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Kym Anderson is Professor of Economics at the University of Adelaide and the Australian National University; Shikha Jha is Principal Economist in the Asian Development Bank; Signe Nelgen is a Visiting Research Fellow at the University of Adelaide; and Anna Strutt is Associate Professor at the University of Waikato and Visiting Research Fellow at the University of Adelaide. The authors are grateful for helpful interactions with Johanna Croser and Ernesto Valenzuela. Anderson, Nelgen, and Strutt also acknowledge funding support from the Asian Development Bank, the Australian Research Council, the Rural Industries Research and Development Corporation, and the World Bank. The authors accept responsibility for any errors in the paper.

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Contents

Abstract

In the wake of recent food price spikes, plus growing demands for food in emerging Asia and for biofuels in Europe and the United States, governments are reexamining their strategies for dealing with both short-term and long-term food security concerns. This paper argues that long-run trends in real agricultural prices have policy implications for food security that are at least as important as those related to short-lived spikes around trend prices. The paper therefore summarizes recent projections of markets to 2030 under various scenarios, and then reviews evidence on how trade policy restrictions typically are altered to insulate domestic markets from short-run fluctuations in international prices around their long-run trends. That provides a firm empirical basis for reexamining the effectiveness and efficiency of various policy options for ensuring food security in Asia and elsewhere. Those options include boosting agricultural productivity growth rates to deal with long-run concerns, and using more appropriate domestic policy measures rather than trade policies to cope with price volatility.

I. Introduction

Between 2004 and 2008, real food prices in international markets rose by 55%. They began to drop back toward trend late in 2008, only to rise steeply again in 2010–2011, along with the prices of energy raw materials. Since Asia is home to the majority of the world's poor, and more than 60% of the budget of poor households in Asia is spent on food, this is both exacerbating global poverty and contributing to inflation in the region (ADB 2011a; Sumner 2011; Ivanic, Martin, and Zaman 2011).

This combination of high and fluctuating food prices understandably raises food security concerns in developing countries. One consequence has been a call for emergency physical grain reserves (Fan, Torero, and Headey 2011), and discussions among ASEAN+3 countries (Association of Southeast Asian Nations plus the People's Republic of China [PRC], Japan, and the Republic of Korea) have focused on coordination of rice reserves (Briones 2011). Governments in high-income countries also have expressed concern. Thus another consequence has been that food price volatility was high on the agenda of the G-8 and G-20 meeting in late 2011 (FAO et al. 2011), and is expected to remain there in 2012.

However, the set of factors influencing the *trend level* of food prices is not the same as the set affecting the *volatility* of food prices around that longer-run trend. Also, the distributional and especially poverty effects of fluctuating prices—and of policy responses to them—differ from those associated with changes in the trend price level. This pair of facts is important to recognize because unless societies and governments clarify what concerns them most, it is not possible to identify the most appropriate policy actions to ease those concerns.

From the viewpoint of meeting Millennium Development Goal 1 of eradicating extreme poverty and hunger, the concern over high prices should dominate concerns over fluctuating prices. Certainly some groups are harmed by fluctuating food prices, but others can benefit or at least adapt with agility. Barrett and Bellemare (2011) argue that small farmers—who are often net buyers of food—would be less worried than larger farmers by fluctuation in the price of their main crop. This, they suggest, is because (i) as consumers, poor farm households can switch to a lower-priced substitute as and when the relative price of a traded staple food item spikes; and (ii) as producers, their product mix is typically more diversified than that of larger farmers, for self-insurance reasons (see de Janvry, Fafchamps, and Sadoulet 1991). Even so, governments of low-income countries do worry about sudden spikes in food prices and are prone to respond

in an attempt to reduce the extent of the rise in the domestic market, but not always in the most appropriate ways. This paper begins by focusing on the long-run trend level of food prices, before turning to short-run price volatility.

During the 20th century, real food prices in international markets traced a downward path, to the point that by the late 1980s, many felt the fear of Malthus was behind us. As a result, growth in funding for rural development in general and agricultural R&D in particular slowed as development assistance resources were directed elsewhere. Two decades later it is evident that, as a consequence, productivity growth has slumped in both advanced and developing economies (Alston, Babcock, and Pardey 2010). Meanwhile, rapid industrial growth in emerging economies in Asia and elsewhere is raising the demand for imports of primary products, while biofuel subsidies and mandates in numerous countries are reducing available supplies of food. How will these forces play out in the decades ahead? Will Asia become more dependent on imported food, and what does that imply about its food security? To address these questions, we summarize a recent set of projections using a model of the world economy that is projected to 2030 both without and then with some policy and climate changes over that period. Projected changes in sectoral shares of GDP, the composition and direction of trade, net farm incomes, and food consumption and self-sufficiency levels are highlighted, including in response to prospective policy shifts such as trade liberalization or agricultural protection growth.

The paper then reviews the ways in which governments have responded in the past to year-to-year fluctuations around the trend level of food prices. It reveals that their trade policy measures seek to insulate domestic food markets from international price fluctuations to a very considerable degree. Moreover, because governments of both food-exporting and food-importing countries do this, their combined actions exacerbate international price fluctuations and thereby offset each other's efforts to stabilize their domestic food prices.

The rest of the paper is structured as follows. Section II explains the projection methodology used to project markets for food (and other) products to 2030. That core projection suggests there could be dramatic growth over the next 2 decades in food import dependence for Asia's large emerging economies if current policies continue. Two alternative projections are therefore also presented in Section II to gauge the sensitivity of that core projection to different assumptions about productivity growth: one lowers the assumed rate of productivity growth in primary sectors; the other assumes there would be more investment in agricultural R&D in developing Asia to speed its grain productivity growth. Section III then considers alternatives to the core projection. One set of alternative simulations involves various degrees of opening up of Asia's economies, another assumes agricultural protection growth in developing countries (a continuing rise in the price of farm products domestically relative to their international level by increasing food import tariffs), and yet another simulates the effect on land and unskilled

labor productivity of climate change. The first of those alternatives generates greater economic benefits and boosts food consumption per capita, in contrast to the second, which is shown to be very costly and to result in lower food consumption levels. Section IV of the paper then assesses the ways in which governments have sought to deal with short-term food security concerns through attempts to insulate domestic markets from volatility in international food markets by varying the restrictiveness of trade measures. In light of those insights into long-term trends and short-term adjustments to border policy interventions, the final section draws out alternative policy options for improving food security in Asia.

Throughout, we have in mind the Food and Agriculture Organization's definition of food security, which is the state "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (FAO 2003, 27). Since access for any poor household largely depends on its (and perhaps also its extended family's) income and assets, pro-poor economic growth is a key to expanding per capita food consumption and thereby reducing food insecurity.

II. Global Long-Term Modeling Methodology, Database, and Core Projection to 2030

Asia's rapid economic growth is shifting the global economic and industrial center of gravity away from the north Atlantic, and globalization has led to trade growing faster than output. Together these forces are raising the importance of Asia's emerging economies in world output and trade. They are also shifting the comparative advantages of the more densely populated economies of the region away from agriculture, and causing intra-Asian trade to grow relative to Asia's trade with the rest of the world.

A. Model Methodology and Database

To examine the extent to which those forces could affect perceived food security (and so could trigger changes to food price and trade policies), a model of the world economy needs to be projected forward. This paper builds on the GTAP model of Anderson and Strutt (2011a), which was used to project South–South trade for ADB (2011b) and whose projections have since been revised for a study on growth in ASEAN, the People's

Republic of China (PRC), and India (Anderson and Strutt 2011b).[1] In particular, this paper modifies food demand elasticities for rapidly developing economies to be consistent with those in currently higher-income countries; includes interim projections from base year 2004 to 2010 to capture the changes that have taken place during the period; adds new results on climate change; and presents disaggregated results for the Asian region.

The model assumes perfect competition and constant returns to scale in production. Agricultural land is mobile among alternative farm activities, according to a relatively high constant elasticity of transformation which, through a revenue function, transforms land from one use to another. The model also assumes that natural resources including coal, oil, and gas are specific to the sector in which they are mined. Each productive factor is assumed to be fully employed in the standard macroeconomic closure, although its stock is assumed to grow over time. Both labor 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 a Cobb-Douglas aggregate utility function, which allocates net national expenditures across private, government, and saving activities. The greatest advantage of this household representation is the unambiguous indicator of economic welfare dictated by the regional utility function. 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 functional form, which has the virtue of capturing the nonhomothetic nature of private household demands, calibrated to replicate a vector of own-price and income elasticities of demand (Hertel et al. 2008). In projecting to 2030, these elasticities are modified for rapidly developing economies so they more closely match the lower income elasticities for food products in currently higher-income countries (following Yu et al. 2004).[2] Bilateral international trade flows are handled through the Armington (1969) specification by which products are differentiated by country of origin.

B. Core Projection to 2030

The GTAP 2004 baseline for the world economy is projected forward to provide a core baseline for 2030 by assuming in the first instance that the 2004 trade-related policies

[1] They employ the GTAP model of the global economy (Hertel 1997) and Version 7.1 of the GTAP database, which is calibrated to 2004 levels of production, consumption, trade, and protection (Narayanan and Walmsley 2008). Its standard price distortion database contains little more than applied import tariffs for developing countries, so they alter it to include a more complete set of estimates of distortions to agricultural prices in developing countries, based on Valenzuela and Anderson (2008), which fully documents the distortions database, using the methodology summarized in Anderson et al. (2008).

[2] This is but one of several differences between the present projection exercise and that reported in Anderson and Strutt (2011a). Other refinements include updating the projections of GDP, population, unskilled labor, skilled labor, and produced capital. Also, land as well as other natural capital endowments are assumed to change slightly over time, and the macro closure now allows investment to respond to changes in rates of return.

of each country do not change over that 26-year period, but that national real gross domestic product (GDP); population; unskilled and skilled labor; capital; agricultural land; and extractable mineral resources (oil, gas, coal, and other minerals) grow at the exogenously set rates summarized in Appendix Table 1. The exogenous growth rates for GDP, investment, and population are based on the latest (August 2011) ADB projections over the next 2 decades, supplemented by World Bank data for real GDP and investment growth for the period to 2010, along with CEPII data for population growth to 2010 and for national projections of GDP, investment and population not readily available in the ADB dataset (Fouré et al. 2010), and Chappuis and Walmsley (2011) for projections of skilled and unskilled labor growth rates. We estimate historical trends in agricultural land from FAOSTAT (summarized in Deininger and Byerlee 2011) and in mineral and energy raw material reserves from BP (2010) and the United States (US) Geological Survey (2010). We assume that past annual rates of change in farmland and fossil fuel reserves since 1990 continue for each country over the next 2 decades.[3] For other minerals, in the absence of country-specific data, the unweighed average of the annual rate of growth of global reserves for iron ore, copper, lead, nickel, and zinc between 1995 and 2009 for all countries is used (from the US Geological Survey 2010). These rates of change in natural resources are summarized in the last five columns of Appendix Table 1.

Given those exogenous growth rates,[4] the model is able to derive implied rates of total factor productivity (TFP) and GDP per capita growth. For any one country the rate of TFP growth is assumed to be the same in each of its nonprimary sectors, and to be somewhat higher in its primary sectors. Higher productivity growth rates for primary activities were characteristic of the latter half of the 20th century (Martin and Mitra 2001), and are necessary in this projection if real international prices of primary products (relative to the aggregate change for all products) are to rise only modestly.[5] The implied TFP growth rates for all sectors are shown in the first column of Appendix Table 2,[6] and the international price consequences for the core simulation are depicted in the first column of Appendix Table 3.

It should be noted that the extent to which productivity growth rates are higher in each primary sector than in other sectors is the same for high-income and developing

[3] For further details on likely developments in energy markets over the next 2 decades, see BP (2011) and Finley (2012).

[4] There is much uncertainty in macroeconomic projections over this kind of timeframe (and even the current size of the Chinese economy is under serious question—see Feenstra et al. (2011). Garnaut (2011) discusses the uncertain nature of GDP, population, and energy projections; and Eichengreen, Park, and Shin (2011) examine prospects for growth in the PRC in particular.

[5] We chose that calibration because it is consistent with the World Bank projections over the next 4 decades (see van der Mensbrugghe and Roson 2010). An alternative in which agricultural prices fall, as projected in GTAP-based projection studies in the late 20th century (e.g., Anderson et al. 1997), is considered unlikely over the next 2 decades given the slowdown in agricultural R&D investment since 1990 and its consequent delayed slowing of farm productivity growth (Alston, Babcock, and Pardey 2010). It is even less likely for farm products if fossil fuel prices and biofuel mandates in the European Union, the US, and elsewhere are maintained over the next decade. Timilsina et al. (2010) project that by 2020, international prices will be higher in the presence versus absence of those biofuel mandates for sugar (10%), corn (4%), oilseeds (3%), and wheat and coarse grains (2.2%), while petroleum product prices will be 1.4% lower.

[6] In the core baseline, these TFP estimates are endogenously determined. However, in the simulations modelling lower worldwide primary sector productivity, it is the TFP estimates that are exogenous while GDP is endogenous.

countries, and is the same for all crop and livestock industries within each country's farm sector. Since overall TFP growth is higher for developing than high-income countries in Appendix Table 2, this means we are assuming agricultural TFP growth is higher for developing than high-income countries on average (consistent with the estimate by Ludena et al. [2007, Table 2] that agricultural TFP annual growth during 1981–2000 averaged 1.3% globally and only 0.9% for high-income countries).

As of 2004, developing countries in Asia were close to self-sufficient in agricultural and food products as a group at 98%, and that ratio is between 94% and 104% for the PRC, Indonesia, India, and the Philippines (Table 1, column 1). There was little intrasectoral trade in farm products then: agricultural and food exports by Developing Asia were only 4% of their total exports in 2004, and those goods also comprise only 5% of total imports (Tables 2 and 3). The food import bill as of 2004 was thus not a large burden for those developing countries, and Asian food trade accounted for less than 1% of global merchandise trade, and just 14% of global agricultural and food trade (Anderson and Strutt 2011b, Tables 4–6).

Table 1: Agricultural Self-Sufficiency Ratio[a] (percent)

	Baseline Scenarios					
	2004	**2030 Core**	**2030 Slower Primary TFP**	**2030 Faster ACI Grain TFP**	**Increase in Agricultural Protection**	**Climate Change**
Western Europe	0.94	1.05	1.01	1.05	1.04	1.07
Russian Federation	0.88	0.87	0.82	0.86	0.86	0.88
Rest of Eastern Europe	1.00	1.03	1.06	1.02	1.01	1.05
United States	1.04	1.19	1.18	1.18	1.16	1.20
Canada	1.09	1.27	1.24	1.27	1.24	1.29
Australia	1.39	1.55	1.42	1.53	1.45	1.57
New Zealand	1.62	1.90	1.97	1.89	1.88	1.93
Japan	0.81	0.83	0.82	0.83	0.83	0.84
China, People's Rep. of	0.97	0.83	0.84	0.83	0.85	0.82
Singapore	0.40	0.61	0.72	0.59	0.52	0.62
Indonesia	0.95	0.83	0.83	0.84	0.85	0.83
Malaysia	0.61	0.47	0.37	0.48	0.48	0.46
Philippines	0.94	0.80	0.81	0.82	0.85	0.80
Thailand	1.13	1.02	1.03	1.04	0.98	1.02
Viet Nam	1.15	1.06	1.01	1.06	1.04	1.06
Rest of Southeast Asia	1.02	0.93	0.92	0.94	0.95	0.93
Pacific Islands	0.92	0.90	0.88	0.90	0.88	0.90
Hong Kong, China	0.40	0.37	0.35	0.37	0.36	0.37
Korea, Rep. of	0.82	0.84	0.79	0.83	0.84	0.87
Taipei,China	0.78	0.84	0.83	0.83	0.84	0.84
Rest of Northeast Asia	0.83	0.73	0.69	0.73	0.77	0.73
India	1.01	1.00	1.00	1.01	1.00	0.99
Pakistan	0.98	0.84	0.89	0.84	0.83	0.84
Bangladesh	0.92	0.87	0.92	0.87	0.88	0.87
Rest of South Asia	0.96	0.91	0.89	0.90	0.93	0.90
Central Asia	1.04	1.09	1.05	1.09	1.08	1.11
Latin America	1.10	1.23	1.29	1.22	1.20	1.22
Middle East and Africa	0.93	0.92	0.93	0.92	0.93	0.92
High-income	0.97	1.09	1.06	1.09	1.07	1.10
Developing	0.98	0.91	0.93	0.92	0.92	0.91
of which Asia:	0.96	0.87	0.87	0.87	0.88	0.86
Total	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**

continued.

Table 1: *continued.*

	Trade Reform Scenarios		
	ASEAN +6, Preferential	**ASEAN +6, MFN**	**Full Liberalization from Higher Agricultural Protection**
Western Europe	1.04	1.07	1.01
Russian Federation	0.86	0.84	0.75
Rest of Eastern Europe	1.03	1.03	1.05
United States	1.18	1.22	1.22
Canada	1.26	1.30	1.33
Australia	1.73	1.57	1.63
New Zealand	2.08	1.98	2.03
Japan	0.75	0.65	0.65
China, People's Rep. of	0.82	0.80	0.79
Singapore	0.78	0.76	0.91
Indonesia	0.82	0.82	0.82
Malaysia	0.47	0.46	0.45
Philippines	0.76	0.72	0.72
Thailand	1.08	1.08	1.08
Viet Nam	1.22	1.21	1.20
Rest of Southeast Asia	0.95	0.94	0.94
Pacific Islands	0.91	0.92	2.05
Hong Kong, China	0.37	0.36	0.36
Korea, Rep. of	0.93	0.90	0.88
Taipei,China	0.86	0.84	0.75
Rest of Northeast Asia	0.73	0.73	0.71
India	1.02	0.99	1.00
Pakistan	0.85	0.85	0.84
Bangladesh	0.88	0.89	0.87
Rest of South Asia	0.92	0.91	0.87
Central Asia	1.08	1.08	1.10
Latin America	1.23	1.26	1.40
Middle East and Africa	0.92	0.92	0.91
High-income	1.09	1.11	1.09
Developing	0.92	0.91	0.93
of which Asia:	0.87	0.85	0.85
Total	**1.00**	**1.00**	**1.00**

[a]Agricultural self-sufficiency ratio excludes "other (processed) food products".

ACI = ASEAN, the PRC, India; ASEAN = Association of Southeast Asian Nations; MFN = most favored nation; TFP =total factor productivity.

Source: From GTAP model results summarized in Anderson and Strutt (2011b).

Table 2: Sectoral Shares of National Exports, 2004 and 2030 Core (percent)

A. 2004

	Agriculture and Food	Other Primary	Manufactures	Services	Total
Western Europe	6.8	2.3	69.4	21.5	**100.0**
Russian Federation	2.8	46.6	41.2	9.3	**100.0**
Rest of Eastern Europe	9.6	1.8	66.9	21.6	**100.0**
United States	6.7	1.0	68.0	24.3	**100.0**
Canada	7.4	9.8	69.7	13.0	**100.0**
Australia	19.3	21.8	35.8	23.0	**100.0**
New Zealand	39.6	3.0	33.4	24.0	**100.0**
Japan	0.5	0.1	90.1	9.3	**100.0**
China, People's Rep. of	3.5	1.2	88.6	6.7	**100.0**
Singapore	2.0	0.1	75.6	22.3	**100.0**
Indonesia	11.1	17.9	64.4	6.6	**100.0**
Malaysia	6.2	6.3	80.1	7.4	**100.0**
Philippines	5.5	0.9	87.2	6.4	**100.0**
Thailand	11.5	0.6	74.9	13.0	**100.0**
Viet Nam	16.7	17.9	56.3	9.1	**100.0**
Rest of Southeast Asia	5.7	39.4	43.8	11.0	**100.0**
Pacific Islands	17.1	25.2	31.9	25.7	**100.0**
Hong Kong, China	0.5	0.0	28.2	71.3	**100.0**
Korea, Rep. of	1.0	0.2	91.2	7.6	**100.0**
Taipei,China	1.1	0.2	92.1	6.6	**100.0**
Rest of Northeast Asia	2.5	4.7	38.1	54.7	**100.0**
India	9.4	4.8	67.6	18.3	**100.0**
Pakistan	9.7	0.5	72.7	17.1	**100.0**
Bangladesh	5.6	0.3	83.1	11.0	**100.0**
Rest of South Asia	16.0	5.2	54.5	24.3	**100.0**
Central Asia	8.4	53.1	26.7	11.8	**100.0**
Latin America	16.6	15.1	56.5	11.8	**100.0**
Middle East and Africa	6.1	48.0	32.5	13.5	**100.0**
High-income	6.5	3.9	69.5	20.1	**100.0**
Developing	6.7	14.6	65.6	13.1	**100.0**
of which Asia:	4.4	3.6	78.7	13.3	**100.0**
Total	**6.6**	**7.4**	**68.2**	**17.8**	**100.0**

continued.

Table 2: *continued.*

B. 2030 Core

	Agriculture and Food	Other Primary	Manufactures	Services	Total
Western Europe	9.0	6.8	64.3	20.0	**100.0**
Russian Federation	2.7	80.0	11.5	5.8	**100.0**
Rest of Eastern Europe	9.9	2.7	69.4	18.0	**100.0**
United States	14.3	3.7	62.3	19.7	**100.0**
Canada	10.8	37.2	44.9	7.1	**100.0**
Australia	23.0	53.1	15.7	8.3	**100.0**
New Zealand	57.6	10.7	17.6	14.2	**100.0**
Japan	1.7	1.7	88.6	7.9	**100.0**
China, People's Rep. of	0.2	0.1	89.3	10.5	**100.0**
Singapore	3.3	0.3	77.6	18.7	**100.0**
Indonesia	4.7	18.5	64.1	12.6	**100.0**
Malaysia	12.2	8.5	72.7	6.6	**100.0**
Philippines	1.3	0.2	95.1	3.4	**100.0**
Thailand	7.7	1.4	76.3	14.7	**100.0**
Viet Nam	8.5	56.4	28.6	6.5	**100.0**
Rest of Southeast Asia	1.9	29.5	47.0	21.6	**100.0**
Pacific Islands	13.0	36.4	34.7	15.9	**100.0**
Hong Kong, China	1.3	0.1	38.2	60.4	**100.0**
Korea, Rep. of	1.8	0.7	91.9	5.6	**100.0**
Taipei,China	1.5	0.7	92.4	5.4	**100.0**
Rest of Northeast Asia	1.3	9.7	24.8	64.2	**100.0**
India	5.3	6.8	61.1	26.9	**100.0**
Pakistan	3.3	0.2	70.2	26.3	**100.0**
Bangladesh	3.6	0.0	59.0	37.4	**100.0**
Rest of South Asia	10.5	4.0	64.7	20.8	**100.0**
Central Asia	9.7	77.4	8.4	4.5	**100.0**
Latin America	15.4	23.2	52.3	9.1	**100.0**
Middle East and Africa	5.0	46.3	28.5	20.1	**100.0**
High-income	9.8	12.8	60.1	17.4	**100.0**
Developing	4.8	14.9	66.2	14.1	**100.0**
of which Asia:	2.6	4.4	79.5	13.4	**100.0**
Total	**6.9**	**14.0**	**63.6**	**15.5**	**100.0**

Source: Derived from GTAP model results summarized in Anderson and Strutt (2011b).

continued.

Table 3: Sectoral Shares of National Imports, 2004 and 2030 (percent)

A. 2004

	Agriculture and Food	Other Primary	Manufactures	Services	Total
Western Europe	7.4	5.9	66.4	20.3	**100.0**
Russian Federation	13.0	2.5	60.8	23.7	**100.0**
Rest of Eastern Europe	6.8	16.1	67.2	9.9	**100.0**
United States	4.3	9.4	72.3	14.0	**100.0**
Canada	5.6	3.4	76.0	14.9	**100.0**
Australia	4.4	3.7	74.3	17.5	**100.0**
New Zealand	6.9	4.4	68.4	20.3	**100.0**
Japan	9.6	16.3	55.0	19.1	**100.0**
China, People's Rep. of	4.3	8.5	77.1	10.0	**100.0**
Singapore	3.5	7.5	69.3	19.7	**100.0**
Indonesia	8.4	5.7	65.9	19.9	**100.0**
Malaysia	6.1	2.2	80.1	11.6	**100.0**
Philippines	8.3	7.8	77.2	6.7	**100.0**
Thailand	5.1	13.3	69.8	11.9	**100.0**
Viet Nam	7.0	1.1	80.9	11.0	**100.0**
Rest of Southeast Asia	13.0	1.1	76.0	9.9	**100.0**
Pacific Islands	11.7	0.8	69.1	18.4	**100.0**
Hong Kong, China	6.9	1.3	67.9	23.8	**100.0**
Korea, Rep. of	4.5	16.7	63.5	15.3	**100.0**
Taipei,China	4.3	10.7	76.2	8.7	**100.0**
Rest of Northeast Asia	14.5	3.3	54.5	27.7	**100.0**
India	4.5	28.5	52.0	15.0	**100.0**
Pakistan	10.2	9.1	59.0	21.6	**100.0**
Bangladesh	19.7	3.6	69.9	6.8	**100.0**
Rest of South Asia	14.1	5.7	68.1	12.1	**100.0**
Central Asia	7.7	5.5	63.4	23.5	**100.0**
Latin America	7.9	4.6	73.4	14.0	**100.0**
Middle East Africa	11.4	3.5	67.9	17.2	**100.0**
High-income	6.8	7.5	67.4	18.3	**100.0**
Developing	7.0	7.9	70.7	14.4	**100.0**
of which Asia:	5.4	10.1	71.0	13.6	**100.0**
Total	**6.9**	**7.6**	**68.3**	**17.2**	**100.0**

Table 3: *continued.*

B. 2030

	Agriculture and Food	Other Primary	Manufactures	Services	Total
Western Europe	6.4	6.6	65.4	21.6	**100.0**
Russian Federation	10.1	2.6	61.4	26.0	**100.0**
Rest of Eastern Europe	5.6	23.7	61.1	9.5	**100.0**
United States	3.4	10.8	71.8	14.0	**100.0**
Canada	5.2	2.2	73.5	19.0	**100.0**
Australia	3.9	2.5	73.0	20.6	**100.0**
New Zealand	5.9	4.1	67.9	22.0	**100.0**
Japan	6.1	10.9	63.3	19.7	**100.0**
China, People's Rep. of	11.8	33.4	49.8	4.9	**100.0**
Singapore	3.5	8.2	70.0	18.3	**100.0**
Indonesia	12.0	18.2	58.9	10.9	**100.0**
Malaysia	7.3	3.4	79.2	10.1	**100.0**
Philippines	8.9	13.1	73.6	4.4	**100.0**
Thailand	5.0	12.6	73.2	9.2	**100.0**
Viet Nam	6.7	1.7	79.4	12.1	**100.0**
Rest of Southeast Asia	16.1	2.1	77.2	4.6	**100.0**
Pacific Islands	10.5	2.6	67.4	19.6	**100.0**
Hong Kong, China	6.2	1.3	68.8	23.7	**100.0**
Korea, Rep. of	4.0	20.8	60.0	15.3	**100.0**
Taipei,China	3.3	14.4	74.7	7.6	**100.0**
Rest of Northeast Asia	16.1	15.0	47.4	21.5	**100.0**
India	3.1	52.9	36.8	7.2	**100.0**
Pakistan	22.3	23.2	45.6	8.9	**100.0**
Bangladesh	18.1	28.4	50.5	3.0	**100.0**
Rest of South Asia	10.3	11.5	67.2	11.0	**100.0**
Central Asia	6.4	4.9	63.8	24.9	**100.0**
Latin America	6.7	8.4	70.5	14.4	**100.0**
Middle East Africa	12.8	5.5	68.8	13.0	**100.0**
High-income	5.5	8.2	67.2	19.0	**100.0**
Developing	9.2	21.3	59.7	9.8	**100.0**
of which Asia:	8.8	26.3	56.4	8.5	**100.0**
Total	**7.2**	**14.2**	**63.8**	**14.8**	**100.0**

continued.

Source: Derived from GTAP model results summarized in Anderson and Strutt (2011b).

Table 4: Self-sufficiency Ratio for Various Agricultural Products

A. 2004 Base

	Rice	Wheat	Coarse Grains	Oilseeds	Sugar	Cotton	Beef and Sheep	Pork and Chicken	Dairy
Western Europe	0.69	0.96	0.95	0.68	0.88	0.65	0.94	0.99	1.02
Russian Federation	0.58	1.10	0.99	0.99	0.69	0.08	0.93	0.75	0.94
Central Asia	0.90	1.06	1.03	0.93	0.51	3.15	1.00	0.94	0.97
Rest of Eastern Europe	0.79	0.96	1.05	0.87	1.02	0.92	1.00	0.88	1.03
United States	1.29	8.72	1.42	1.64	0.95	2.59	0.97	1.03	0.99
Canada	0.27	2.75	1.17	2.21	0.87	0.84	1.12	1.17	0.96
Australia	1.14	n.a.	3.62	8.71	1.31	2.43	1.66	1.12	1.16
New Zealand	0.23	0.73	0.95	0.71	1.01	0.94	1.73	1.54	1.73
Japan	0.96	0.11	0.02	0.08	0.84	0.56	0.83	0.66	0.95
China, People's Rep. of	1.00	0.84	1.01	0.47	0.95	0.64	0.89	1.01	0.97
Singapore	0.60	0.20	0.61	0.23	0.57	0.58	0.46	0.20	0.59
Indonesia	0.99	0.01	0.96	0.91	0.76	0.05	0.93	1.02	0.78
Malaysia	0.68	0.02	0.05	0.34	0.69	0.40	0.19	1.08	0.35
Philippines	0.93	0.34	0.96	0.75	1.06	0.63	0.83	0.99	0.60
Thailand	1.38	0.01	1.25	0.34	1.55	0.18	0.94	1.07	0.72
Viet Nam	1.20	0.01	0.90	1.47	0.97	0.12	0.98	0.99	0.64
Rest of Southeast Asia	1.00	0.03	1.31	1.31	0.89	0.79	0.98	0.99	0.25
Pacific Islands	0.03	0.35	0.46	6.58	1.35	1.52	0.81	0.56	0.93
Hong Kong, China	0.04	0.57	0.26	0.04	0.02	0.01	0.38	0.46	0.67
Korea, Rep. of	0.95	0.02	0.11	0.17	0.70	0.11	0.75	0.86	0.92
Taipei,China	0.90	0.01	0.22	0.00	0.58	0.10	0.78	0.93	0.72
Rest of Northeast Asia	0.82	0.45	0.61	0.29	0.53	0.85	0.95	0.85	0.75
India	1.04	1.03	1.03	1.01	0.98	1.00	1.03	1.00	1.00
Pakistan	1.32	0.87	0.85	0.58	1.02	0.80	0.99	1.00	1.00
Bangladesh	0.98	0.63	0.36	0.71	0.86	0.68	1.00	0.95	0.74
Rest of South Asia	0.96	0.33	0.60	0.99	0.66	1.18	0.97	0.90	0.71
Mexico	0.39	0.45	0.86	0.03	0.98	0.73	0.90	0.91	0.97
Argentina	1.40	3.34	1.97	1.24	1.18	0.82	1.16	1.22	1.16
Brazil	0.94	0.59	1.22	1.66	1.42	1.25	1.12	1.46	1.00
Rest of Latin America	0.89	0.59	0.81	1.11	1.11	0.91	1.01	0.99	0.95
Middle East and North Africa	0.68	0.70	0.62	0.60	0.71	1.06	0.85	0.97	0.89
South Africa	0.18	0.62	1.09	0.82	1.02	0.99	1.00	0.99	1.02
Rest of South Africa	0.59	0.32	0.98	1.24	0.93	2.36	1.03	0.94	0.60

continued.

Table 4: *continued.*

B. 2030 Core Simulation

	Rice	Wheat	Coarse Grains	Oilseeds	Sugar	Cotton	Beef and Sheep	Pork and Chicken	Dairy
Western Europe	0.98	1.33	1.00	0.83	0.90	1.90	0.95	1.21	1.03
Russian Federation	0.50	1.13	1.00	0.96	0.57	0.27	0.92	0.74	0.89
Central Asia	1.28	1.09	1.03	0.90	0.56	4.72	1.00	0.86	0.95
Rest of Eastern Europe	0.90	1.03	1.09	0.81	1.08	1.20	0.99	0.80	1.06
United States	1.67	12.02	1.46	2.29	0.94	7.30	1.00	1.29	1.00
Canada	0.22	3.67	1.48	2.70	0.80	1.08	1.21	1.38	0.96
Australia	1.32	n.a.	5.15	9.40	1.31	3.68	1.62	1.57	1.09
New Zealand	0.28	0.82	0.97	1.08	1.01	2.03	1.89	3.14	1.69
Japan	0.97	0.19	0.03	0.11	0.85	0.78	0.86	0.65	0.94
China, People's Rep. of	0.98	0.60	0.96	0.19	0.84	0.48	0.63	0.79	0.93
Singapore	0.99	0.13	0.50	0.20	0.64	0.96	1.27	0.28	1.05
Indonesia	0.96	0.00	0.94	0.75	0.68	0.02	0.76	0.96	0.67
Malaysia	0.68	0.01	0.06	0.29	0.48	0.27	0.19	0.91	0.27
Philippines	0.82	0.11	0.92	0.45	0.95	0.26	0.69	0.91	0.76
Thailand	1.21	0.00	1.01	0.27	1.72	0.10	0.96	0.97	0.72
Viet Nam	1.20	0.00	0.89	1.34	0.96	0.06	0.89	0.80	0.61
Rest of Southeast Asia	0.98	0.02	1.20	1.06	0.92	0.53	0.78	0.93	0.28
Pacific Islands	0.04	0.33	0.45	7.83	1.27	2.87	0.78	0.63	0.83
Hong Kong, China	0.06	0.60	0.25	0.04	0.01	0.01	0.27	0.39	0.78
Korea, Rep. of	0.94	0.02	0.10	0.19	0.93	0.13	0.74	0.88	0.91
Taipei,China	0.95	0.01	0.17	0.00	0.58	0.16	0.86	1.04	0.75
Rest of Northeast Asia	0.79	0.35	0.63	0.20	0.42	0.89	0.64	0.68	0.68
India	1.09	1.13	1.07	1.00	0.95	0.91	0.99	0.97	1.02
Pakistan	1.44	0.60	0.74	0.26	1.05	0.44	0.95	0.92	0.99
Bangladesh	1.00	0.65	0.34	0.72	0.86	0.64	0.99	0.91	0.75
Rest of South Asia	0.98	0.31	0.62	0.94	0.61	1.21	0.96	0.85	0.75
Mexico	0.50	0.56	0.87	0.09	1.06	1.32	1.01	0.98	0.97
Argentina	1.21	2.80	1.69	1.23	1.23	0.88	1.08	1.17	1.15
Brazil	0.99	0.57	1.10	1.99	1.50	2.08	1.45	1.99	1.17
Rest of Latin America	0.89	0.58	0.80	1.14	1.13	1.40	0.96	0.97	0.92
Middle East and North Africa	0.72	0.70	0.58	0.55	0.77	1.33	0.89	1.10	0.94
South Africa	0.29	0.95	1.43	1.00	1.19	2.13	1.06	1.04	1.11
Rest of South Africa	0.53	0.24	0.96	1.03	0.75	1.67	0.92	0.86	0.53

continued.

Table 4: *continued.*

C. 2030 Higher Grain TFP Growth in the People's Republic of China, India, and ASEAN

	Rice	Wheat	Coarse Grains	Oilseeds	Sugar	Cotton	Beef and Sheep	Pork and Chicken	Dairy
Western Europe	0.88	1.27	1.00	0.83	0.89	1.93	0.94	1.21	1.03
Russian Federation	0.47	1.11	1.00	0.96	0.57	0.27	0.92	0.74	0.89
Central Asia	1.17	1.07	1.03	0.90	0.56	4.70	1.00	0.86	0.95
Rest of Eastern Europe	0.86	1.00	1.09	0.81	1.08	1.20	0.99	0.80	1.06
United States	1.45	11.53	1.45	2.30	0.94	7.34	1.00	1.28	1.00
Canada	0.20	3.56	1.41	2.77	0.80	1.08	1.21	1.38	0.96
Australia	1.19	n.a.	4.81	9.53	1.31	3.74	1.63	1.56	1.09
New Zealand	0.25	0.80	0.97	1.08	1.01	2.03	1.89	3.09	1.69
Japan	0.97	0.18	0.03	0.10	0.85	0.77	0.86	0.65	0.94
China, People's Rep. of	0.98	0.65	0.96	0.19	0.85	0.48	0.64	0.79	0.93
Singapore	0.73	0.16	0.57	0.22	0.64	1.02	1.24	0.28	1.04
Indonesia	0.99	0.00	0.95	0.75	0.68	0.02	0.77	0.96	0.68
Malaysia	0.73	0.01	0.06	0.29	0.49	0.27	0.19	0.92	0.27
Philippines	0.89	0.15	0.93	0.45	0.95	0.26	0.69	0.91	0.76
Thailand	1.29	0.00	1.06	0.27	1.70	0.10	0.96	0.98	0.74
Viet Nam	1.21	0.00	0.92	1.34	0.96	0.06	0.89	0.81	0.61
Rest of Southeast Asia	1.00	0.03	1.33	1.07	0.92	0.54	0.79	0.94	0.28
Pacific Islands	0.03	0.32	0.45	7.84	1.27	2.86	0.78	0.63	0.83
Hong Kong, China	0.05	0.57	0.24	0.04	0.01	0.01	0.28	0.39	0.77
Korea, Rep. of	0.93	0.02	0.10	0.19	0.93	0.13	0.74	0.88	0.91
Taipei,China	0.91	0.01	0.17	0.00	0.58	0.16	0.86	1.04	0.75
Rest of Northeast Asia	0.74	0.35	0.63	0.20	0.43	0.89	0.64	0.69	0.68
India	1.11	1.22	1.08	1.00	0.95	0.91	0.99	0.97	1.02
Pakistan	1.36	0.59	0.74	0.26	1.05	0.44	0.95	0.92	0.99
Bangladesh	0.99	0.60	0.32	0.72	0.86	0.64	0.99	0.91	0.75
Rest of South Asia	0.96	0.28	0.60	0.93	0.61	1.22	0.96	0.86	0.76
Mexico	0.48	0.54	0.87	0.09	1.06	1.31	1.01	0.98	0.98
Argentina	1.20	2.72	1.65	1.24	1.23	0.88	1.08	1.17	1.15
Brazil	0.98	0.56	1.09	1.99	1.50	2.09	1.45	1.99	1.17
Rest of Latin America	0.87	0.56	0.80	1.13	1.13	1.40	0.96	0.97	0.92
Middle East and North Africa	0.67	0.69	0.58	0.55	0.77	1.33	0.89	1.10	0.94
South Africa	0.29	0.88	1.42	1.00	1.19	2.11	1.06	1.04	1.10
Rest of South Africa	0.47	0.23	0.96	1.03	0.75	1.67	0.92	0.86	0.53

continued.

Table 4: *continued.*

D. 2030 with Higher Developing Country Agricultural Protection

	Rice	Wheat	Coarse Grains	Oilseeds	Sugar	Cotton	Beef and Sheep	Pork and Chicken	Dairy
Western Europe	0.97	1.22	1.04	0.81	0.86	2.01	0.92	1.21	1.02
Russian Federation	0.49	1.05	0.99	0.95	0.57	0.30	0.92	0.71	0.89
Central Asia	1.25	1.04	1.02	0.96	0.45	4.30	1.00	0.87	0.99
Rest of Eastern Europe	0.87	0.98	1.01	0.79	1.06	1.17	0.98	0.79	1.06
United States	1.26	10.25	1.33	2.29	0.94	7.56	0.99	1.25	0.99
Canada	0.21	3.40	1.27	2.80	0.80	1.08	1.14	1.38	0.96
Australia	1.20	n.a.	3.54	10.24	1.20	4.21	1.50	1.33	1.08
New Zealand	0.50	0.80	0.97	1.14	1.00	2.23	1.63	4.00	1.66
Japan	0.96	0.16	0.03	0.10	0.85	0.76	0.85	0.66	0.94
China, People's Rep. of	0.99	0.71	0.97	0.18	0.99	0.50	0.71	0.81	0.94
Singapore	0.87	0.09	0.37	0.16	0.57	1.02	0.85	0.27	0.92
Indonesia	1.00	0.00	0.94	0.81	0.85	0.02	0.80	0.95	0.62
Malaysia	0.91	0.00	0.06	0.28	0.43	0.23	0.17	0.89	0.17
Philippines	0.98	0.09	0.90	0.41	1.00	0.23	0.81	0.93	0.72
Thailand	1.11	0.00	1.00	0.27	1.45	0.10	1.00	0.97	0.81
Viet Nam	1.14	0.00	0.88	1.22	1.00	0.06	0.93	0.90	0.79
Rest of Southeast Asia	1.00	0.01	1.16	1.03	1.00	0.53	0.87	0.95	0.34
Pacific Islands	0.05	0.36	0.45	6.96	1.19	2.38	0.78	0.73	0.87
Hong Kong, China	0.05	0.58	0.24	0.04	0.01	0.01	0.27	0.39	0.77
Korea, Rep. of	0.93	0.02	0.10	0.31	0.65	0.13	0.77	0.94	0.98
Taipei,China	0.89	0.01	0.18	0.00	0.64	0.15	0.93	1.03	0.85
Rest of Northeast Asia	0.93	0.34	0.64	0.21	0.81	0.84	0.70	0.73	0.76
India	1.02	1.08	1.06	1.00	0.98	0.93	1.00	0.98	1.02
Pakistan	1.25	0.72	0.80	0.27	1.02	0.43	0.95	0.92	0.99
Bangladesh	1.00	0.62	0.33	0.70	0.99	0.62	1.00	0.94	0.74
Rest of South Asia	1.00	0.35	0.62	0.96	0.89	1.18	0.96	0.84	0.77
Mexico	0.53	0.63	0.98	0.08	1.06	1.20	1.05	1.00	0.98
Argentina	1.07	2.83	1.48	1.20	1.13	0.89	1.07	1.10	1.10
Brazil	0.99	0.64	1.06	1.97	1.25	2.12	1.50	1.86	1.16
Rest of Latin America	0.95	0.77	0.84	1.03	1.06	1.30	1.01	1.00	0.95
Middle East and North Africa	0.81	0.75	0.63	0.59	0.96	1.20	0.84	1.03	0.96
South Africa	0.10	0.92	1.29	0.90	1.39	2.24	1.02	0.99	1.01
Rest of South Africa	0.78	0.28	0.97	1.02	0.87	1.40	0.94	0.90	0.68

Table 4: *continued.*

E. 2030 with Climate Change

	Rice	Wheat	Coarse Grains	Oilseeds	Sugar	Cotton	Beef and Sheep	Pork and Chicken	Dairy
Western Europe	1.03	1.37	1.02	0.84	0.90	2.09	0.96	1.24	1.04
Russian Federation	0.51	1.16	1.00	0.97	0.58	0.31	0.92	0.74	0.89
Central Asia	1.32	1.11	1.04	0.91	0.56	5.20	1.00	0.87	0.95
Rest of Eastern Europe	0.91	1.06	1.11	0.85	1.08	1.25	0.99	0.80	1.06
United States	1.72	11.73	1.42	2.27	0.94	6.95	1.00	1.31	0.99
Canada	0.21	3.72	1.54	2.87	0.80	1.10	1.22	1.40	0.96
Australia	1.35	n.a.	5.46	9.10	1.33	3.54	1.63	1.61	1.09
New Zealand	0.28	0.81	0.98	1.05	1.01	2.14	1.88	3.17	1.68
Japan	0.98	0.20	0.03	0.11	0.86	0.79	0.87	0.66	0.95
China, People's Rep. of	0.98	0.59	0.96	0.19	0.82	0.48	0.63	0.77	0.92
Singapore	1.06	0.12	0.50	0.19	0.64	0.91	1.31	0.28	1.07
Indonesia	0.96	0.00	0.93	0.74	0.68	0.02	0.75	0.96	0.65
Malaysia	0.68	0.00	0.06	0.28	0.47	0.25	0.19	0.91	0.27
Philippines	0.81	0.10	0.92	0.43	0.95	0.25	0.69	0.91	0.77
Thailand	1.20	0.00	1.00	0.26	1.73	0.09	0.96	0.96	0.72
Viet Nam	1.19	0.00	0.88	1.28	0.96	0.06	0.89	0.79	0.61
Rest of Southeast Asia	0.97	0.02	1.18	1.03	0.91	0.51	0.77	0.93	0.28
Pacific Islands	0.04	0.31	0.45	7.45	1.29	2.85	0.78	0.64	0.83
Hong Kong, China	0.05	0.58	0.25	0.04	0.01	0.01	0.27	0.39	0.78
Korea, Rep. of	0.96	0.02	0.11	0.21	0.97	0.14	0.75	0.89	0.92
Taipei,China	0.97	0.01	0.18	0.01	0.58	0.16	0.86	1.03	0.75
Rest of Northeast Asia	0.78	0.34	0.62	0.19	0.41	0.88	0.63	0.68	0.67
India	1.09	1.10	1.06	1.00	0.95	0.90	0.98	0.96	1.02
Pakistan	1.43	0.58	0.74	0.25	1.05	0.44	0.95	0.92	0.99
Bangladesh	1.00	0.64	0.34	0.70	0.86	0.63	0.99	0.90	0.75
Rest of South Asia	0.98	0.30	0.62	0.91	0.61	1.18	0.96	0.85	0.76
Mexico	0.49	0.54	0.87	0.09	1.06	1.33	1.01	0.97	0.97
Argentina	1.22	2.71	1.71	1.21	1.24	0.89	1.07	1.13	1.14
Brazil	0.99	0.54	1.08	2.01	1.51	2.04	1.45	1.99	1.17
Rest of Latin America	0.89	0.55	0.80	1.10	1.13	1.37	0.96	0.97	0.92
Middle East and North Africa	0.74	0.69	0.59	0.55	0.76	1.37	0.88	1.09	0.93
South Africa	0.29	0.83	1.41	0.95	1.21	2.02	1.07	1.04	1.11
Rest of South Africa	0.52	0.22	0.96	1.01	0.74	1.60	0.91	0.85	0.52

Source: Derived from GTAP model results summarized in Anderson and Strutt (2011b).

continued.

Table 5: Changes in Real Household Consumption per Capita of Agricultural and Food Products from 2004 Base, Core and Alternative Growth Scenarios in 2030, and Variations from that Core Base due to Trade Reforms (percent)

A. Baseline Scenarios

	Core Base line	Lower Primary TFP	Higher AIC grain production	Increased agric prot	Climate change
Western Europe	33	25	33	33	33
Russian Federation	99	105	99	99	99
Rest of Eastern Europe	61	39	61	61	61
United States	41	28	41	41	41
Canada	48	43	49	49	48
Australia	64	60	64	64	64
New Zealand	62	49	62	62	62
Japan	31	23	31	31	30
China, People's Rep. of	226	160	228	226	225
Singapore	69	40	69	66	68
Indonesia	113	78	115	112	112
Malaysia	109	92	110	108	108
Philippines	143	88	145	142	142
Thailand	83	38	84	83	82
Viet Nam	251	265	253	251	250
Rest of Southeast Asia	103	86	106	103	102
Pacific Islands	61	69	61	60	60
Hong Kong, China	67	50	68	67	67
Korea, Rep. of	67	47	67	66	67
Taipei,China	75	56	76	74	75
Rest of Northeast Asia	105	84	105	103	104
India	177	131	178	177	176
Pakistan	212	144	212	212	211
Bangladesh	141	101	141	140	140
Rest of South Asia	130	100	130	130	129
Central Asia	132	141	132	131	131
Latin America	79	67	79	79	78
Middle East and Africa	108	85	108	107	107
High-income	40	31	40	40	40
Developing	141	107	142	141	140
of which Asia:	168	123	169	168	167
Total	**67**	**48**	**67**	**66**	**66**

Table 5: *continued*.

B. Trade Reform Scenarios

	ASEAN+6 Preferential Treatment	ASEAN+6 MFN	Full Liberalization	Full Liberalization from Higher Agricultural Protection
Western Europe	0.0	0.1	4.5	4.4
Russian Federation	0.3	0.3	4.0	4.0
Rest of Eastern Europe	−0.1	−0.2	0.8	0.6
United States	0.0	0.0	0.2	0.0
Canada	0.1	0.1	5.1	4.9
Australia	0.1	−0.1	−0.2	−0.2
New Zealand	1.9	1.2	2.8	2.9
Japan	3.6	5.5	5.7	5.5
China, People's Rep. of	0.2	0.9	1.3	2.1
Singapore	2.6	3.0	3.9	6.5
Indonesia	0.7	0.8	0.9	1.6
Malaysia	3.5	15.4	16.6	17.3
Philippines	0.8	1.8	1.9	3.4
Thailand	3.8	5.2	6.0	5.7
Viet Nam	2.7	4.9	4.7	5.3
Rest of Southeast Asia	1.1	2.5	2.4	3.2
Pacific Islands	−0.8	0.2	6.4	7.0
Hong Kong, China	−0.3	2.8	3.0	3.0
Korea, Rep. of	7.2	8.7	9.2	10.0
Taipei,China	−0.9	1.1	7.6	8.5
Rest of Northeast Asia	−0.1	1.2	3.9	5.4
India	0.4	1.3	1.3	1.4
Pakistan	−0.4	−0.2	1.3	1.6
Bangladesh	−0.1	0.2	0.7	0.9
Rest of South Asia	−0.5	0.2	1.8	2.3
Central Asia	0.2	0.6	2.0	2.7
Latin America	0.1	0.0	0.0	0.6
Middle East and Africa	0.1	0.6	2.2	3.3
High-income	0.5	0.8	3.1	3.0
Developing	0.5	1.1	1.9	2.6
of which Asia:	0.7	1.6	2.2	2.7
Total	**0.5**	**1.0**	**2.5**	**2.8**

MFN = most favored nation, TFP = total factor productivity.
Source: Derived from GTAP model results summarized in Anderson and Strutt (2011b).

Table 6: Short-Run (1 year) Price Transmission Elasticities,[a] Key Foodcrop Products, Asian Developing Countries, 1985–2004

	Rice	Wheat	Maize	Soybean	Sugar	Unweighted Average
Bangladesh	0.40	0.22			0.10	**0.24**
China, People's Rep. of	0.79	0.62	0.53	0.80	0.54	**0.65**
India	0.10	0.00	0.48	1.00	0.19	**0.35**
Indonesia	0.55		0.84	0.95	0.38	**0.68**
Korea, Rep. of	0.25			0.14		**0.20**
Pakistan	0.12	0.24	0.29		0.13	**0.20**
Philippines	0.45		0.47		0.35	**0.42**
Sri Lanka	0.57					**0.57**
Taipei,China	0.32					**0.32**
Thailand	0.93		0.63	0.09	0.84	**0.62**
Viet Nam	0.67				0.46	**0.57**
Unweighted Average of Above	**0.47**	**0.27**	**0.54**	**0.60**	**0.37**	**0.45**

[a] The proportion of a change in the international price that is transmitted to the domestic market of a country within a year.
Source: Authors' estimates, drawing on NRA estimates from Anderson and Valenzuela (2008).

The differences across regions in rates of growth of factor endowments and TFP, the fact that sectors differ in their relative factor intensities and their share of GDP, and the fact that demands are nonhomothetic ensure that the structures of production, consumption, and trade across sectors within countries, and also between countries, is going to be different in 2030 than in 2004. In particular, the faster-growing developing economies (especially those of Asia) will account for considerably larger shares of the projected global economy over the next 2 decades. Their aggregate share of world GDP is projected to rise from 20% in 2004 to 41% in 2030, and for just Developing Asia from 11% to 28%. Western Europe's share, meanwhile, is projected to fall from one third to less than one quarter. Population shares change much less, with the developing countries' share rising from 80% to 83%, but Developing Asia's component will be falling slightly, from 55% to 53% between 2004 and 2030. Thus per capita incomes converge considerably, with the ratio of the high-income to developing country average more than halving, from 16 to 7 between 2004 and 2030. In particular, the per capita income of Developing Asia is projected to rise from 20% to 53% of the global average over the projection period (Anderson and Strutt 2011b, Appendix Table A.6).

When global value added is broken down by sector, the changes are more striking. This is especially so for the PRC: by 2030 its relatively very rapid economic growth is projected to return it to supremacy as the world's top producing country not only of primary products but also of manufactures—a ranking the PRC has not held since the mid-19th century when first the United Kingdom and then (from 1895) the US became the top-ranked country for industrial production (Allen 2011, Figure 2).

The developing country share of global exports of all products is projected to increase by half, rising from one third in 2004 to 57% by 2030. The PRC's share alone grows from 6.7% to 18.4%, at the expense of high-income countries. The group's import share also rises, although not quite so dramatically: the increase for Developing Asia is from 18% to 34%. The developing country share of primary products in world exports rises slightly and its share of manufactures in world exports rises dramatically over the projection period (almost doubling in Asia's case, as does its services share). The developing country share of primary products in world imports rises substantially though, almost all of which is due to Developing Asia's expected continuing rapid industrialization. Developing Asia and other developing countries increase their share in total world imports by nearly half, and even by half in manufactures (Anderson and Strutt 2011b, Tables 4 and 5).

The developing country share of global exports of agricultural and food products is projected to remain virtually unchanged, while their share of global imports of farm products rises considerably. Hence its self-sufficiency in farm products is lower in this core scenario for 2030 than in 2004, dropping from 96% to 87% in the case of Developing Asia. The source of that change is mainly the PRC, but also some countries in Southeast Asia and also Pakistan (Table 1, columns 1 and 2).

Continuing Asian industrialization causes primary products to become less important in developing country exports and considerably more important in their imports, and conversely for nonprimary products, with the changes being largest in Developing Asia. The opposite is true for high-income countries (Tables 2 and 3), which may seem surprising, but recall that what one part of the world imports, the remaining part of the world must export to maintain global equilibrium.[7] Services exports, however, are far more important for India than for the PRC or the large ASEAN countries in 2004, and that difference is projected to increase substantially by 2030.

For the PRC, Indonesia, Malaysia, Pakistan, the Philippines, and Viet Nam, the projected economic growth to 2030 leads to a substantial decline in their projected agricultural self-sufficiency, spread over most farm product groups, while for India and Bangladesh the changes are much smaller (compare panels A and B of Table 4). The consequent increase in the share of world imports accounted for by Developing Asia's imports of agricultural produce is from 1.0% to 3.0%, and its rise in the share of global imports of agricultural and food is from 14% to 41% while its change in the share of world exports is only from 13.9% to 14.7% percent (Anderson and Strutt 2011b, Tables 4–6).

Self-sufficiency is a poor indicator of food security, however (Warr 2011). A more meaningful indicator is real per capita household consumption of agricultural and

[7] As can be inferred from the first two columns of Table 1, some of the increased imports of farm products by developing countries would come from Australasia, Western Europe, and North America (where food consumption is increasing only very slowly). Further disaggregation of the results reveals that some of those imports would come also from such large food-exporting developing countries as Brazil and South Africa, both of whose self-sufficiency rises by around 20%.

processed food products (valued at constant 2004 prices). The first column of Table 5 shows that, for Developing Asia, the volume consumed per capita in the core 2030 scenario would be 1.4 times that in 2004. The increase is even larger for the PRC, India, Pakistan, the Philippines, and Viet Nam, while somewhat smaller for other Asian countries. That clearly represents a huge improvement in food security. But how sensitive is that number to the model's assumptions about farm productivity growth?

C. Sensitivity of 2030 Projections to Farm Productivity Assumptions

The above core projection is compared in this subsection with two alternative growth scenarios:

(i) Slower TFP growth in primary sectors in all countries

(ii) Faster TFP growth in grain cropping in key Developing Asian countries

The first of these alternative scenarios involves dropping the assumption that productivity growth in the primary sectors increases to nearly match the growing global demand for such products due to Asia's rapid industrialization. This is a plausible alternative, given the experience of the past 2 decades of a slowdown in productivity growth in agriculture in both high-income and developing countries (Alston, Babcock, and Pardey 2010), and the possibility of a similar slowdown in mineral and energy productivity growth due to, for example, political disruptions in the Middle East and parts of Africa. In this alternative case, real international prices for agricultural, mineral, and energy raw material products by 2030 are much more above 2004 levels than in the core projection. Consistent with the price projections of several international agencies (FAO/OECD 2010, Nelson et al. 2010, IEA 2010), the additional TFP growth rate of 2.5 percentage points per year for forestry and fishing is reduced to 1 percentage point. For mining, agriculture, and lightly processed food, the productivity differential in the core projection is smaller, but it too is reduced by 1 percentage point. These amendments lead to real international prices for farm products in 2030 to be 25% instead of just 9% above those in 2004, and those for other primary products to be 101% instead of 25% above 2004 levels (see Appendix Table 3 for details by product).

The higher prices more than compensate for lower farming and mining productivity such that the share of primary products in GDP is slightly higher in this scenario than in the core projection. This does not lead to developing countries being more food self-sufficient though (Table 1), or to much change in their share of global trade in farm products (Tables 2 and 3). This is because the slower farm productivity growth is assumed to apply to all countries, so they tend to adjust in unison.

By contrast with the above alternative, the second alternative scenario presumes there is increased investment in the production of new or adaption of imported crop

technologies so as to ensure grain output is higher for key Asian countries than in the core scenario. This might come about through, for example, greater recognition on the part of government leaders in those countries of the extremely high marginal social rate of return from further agricultural R&D in developing countries (Alston, Beddow, and Pardey 2009).[8] In this alternative scenario the TFP growth rates for rice, wheat, and coarse grains are set an extra 1 percentage point higher for just the PRC, India, and the ASEAN countries. This raises overall agricultural self-sufficiency rates of those countries by between 1 and 3 percentage points, but lowers them slightly for other Asian countries (Table 1). More importantly, it raises by several percentage points self-sufficiency in the staple grain crops of the PRC, India, Indonesia, the Philippines, Thailand, and Viet Nam (compare parts B and C of Table 4). It also increases slightly the extent of agricultural trade among Developing Asian countries (Anderson and Strutt 2011b, Table 12). This positive shock to grain productivity—even though it is confined just to ASEAN, the PRC, and India—has a noticeable impact on the projected real international prices of grains. Instead of rice, wheat, and coarse grain prices rising between 2004 and 2030 by 10%, 15%, and 22%, as in the core simulation, they rise in this alternative scenario by only 4%, 12%, and 18%, respectively (compare columns 1 and 3 of Appendix Table 3). This means that even though the demand for livestock products expands because of higher incomes in those more productive countries, the international prices of meat and milk do not rise, because animal feed prices are lower.

III. Alternative Policy and Climate Scenarios by 2030

The above projections all assume trade policies remain unchanged between the base period and 2030. This section examines how the above core scenario for 2030 would be altered if some trade policy reforms were to be undertaken over the projection period. Two trade liberalization scenarios are compared with the 2030 core baseline. They are then contrasted with an agricultural protection scenario, in which it is assumed that a strong agreement is not reached under the World Trade Organization's (WTO) Doha Development Agenda, and as a consequence, developing countries follow the prior example of earlier-industrializing countries in Europe and Northeast Asia and allow tariffs on farm products to increase as their incomes and agricultural comparative disadvantage rise.

[8] Recent revisions of marginal rates of return suggest earlier numbers were exaggerated, but even those latest estimates suggest very high benefit–cost ratios. See Alston et al. (2011).

A. Regional and Global Trade Liberalization Options

The trade reform possibilities considered are the following, which assumes that membership of the ASEAN free trade area is extended to six additional countries (Australia, the PRC, India, Japan, the Republic of Korea, and New Zealand) currently being considered to form ASEAN+6.

(i) All merchandise trade is freed on a preferential basis within the expanded ASEAN+6 bloc.

(ii) All merchandise trade is freed by all countries in the expanded ASEAN+6 group and not on a preferential basis but rather also with the rest of the world (that is, on a most favored nation [MFN] basis).

If the ASEAN+6 initiative was purely preferential, the global gains by 2030 would be $60 billion per year but most of them would be enjoyed in East Asia and Australia/New Zealand, and non-Asian developing countries as a group would be slightly worse off. In that scenario, ASEAN agricultural output would be one sixth higher because the more densely populated countries in South and East Asia would specialize more in nonfarm products and import more agricultural goods from ASEAN. Were those trade policy reforms by ASEAN+6 on an MFN basis (that is, if tariffs were removed for trade not only within the group but also with nonmembers), the global gains would nearly treble, to $166 billion per year by 2030, of which Developing Asia's share would be $52 billion. In that case non-Asian developing countries would gain around $30 billion, and they would compete with ASEAN+6 exporters of farm products in supplying even more agricultural goods to the PRC, India, and Japan.[9]

The impact of expanding the ASEAN bloc by six members and freeing trade among the expanded membership causes ASEAN's agricultural exports to increase dramatically. With the PRC and India, their share of world agricultural exports (imports) in 2030 would be 15% instead of 12% (39% instead of 34%)—even though agricultural self-sufficiency of the PRC, India, and ASEAN would not change by more than 1 or 2 percentage points (Table 1).

Accompanying that liberalization would be an expansion in per capita food consumption. This is not surprising, because agricultural trade reform typically lowers food prices in protective import-dependent countries; raises international food prices, and hence the earnings of food producers in other countries; and increases economic welfare

[9] Those welfare benefits are nearly half what they would be if all countries of the world were to remove their barriers to goods trade. Such an extreme reform would generate welfare gains of $384 billion per year globally by 2030, made up of $150 billion for high-income countries, $134 billion for Developing Asia, and $101 billion for other developing countries (Anderson and Strutt 2011b, Table 16).

in the world as a whole. The extent of the improvement in real per capita household consumption of agricultural and food products in Developing Asian countries is 1%–2% (Table 5b).

B. The Agricultural Protection Option

Historically, the trend level of national nominal rates of assistance to agriculture[10] has tended to be higher, the higher a country's income per capita and the weaker a country's agricultural comparative advantage (Anderson 2009a, chapter 1). Thus when mapped over time, the agricultural nominal rates of assistance to agriculture (NRA) has been gradually rising for developing countries as a group, and also for high-income countries prior to the 1990s. If past policy trends were to continue for today's developing countries, then in the absence of a strong Doha agreement to lower WTO-bound tariffs on farm products, their NRA may keep increasing above zero. That is certainly what the Republic of Korea and Taipei,China did in following Japan; and the PRC, India, and ASEAN appear to be on a similar trajectory (Anderson 2009b).

Drawing on political economy theory and past experience, Anderson and Nelgen (2011a) examine econometrically whether agricultural protection increases with per capita income and agricultural comparative disadvantage, and tends to be higher for import-competing than exported products. They estimate a relationship for 10 key traded farm products as of 2004, and project NRAs for each of those products to 2030 for each developing country in the World Bank distortion database compiled by Anderson and Valenzuela (2008).[11] They assume all developing countries respect their current commitment to WTO not to exceed their tariff bindings but otherwise feel free to allow domestic political forces to determine the degree of protection provided to import-competing farm industries. They use those criteria to obtain projected values for each of the 10 products and for each of the 39 developing countries in the World Bank sample. For developing countries as a whole, the average NRA for these products is projected to rise from 7% in 2004 to 35% by 2030, while for Developing Asia the average rises from 11% to 42%.

To see what those projected NRAs imply about the cost of agricultural and other price- and trade-distorting policies in the world economy in 2030, compared with assuming no changes in trade policies since 2004, the above results from the full global trade liberalization are compared with those generated by assuming such farm protection

[10] The nominal rates of assistance to agriculture (NRA) is defined as the percentage by which government policies have raised gross returns to farmers above what they would be without the government's intervention (or lowered them, if NRA<0). See Anderson et al. (2008).

[11] Their findings are as expected from political economy theory and past experience, so they use them to project NRAs for 2030. The projected NRAs are then subjected to the following two tests for each developing country. First, if a product was in 2004 and is projected to still be a net export product for a country in 2030, then its 2030 NRA is assumed to be the lesser of its 2004 NRA or zero. That is, it is assumed all export taxes will be phased out by 2030, and that no new export subsidies will be introduced. Second, if the product is projected to be an import-competing product in 2030, then its 2030 NRA is assumed to be the lesser of the equation's projected NRA or the country's WTO-bound tariff rate.

growth. It makes Asian developing countries slightly more agriculturally self-sufficient in 2030 (Table 1, and parts B and D of Table 4), but their real food consumption would grow slightly less in this agricultural protection growth scenario than in the core scenario (compare columns 1 and 4 in Table 5, panel A).

C. The Effect of Climate Change

Finally in this section, we discuss one more set of results to get a sense of how the core scenario to 2030, which was constructed assuming no climate change, might alter if there is no accelerated mitigation of greenhouse gases by 2030 and if the productivity of agricultural cropland and unskilled labor are altered as a consequence. Valenzuela and Anderson (2011) review the work of many others, including Hertel, Burke, and Lobell (2010), to come up with a set of scenarios to 2030 as they affect agriculture. For present purposes we assume crop yields would be affected as in Appendix Table 4. They represent a most likely or medium case. We also assume that since temperatures and humidity are expected to rise from already very high levels in most tropical developing countries, the productivity of workers in those countries (especially for those involved in manual farm work activities) will 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 from high current levels. We follow van der Mensbrugghe and Roson (2010) in relying on Kjellstrom et al. (2009) to suggest the effect of climate change in tropical and desertified developing countries is to reduce the productivity of unskilled workers in both agricultural and nonfarm sectors by 3% by 2030 (other than the relatively temperate countries of Argentina; the Republic of Korea; South Africa; and Taipei,China; and the most affluent ones of Hong Kong, China and Singapore).

With that shock to land and unskilled labor, agricultural self-sufficiency in 2030 is slightly higher in high-income countries and slightly lower in developing countries than in the core scenario, but only by about 1 percentage point (Table 1). Importantly for rice in particular, national self-sufficiency rates in Asia are projected to be no more than one percentage point lower (or, in the Republic of Korea and Taipei,China's cases, two points higher, and in Singapore, 7 points higher—compare parts B and E of Table 4). As for household food consumption in Asia, again it would be lowered by no more than 1 percentage point in each country, according to Table 5, panel A.

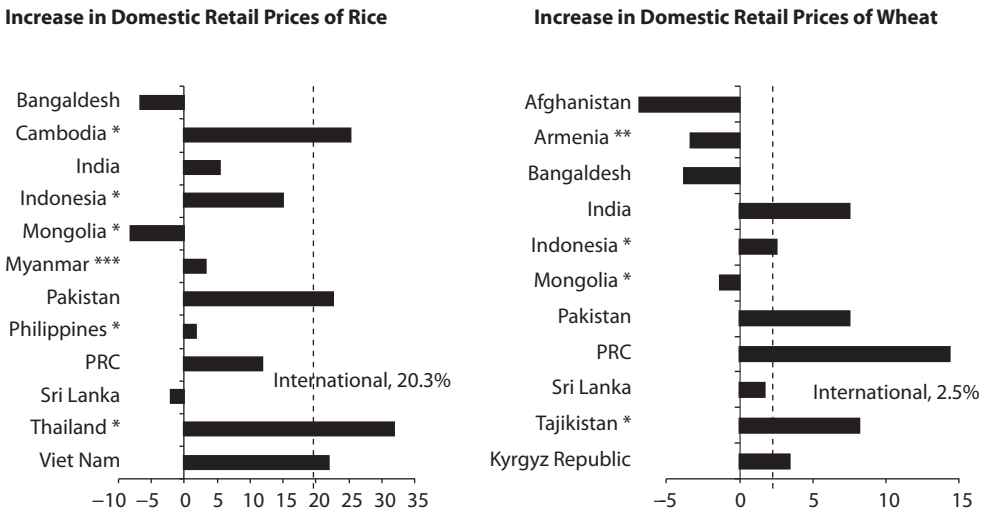
Of course there will be other effects of climate change in addition to cropland and unskilled labor productivity effects, and many effects may be much worse in subsequent decades than in just 20 years' time.[12] More importantly for vulnerable farm households is the possibility of more frequent and more severe extreme weather events, whose stochastic effects cannot be assessed with the comparative static model used here. That possibility could lead to more sudden shocks to global supplies that cause prices in international food markets to temporarily spike. We turn now to examine how governments in the past have dealt with that aspect of food security.

IV. Trade Policy Responses to Short-Term Food Security Concerns with Volatile Prices

Both politicians and vulnerable households worry about short-term fluctuations around long-run trends in markets for staple foods. Fluctuations are to be expected in commodity markets subject to periodic supply or demand shocks, especially if adverse supply shocks occur when stocks are at low levels (Wright 2011; Carter, Rausser, and Smith 2011). They are even more likely in the presence also of sporadic changes in government storage activity. Many governments seek to shield their domestic market somewhat from those fluctuations, and especially from severe spikes in international prices of staple foods. Not surprisingly, then, variations in domestic prices often are less than variations in world prices (Figure 1). The extent to which world prices transmit to national markets depends on trade policies, domestic price support, market integration, infrastructure, and domestic market inefficiency.

[12] One of the more widely cited studies is by Cline (2007), who predicts that by the 2080s, even with carbon fertilization, agricultural output will be 8% lower in developing countries, 8% higher in high-income countries, and 3% lower globally. Those larger magnitudes refer to 5 decades later than the above projections though, so they may not be inconsistent with our findings for 2030 if indeed it is not until the middle half of the present century that the effects of climate change on agriculture accelerate. A more recent study by Nelson et al. (2010, Table 2.2) suggests that climate change will cause real international prices of grain to be between one-fifth and one-third higher in 2050 than they would be without the climate changes expected in the first half of this century. Again those results for 2 decades later may not be inconsistent with the above findings for 2030.

Figure 1: Increase in Domestic Retail Prices of Rice and Wheat vis-à-vis their International Prices, November 2011 (% year-on-year)



* means October 2011; ** means September 2011; *** means August 2011.
Source: Jha and Rhee (2012).

Typically governments insulate their domestic markets by altering the restrictiveness of their trade policies, on both imports and exports.[13] An export tax or its equivalent lowers the domestic price below the border price of a tradable product such as grain (as does an import subsidy), whereas an import tax or its equivalent raises its domestic price above the border price (as does an export subsidy). Hence it is not surprising that governments, in seeking to protect domestic consumers from an upward spike in international food prices, consider a change in trade measures as an appropriate response, since that can lower the consumer tax equivalent of any such measure.

However, an import tax (or export subsidy) is the equivalent of a consumer tax and a producer subsidy, hence lowering it also reduces the extent to which the measure assists producers of the product in question. Likewise, since an export tax (or import subsidy) is the equivalent of a consumer subsidy and a producer tax, raising it not only helps consumers but also harms farmers. If farming is discouraged, the demand for labor on farms falls, and with it the wages of unskilled workers not only in farm jobs but also in nonfarm jobs—and more so the more agrarian is the economy. Thus while poor households may benefit on the expenditure side from a measure that reduces the extent to which the price of food would otherwise rise, they could be harmed on the earnings side if they are sellers of food or suppliers of unskilled labor. Such trade policy responses

[13] For reviews of recent examples of such interventions, see Jones and Kwiecinski (2010), ADB (2011a), and FAO et al. (2011).

herefore could add to rather than reduce poverty.[14] In the case of small intervening countries unable to influence their terms of trade, such trade measures also are likely to reduce their national economic welfare, because they distort domestic production in addition to lowering the consumer price of food.[15] They are also wasteful if it is only the poorest consumers who need to be helped, since a trade measure affects all food consumers in the country. Conversely, in the case of opposite changes to trade measures aimed at protecting farmers from a downward spike in international prices, it is consumers who are inadvertently harmed by such trade policy responses, and all producers are helped—and in proportion to their output—rather than just the poorest, thereby adding to farm income inequality.

Moreover, trade measures are not only inefficient at protecting a needy group from being harmed by a temporary shock to international food markets, they are also ineffective if many countries respond similarly. Their ineffectiveness comes about because trade barriers of both food-exporting and food-importing countries often are altered in an effort to prevent the transmission of the international price shock. If only food-exporting countries respond to an upward price spike, the international terms of trade would turn even further in their favor because of the additional reduction in available supplies on the international markets (and conversely if only food-importing countries alter their trade restrictions when the world price of food collapses). Such action would thus add both to the extent of the international price spike and to the transfer of welfare from food-deficit to food-surplus countries (or from food-surplus to food-deficit countries when the price spike is downward and only food-deficit countries respond).

However, when both sets of countries seek to insulate their domestic markets from an external shock, their impacts on the international price spike are reinforcing but their impacts on the volume they trade internationally—and hence on their domestic prices—are offsetting. In the extreme case in which food-deficit countries expand their imports to exactly the same extent as food-surplus countries reduce exports, the domestic price in both sets of countries would be no different than if neither country altered their trade measures following the exogenous shock. That is, the international price change from the initial shock would be fully transmitted to both sets of countries, despite their efforts to fully insulate their domestic markets in that extreme case. Moreover, the more countries that participate and thus the more the international price spike is accentuated, the more compelled will other countries feel to join the bandwagon and push that price even higher. This is a classic collective-action problem akin to when a crowd stands up in a stadium to get a better view: on average no one gets a better view by standing, but those that

[14] Recent empirical studies provide numerous cases of where trade restrictions have added to or would add to poverty. See, for example, Warr (2005); Hertel and Winters (2006); and Anderson, Cockburn, and Martin (2011).

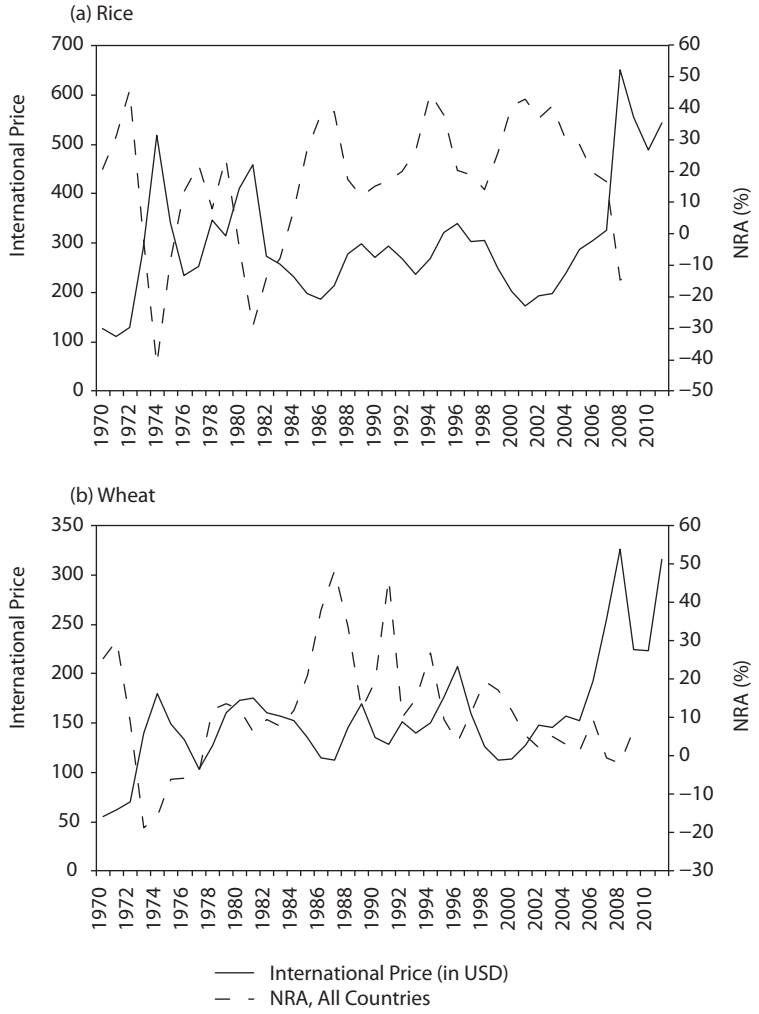
[15] Variable trade restrictions can also affect long-term investments and hence economic growth rates. Drawing on a broad range of developing country case studies, Bevan, Collier, and Gunning (1990) and Collier, Gunning, and Associates (1999) suggest that faster economic growth would result from allowing producers access to high prices in those rare occasions when they spike, rather than taxing it away. According to the evidence in their case studies, this is because governments are more prone than farm households to squander the windfall either in poor investments or in extra consumption.

remain seated get a worse view and so are induced to stand as well. Clearly there is a case for multilateral agreement to desist from using trade measures for this purpose, but so far no such agreement has been reached.

Governments do not limit their interventions in markets for farm products to periods of extreme prices of course. Around the long-run trends in agricultural NRAs for each country there is much fluctuation from year to year in individual product NRAs.[16] NRAs are negatively correlated with deviations from trend in the international price of the product in question, and especially for rice and wheat (Figure 2). To examine how much that behavior varies across products, Table 6 provides new estimates of the elasticity of transmission of the international product price to the domestic market for key crop products in Asian economies. Following Nerlove (1972) and Tyers and Anderson (1992, 65–75), we use a partial-adjustment geometric distributed lag formulation to estimate elasticities for the period 1985 to 2004. Those short-run elasticities range from a low of 0.3 for sugar to around 0.5 for rice and wheat, and around 0.7 for soybean. The unweighted average across those key crop products is 0.45. Anderson and Nelgen (2011b) repeat this exercise for 77 countries and the 10 most important farm products, and get an unweighted average of 0.46. Together this suggests that within 1 year, less than half the movement in international prices of key farm products is transmitted domestically.

[16] A change in NRA may not require any policy action on the part of the government, but rather be part of the original policy design. For example, the use of specific rather than ad valorem rates of trade taxation or trade subsidization automatically ensures some insulation of the domestic market from international price changes, as does the use of quantitative restrictions on trade such as fixed import or export quotas or bans. Explicit formulae for varying the import or export duty according to international price movements also may be part of the policy regime. And in some cases explicit provisions for restricting or relaxing trade barriers in price spike periods also are part of a policy's legislation, even though the use of that provision may lie dormant in all but extreme periods. In what follows such possibilities will be treated no differently than any formal change of policy: both will show up as a change in the NRA.

Figure 2: Rice and Wheat NRAs and their International Price, 77 Countries,[a] 1970–2010



NRA = nominal rate of assistance.
Note: Left axis is international price in current US$, right axis is weighted average NRA.
Sources: Based on the update of NRA estimates in Anderson and Valenzuela (2008) by Anderson and Nelgen (2012).

How successfully has such policy action reduced instability in domestic relative to international markets for farm products? A statistical indicator that can help answer this question is the coefficient of variation (the standard deviation divided by the sample mean) of the domestic price relative to that for the border price.[17] Table 7 provides estimates of that relative indicator for key farm products in various Asian countries for the period 1965–2004. The averages across countries of those estimates suggest that interventions in Developing Asia were severe enough to provide some insulation for rice and sugar, but to have had little impact in preventing domestic market prices from

[17] The domestic producer price and the corresponding border price are deflated by the GDP deflator, measured around log-linear trends and expressed as a percentage.

gyrating less than prices in international markets for the other products shown.[18] This is consistent with a stochastic dynamic simulation exercise for India's grain markets, which showed that unilateral liberalization of trade could lead to greater domestic price stability even though it would make world prices more volatile (Srinivasan and Jha 2001).

Table 7: Index of Relative Domestic Food Price Stability,[a] Selected Products, Asian Developing Countries, 1965–2004 (percent)

	Rice	Wheat	Maize	Soybean	Sugar	Average of 12 Products[b]
Bangladesh	134	244			25	136
China, People's Rep. of	79	88	86	108	92	76
India	27	85	98	109	26	47
Indonesia	103		92	117	78	100
Korea, Rep. of	56	86		74		86
Malaysia	52					59
Pakistan	59	109	148		29	88
Philippines	43		63		44	57
Sri Lanka	88					88
Taipei,China	63	43				64
Thailand	63		92	56	82	71
Unweighted Average	70	109	97	93	53	79

[a] Ratio of the coefficient of variation of the domestic producer price to the coefficient of variation of the corresponding border price, both deflated by the gross domestic product deflator, measured around log-linear trends and expressed as a percentage.

[b] Weighted by the value of production at undistorted prices for the above five products plus cotton, coffee, cocoa, milk, beef, pig meat, and poultry.

Source: Authors' calculations, drawing on price data in Anderson and Valenzuela (2008).

As mentioned above, such a modest outcome is possible when food-exporting and food-importing countries both alter their trade restrictions in offsetting ways when international prices move away from trend. Indeed the indicator in Table 7 overstates the degree of success of national governments in stabilizing domestic prices, because without such policy actions the international price fluctuations would have been smaller. Martin and Anderson (2012) suggest a method to estimate by how much smaller. While their method relies on a number of simplifying assumptions,[19] it at least provides an indication of the combined influence of such variations in trade restrictions on each product market. Applying that method to data for the 1972–1974 and 2005–2008 grain price spikes yields the results shown in Tables 8 and 9.

The first column of Table 8 suggests that in both periods about one sixth of the maize price rise, between one eighth and one quarter of the wheat price rise, and more than one quarter of the rice spike, can be attributed to variations in trade restrictions.

[18] This is consistent with the findings of a recent study that assessed the contributions that parastatals have made to food security in the six most populous economies of South and Southeast Asia, which found them wanting (Shahidur, Gulati, and Cummings 2008).

[19] It assumes that output cannot respond in the short run, that inventory levels are so low that stock adjustments have a limited effect (as is typically the case in a price spike period; see Wright 2011) and that the national elasticities of final demand for the product in question are the same across countries. It also ignores cross-elasticities between products.

Furthermore, the right-hand columns show how much of those impacts came from exporting as distinct from importing countries: when averaged across the three grains, the contribution of exporting countries is only slightly greater than that of importing countries.

Table 8: Contributions[a] of Importing and Exporting Countries to the Proportion of the International Price Change that is Due to Policy-Induced Trade Barrier Changes, 1972–1974 and 2005–2008

	Total Proportional Contribution	Importing Countries' Contribution	Exporting Countries' Contribution
1972–1974			
Rice	0.27	0.10	0.17
Wheat	0.23	0.18	0.05
Maize	0.18	0.06	0.12
2005–2008			
Rice	0.31	0.13	0.18
Wheat	0.13	0.06	0.07
Maize	0.18	0.07	0.11

[a] Expressed such that the two numbers in the right-hand pair of columns add to add to the total proportion shown in column 1 of each row.

Source: Authors' calculations based on the distortion estimates in Anderson and Nelgen (2012) and based on the methodology in Martin and Anderson (2012).

The proportional contribution of both sets of countries' governments, shown in column 1 of Table 8, can be used to discount the rise in the international prices of those grains to suggest how much those prices would have risen if governments had not altered their trade restrictions. That can be seen in column 2 of Table 9. Column 3 gives the unweighted average across all countries in our sample of the domestic price rises for those grains. The numbers for 2005–2008 suggest that, on average, domestic prices rose slightly more than the adjusted international price change for wheat and maize, and only one quarter less for rice. The extent of insulation was greater in developing countries, especially for wheat and maize. This recent experience contrasts with the early 1970s, when high-income countries were much more insulated than recently, and also compared with developing countries in the 1970s (see upper half of Table 9). These results provide further evidence that the combined responses by governments of all countries have been sufficiently offsetting as to do very little to insulate domestic markets from this recent international food price spike.

Table 9: Comparison of the Domestic Price Rise with the Rise in International Grain Prices Net of the Contribution of Changed Trade Restrictions, Rice, Wheat and Maize, 1972–1974 and 2005–2008 (percent, unweighted averages)

	International Price Rise		Domestic Price Rises		
	Including Contribution of Changed Trade Restrictions	Net of Contribution of Changed Trade Restrictions	All Countries	Developing Countries	High-income Countries
1972–1974					
Rice	300	219	59	72	27
Wheat	158	121	64	77	55
Maize	135	111	49	48	52
2005–2008					
Rice	127	88	65	64	66
Wheat	100	87	98	60	113
Maize	126	103	106	78	129

Sources: Authors' calculations, drawing on price data in Anderson and Nelgen (2012) and, for column 2, the methodology in Martin and Anderson (2012).

This evidence that even the substantial variations in border trade restrictions practiced in the past have been ineffective in reducing domestic food price fluctuations is of concern for Asia's developing countries not only from a food security viewpoint but also from an inflation viewpoint (ADB 2011a). This is because, leaving aside Japan; the Republic of Korea; and Taipei,China, food has a weight of between 30% and 60% in the consumer price index of developing Asian countries. It has an even higher weight in the consumption basket of poor households within those countries (Deaton and Dupriez 2011).

V. Policy Options and Implications

Given the above findings on long-run trends and short-term market fluctuations in global food markets, and past government responses to and influences on both, it is now possible to examine in a more informed way the options available to national governments—unilaterally, plurilaterally, and multilaterally—for dealing with food security issues in the years ahead. Asia's two largest developing countries, the PRC and India, have a particularly large stake in this issue, because of their declining food self-sufficiency (Table 1) and their rising shares of global grain consumption, which is projected to increase from 25% to 40% between 2004 and 2030 (Table 10).

Table 10: Regional Shares of Global Consumption of Grains, 2004 and 2030 Core (percent)

	2004	2030
Latin America	8.4	6.9
Middle East and Africa	12.9	15.0
Japan	11.7	5.0
Other High-Income	21.9	14.8
Developing Asia:	**45.0**	**58.4**
China, People's Rep. of	12.0	27.1
ASEAN	9.3	10.5
India	13.2	12.2
Rest of South Asia	5.3	4.8
Other Asia	5.2	3.8
Total	**100.0**	**100.0**

ASEAN = Association of Southeast Asian Nations.
Source: Derived from GTAP model results of Anderson and Strutt (2011b).

The trade policy scenarios analyzed above suggest that agricultural protection growth is not a long-run solution to boosting food security, in the sense of raising per capita food consumption. On the contrary, it raises the price of food in protecting countries, and lowers overall national economic welfare in both protecting and food-exporting countries. More specifically, import-restricting food policies reduce the food security of all households that are net buyers of food, including those farm households specializing in producing products other than food staples. In countries where such households account for majority of the poor, such import restrictions add to poverty (Ivanic and Martin 2010). Thus governments of countries experiencing a long-run decline in food self-sufficiency need to resist the temptation to go down the agricultural protection growth path, and instead consider other options for ensuring food security.

As for short-run food security concerns, fluctuations in national trade barriers are not a very effective way of dealing with international price spikes, because when many exporting and importing countries so act, they tend to neutralize each other's domestic market stabilizing efforts and at the same time accentuate the international price spike and so push more countries into acting similarly. The evidence summarized above suggests there is a strong case for multilateral agreement to desist from using trade measures for this purpose. The case for countries to get together to agree not to alter their border measures in response to price fluctuations is especially strong in situations where only a few countries account for most of the world's production and consumption. Since a dozen Asian countries account for all but one tenth of the global rice market, it should be relatively easy for the region's governments to cooperate in this way to reduce short-run rice security concerns. Even if they differ in their desired national long-term trend levels of rice protection, they could at least reduce fluctuations in the international price of rice by agreeing to use fixed ad valorem tariffs rather than variable or volumetric import taxes or quantitative trade restrictions.

Another option for Asian countries is to liberalize their trade, which is shown above to be able to boost per capita food consumption. The extent of those benefits is likely to be greater the more encompassing any such liberalization is.

Turning to domestic measures, possibly the best long-term option for many developing countries is investing more in agricultural R&D. The above results show that this has the potential to boost per capita food consumption in both food-exporting and food-importing countries. If there are high marginal social rates of return from such investments, then they will also boost economic growth. Provided the resulting supply expansion does not depress world food prices too much, it could also boost the incomes of farmers. For both reasons, this option is likely also to be poverty alleviating over the longer term (Ivanic and Martin 2010). So too would be improvements in the formal credit market, since it is the asset- and income-poor who are usually the least able to access credit at reasonable (let alone subsidized) interest rates to tide them over short-term periods of hardship. The development of markets for commodity futures, weather-index insurance, and currency hedging are also financial mechanisms for helping traders deal with risk and uncertainty, and ones that are becoming gradually more accessible in many developing country settings (Byerlee, Jayne, and Myers 2006; OECD 2009; FAO et al. 2011).

In the past 3 years there has been a range of other domestic measures adopted by various Asian developing countries to deal with short-term concerns associated with a food price spike (see Jones and Kwiecinski 2010, Tangermann 2011). Two are mentioned by way of conclusion: altering grain stocks and conditional/targeted cash transfers.

Government involvement in grain stock holding appeals to many as a sensible food security strategy. However, their involvement in the market for storage services crowds out private stock holding. This is because it adds to market uncertainty, since predicting the sporadic and often politically driven purchase and selling decisions of a parastatal agency is typically very difficult. This is again a collective action problem: if all governments agreed not to engage in large-scale grain storage, there would be no need for any government to do so because the private sector would then find it profitable to purchase and store when prices were low (thereby putting a floor under farmer prices), and to sell from those stock holdings when prices are high (Wright 2011). If governments are still fearful that a widespread crop failure may deplete those stocks, they may be tempted to get together and contribute to a joint stock holding program with firmly agreed rules for buying and selling. Past experience cautions against such action, however, because previous international commodity agreements have led at best to disappointing outcomes (Gilbert 2010).

Potentially, schemes that target only those in most need are more efficient than administered pricing schemes and trade policies that affect all producers and consumers. In the case of upward spikes in staple food prices, the distribution of coupons for the poor is one example of such a targeted scheme. In the past the transactions cost of

making such transfers to poor households was prohibitively expensive, but thanks to the information technology revolution, it is now possible for developing country governments to provide conditional cash transfers electronically at relatively little cost (see, for example, Adato and Hoddinott 2010).

In short, governments can play a useful role in enhancing food security, but the societal payoffs will be greatest if their activities are focused on improving the efficiency of their domestic markets (e.g., for smallholder credit); overcoming externalities (such as the free-rider problem that leads to under-investment in agricultural R&D); improving rural transport and communication infrastructure; and coordinating with other governments to multilaterally dismantle market-distorting price and trade policies (so many of which increase the volatility of international food prices and reduce per capita food consumption).

Appendix

Appendix Table 1: Average Annual GDP and Endowment Growth Rates, 2004–2030

	GDP Growth	Population Growth	Unskilled Labor	Skilled Labor	Produced Capital	Agricultural Land	Oil	Gas	Coal	Other Minerals
Western Europe	1.48	0.14	–1.09	1.50	1.60	–0.28	2.81	0.77	–2.51	2.07
Eastern Europe	3.51	0.02	–0.57	1.49	4.03	–0.23	2.64	0.12	–1.86	2.07
United States and Canada	2.09	0.82	0.17	1.59	1.75	–0.20	1.00	–0.14	0.19	2.07
Australia and New Zealand	2.78	1.07	0.31	1.89	1.59	–0.56	1.49	6.10	3.55	2.07
Japan	0.92	–0.21	–1.45	0.98	0.40	–1.14	0.00	0.00	–9.34	2.07
China, People's Rep. of	8.05	0.29	0.03	2.88	7.62	–0.36	–0.40	4.85	5.62	2.07
ASEAN	5.25	0.97	0.45	3.67	5.95	0.17	1.31	1.48	11.71	2.07
Pacific Islands	3.66	1.72	2.30	1.88	3.86	0.19	1.54	1.21	0.15	2.07
Rest of East Asia	3.47	0.31	–0.45	2.20	3.11	–0.87	0.00	0.00	–1.59	2.07
India	7.88	1.18	1.37	4.03	7.27	–0.04	0.24	0.00	4.93	2.07
Rest of South Asia	7.23	1.36	1.99	4.93	8.14	–0.10	0.27	–2.18	2.26	2.07
Central Asia	4.09	–0.46	–0.67	1.07	4.38	–0.29	2.81	0.77	–2.51	2.07
Latin America	3.81	0.92	0.78	3.32	4.85	0.22	3.29	–0.34	5.15	2.07
Middle East and Africa	4.55	1.92	1.04	4.16	5.46	0.05	1.27	3.64	1.89	2.07
High-Income	1.73	0.27	–0.55	1.49	1.56	–0.33	2.07	0.40	–0.26	2.07
Developing	5.28	1.03	0.52	3.28	5.81	–0.09	1.48	2.24	5.57	2.07
of which Asia:	6.24	0.78	0.26	2.93	6.26	–0.16	0.72	0.93	5.93	2.07
Total	2.45	0.88	–0.37	1.68	2.65	–0.17	1.67	1.23	2.50	2.07

ASEAN = Association of Southeast Asian Nations, GDP = gross domestic product.
Source: Anderson and Strutt (2011b).

Appendix Table 2: Implied Annual Growth in TFP for Nonprimary Sectors, 2004–2030 (percent, using 2004 national GDP values as weights)

	2030 Core			2030 Slower Primary TFP Growth			
	A	B	C	A	B	C	D
Western Europe	0.7	1.7	3.2	0.7	0.7	1.7	–0.3
Eastern Europe	1.2	2.2	3.8	1.2	1.2	2.2	0.3
United States and Canada	1.0	2.0	3.5	1.0	1.0	2.0	0.0
Australia and New Zealand	1.4	2.4	4.0	1.4	1.4	2.4	0.5
Japan	1.0	2.0	3.5	1.0	1.0	2.0	0.0
China, People's Rep. of	2.9	3.9	5.5	2.9	2.9	3.9	2.3
ASEAN	1.3	2.4	3.9	1.3	1.3	2.4	0.4
Pacific Islands	0.6	1.6	3.1	0.6	0.6	1.6	–0.5
Rest of East Asia	1.7	2.7	4.2	1.7	1.7	2.7	0.9
India	3.1	4.2	5.7	3.1	3.1	4.2	2.6
Rest of South Asia	2.2	3.2	4.7	2.2	2.2	3.2	1.4
Central Asia	1.8	2.8	4.4	1.8	1.8	2.8	1.0
Latin America	0.7	1.7	3.2	0.7	0.7	1.7	–0.4
Middle East and Africa	0.8	1.8	3.4	0.8	0.8	1.8	–0.2
High Income	0.9	1.9	3.4	0.9	0.9	1.9	–0.1
Total Developing	1.7	2.7	4.3	1.7	1.7	2.7	0.9
Developing Asia	2.4	3.4	4.9	2.4	2.4	3.4	1.7
Total World	1.1	2.1	3.6	1.1	1.1	2.1	0.1

ASEAN = Association of Southeast Asian Nations, GDP = gross domestic product, TFP = total factor productivity.

Note: The above TFP growth rates are those implied for the nonprimary sectors by the GDP and factor growth rates in Appendix Table 3, based on the following assumptions about primary sector TFP growth. Primary sector TFP rates were exogenously set higher than those for the nonprimary sectors to the following extent in the core projection for all countries, with the aim of ensuring only modest growth in international relative prices for those products (shown in Appendix Table 5): 1% for agriculture, lightly processed food and other minerals, 0% for fossil fuels, and 2.5% for the forestry and fishing sector. (N.B. The actual sectoral TFP increase implemented is a little higher than this, due to interactions with economywide TFP). In the slower primary TFP growth scenario, the increment for forestry, fishing is reduced to 1% per annum, the increment for agriculture and lightly processed food is removed, and productivity growth in fossil fuels is assumed to be 1% lower than in nonprimary sectors. For the trade reform scenarios, the core projection's TFP growth assumptions are maintained.
Column heading letters refer to:
A: Nonprimary sectors
B: Agriculture, lightly processed food, and other minerals
C: Forestry and fishing
D: Extractive sectors (coal, oil, and gas)

Source: Derived from GTAP model results of Anderson and Strutt (2011b).

Appendix Table 3: Cumulative Changes in International Prices, 2004–2030 (price relative to global average output price change across all sectors, percent)

	Core 2030 Simulation	Slower Growth High-Income Countries	Slower Primary TFP Growth	Climate Change	ASEAN+6, Preferential Treatment	ASEAN+ 6, Most Favored Nation	Global Most Favored Nation	South–South Partial Liberalization
Rice	9.7	10.0	22.1	1.7	–0.8	–3.2	–2.1	–0.5
Wheat	14.6	15.6	48.4	0.4	–1.1	5.7	5.0	–0.7
Coarse Grains	22.0	23.3	61.3	8.8	–0.6	1.5	3.4	0.2
Fruit and Vegetables	40.8	43.1	85.8	6.7	–0.9	–4.5	–3.5	–0.4
Oilseeds	21.4	22.9	63.9	2.0	–2.1	–2.4	2.1	–0.5
Sugar	–2.0	–2.1	5.3	0.8	–1.2	–3.5	–2.8	0.0
Cotton	30.5	32.2	67.6	2.2	–2.0	–2.3	5.3	–1.0
Other Crops	12.8	13.3	48.9	1.4	–1.2	–2.0	–1.6	–0.5
Beef and Sheep	1.7	2.2	13.3	0.9	–0.4	–0.5	–0.2	–0.2
Pork and Chicken	12.7	13.7	24.6	1.3	–0.7	–2.5	–3.0	–0.1
Dairy	–2.1	–2.0	8.0	0.6	–0.8	–0.3	1.1	–0.3
Other Food	4.3	4.9	12.4	1.1	–0.7	–1.8	–1.9	–0.3
Forest and Fish	22.2	24.5	198.3	–1.9	–0.4	–0.8	–1.2	1.0
Coal	–12.3	–14.5	–9.6	–0.2	0.6	–0.4	0.5	0.7
Oil	35.5	37.0	102.3	–1.4	0.5	2.6	0.6	3.4
Gas	10.8	1.0	54.5	–0.5	–0.3	–0.2	–1.2	–2.4
Other Minerals	23.8	27.6	91.7	–0.5	0.9	–1.2	–0.6	2.1
Textiles, Apparel, and Leather	–3.8	–4.2	–8.1	0.7	–0.8	–2.0	–1.9	0.0
Motor Vehicle	0.0	–0.2	–3.8	–0.2	–0.1	–0.4	–1.0	–0.4
Electronics	–5.2	–6.0	–13.6	–0.2	0.1	–0.4	0.3	0.4
Other Light Manufactures	–0.9	–1.2	–1.2	–0.1	–0.1	–0.4	–0.4	–0.1
Heavy Manufactures	1.6	1.5	6.9	–0.3	0.1	–0.2	–0.3	0.4
Utilitiies and Construction	1.0	0.9	–1.1	–0.1	0.2	0.2	0.1	–0.1
Electricity and Gas	–5.7	–6.2	–7.1	–0.2	0.0	0.2	0.2	–0.1
Trade and Transportation	–1.5	–1.5	–6.8	–0.1	0.1	0.4	0.3	0.0
Other Services	–2.3	–2.3	–8.2	–0.1	0.1	0.4	0.5	–0.2
Aggregate Prices:								
Agriculture and Food	8.9	9.7	24.5	1.7	–0.8	–1.7	–1.3	–0.3
Other Primary	24.7	25.3	100.6	–1.1	0.3	0.9	–0.1	2.0
Manufactures	–0.2	–0.4	0.9	–0.2	0.0	–0.4	–0.5	0.2
Services	–1.8	–1.8	–7.0	–0.1	0.1	0.4	0.4	–0.1

TFP = total factor productivity.
Source: Derived from a revision and expansion of GTAP model results in Anderson and Strutt (2011b).

Appendix Table 4: Exogenous Crop Yield Shocks Attributed to Climate Change, by Region and Subsector, 2030 (percentage change in land productivity)

Regions	Rice	Wheat	Coarse Grains	Fruits and Vegetables	Oil Seeds	Cotton	Other Crops[a]
United States	–3	2	–15	2	2	–3	2
Canada	–3	7	–10	2	10	–3	2
EU27 and EFTA	7	7	–5	7	7	7	7
Russian Federation	7	7	–5	7	7	7	7
Rest of Europe/Central 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, Rep. of	12	12	5	12	12	12	12
Hong Kong, China; Singapore; Taipei,China	12	12	5	–3	12	12	12
China, People's Rep. of	0	2	–10	–8	0	0	–8
Indonesia	–3	–3	–10	–3	–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/North Africa	2	2	–5	2	2	2	2
South Africa	–8	–8	–20	–8	–8	–8	–8
Rest of South Africa	–3	–3	–10	–3	–3	–3	–3

[a] Except for sugar crops, whose productivity shock is assumed to be 0 in all regions.

Sources: Authors' compilation drawing on Hertel, Burke, and Lobell (2010) and Valenzuela and Anderson (2011).

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About the Paper

Recent food price spikes, plus growing demands for food in emerging Asia and for biofuels in Europe and the United States, have prompted governments to review their strategies for dealing with both short-term and long-term food security concerns. Kym Anderson, Shikha Jha, Signe Nelgen, and Anna Strutt summarize both long-run projections of markets under various scenarios and evidence on how trade policy restrictions were altered to insulate domestic markets from short-run fluctuations in international prices around their long-run trends. This provides a firm empirical basis for reexamining the effectiveness and efficiency of various policy options for ensuring food security in Asia, including boosting agricultural productivity growth rates to deal with long-run concerns and using more appropriate domestic policy measures rather than trade policies to cope with price volatility.

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