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Emerging economies, productivity growth and trade with resource-rich economies by 2030*

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Rapid economic growth in some emerging economies in recent decades has significantly increased their global economic importance. If this rapid growth continues and is strongest in resource-poor Asian economies, the growth in global demand for imports of primary products also will continue, to the ongoing benefit of natural resource-rich countries. This paper explores how global production, consumption and trade patterns might change over the next two decades in the course of economic development and structural changes under various scenarios. We employ the GTAP model and version 8.1 of the GTAP database with a base year of 2007, along with supplementary data from a range of sources, to support projections of the global economy to 2030. We first project a baseline assuming that trade-related policies do not change in each region but that factor endowments and real GDP grow at exogenously estimated rates. That baseline is compared with two alternative scenarios: one in which the growth rates of China and India are lower by one-quarter and the other in which this slowdown in emerging economies leads to slower productivity growth in the primary sectors of all countries. Throughout the results, implications are drawn out for natural resource-abundant economies, including Australia and New Zealand.

Key words: Asian economic growth and structural change, booming sector economics, food security, global economy-wide model projections.

1. Introduction

The recent slowdown in Western economies and the rapid economic growth in emerging economies are shifting the global industrial centre of gravity away from the north Atlantic and raising the importance of natural resource-poor Asian economies in world output and trade. That in turn is increasing the demand for exports from natural resource-rich economies. This is a continuation of a process begun in Japan in the 1950s and followed by Korea and Taiwan from the late 1960s and then by some Southeast Asian countries. Most recently, it has involved far more populous China and India. The earlier Northeast Asian group represents just 3 per cent of the world's population, hence its rapid industrial growth was accommodated by the rest of the world without much difficulty, including in primary product markets. China and

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India, by contrast, account for more than two-fifths of humanity. Their rapid and persistent growth thus has far greater significance for primary product markets and for such things as food and energy security and greenhouse gas emissions nationally, regionally and globally. How markets and governments respond to these concerns could have nontrivial effects in both the emerging economies and their trading partners, especially natural resource-rich economies.

This paper focusses on the consequences for primary product markets of the prospective continuation of this latest and largest emergence of Asian industrialisation. There is a strong body of trade and development theory to suggest what to expect. There is also the historical experience of the two previous generations of Asia's industrialising economies and, since the 1980s, of the newest generation's first decades of rapid growth. We briefly summarise that theory and history as a way of anticipating likely trends over the next two decades. Those expectations are then put to the test using a global economy-wide model for projecting the world economy to 2030. Results that emerge from a core business-as-usual projection are compared with those generated using alternative assumptions about Asian growth and global primary sector productivity growth rates. The paper concludes by drawing out key lessons and implications from the results for resource-abundant economies, including Australia and New Zealand.

2. Theory

Like Northeast Asia's earlier rapidly industrialising economies, China and India are relatively natural resource-poor and densely populated. So too are some other Asian countries. According to the workhorse theory of comparative cost advantage (Krueger 1977; Deardorff 1984; Leamer 1987), that means their industrialisation will make them highly complementary with relatively lightly populated economies that are well endowed with agricultural land and/or mineral resources in Australasia, Latin America, the Middle East and Africa. This is because the commodity composition of each country's trade – that is, the extent to which it is a net exporter of primary or industrial products – is largely determined by its endowment of natural relative to industrial capital compared with that ratio for the rest of the world.

Domestic or foreign savings can be invested to enhance the stock and/or improve the quality not only of a country's produced capital but also of its economically exploitable stock of natural resources. Any increase in the stock of capital (net of depreciation) per worker will put upward pressure on real wages. Whether such investment boosts industrialisation more than agriculture or other primary production will depend on the relative speed of sector-specific productivity growth that such R&D investments yield.

Trade patterns are also affected by growth in domestic demands, insofar as preferences are nonhomothetic (Markusen 2013). Food has an income elasticity of demand of <1, for example. While this may dampen somewhat the decline in comparative advantage in farm products in resource-poor

emerging economies, it does not do so initially when consumers switch from staples to higher valued foods, including intensively fed livestock. By contrast, at early stages of industrialisation and urbanisation, the requirements of minerals and energy raw materials for producing such essentials as steel and electricity are quite high, before they decline as the economy matures. This adds to the decline in comparative advantage of the mining sector in Asia's rapidly industrialising economies.

3. Modelling methodology and database

Given the interdependence between sectors of growing economies described above, an economy-wide model of the world's national markets is needed to project future trends in primary product markets. In this study, we employ the GTAP model (Hertel 1997) of the global economy and the latest available version 8.1 of the GTAP database which is calibrated to 2007 levels of production, consumption, trade and protection (Narayanan *et al*. 2012). The standard GTAP model is perhaps the most widely used CGE model for economy-wide global market analysis, in part due to its robust and explicit assumptions. The version 8.1 base period of 2007 is ideal for projecting forward to 2030 because it immediately precedes the recent period of temporary spikes in food and fuel prices and the global financial crisis and recession.

In its simplest form, the model assumes perfect competition and constant returns to scale in production. The functional forms are nested constant elasticities of substitution (CES) production functions. Land and other natural resources, labour (skilled and unskilled) and produced physical capital substitute for one another in a value added aggregate, and composite intermediate inputs substitute for value added at the next CES level in fixed proportions. Land is specific to agriculture in the GTAP database and is mobile among alternative agricultural uses over this projection period, according to a constant elasticity of transformation (CET) which, through a revenue function, transforms land from one use to another. In the modified version of the GTAP model we use, natural resources, including coal, oil, gas and other minerals, are specific to the sector in which they are mined. Aggregate national employment of each productive factor is fixed in the standard macroeconomic closure, although we use exogenous projections to model changes in factor availability over time. In the model closure adopted here, labour and produced capital are assumed to be mobile across all uses within a country, but immobile internationally.

On the demand side, there is a national representative household whose expenditure is governed by a Cobb–Douglas aggregate utility function which allocates net national expenditures across private, government and saving activities. Government demand across composite goods is determined by a Cobb–Douglas assumption (fixed budget shares). Private household demand is represented by a constant difference of elasticities (CDE) functional form,

which has the virtue of capturing the nonhomothetic nature of private household demands, calibrated to replicate a vector of own-price and income elasticities of demand (Hertel *et al.* 2012). In projecting to 2030, we acknowledge the theory point made by Markusen (2013) and follow Yu *et al.* (2004) in modifying these elasticities. We do so by econometrically estimating the relationship between per capita incomes and income elasticities of demand for food crops, as reflected in the full GTAP database.[1] These estimates are then used to alter the income elasticities of demand for foods in each region by 2030, given projections of per capita income for each region.

Bilateral international trade flows are handled through the Armington (1969) specification by which products are differentiated by country of origin. These Armington elasticities are the same across countries but are sector-specific, and the import–import elasticities have been estimated at the disaggregated GTAP commodity level (Hertel *et al.* 2007). For present purposes, where we are dealing with long-term changes, we follow the typical modelling practice of doubling the short- to medium-term Armington elasticities. The national balance of trade is determined by the relationship between national savings and investment. Investment in our model is allocated in response to rates of return with capital markets kept in equilibrium. Expected rates of return are assumed to be relatively sensitive to investment, helping to ensure that the model-generated changes in regional investment are comparable to the exogenous increases in capital stocks assumed in our projection.

The GTAP version 8.1 database divides the world into 134 countries/country groups, and each economy into 57 sectors. For the sake of both computational speed and digestion of model outputs, we initially aggregate the number of regions and sectors to 35 countries/country groups and to 34 sector/product groups. We then further aggregate to 10 regions and just four sectors for reporting many results. We also distinguish countries that are natural resource rich (NRR) from others (denoted NRP), based on their trade specialisation patterns as of 2005–09 (shown in appendix Table A1 of Anderson and Strutt 2013).[2]

4. Core projection of the database to 2030

We project the GTAP database's 2007 baseline for the world economy to provide a new core baseline for 2030, assuming that the 2007 trade-related policies of each country do not change. However, over the 23-year period, we assume that national real GDP, population, unskilled and skilled labour, capital, agricultural land and extractable mineral resources (oil, gas, coal and

[1] Elasticities are modified for rice (paddy and processed), wheat, coarse grains, fruit and vegetables, oilseeds, sugarcane and other crops. We are grateful to Papu Siameja for his excellent research assistance with econometrically estimating these projected income elasticities.

[2] The so-defined natural resource-rich (NRR) countries accounted in 2007 for one-fifth of global GDP, one-fourth of global trade, one-third of the world's agricultural trade, two-thirds of its trade in other primary products and just one-sixth of global exports of nonprimary products.

other minerals) grow at exogenously set rates. The exogenous growth rates for GDPs, capital stocks and populations are based mainly on estimates from the World Bank and CEPII (Fouré *et al*. 2012). For projections of skilled and unskilled labour growth rates, we draw on Chappuis and Walmsley (2011). Historical trends over the past two decades in agricultural land from FAOSTAT and in mineral and energy raw material reserves from BP (2012) and the US Geological Survey (2012) and earlier editions) are assumed to continue for each country over the next two decades. These rates of change in natural resources are summarised in the last five columns of appendix Table A2 of Anderson and Strutt (2013).

Given those exogenous endowment and GDP growth rates, the model is able to derive implied rates of total factor productivity and GDP per capita growth. For any one country, the rate of total factor productivity growth is assumed to be the same in each of its manufacturing sectors, somewhat higher in primary sectors (in the light of findings by Martin and Mitra 2001) and somewhat lower in services (following Roson and van der Mensbrugghe 2012). Our core calibration is consistent with the World Bank projections over the next four decades provided by Roson and van der Mensbrugghe (2012). It differs a little from GTAP-based projection studies in the late 20th century (eg Anderson *et al*. 1997) in which agricultural prices were projected to fall to 2005. We believe further falls to 2030 are unlikely given the slower growth in agricultural R&D investment since 1990 (Fuglie 2008) and the decline in the real price of manufactures thanks to Asia's industrialisation – as occurred also with the original industrial revolution in the first half of the 19th century (Williamson 2012).[3] Our core projection has real international prices in 2030 differing from 2007 levels by just 2 per cent for farm products, −5 per cent for other primary products, −1 per cent for manufactures and 4 per cent for services.

4.1. Impacts on sectoral and regional GDP and trade compositions

The differences across regions in rates of growth of factor endowments and total factor productivity, and the fact that sectors differ in their relative factor intensities and their share of GDP, ensure that the structures of production, consumption and trade across sectors within countries, and also between countries, are going to be very different in 2030 than in 2007. In particular, Asia's faster-growing developing economies will account for considerably larger shares of the projected global economy over the next two decades. Based on the exogenous GDP growth assumptions we use, the developing country aggregate share of world GDP (measured in 2007 US$, not PPP dollars in

[3] It is even less likely that farm product prices will fall if fossil fuel prices and biofuel mandates in the United States, EU and elsewhere are maintained over the next decade. Timilsina *et al*. (2010) project that by 2020 international prices will be higher in the presence vs the absence of those biofuel mandates for sugar (10 per cent), corn (4 per cent), oilseeds (3 per cent), and wheat and coarse grains (2 per cent).

which developing country shares are much larger) is projected to rise from 27 per cent in 2007 to 46 per cent in 2030, and for just developing Asia from 14 to 32 per cent. Europe's share, meanwhile, is projected to fall from over one-third to just above one-quarter. Thus, GDP per economically active person converges considerably between 2007 and 2030. In particular, appendix Table A3 of Anderson and Strutt (2013) shows that the per capita income of Developing Asia is projected to rise from 25 to 57 per cent of the global average over the projection period.

When global value added (based on producer expenditure) is broken down by sector, as in Table 1, the changes are more striking. This is especially so for China: by 2030, it is projected to return to its supremacy as the world's top producing country not only of primary products but also of manufactures. This is a ranking China has not held since the mid-19th century when first the UK and then (from 1895) the US was the top-ranked country for industrial production (Allen 2011; Figure 2). The NRR economies' contribution to global GDP rises 3 percentage points, even though their share of the global primary sector value added slips slightly because of the huge growth in Asia – and despite the high-income countries' share falling substantially (Table 1).

The Asian developing country share of global exports of all products nearly doubles, rising from 22 to 40 per cent between 2007 and 2030. China's share alone grows from 8 to 21 per cent. The growth of China's share is entirely at the expense of high-income countries, as the export shares for the other developing country regions in Table 2 also grow. 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. Asia's import shares also rise, although not quite so dramatically: the increase for developing Asia is from 19 to 32 per cent for all products, but the rise is much sharper for China's primary product imports – from 1.3 to 6.5 per cent (Table 3).

The consequences of continuing Asian industrialisation are also evident in the sectoral shares of national trade, which can be derived from Tables 2 and 3: primary products are less important in developing country exports and considerably more important in their imports, and conversely for nonprimary products, with the changes to 2030 being largest in developing Asia. The opposite is true for NRR countries.

The export composition of NRR countries strengthens a little in farm and other primary products – at the expense of manufactures and services, which suffer the Dutch disease problem associated with the strengthening of primary product demands resulting from Asia's rapid industrialisation. The shares of nonfarm primary products in Australia's and Latin America's exports increase significantly: while their comparative advantage strengthens somewhat in farming, it strengthens even more in mining as it weakens in nonprimary goods and services. NRR's share of global exports of agricultural products is projected to rise 8 percentage points between 2007 and 2030, as those countries

Table 1 Regional shares of global value added by sector, 2007 and 2030 core (per cent)

	Agric. and food	Other primary	Manufactures	Services	Total
(a) 2007 base					
Australia	1.2	2.3	0.8	1.6	1.5
New Zealand	0.4	0.2	0.2	0.2	0.2
Europe	31.5	21.8	36.9	35.8	35.1
USC	13.7	11.7	23.8	32.0	28.6
China	14.4	9.4	11.7	4.3	6.4
Rest East Asia	10.4	7.4	14.6	13.7	13.4
South Asia	8.5	2.6	2.1	2.4	2.7
Latin America	10.9	9.0	6.1	6.7	6.9
MENA	3.6	29.0	2.8	2.3	3.6
SubSAfrica	5.4	6.5	1.0	1.1	1.6
HICs	**50.2**	**34.4**	**68.7**	**78.2**	**73.1**
Developing	**49.8**	**65.6**	**31.3**	**21.8**	**26.9**
of which Asia	29.3	18.9	21.3	11.4	14.5
NR Rich	**30.1**	**66.6**	**16.3**	**17.8**	**20.4**
NR Poor	**69.9**	**33.4**	**83.7**	**82.2**	**79.6**
World	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
(b) 2030 core					
Australia	0.8	2.0	0.5	1.5	1.3
New Zealand	0.3	0.2	0.1	0.2	0.2
Europe	17.6	15.6	22.7	28.2	25.8
USC	9.3	6.6	17.0	27.6	23.3
China	33.1	24.9	29.9	11.2	16.6
Rest East Asia	8.1	7.6	13.2	12.6	12.1
South Asia	14.0	5.3	4.7	5.8	6.2
Latin America	8.0	8.1	6.0	7.8	7.6
MENA	3.0	18.9	4.4	3.0	4.1
SubSAfrica	5.9	10.7	1.4	2.0	2.7
HICs	**29.3**	**23.0**	**44.2**	**63.5**	**55.6**
Developing	**70.7**	**77.0**	**55.8**	**36.5**	**44.4**
of which Asia	53.3	37.6	43.9	23.3	29.7
NR Rich	**25.2**	**56.6**	**17.6**	**21.0**	**22.8**
NR Poor	**74.8**	**43.4**	**82.4**	**79.0**	**77.2**
World	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Derived from the authors' GTAP model results.
Bold values indicate totals and subtotals. USC, United States and Canada; MENA, Middle East and North Africa; SubSAfrica, Sub-Saharan Africa; HICs, high-income countries (including the transition economies of Eastern Europe and the former Soviet Union); Developing, all other countries.

out-compete others in supplying the huge growth in imports of farm products by China (Table 4).

4.2. Impacts on bilateral trade

In our core scenario, it is the phenomenal growth in China's share of global imports of primary products that dominates the bilateral trade picture, with all regions significantly increasing the proportion of their exports of primary products going to China (Table 5). The other developing country grouping, which comprises the natural resource rich countries of Latin America, the Middle East and Africa, significantly increases the share of their primary

Table 2 Regional and sectoral shares of global exports, 2007 and 2030 core (per cent)

	Agric. and Food	Other Primary	Manufactures	Services	Total
(a) 2007 base					
Australia	0.1	0.3	0.4	0.2	1.1
New Zealand	0.1	0.0	0.1	0.1	0.2
Europe	2.9	2.6	30.5	9.8	45.8
USC	0.8	0.5	8.0	2.7	12.1
China	0.2	0.1	7.4	0.6	8.3
Rest East Asia	0.5	0.5	13.0	2.6	16.6
South Asia	0.1	0.1	1.1	0.5	1.8
Latin America	0.9	1.0	3.1	0.7	5.7
MENA	0.2	3.6	1.7	0.8	6.3
SubSAfrica	0.2	1.1	0.6	0.2	2.1
HICs	**4.0**	**3.1**	**43.3**	**13.2**	**63.6**
Developing	**2.1**	**6.7**	**22.6**	**5.0**	**36.4**
of which Asia	0.9	0.6	17.0	3.2	21.7
NR rich	**2.1**	**8.5**	**10.6**	**3.2**	**24.4**
NR poor	**4.0**	**1.3**	**55.2**	**15.0**	**75.6**
World	**6.1**	**9.8**	**65.8**	**18.2**	**100.0**
(b) 2030 core					
Australia	0.1	0.6	0.2	0.1	1.1
New Zealand	0.1	0.0	0.0	0.0	0.2
Europe	2.7	3.3	16.5	7.7	30.2
USC	1.4	0.8	5.3	2.2	9.6
China	0.0	0.1	19.2	2.0	21.3
Rest East Asia	0.8	0.7	12.9	2.4	16.9
South Asia	0.1	0.2	3.0	1.3	4.6
Latin America	1.2	1.5	2.5	0.6	5.7
MENA	0.2	2.7	2.9	1.1	6.9
SubSAfrica	0.3	2.1	0.7	0.3	3.5
HICs	**4.3**	**4.2**	**24.4**	**10.3**	**43.2**
Developing	**2.6**	**7.7**	**39.0**	**7.5**	**56.8**
of which Asia	0.9	1.0	32.7	5.4	39.9
NR rich	**2.9**	**10.1**	**10.7**	**3.3**	**27.1**
NR poor	**4.0**	**1.8**	**52.6**	**14.4**	**72.9**
World	**6.9**	**12.0**	**63.3**	**17.8**	**100.0**

Source: Derived from the authors' GTAP model results.
Bold values indicate totals and subtotals.

exports going to China and maintains the share going to other Asian economies. Among the NRR countries, Australia had the highest share of primary exports with China as of 2007, but other NRR countries, especially New Zealand, are projected to move a long way towards catching up by 2030 (Table 5).

4.3. Impacts on food self-sufficiency and consumption of primary products

These changes mean that food self-sufficiency is projected in this core scenario to fall considerably by 2030 in China (from 97 to 87 per cent) and South Asia (from 100 to 95 per cent). It is possible that these populous countries will seek to prevent such a growth in food import dependence in practice, by erecting protectionist barriers at least for food staples, but that is not modelled here (however, see Anderson and Nelgen 2011).

Table 3 Regional sectoral shares of global imports, 2007 and 2030 (per cent)

	Agric. and Food	Other Primary	Manufactures	Services	Total
(a) 2007 base					
Australia	0.1	0.1	0.8	0.2	1.1
New Zealand	0.0	0.0	0.1	0.0	0.2
Europe	3.2	3.5	30.2	9.3	46.1
USC	0.8	2.0	12.0	2.5	17.2
China	0.3	1.0	4.5	0.7	6.5
Rest East Asia	0.9	2.5	8.8	2.4	14.6
South Asia	0.1	0.6	1.3	0.4	2.4
Latin America	0.4	0.3	3.7	0.7	5.1
MENA	0.5	0.2	3.2	1.0	4.8
SubSAfrica	0.2	0.1	1.3	0.4	2.0
HICs	**4.3**	**6.7**	**45.1**	**12.6**	**68.8**
Developing	**2.0**	**3.5**	**20.7**	**4.9**	**31.2**
of which Asia	1.0	3.0	12.3	2.7	18.9
NR rich	**1.7**	**0.9**	**14.4**	**3.6**	**20.6**
NR poor	**4.7**	**9.3**	**51.4**	**14.0**	**79.4**
World	**6.4**	**10.2**	**65.9**	**17.6**	**100.0**
(b) 2030 core					
Australia	0.1	0.0	0.8	0.2	1.2
New Zealand	0.0	0.0	0.1	0.0	0.2
Europe	2.1	2.2	22.2	7.3	33.8
USC	0.6	1.6	10.7	2.3	15.3
China	2.0	4.5	7.4	1.0	14.9
Rest East Asia	0.9	2.1	10.2	2.8	15.9
South Asia	0.4	1.4	2.0	0.7	4.5
Latin America	0.3	0.2	4.2	0.9	5.6
MENA	0.5	0.3	3.5	1.1	5.3
SubSAfrica	0.3	0.2	2.1	0.7	3.2
HICs	**2.9**	**4.5**	**35.6**	**10.3**	**53.4**
Developing	**4.2**	**8.1**	**27.7**	**6.6**	**46.6**
of which Asia	3.1	7.4	17.6	3.8	31.8
NR Rich	**1.7**	**1.1**	**16.5**	**4.4**	**23.7**
NR Poor	**5.4**	**11.5**	**46.8**	**12.6**	**76.3**
World	**7.1**	**12.6**	**63.3**	**16.9**	**100.0**

Source: Derived from the authors' GTAP model results.
Bold values indicate totals and subtotals.

A more meaningful indicator of food security than self-sufficiency is real per capita private consumption of agricultural and processed food products by households. Table 6 shows that between 2007 and 2030, real per capita food consumption is projected to increase by 79 per cent for developing countries as a group and to more than double in China and South Asia. These are major improvements in food consumption per capita. Even if income distribution were to worsen in emerging economies over the next two decades, virtually all developing country regions could expect to be much better fed by 2030, according to this core scenario.

Turning to global consumption shares, the rise in grain consumption is especially great in China because of their expanding demand for livestock products, most of which continue to be produced domestically in this core scenario. So even though China's share of the world's direct grain

Table 4 Regional shares of world trade in agricultural and food products, 2007 base, 2030 core and 2030 alternative growth scenarios (per cent)

	Exports				Imports			
	2007	2030 Core baseline	2030 slower China and India growth	2030 slower China and India growth + slower global primary TFP growth	2007	2030 Core baseline	2030 slower China and India growth	2030 slower China and India growth + slower global primary TFP growth
Australia	2.3	2.0	2.1	1.9	0.8	0.8	0.8	0.8
New Zealand	1.6	1.3	1.5	1.3	0.3	0.2	0.2	0.2
Europe	47.8	38.9	40.6	42.2	49.8	29.1	34.6	31.3
USC	13.7	19.7	17.3	19.4	12.4	8.7	10.0	9.5
China	3.9	0.4	0.8	0.4	4.3	28.6	17.8	20.2
Rest East Asia	8.2	11.3	10.8	9.5	13.9	11.9	13.6	13.7
South Asia	2.4	1.5	1.5	1.2	2.1	5.5	5.5	6.2
Latin America	14.5	16.9	17.8	16.1	6.1	4.7	5.4	5.6
MENA	2.5	3.2	3.1	3.4	7.2	6.4	7.5	7.5
SubSAfrica	3.1	4.7	4.6	4.6	3.2	4.1	4.6	5.1
HICS	**65.2**	**61.8**	**61.1**	**64.6**	**68.0**	**41.0**	**48.4**	**44.0**
Developing	**34.8**	**38.2**	**38.9**	**35.4**	**32.0**	**59.0**	**51.6**	**56.0**
of which Asia	14.1	12.6	12.6	10.4	14.9	43.3	33.5	37.2
NR rich	**34.0**	**41.9**	**42.4**	**40.0**	**26.6**	**24.0**	**27.1**	**28.1**
NR poor	**66.0**	**58.1**	**57.6**	**60.0**	**73.4**	**76.0**	**72.9**	**71.9**
World	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Soure: Derived from the authors' GTAP model results.
Bold values indicate totals and subtotals.

Table 5 Shares of bilateral trade in all primary products, 2007 base, 2030 core and 2030 alternative growth scenarios (per cent)

Importer: exporter:	Australia	New Zealand	Europe and NA	China	Rest Asia	Other DCs	Total
(a) 2007 base							
Australia	0.0	1.8	15.1	22.4	56.6	4.1	100
New Zealand	9.8	0.0	33.2	6.0	33.9	17.2	100
Europe and NA	0.3	0.1	79.4	3.5	7.8	8.9	100
China	1.2	0.2	34.9	0.0	56.4	7.3	100
Rest Asia	4.6	0.5	20.1	14.4	51.6	8.9	100
Other DCs	0.1	0.1	47.3	9.2	32.4	10.8	100
Total	**0.6**	**0.2**	**57.8**	**7.4**	**24.4**	**9.6**	**100**
(b) 2030 core baseline							
Australia	0.0	0.9	9.3	54.5	33.0	2.4	**100**
New Zealand	6.4	0.0	12.8	47.3	24.3	9.3	**100**
Europe and NA	0.4	0.1	51.7	26.8	11.5	9.5	**100**
China	0.8	0.1	39.7	0.0	54.2	5.1	**100**
Rest Asia	2.8	0.2	7.5	46.2	38.9	4.4	**100**
Other DCs	0.1	0.1	24.9	32.5	32.5	10.0	**100**
Total	**0.5**	**0.1**	**34.1**	**32.2**	**24.2**	**8.9**	**100**
(c) 2030 with slower China and India growth							
Australia	0.0	1.1	13.3	39.3	43.0	3.4	**100**
New Zealand	8.1	0.0	18.2	29.3	31.5	13.0	**100**
Europe and NA	0.4	0.1	60.6	15.8	12.2	11.0	**100**
China	1.0	0.2	39.5	0.0	53.2	6.2	**100**
Rest Asia	3.4	0.3	11.3	32.3	46.5	6.2	**100**
Other DCs	0.1	0.1	32.2	22.3	33.1	12.2	**100**
Total	**0.6**	**0.1**	**41.6**	**21.0**	**25.9**	**10.8**	**100**
(d) 2030 with slower China and India economic growth and slower global primary productivity growth							
Australia	0.0	1.1	13.1	39.3	43.0	3.4	**100**
New Zealand	7.2	0.0	14.8	34.9	32.0	11.1	**100**
Europe and NA	0.4	0.1	56.9	18.4	12.5	11.8	**100**
China	0.4	0.1	40.7	0.0	52.0	6.9	**100**
Rest Asia	3.5	0.3	8.4	34.8	47.9	5.0	**100**
Other DCs	0.1	0.1	30.7	23.7	33.5	11.8	**100**
Total	**0.6**	**0.1**	**39.8**	**22.7**	**25.9**	**10.9**	**100**

Source: Derived from the authors' GTAP model results.
Bold values indicate totals and subtotals.

consumption by households grows little, its share of grain consumed indirectly grows substantially, leading to an increase in overall grain usage in China from 12 to 32 per cent of the global total (Table 7). That promises to provide ongoing growth in the market for grain (and soybean) exports to China. China's share of global consumption of fossil fuels is projected to rise by a similar proportion over this period (from 10 to 25 per cent) and likewise for other minerals (from 27 to 61 per cent).

5. Alternative growth projections to 2030

The above core projection is but one of myriad possibilities, so in this section we explore others and compare their economic consequences with those just

Table 6 Changes in real household consumption per capita of agricultural and food products from 2007 base, core and alternative growth scenarios in 2030 (per cent)

	2030 core	2030 slower China and India growth	2030 slower China and India growth + slower primary productivity growth
Australia	27	28	18
New Zealand	26	27	16
Europe	36	37	28
USC	31	33	23
China	150	99	76
Rest East Asia	34	35	25
South Asia	110	81	60
Latin America	43	43	35
MENA	41	39	31
SubSAfrica	70	68	59
HICs	33	33	24
Developing	79	65	51
of which Asia	109	81	61
NR rich	44	44	36
NR poor	47	39	26
World	45	39	27

Source: Derived from the authors' GTAP model results.

summarised for 2030. Specifically, the following two alternative growth scenarios are considered:

- One-quarter slower GDP, skilled labour and capital stock growth in China and India, and
- Also 1 percentage point slower annual total factor productivity (TFP) growth in primary sectors globally, in response to the assumed growth slowdown in China and India.

The core projection sets real GDP growth rates between 2007 and 2030 for China and India well below those economies' actual growth rates during 2007–12, implying growth rates of around 7 per cent/year for China and 6 per cent for India for the remainder of the projection period (2013–30). Some commentators feel those rates are too optimistic, particularly given their slowdown in 2013 as a result of slow growth since 2008 in developed country economies.[4] Hence, our first alternative scenario reruns the projections assuming that annual GDP, skilled labour and capital stock growth rates in China and India are one-quarter lower per year than in the core

[4] Though, such a slowdown may be less likely than some observers fear. According to one of China's most prominent economists and former Senior Vice-President of the World Bank, 'China can maintain an 8 per cent annual GDP growth rate for many years to come. … China's per capita GDP in 2008 was 21 per cent of per capita GDP in the United States. That is roughly the same gap that existed between the United States and Japan in 1951, Singapore in 1967, Taiwan in 1975, and South Korea in 1977. … Japan's average annual growth rate soared to 9.2 per cent over the subsequent 20 years, compared to 8.6 per cent in Singapore, 8.3 per cent in Taiwan, and 7.6 per cent in South Korea' (Lin 2013).

Table 7 Regional shares of global consumption of grains, fossil fuels and other minerals, 2007 base and 2030 core (per cent)

	2007 base				2030 core			
	Grains	Grains HH consumption[a]	Fuel	Other minerals	Grains	Grains HH consumption[a]	Fuel	Other minerals
Australia	0.9	0.1	1.0	4.1	0.7	0.1	0.7	1.7
New Zealand	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0
Europe	19.2	13.2	29.7	23.2	11.4	8.4	19.0	8.6
USC	8.4	1.3	22.4	8.7	6.1	0.9	15.4	3.3
China	12.3	3.5	10.0	27.4	32.0	4.6	25.1	60.7
Rest East Asia	20.1	20.3	15.4	16.3	13.8	16.5	13.4	8.8
South Asia	14.9	22.5	4.7	4.5	16.0	26.7	9.0	6.3
Latin America	9.3	9.0	6.1	9.0	6.5	7.1	5.0	5.2
MENA	7.6	13.2	9.3	5.6	6.0	12.5	10.8	4.3
SubSAfrica	7.2	16.9	1.2	1.1	7.5	23.2	1.5	1.0
HICs	**34.6**	**19.7**	**58.0**	**41.5**	**20.7**	**11.8**	**37.2**	**15.1**
Developing	**65.4**	**80.3**	**42.0**	**58.5**	**79.3**	**88.2**	**62.8**	**84.9**
of which Asia	40.3	39.7	24.2	41.9	58.8	44.4	44.3	73.8
NR rich	**37.0**	**50.0**	**29.5**	**27.5**	**29.9**	**52.5**	**28.2**	**16.7**
NR poor	**63.0**	**50.0**	**70.5**	**72.5**	**70.1**	**47.5**	**71.8**	**83.3**
World	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

[a]Private household and government consumption (excluding use by firms). Source: Derived from the authors' GTAP model results.
Bold values indicate totals and subtotals.

scenario. This causes international prices of primary products on average to fall by 7 per cent, compared with 2 per cent in the core scenario.

The second of our alternative scenarios involves dropping the assumption that productivity growth in the primary sectors increases to nearly match the growing global demand for such products. This is a plausible alternative to the core projection that is more consistent with the evidence of the past two decades provided by Alston *et al*. (2010) of a slowdown in productivity growth in agriculture in both high-income and developing countries and of the price projections of several international agencies (Nelson *et al*. 2010; IEA 2011; FAO/OECD 2012). In this second alternative case, real international prices for primary products on average are 10 per cent above 2007 levels by 2030, compared with 2 per cent below in the core projection.

Slower growth in these two populous emerging economies has a marked impact on primary product markets and trade with NRR economies. Developing Asia's share of global agricultural imports in 2030 drops from 43 to 33 per cent (Table 4), and the growth in China's share of exports from the various regions is dampened substantially (Table 5). Consumption of food in those two economies also grows much less, because of their slower income growth (Table 6).

If slower growth in China and India were to dampen annual total factor productivity (TFP) growth in primary sectors around the world by 1 percentage point annually, this would cause international prices of farm and other primary products to be higher than in the core scenario, by 9 and 14 percentage points respectively. Those higher prices would compensate somewhat for the impact on primary producers in NRR countries of slower Asian growth. And because this scenario would see slower primary production growth in Asia, it would also mean a slightly larger share of primary exports going to China than in the previous alternative scenario (Table 5). The slowdown in farm productivity growth would result in 1–2 per cent lower food self-sufficiency rates in Asia and a further one-quarter less growth in their household food consumption (Table 6).

6. Some qualifications

As with the results from all other economy-wide projections modelling, it is necessary to keep in mind numerous qualifications. One is that we have aggregated the model into just 34 sectors/product groups. This leads to gross underestimation of the extent to which firms can take advantage of intra-industry trade through exploiting the increasing opportunities to lower costs through fragmenting the production process into ever-more pieces whose location is footloose (Feenstra 1998; Baldwin and Lopez-Gonzales 2013).

Second, we have assumed constant returns to scale and perfect competition rather than allowing firms to enjoy increasing returns and some degree of monopoly power for their differentiated products. This too leads to

underestimate of the changes associated with production and trade growth (Krugman 2009).

Third, where consumers (including firms importing intermediate inputs) value a greater variety of goods, or a greater range of qualities, intra-industry trade can grow as a result of both economic growth and trade policy reform (Rutherford and Tarr 2002), but that too is not taken into account in the above analysis.

Fourth, our model has not included the new biofuel policies that have been put in place in many countries but mostly since our 2007 base year. The new biofuel mandates and subsidies have had a nontrivial effect of increasing both the mean and the variance of international food prices and are expected to become even more important over the next decade as the mandates in the United States and EU in particular increase to 2020–21 (see Hertel and Beckman 2011 and the references therein). Whether these policies will still be in place in 2030 is a moot point. If the expected dramatic expansion in unconventional gas production materialises and drives down fossil fuel prices (see IEA 2012), and if biofuel mandates were removed, this omission from our modelling of 2030 may be inconsequential.

Finally, the standard GTAP model used here is comparative static and will not capture all of the dynamic impacts of global change.

7. Conclusions

Should relatively rapid economic growth in Asia, and to a lesser extent in other developing countries, continue to characterise world economic development as suggested above, developing Asia's share of global GDP and trade will continue to rise steeply over the next two decades. In the core projection, its share of global agricultural GDP is projected to increase significantly also, but that is not fast enough to keep pace with the growing consumption of food. By 2030, developing Asia is projected to consume almost 60 per cent of the world's grain, 45 per cent of the world's fossil fuels (or even more if carbon taxes are introduced in high-income countries but not emerging economies) and three-quarters of the world's other minerals. This is possible because their share of the world's imports of primary products are projected to more than double between 2007 and 2030 in the core scenario – and paid for with their rapidly rising earning from exports of manufactures. Over this period real per capita food consumption is projected to increase by about four-fifths for developing countries as a group and to more than double in China and South Asia. These represent substantial increases in global food consumption per capita. Even if income distribution were to worsen in emerging economies over the next two decades, virtually all developing country regions could expect to be much better fed by 2030 if high Asian economic growth continues.

The bright export prospects for natural resource-rich economies are considerably dampened if economic growth in China and India is one-

quarter slower than in that core scenario, however; and the world's food and energy security would be reduced if such a slowing of growth in emerging Asia were to lead to a global slowdown in productivity growth in farm and mineral production. Furthermore, were China and India to follow Northeast Asian economies in raising their protection of farmers as their per capita incomes grew – as they have been doing already in recent years – that would be harmful not only to those Asian economies but also to NRR countries' farm trade interests, given the huge growth in agricultural exports to China projected above. It increases the stake farm-exporting countries have in the resumption and successful conclusion of the WTO's Doha Development Agenda as it relates to agricultural trade in particular.

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