POLICY STUDIES National University Australian Government AusAID
Asia & the Pacific Policy Studies, vol. ••, no. ••, pp. ••–••

Original Article

Growth in Densely Populated Asia: Implications for Primary Product Exporters

Kym Anderson and Anna Strutt*

Abstract

Economic growth and integration in Asia is rapidly increasing the global economic importance of the region. To the extent that this growth continues and is strongest in natural resource-poor Asian economies, it will add to global demand for imports of primary products, to the benefit of (especially nearby) resource-abundant countries. How will global production, consumption and trade patterns change by 2030 in the course of such economic developments and structural changes? We address this question using the GTAP model and Version 8.1 of the 2007 GTAP database, together with supplementary data from a range of sources, to support projections of the global economy from 2007 to 2030 under various scenarios. Factor endowments and real gross domestic product are assumed to grow at exogenous rates, and trade-related policies are kept unchanged to generate a core baseline, which is compared with an alternative slower growth scenario. We also consider the impact of several policy changes aimed at increasing China's agricultural self-sufficiency relative to the 2030 baseline. Policy implications for countries of the Asia-Pacific region are drawn out in the final section.

Key words: Asian economic growth, global economy-wide model projections, booming sector economics, food security, bilateral trade

Asia's rapid economic growth is shifting the global industrial centre of gravity away from the north Atlantic and raising the importance of natural resource-poor Asian economies in world production, consumption and trade. That trend—which the recent slowdown in Western economies has accentuated—is increasing the demand for primary product exports from natural resource-rich (NRR) economies, especially nearby ones. 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. However, it has involved far more populous China and India most recently, so the impact on the rest of the world is far more marked. Because the earlier Northeast Asian group represents just 3 per cent of the world's population, its rapid industrial growth was easily accommodated by the rest of the world.

* Anderson: School of Economics, University of Adelaide, Adelaide, South Australia 5005, Australia; Strutt: University of Waikato, Hamilton 3240, New Zealand. Corresponding author: Anderson, email <kym.anderson@adelaide.edu.au>. Revision of a paper presented at the Inaugural Conference of the Asia and the Pacific Policy Society, Canberra, 7 September 2012. The authors are grateful for helpful referee comments and interactions including with Tom Hertel, Terrie Walmsley, Dominique van der Mensbrugghe, Fan Zhai and Rob McDougall. Funding support from the Asian Development Bank, the Australian Research Council and the Rural Industries Research and Development Corporation, and Waikato Management School is gratefully acknowledged. Views expressed are the authors' alone.

China and India, by contrast, account for more than two fifths of humanity so their rapid and persistent growth has far greater regional and global significance for primary product markets (not to mention food and energy security, and greenhouse gas emissions).

The consequences for primary product markets of the prospective continuation of this latest and largest emergence of Asian industrialisation are the focus of this article. Both trade and development theory and the historical experience of the two previous generations of Asia's industrialising economies, together with the newest generation's first decades of rapid growth, provide strong indicators of what to expect. That theory and history are briefly summarised as a way of anticipating likely trends over the next two decades, and those expectations are then put to the test using a global economy-wide model for projecting the world economy to 2030. Our core projection is compared with one involving slower growth in emerging Asia and, as a consequence, in global primary sector productivity. We also consider alternative 2030 scenarios where China aims to raise self-sufficiency relative to the 2030 baseline. In particular, we consider a rise in agricultural protection in China aimed at self-sufficiency for a few key farm products and contrast this with policies that raise agricultural productivity. The final section draws out some policy implications for both rapidly growing Asia and its resource-abundant trading partners.

1. Learning from the Past

China and India, like Northeast Asia's earlier rapidly industrialising economies, are relatively natural resource poor and densely populated. So, too, are some other emerging Asian countries. They are therefore highly complementary with relatively lightly populated economies that are well endowed with agricultural land and/or mineral resources, according to the workhorse theory of comparative cost advantage provided by Krueger (1977) and explored further by Deardorff (1984). They consider two tradable sectors each using intersectorally mobile labour plus one sector-specific factor (natural resource capital or produced industrial capital). Assuming that labour exhibits diminishing marginal product in each sector, and that there are no services or nontradables and no policy distortions, then at a given set of international prices the real wage in each economy is determined by the aggregate per worker endowment of natural resource and produced capital. The commodity composition of a country's trade—that is, the extent to which a country is a net exporter of primary or industrial products—is determined by its endowment of natural relative to industrial capital compared with that ratio for the rest of the world.

That model is developed further by Leamer (1987), who relates it to paths of economic development. If the stock of natural resources is unchanged, rapid growth by one or more economies relative to others in their availability of produced capital (physical plus human skills and technological knowledge) per unit of available labour time would tend to cause those economies to strengthen their comparative advantage in non-primary products. By contrast, a discovery of minerals or energy raw materials would strengthen that country's comparative advantage in mining and weaken its comparative advantage in agricultural and other tradable products, ceteris paribus. It would also boost national income and hence the demand for nontradables, which would cause mobile resources to move into the production of nontradable goods and services, further reducing farm and industrial production (Corden 1984).

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 such increase in the stock of produced capital (net of depreciation) per worker will put upward pressure on real wages. That will encourage, in all sectors, the use of more labour-saving techniques and the development and/or importation of better technologies that are less labour intensive. Whether it boosts industrialisation more than agriculture or other primary production will depend on the relative speed of sector-specific productivity growth that such research and development (R&D) investments yield. Which types of investment would expand fastest in a free-market setting depends on their expected rates of return. The more densely populated, natural resource poor an open economy is, the greater the likelihood that the highest payoff would be in expanding stocks of capital (including technological knowledge) for non-primary sectors. That gives rise to the Rybczynski effect, of pulling mobile resources (most notably labour) out of agriculture. If there is also relatively rapid productivity growth in primary sectors (as Martin & Mitra 2001 have found to be the case historically), and especially if that productivity growth is labour saving, this also pushes labour into non-primary sectors.

At early stages of development of a country with a relatively small stock of natural resources per worker, wages would be low and the country would have a comparative cost advantage in unskilled labour-intensive, standard-technology manufactures. Then as the stock of industrial capital grows, there would be a gradual move towards exporting manufactures that are relatively intensive in their use of physical capital, skills and knowledge. Natural resource-abundant economies, however, would invest more in capital-specific to primary production and so would not develop a comparative advantage in manufacturing until a later stage of development, at which time their industrial exports would be relatively capital intensive.

The above theory of changing comparative advantages for a growing economy—which can also be used to explain shocks to that pattern from discovery-driven mining booms or major terms of trade changes imposed from the rest of the world—has been used successfully to explain the evolving trade patterns of Asia's resource-poor first- and second-generation industrialising economies and their resource-rich trading partners (see, e.g. Anderson & Smith 1981). It has also explained the 20th century evolution, for early- and later-industrialising countries, of the flying geese pattern of comparative advantage and then disadvantage in unskilled labour-intensive manufactures as some rapidly growing economies expand their endowments of industrial capital per worker relative to the rest of the world—the classic example being clothing and textiles.

2. The GTAP Global Model

An economy-wide model of the world's national markets is needed to project future trends in primary product trade. The GTAP model (Hertel 1997) of the global economy is employed here, together with its latest Version 8.1 of the GTAP database which is calibrated to levels of production, consumption, trade and protection in 2007 (Narayanan et al. 2012), that is, just prior to the disruptions of spikes in food and fuel prices and the global financial crisis and recession.

GTAP is a very widely used computable general equilibrium model for economy-wide global market and trade policy analysis (see www.gtap.org). It assumes perfect competition and constant returns to scale in production. Farm land and other natural resources, labour (skilled and unskilled), and produced physical capital all substitute for one another, while intermediate inputs are combined in fixed proportions with value added. Labour and produced capital are assumed immobile internationally but mobile across uses within each country. Land is somewhat mobile among alternative agricultural uses over this projection period while natural resources, including coal, oil, gas and other minerals, are specific to the sector in which they are mined.

There is a national representative household whose expenditure is governed by a Cobb–Douglas aggregate utility function. Private household demand is represented by a constant difference of elasticities functional form, which is calibrated to replicate a vector of own-price and income elasticities of demand. In projecting to 2030, we follow Yu et al. (2004) in modifying these elasticities based on our own econometrically estimated relationships between per capita income and income elasticities of demand for agricultural and food products as reflected in the full GTAP database.[1] These estimates are then used to modify the elasticities for each region by 2030, given projections of per capita income for each region. The standard Armington (1969) specification is used to handle bilateral international trade flows by differentiating products by their country of origin. The Armington elasticities are the same across countries but are sector specific. Because we are dealing here with long-term changes, we follow the typical modelling practice of doubling the short- to medium-term estimated Armington elasticities. We assume that investment is allocated in response to rates of return, although these are assumed to be relatively sensitive to investment, helping to ensure that the model-generated changes in regional investment are comparable with the exogenous increases in capital stocks assumed in our projection.

The world economy is divided into 134 countries and residual country groups and 57 sectors in the GTAP database, but, for the sake of both computational speed and digestion of model outputs, we compress the number to 35 regions and 34 sectors. We further aggregate for reporting many results; and we distinguish countries that are NRR from others, based on their trade specialisation patterns as of 2005–2009 (Anderson & Strutt 2014).[2]

3. Projecting the World Economy to 2030

The GTAP database's 2007 baseline for the world economy is projected to provide a new core baseline for 2030. In doing so, we assume in all but the third simulation that the 2007 trade-related policies of each country do not change, but that national real goss domestic product (GDP), population, unskilled and skilled labour, capital, agricultural land and extractable mineral resources (oil, gas, coal and other minerals) grow at exogenously set rates. The exogenous growth rates for GDPs, capital stocks and populations are based 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 in agricultural land are estimated from FAO (2012), and in mineral and energy raw material reserves from BP (2012) and the US Geological Survey (2012 and earlier editions), assuming that annual rates of change in fossil fuel reserves over the past two decades continue for each country over the next two decades. 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). The aggregate rates of change assumed are summarised in Table 1.

Once those exogenous growth rates are set, the model is able to derive implied rates of total factor productivity (TFP) and GDP per capita growth. The rate of TFP growth for any one country is assumed to be the same in each of its manufacturing sectors, somewhat higher in most primary sectors and somewhat lower in services.[3] Higher productivity growth rates for primary activities were characteristic of the latter half of the 20th century (Martin & Mitra 2001) and are assumed to continue so that we project real international prices of primary products (relative to the aggregate change for all products) to rise only modestly in our core projection, consistent with the World Bank projections over the next four decades (see Roson & van der Mensbrugghe 2012).[4]

1. Elasticities are modified for rice (paddy and processed), wheat, coarse grains, fruit and vegetables, oilseeds, sugar cane and other crops. We are very grateful to Papu Siameja for his assistance with econometrically estimating these projected income elasticities, based on the 2007 cross-country elasticities and GDP per capita in the GTAP database.
2. Our so-defined 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 non-primary product exports.

3. We assume that productivity growth rates are higher in each primary sector than in other sectors, with the exception of agriculture in China and India. Because overall TFP growth tends to be higher for developing than high-income countries, agricultural TFP growth is higher for developing than high-income countries.
4. An alternative in which agricultural prices fall, as projected in GTAP-based projection studies in the late 20th century, is considered unlikely over the next two decades

Table 1 Average Annual Gross Domestic Product (GDP) and Endowment Growth Rates, 2007–2030 (% p.a.)

	High-income countries	*Developing countries . . .*	*. . . of which Asia*	*Total*
GDP	1.6	5.6	*6.6*	3.0
Population	0.3	1.1	*0.8*	0.9
Unskilled labour	–0.5	0.5	*0.3*	–0.2
Skilled labour	1.4	3.2	*3.0*	1.9
Capital	1.3	5.0	*6.0*	2.9
Agric. land	–0.3	–0.1	*–0.2*	–0.2
Oil	2.5	2.0	*0.7*	2.2
Gas	0.7	2.9	*1.6*	2.0
Coal	0.2	5.0	*5.2*	3.3
Other minerals	2.1	2.1	*2.1*	2.1

p.a., per annum.

Source: Anderson and Strutt (2014).

3.1 Consequences for Sectoral and Regional GDP and Trade Compositions

The fact that sectors differ in their relative factor intensities and their share of GDP, together with differences across regions in rates of growth of factor endowments and TFP, ensure that the projected structures of production, consumption and trade across sectors within countries, and also between countries, are very different in 2030 than in 2007. In particular, the faster-growing economies in Asia will account for considerably larger shares of the projected global economy over the next two decades. The developing country aggregate share of world GDP (measured in 2007 US$, not PPP dollars in 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 (Figure 1). Europe's share, meanwhile, is projected to fall from over one third to just above one quarter. Economically active population shares change much less, with the developing countries' share rising from 79 to 83 per cent[5] but Developing Asia's component remaining fairly steady between 2007 and 2030. The per capita income of the economically active population in Developing Asia is projected to rise from 25 to 57 per cent of the global average over this projection period.

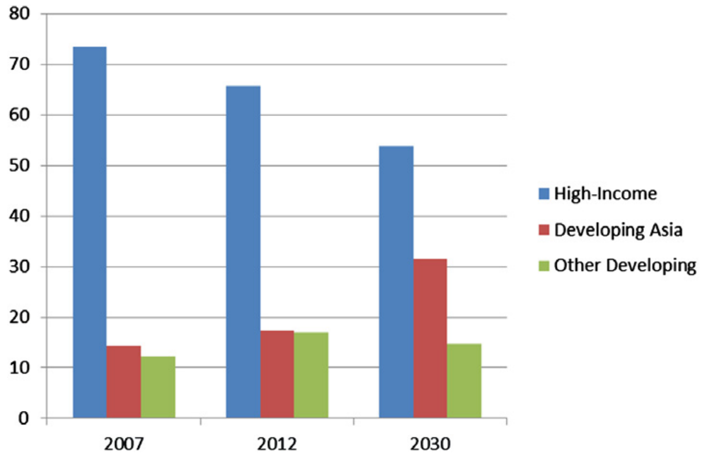
The changes are more striking when global value added is broken down by sector. This is especially for China: by 2030 it is projected to return to its supremacy as the world's top producing country not only of primary products, but also of manufactures. This is a ranking China has not held since the mid-19th century when first the United Kingdom and then (from 1895) the United States were the top-ranked country for industrial production (Crafts & Venables 2003; Allen 2011).

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 (Figure 2). The growth of China's export share is entirely at the expense of high-income countries, as the export shares for the other developing country regions 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

given the slowdown in agricultural R&D investment since 1990 and its consequent delayed slowing of farm productivity growth (Alston et al. 2010) and the decline in the real price of manufactures as industrialisation in China and other Asian countries booms. It is even less likely for farm products if fossil fuel prices and biofuel mandates in the United States, European Union and elsewhere are maintained over the next decade.

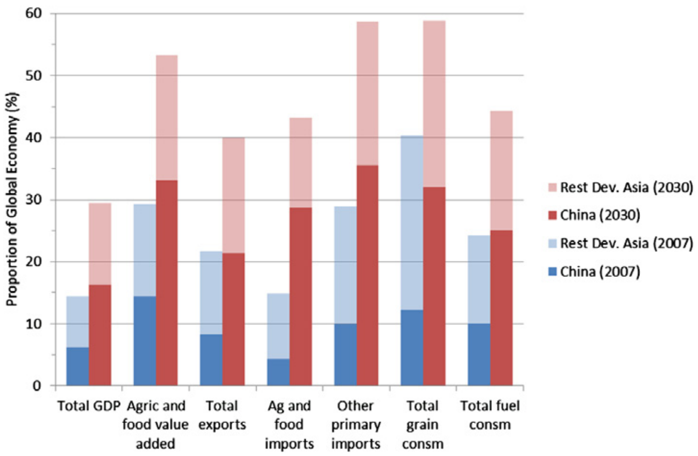
5. Drawing on estimates from Fouré et al. (2012).

Figure 1 Regional Shares of Global Gross Domestic Product (GDP), 2007–2030 (%)



Source: Derived from the GTAP database for 2007, IMF (2012) for 2012 and the authors' real GDP assumptions to 2030 (see Table 1 and text for details).

Figure 2 China's and Developing Asia's Shares of Global Markets, 2007 and 2030 (%)



Source: Authors' GTAP model results.

China's primary product imports—from 1.3 to 6.5 per cent of total world imports.

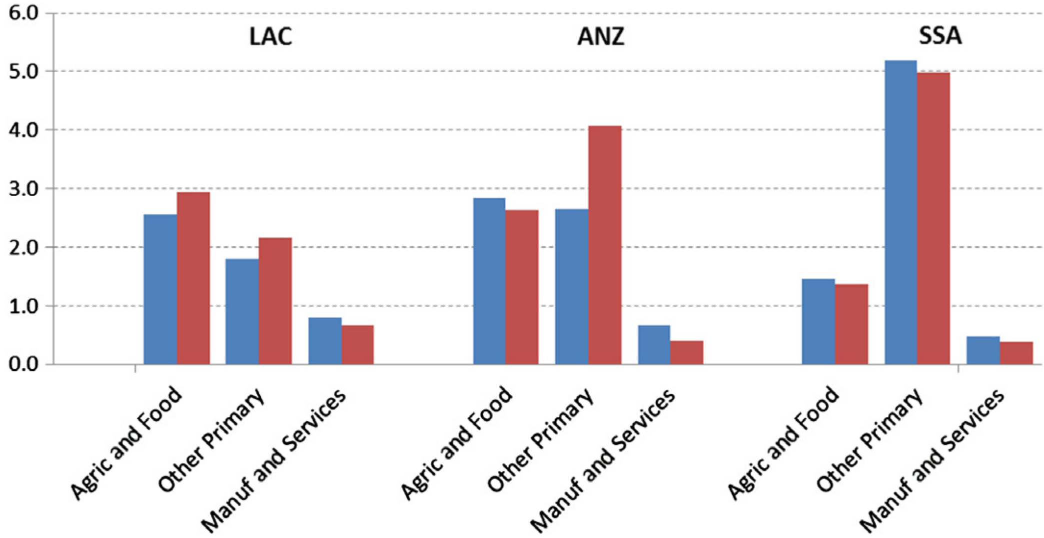
The consequences of continuing Asian industrialisation show up in the projected sectoral shares of national trade: primary products become less important in developing country exports and considerably more important in their imports, and conversely for non-primary products, with the changes being largest 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 sector prices, resulting from Asia's rapid industrialisation. These developments are reflected in the changing regional shares of global exports of primary products, manufactures and services, summarised in Table 2. The comparative advantages of both Latin America and the Caribbean, and

Table 2 Sectoral and Regional Shares of Global Exports of all Products, 2007 and 2030 Core Projection

	Primary goods (%)		*Manufactured goods (%)*		*Services (%)*	
	2007	*2030*	*2007*	*2030*	*2007*	*2030*
World	16	19	66	63	18	18
Of which:						
Developing Asia	2	2	17	33	3	5
Resource-rich countries	11	13	11	11	3	3

Source: Authors' GTAP model results.

Figure 3 Indexes of 'Revealed' Comparative Advantage[a] in Primary and Other Products, 2007 and 2030.



Note: (a) Sectoral share of country's exports divided by sectoral share of global exports.
Source: Authors' GTAP model results.

Australia and New Zealand strengthen in primary products, particularly in mining, at the expense of non-primary goods and services (Figure 3).

3.2 Consequences for Food Self-Sufficiency and Consumption of Primary Products

Food self-sufficiency in developing countries is projected in this core scenario to fall considerably by 2030, but the source of that change is mainly China and to a smaller extent India—assuming these populous countries do not seek to prevent such a growth in food import dependence by erecting protectionist barriers.

Self-sufficiency is a poor indicator of food security, however. A more meaningful indicator is real per capita private consumption of farm products by households (Tiwari et al. 2013). Figure 4 summarises those results, showing that between 2007 and 2030, real per capita farm (including livestock) product consumption doubles or more in China and South Asia, and increases by almost two thirds in Sub-Saharan Africa. This implies major improvements in food consumption per capita in the regions housing the vast majority of the world's poor. 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

Table 3 Resource-Rich Countries' Share (%) of Total Exports Going To China and All Resource-Poor Asian Developing Countries, 2007 and 2030

	Australia	*New Zealand*	*Russia and C. Asia*	*Other resource-rich developing countries*
Exports to all resource-poor Asia:				
2007	56	27	13	31
2030 core	74	48	42	45
2030, slower China and India growth + all prim prod.	67	42	34	40
Exports to China:				
2007	16	5	6	7
2030 core	44	32	31	22
2030, slower China and India growth + all prim prod.	31	23	23	16

Source: Authors' GTAP model results.

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 consumption by households grows little, its share of grain consumed indirectly grows from 12 to 32 per cent of the global total (Figure 2). That promises to provide ongoing growth in the market for grain (and soy bean) exports to China. Figure 2 also indicates that 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).

3.3 Consequences for Bilateral Trade

It is the phenomenal growth in China's share of global imports of primary products that dominates the bilateral trade picture: virtually all NRR countries boost their share of exports to China. Most also increase exports to other resource-poor Asian countries, although to a much lesser extent than to China. These increases are at the expense of their primary product exports to most other regions. A relatively high share of Australia's exports, particularly of primary products, went to China as of 2007. This share is projected to rise even further by 2030. Meanwhile, other resource-rich countries are projected to move a long way towards catching up with Australia (Table 3).

4. A Slower Growth Projection to 2030

In this section, we compare the economic consequences of the above core scenario with those from a slower growth scenario. Specifically, we consider a scenario in which China and India experience one-quarter slower GDP, skilled labour and capital stock growth than in the core projection, and this is assumed to cause a one percentage point slower rate of growth in TFP in primary sectors globally. In this alternative case, real international prices for primary products by 2030 are much more above 2007 levels than in the core projection, making them more consistent with the price projections of some key international agencies (FAO/OECD 2012; IEA 2011).

In the core projection, we set real GDP growth rates for China and India at just under 8 and 7 per cent per year, respectively, between 2007 and 2030. These are well below those economies' recent growth rates, especially when their rapid growth during 2007–2012 is taken into account. Yet some commentators still feel that those rates are too optimistic, particularly given the recent slowdown in developed country economies and their modest prospects. Hence, our projections were re-run assuming slower growth in these two economies. When we also assume that slowdown dampens global TFP growth in primary sectors by one percentage point annually, international prices of farm and other primary products are higher than in the core scenario. Those higher prices compensate only somewhat for the impact on primary producers in resource-rich countries of slower Asian growth (Table 3).

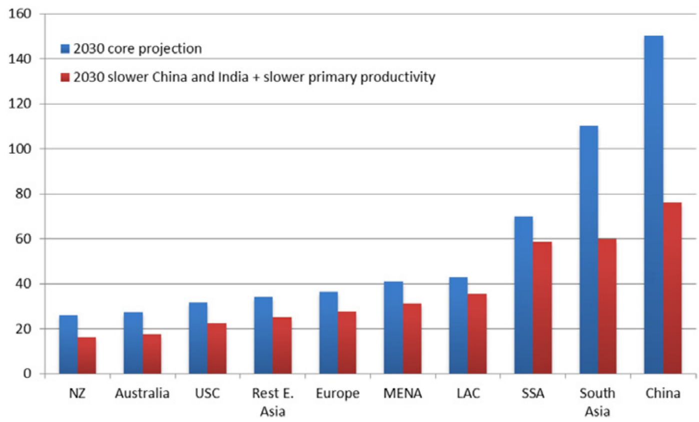
The slowdown in farm productivity growth would result in lower agricultural

Table 4 Self-Sufficiency in Farm Products, 2007 and 2030 (%)

	2007 base	*2030 core*	*2030 with slower China/ India growth and slower global primary TFP growth*
China	97	87	88
South Asia	100	95	94
Other East Asia	93	100	95
Sub-Saharan Africa	101	104	102

Source: Authors' GTAP model results.

Figure 4 Cumulative Increase in Real Per Capita Household Consumption of Farm Products from 2007 Base, Core and Slower Growth Scenario to 2030 (%)



Source: Authors' GTAP model results.

self-sufficiency ratios in Asia and considerably less growth in their household food consumption (Table 4 and Figure 4). And slower growth in the two most populous economies has an especially marked impact on primary product trade with resource-rich countries. Asia's share of global agricultural imports in 2030 drops from 43 to 34 per cent, and the growth in China's share of imports from resource-rich countries is dampened substantially. Clearly, not only the resource-poor Asian countries, but also their resource-rich trading partners have a strong interest in the former continuing to enjoy rapid economic growth.

5. A Possible Policy Response by China

The decline in China's self-sufficiency in farm products by 2030 in either the core or slower growth scenarios, from 97 to 88 per cent or less (Table 4), may well lead China to follow its earlier-industrialising Northeast Asian neighbours (see Anderson 2009) in imposing import restrictions on at least their key food grains. And in the interest of boosting farm incomes to reduce the yawning urban–rural income gap, import restrictions may also be imposed on meat and milk products (but not on coarse grains and oilseed products required for animal feedstuffs).[6]

If such restrictions were in the form of tariff equivalents severe enough to virtually eliminate imports of those selected products in 2030, then according to our GTAP modelling

6. Similar restrictions have been built into a Food Law introduced by Indonesia's government in late 2012 (Anderson & Strutt 2013). India's latest approach has been to broaden its rice and wheat consumer subsidy programme to two thirds of the population and to continue to provide large farm input subsidies as well as vary border restrictions in an attempt to stabilise domestic producer prices (Hoda & Gulati 2013).

Table 5 China's Self-Sufficiency in Selected Farm Products, 2007 and 2030 without and with Import Bans on Rice, Wheat, Meats and Milk Products or Increased Agricultural TFP Growth (%)

	2007	2030 with slower China/India and global primary product TFP growth	2030 with slower China/India growth plus selected China food import bans	2030 with slower China/India growth plus 33% extra agricultural TFP growth	2030 with slower China/India growth plus 59% extra agricultural TFP growth
Rice†	101	95	100	99	103
Wheat†	103	97	100	101	107
Coarse grains	105	98	98	101	103
Fruits and vegetables	102	96	95	99	102
Oilseeds	56	35	32	48	56
Vegetable oils	88	61	55	82	92
Sugar	96	79	74	93	98
Cotton	74	66	64	75	78
Other crops	132	45	40	79	123
Beef and sheepmeat†	94	89	100	94	100
Other meats†	101	37	100	88	99
Dairy products†	97	75	100	94	101

†Indicates sectors subject to the self-sufficiency policy.

Source: Authors; GTAP model results.

such a trade policy response by China would alter its projected self-sufficiency rates in 2030 as shown in the third column of Table 5: as resources move towards rice, wheat and livestock production, self-sufficiency would fall further for crops that provide inputs into feedstuffs and also for other crops.

The tariff equivalents of such import restrictions would range from 114 per cent for wheat to 255 per cent for red meats. These are well above China's bound out-of-quota tariffs (compare the last two columns in Table 6) and so would be clearly inconsistent with China's World Trade Organization commitments under international law.

Moreover, such a policy response would impose a burden on Chinese households that are net buyers of those grain, meat and milk products because domestic consumer prices for those products would increase along with the producer price hike. Projected per capita household utility declines by almost 1 per cent in China as a result of this policy change, with a similar reduction in real GDP and total consumption of food and agricultural products. This therefore undermines China's food security by reducing households' access to food.

Despite the high costs of such import restrictions (even ignoring retaliation by trading partners), overall self-sufficiency in agricultural products for China only increases to 94 per cent with these policies. While this is somewhat higher than the 88 per cent self-sufficiency rate estimated in the absence of such policies, it remains well below the 97 per cent level of 2007.

Given the costs and relative inefficiency of such import-limiting policies, alternative approaches to maintaining food security are worth considering. We therefore explore the implications of China increasing the productivity of agriculture, for example, through further investment in agricultural research. China's public agricultural R&D expenditure has risen considerably in recent decades, but in 2008 it was still only four fifths of the Asia-Pacific average (ASTI 2013). It has been shown in general that the marginal returns from boosting such levels of public investment are extremely high (Rao et al. 2012). The evidence from Brazil is particularly compelling: during the 1980s and 1990s, Brazil invested more than four times as intensely as China in public agricultural R&D as a per cent of national agricultural GDP. It is therefore not surprising that Brazil's output of both crop and livestock products have more than doubled since the early 1990s, and its food self-sufficiency has been boosted commensurately. And by biasing that research towards

Table 6 Shares of Agricultural Imports and Agricultural Tariff Rates for China, 2030, Including Slower China and India and Primary Product Growth, and 2030 after Policy Changes (%)

	Share of agr. imports, 2030, with slower China/India growth	*Share of agr. imports, 2030, with slower growth plus selected food import bans*	*Share of agr. imports, 2030, with slower growth plus 33% higher agric. TFP growth*	*Share of agr. imports, 2030, with slower growth plus 59% higher agric. TFP growth*	*2030 tariff rates, China*	*2030 tariff rates, China with selected import bans*	*China's out-of-quota bound tariff at WTO*
Rice†	1	0	0	0	2	196	*65*
Wheat†	0	0	0	0	2	114	*65*
Coarse grains	0	1	0	0	2	2	*65*
Fruits and vegetables	8	16	5	3	7	8	*11*
Oilseeds	11	15	24	35	3	3	*3*
Vegetable oils	18	30	18	14	2	2	*3*
Sugar	1	2	1	1	0	0	*50*
Cotton	3	4	5	8	4	4	*40*
Other crops	2	2	2	3	8	8	*na*
Beef and sheepmeat†	1	0	1	1	11	255	*12*
Other meats†	26	0	12	4	8	164	*12*
Dairy products†	4	0	2	1	8	159	*11*
Other + processed food	25	30	28	30			
Total	100	100	100	100			
Proportion of total imports	13	10	6	4			

†Indicates sectors subject to the self-sufficiency policy.

Source: Authors' GTAP model results.

labour-saving technologies, that investment also helped farmers adjust to rising rural wages—something that is becoming more pressing also in China as the supply of under-employed labour in rural areas shrinks (Zhang et al. 2011).

Specifically, we model the increase in TFP that would be required in Chinese agriculture (i) to achieve the same self-sufficiency rate in 2030 as with the import restrictions (94 per cent) and, even more ambitiously, (ii) to return to the same overall agricultural self-sufficiency as in 2007, namely 97 per cent.

To achieve the overall agricultural self-sufficiency rate of 94 per cent as in the import restricting scenario, we introduce a cumulative 33 per cent improvement in agricultural TFP for China over the period to 2030. Results in Table 5 indicate that some of the products, particularly meats, would not achieve 100 per cent self-sufficiency as when protected by the high import restrictions of the previous scenario, but self-sufficiency rates for oilseeds, sugar and other crops are higher in this scenario than the previous one.

To achieve the more ambitious target of returning China's overall agricultural self-sufficiency rate to its 2007 level, we introduce a 59 per cent cumulative improvement in agricultural TFP over the period to 2030. This magnitude of productivity increase slightly overachieves self-sufficiency in cereals and fully achieves it for meat and milk products, with other sectors also seeing increased self-sufficiency rates (Table 5). Because it generates higher incomes, it leads to higher volumes of various foods consumed by households in China. That is, national food security is boosted, in contrast to its deterioration in the import protection scenario where overall food consumption falls. These scenarios also help food consumers abroad more than the import protection scenario: the latter depresses international food and agricultural prices by 1 per cent, whereas the 33 and 59 per cent TFP growth scenarios lower them by 3 and 5 per cent, respectively.

While these cumulative increases in agricultural TFP of 33 or 59 per cent may seem high, recall that they are spread over our 23-year projection period. The annual rates required would be only a little over 1 or 2 per cent. These are not excessive by historical standards—see, for example, Alston et al. (2010) and Fuglie et al. (2012).

Not surprisingly, all of the above policies would reduce the relative importance of agricultural imports in China's total import bundle. In the 2030 slower growth scenario, from which we compare these policy simulation results, agricultural imports account for 13 per cent of total imports, but this reduces to 10 per cent with the high import restriction policy, and to 6 and 4 per cent under the two higher agricultural productivity growth scenarios (final row of Table 6).

In contrast to the agricultural protection scenario, increases in agricultural productivity offer the opportunity to not only improve agricultural self-sufficiency rates, but also to raise overall levels of both farm production and national economic welfare. The increases in import restrictions are estimated to reduce real GDP by 0.9 per cent, whereas an increase in agricultural TFP of 33 (or 59) per cent raises estimated real GDP by 4.5 (or 7) per cent.[7]

6. Implications and Conclusions

The above results make clear that Developing Asia's shares of global GDP and trade are likely to continue to rise steeply over the next two decades. Its share of global agricultural GDP is projected to almost double also, but that is unlikely to be fast enough to keep pace with the growing consumption of food if current policies are not altered. By 2030, Developing Asia is projected to consume around half of the world's grain and 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 shares of the world's imports of primary products are projected to more than double between 2007 and 2030 in the core

7. In these scenarios, we have ignored the cost of the research that might be required to boost farm productivity.

scenario—and to be paid for with their rapidly rising earning from exports of manufactures.

If economic growth in China and India is one-quarter slower than in that core scenario, however, those bright export prospects for NRR economies are dampened somewhat. Furthermore, if such a slowing of growth in emerging Asia were to lead to a slowdown in productivity growth in farm and mineral production globally, the world's food and energy security would improve less. If countries such as China respond to the decline in the international competitiveness of their farmers by imposing import restrictions on key foodgrains and livestock, that will slow the growth in their domestic consumption of food and at the same time lower the export-earning prospects of food surplus countries. By contrast, if China were to boost its agricultural R&D investments from below to above the Asia-Pacific average per dollar of farm output, that would boost China's national welfare and food security.

Needless to say, there are myriad possible events not modelled here that could be relevant in the future. One is the new fraching technology that is dramatically lowering the cost of extracting non-conventional gas supplies (IEA 2012). Its rapid adoption in the United States is lowering that country's dependence on imported petroleum, and it may also eventually do the same for other fossil fuel-importing countries including China. The announcement in early 2013 by the Chinese leadership that the country aims to not increase its consumption of coal much above current levels also would alter trade flows. For example, it would shrink Australia's exports of coal to China—but they may be replaced by exports of uranium or, if Australia embraces and adapts the fraching technology to local conditions, by gas exports.

Given Developing Asia's large share of the world's agricultural and food output and consumption currently and prospectively, its food security is likely to be greatest when markets for farm products are always open and not only regionally, but globally. This is because greater openness ensures that international food markets are 'thicker' and thus more stable and predictable. Yet many Asian governments perceive food security as a production issue rather than a consumption issue by focusing on food self-sufficiency rather than on the spending capability of the poor. Moreover, if China, Indonesia and India were to follow Japan and Korea in subsidising and protecting their farmers increasingly as per capita incomes grow—as they have been doing already in recent years—that would *reduce* affordable access to food for their poor households. Such a policy development also would harm food-exporting countries, dampening the growth in agricultural exports to China that is projected above. Clearly resource-poor Asian countries and their resource-rich trading partners have a mutual strong economic interest in keeping markets as open to international trade as is possible.

October 2013

References

Allen B (2011) *Global Economic History: A Very Short Introduction*. Oxford University Press, London.

Alston JM, Babcock BA, Pardey PG (eds) (2010) *The Shifting Patterns of Agricultural Production and Productivity Worldwide*. Midwest Agribusiness Trade Research and Information Center, Iowa State University, Ames IA.

Anderson K (2009) Distorted Agricultural Incentives and Economic Development: Asia's Experience. *The World Economy* 32(3), 351–84.

Anderson K, Smith B (1981) Changing Economic Relations between Asian ADCs and Resource-Exporting Developed Countries. In: Hong W, Krause L (eds) *Trade and Growth in the Advanced Developing Countries*, pp. 293–338. Korea Development Institute Press, Seoul.

Anderson K, Strutt A (2013) *Asia's Growth to 2030: Implications for Indonesia*. Paper presented at the 16th Annual Conference on Global Economic Analysis, Shanghai, 12–14 June.

Anderson K, Strutt A (2014) Emerging Economies, Productivity Growth, and Trade with

Resource-Rich Economies by 2030. *Australian Journal of Agricultural and Resource Economics* 58 (forthcoming).

Armington P (1969) A Theory of Demand for Products Distinguished by Place of Production. *IMF Staff Papers* 16, 159–78.

ASTI (2013) *ASTI Database*. International Food Policy Research Institute, Washington, D.C., viewed September 2013 <http://www.asti.cgiar.org/data>. Agricultural Science and Technology Indicators.

BP (2012) *BP Statistical Review of World Energy*. British Petroleum, London.

Chappuis T, Walmsley TL (2011) *Projections for World CGE Model Baselines*. GTAP Research Memorandum no. 22, Center for Global Trade Analysis, Purdue University, West Lafayette IN, September.

Corden WM (1984) Booming Sector and Dutch Disease Economics: Survey and Consolidation. *Oxford Economic Papers* 36(3), 359–80.

Crafts N, Venables AJ (2003) Globalization in historical perspective. In: Bordo M, Taylor A, Williamson J (eds) *Globalization in Historical Perspective*, pp. 323–64. University of Chicago Press for the NBER, Chicago, IL.

Deardorff AV (1984) An Exposition and Exploration of Krueger's Trade Model. *Canadian Journal of Economics* 5(4), 731–46.

FAO (2012) *FAOSTAT*, viewed September 2013 <http://faostat.fao.org>.

FAO/OECD (2012) *FAO/OECD Agricultural Outlook 2012–2021*. Paris and Rome: OECD and FAO.

Fouré J, Benassy-Quéré A, Fontagné L (2012) *Macroeconomic Projections for the World Economy at the 2050 Horizon*. Working Paper 2012-3, CEPII, Paris.

Fuglie KO, Wang SL, Ball VE (eds) (2012) *Productivity Growth in Agriculture: An International Perspective*. CABI, London.

Hertel TW (ed) (1997) *Global Trade Analysis: Modeling and Applications*. Cambridge University Press, Cambridge and New York.

Hoda A, Gulati A (2013) *India's Agricultural Trade Policy and Sustainable Development*. ICTSD Issue Paper 49, Geneva: International Centre for Trade and Sustainable Development, September.

IEA (2011) *World Energy Outlook 2011*. Paris: International Energy Agency, November.

IEA (2012) *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*. Paris: International Energy Agency, May.

IMF (2012) *World Economic Outlook*. Washington DC: International Monetary Fund, October.

Krueger AO (1977) *Growth, Distortions and Patterns of Trade Among Many Countries*. International Finance Section, Princeton, NJ.

Leamer EE (1987) Paths of Development in the Three-Factor, n-Good General Equilibrium Model. *Journal of Political Economy* 95(5), 961–99.

Martin W, Mitra D (2001) Productivity Growth and Convergence in Agriculture and Manufacturing. *Economic Development and Cultural Change* 49(2), 403–22.

Narayanan BG, Aguiar A, McDougall RA (eds) (2012) *Global Trade, Assistance, and Production: The GTAP 8 Data Base*. Center for Global Trade Analysis, Purdue University, West Lafayette. viewed November 2013 <http://www.gtap.agecon.purdue.edu/databases/v8/v8_doco.asp>.

Rao X, Hurley TM, Pardey PG (2012) *Recalibrating the Reported Rates of Return to Food and Agricultural R&D*. Staff Paper P12-8, Department of Applied Economics, University of Minnesota, St. Paul, September.

Roson R, van der Mensbrugghe D (2012) Climate Change and Economic Growth: Impacts and Interactions. *International Journal of Sustainable Economy* 4(3), 270–85.

Tiwari S, Skoufais E, Sherpa M (2013) *Shorter, Cheaper, Quicker, Better: Linking Measures of Household Food Security to Nutritional Outcomes*. Policy Research Working Paper 6584, World Bank, Washington DC, August.

US Geological Survey (2012) *Mineral Commodity Summaries*, viewed September 2013 <http://minerals.usgs.gov/minerals/pubs/mcs/>.

Yu W, Hertel TW, Preckel PV, Eales JS (2004) Projecting World Food Demand Using Alternative Demand Systems. *Economic Modelling* 21(1), 99–129.

Zhang X, Yang J, Wang S (2011) China Has Reached the Lewis Turning Point. *China Economic Review* 22(4), 542–54.