7 | -0.5 | 0.9 | -2.3 | 0.9 | 3.1 |
| China | 13.5 | -7.1 | -3.5 | -9.8 | -43.6 | 16.5 |
| Indonesia | -5.3 | 6.0 | 1.0 | 0.1 | 117.0 | -16.1 |
| Malaysia | 2.2 | -2.8 | 0.2 | 0.7 | 2.6 | 2.1 |
| Thailand | 5.3 | -2.9 | -0.9 | -3.6 | 2.5 | 10.4 |
| Rest of East Asia | 4.4 | -4.2 | -2.1 | -1.0 | -4.1 | 7.1 |
| India | 6.1 | -4.9 | -2.7 | -1.8 | -10.1 | 12.1 |
| Rest of South Asia | 3.2 | -3.4 | -1.8 | 0.0 | -6.1 | 4.0 |
| Argentina | 3.7 | -4.1 | -2.2 | -1.2 | -7.0 | 5.0 |
| Brazil | 2.3 | -2.4 | -2.6 | -0.5 | -2.0 | 0.8 |
| Rest of Latin America | 5.7 | -4.9 | -2.5 | -3.6 | -12.3 | 10.1 |
| Middle East/Nth Africa | 1.2 | -0.5 | -0.8 | -1.6 | 7.3 | 0.3 |
| South Africa | 5.1 | -5.5 | -3.0 | -8.4 | -9.2 | 5.4 |
| Rest Sub-Saharan Africa | 9.2 | -6.8 | -3.2 | -3.9 | -19.3 | 9.5 |
| **High-income countries** | **1.3** | **2.5** | **0.6** | **-5.1** | **6.4** | **0.3** |
| **Developing countries** | **7.0** | **-4.3** | **-2.3** | **-4.6** | **-4.8** | **7.9** |
| **World** | **4.7** | **-1.6** | **-1.4** | **-4.7** | **4.1** | **5.8** |

Source: authors' simulations

Table 6: Effects on national economic welfare of crop productivity losses **and** decreases in unskilled labour productivity, 2030 and 2050

(2004 US$ million, deviation from baseline in projected year)

(c) 2030

| | Factor productivity | Terms of trade | Resource use efficiency | Total economic welfare | Total economic welfare as % of Income |
|---|---|---|---|---|---|
| USA | 87 | -163 | -858 | -933 | -0.01 |
| Canada | 114 | -246 | -215 | -347 | -0.03 |
| EU27 and EFTA | 803 | -386 | -4143 | -3726 | -0.02 |
| Russia | 183 | -1826 | -627 | -2270 | -0.23 |
| Rest of Europe/C. Asia | 609 | -477 | 98 | 230 | 0.02 |
| Australia | 8 | -1067 | -167 | -1225 | -0.11 |
| New Zealand | 17 | 57 | -12 | 62 | 0.04 |
| Japan | 189 | 193 | -430 | -48 | 0.00 |
| Korea | -10309 | 1297 | -2758 | -11771 | -0.79 |
| HongKong/Sing/Taiwan | -8852 | 1161 | -490 | -8180 | -0.69 |
| China | -42711 | 3822 | -7855 | -46745 | -1.03 |
| Indonesia | -4841 | -299 | -196 | -5335 | -0.91 |
| Malaysia | -2853 | 165 | -109 | -2797 | -0.92 |
| Thailand | -354 | 448 | -79 | 15 | 0.00 |
| Rest of East Asia | -3172 | -66 | -387 | -3624 | -0.92 |
| India | -18420 | 1628 | -814 | -17606 | -1.05 |
| Rest of South Asia | -4511 | 262 | -213 | -4462 | -1.04 |
| Argentina | -173 | 112 | -135 | -196 | -0.08 |
| Brazil | -9290 | 201 | -1163 | -10253 | -0.97 |
| Rest of Latin America | -15267 | -507 | -6941 | -22716 | -0.89 |
| Middle East/Nth Africa | -9935 | -3227 | -1148 | -14310 | -0.73 |
| South Africa | -84 | -233 | -60 | -377 | -0.11 |
| Rest Sub-Saharan Africa | -6260 | -858 | -430 | -7547 | -1.16 |
| **High-income countries** | 2010 | -3914 | -6353 | -8257 | -0.02 |
| **Developing countries** | -137031 | 3907 | -22779 | -155903 | -0.88 |
| **World** | -135022 | -7 | -29131 | -164160 | -0.28 |

Source: authors' simulations

Table 6 (continued): Effects on national economic welfare of crop productivity losses **and** decreases in unskilled labour productivity, 2030 and 2050

(2004 US$ million, deviation from baseline in projected year)

(d) 2050

| | Factor productivity | Terms of trade | Resource use efficiency | Total economic welfare | Total economic welfare as % of Income |
|---|---|---|---|---|---|
| USA | -4766 | -149 | -659 | -5574 | -0.03 |
| Canada | 429 | -1644 | -930 | -2146 | -0.12 |
| EU27 and EFTA | 1684 | -4303 | -15320 | -17938 | -0.10 |
| Russia | 237 | -8213 | -1594 | -9570 | -0.71 |
| Rest of Europe/C. Asia | 2068 | -1561 | 879 | 1387 | 0.08 |
| Australia | 223 | -4234 | -650 | -4662 | -0.28 |
| New Zealand | 65 | 389 | -31 | 423 | 0.19 |
| Japan | 197 | -898 | -1549 | -2250 | -0.04 |
| Korea | 2162 | 4066 | -2849 | 3378 | 0.13 |
| HongKong/Sing/Taiwan | -128 | 1992 | 49 | 1913 | 0.10 |
| China | -149143 | 18491 | -23808 | -154460 | -1.85 |
| Indonesia | -8367 | -540 | -1082 | -9989 | -0.96 |
| Malaysia | -9413 | 1160 | -297 | -8549 | -1.58 |
| Thailand | -1410 | 1959 | -329 | 220 | 0.04 |
| Rest of East Asia | -9992 | -320 | -1182 | -11495 | -1.71 |
| India | -61146 | 7837 | -1189 | -54499 | -1.82 |
| Rest of South Asia | -14699 | 1269 | -485 | -13915 | -1.85 |
| Argentina | -708 | 756 | -487 | -438 | -0.12 |
| Brazil | -26800 | 952 | -3164 | -29013 | -1.83 |
| Rest of Latin America | -46611 | -3455 | -20528 | -70594 | -1.81 |
| Middle East/Nth Africa | -29479 | -9842 | -3349 | -42670 | -1.34 |
| South Africa | -609 | -632 | -269 | -1510 | -0.30 |
| Rest Sub-Saharan Africa | -21666 | -3144 | -1232 | -26042 | -2.43 |
| **High-income countries** | 138 | -20613 | -19855 | -40329 | -0.08 |
| **Developing countries** | -378011 | 20548 | -60200 | -417663 | -1.38 |
| **World** | -377873 | -64 | -80055 | -457992 | -0.57 |

Source: authors' simulations