08 Revisiting the economic costs of food self-sufficiency in China

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The comparatively rapid economic growth experienced in the economies of East Asia has been associated with declines in food self-sufficiency and increases in agricultural protection. This has been most noteworthy in Japan, Korea and Taiwan, where the relative decline in economic importance of the agricultural sectors has not been accompanied by a similar decline in the political influence of farmers (Anderson et al. 1986; Krueger 1992). Rapid expansion in these countries' manufacturing and services sectors meant that the relative cost of protecting agriculture, as distinct from the expanding sectors, declined. Moreover, as agriculture shed workers to the modern sectors and farms consolidated, the number of farmers declined, reducing the cost of coordinating their political activity (Downs 1957; Olson 1965). The net effect has been the growth of protection to levels so extreme that the cost burden on their economies is large in spite of their small agricultural sectors.

China's very rapid economic expansion of the past two decades now threatens to yield a political economy similar in this respect to those driving the rises in protection in Japan, Korea and Taiwan. Today, along with widening of per capita income disparities between urban and rural areas, the rhetoric of self-sufficiency is the most prominent weapon of China's protectionists. While WTO accession lessens the risk that they will succeed, the agricultural ministry has been assigned a prominent role in

trade policy formation and negotiation, with the power to press for further agricultural protection on self-sufficiency as well as distributional grounds (Anderson et al. 2002; Tong 2003).

Anderson et al. (2002) also put the view that closing the rural–urban per capita income gap will not be achieved by the use of protection of the agricultural sector in that the protection will raise land rents and land values without reducing the numbers of the rural poor. Growth in rural per capita incomes will come, as it has in the industrialised countries, from productivity increases in the agricultural sector, the development of off-farm income opportunities for rural households and the migration of workers to urban areas (Chang and Tyers 2003). In this paper we examine the costs that would be borne by the Chinese economy if it attempted to maintain or increase its levels of self-sufficiency in agricultural commodities, rather than continuing to open its agricultural markets. We also address the Anderson et al. view about urban–rural income distribution.

In an early analysis, Yang and Tyers (1989) used a global agricultural sector model to examine the implications of rapid income growth on the composition of food consumption and the implications of this for food self-sufficiency. They found that the anticipated redistribution of consumption toward livestock products would raise import demand for feed grains and that this would make the maintenance of self-sufficiency through protection very costly. Because their analysis was restricted to the agricultural sector, however, they could not examine the redistributive and overall contractionary effects of the protection needed to maintain self-sufficiency. In this paper we do this using a more general global model, the scope of which is the entire economy. Our model is adapted originally from GTAP,[1] which allows for a multi-region, multi-product general equilibrium analysis. Following Yang and Tyers (2000), to this GTAP base is added independent representations of governments' fiscal regimes, with both direct and indirect taxation.[2]

We begin by using this model to project the world economy to 2010,[3] noting the trends in the self-sufficiency rates for agricultural products in China. We then ask two questions. First, if China's food self-sufficiency rates are to be held constant to 2010, will increases in protection be required? Second, what increases in protection would be required to

achieve self-sufficiency by 2010 and what would be the contractionary and distributional effects of this protection? Consistent with Yang and Tyers (1989) our projections to 2010 show substantial declines in Chinese food self-sufficiency, particularly for livestock products and feed grains, so that substantial increases in protection are needed to maintain the 2001 levels. To achieve self-sufficiency in all agricultural products by 2010 considerable further protection would be required. Moreover, this protection would be both contractionary and redistributive, and it would retard growth in other sectors. The strength of the results notwithstanding, a sensitivity analysis shows they rest quite heavily on the precision with which some parameters are measured, particularly the income elasticity of demand for livestock products.

Modelling the Chinese and world economies, 2001–2010

The model is a modified version of that introduced by Hertel (1997), which is global in scope. It offers the following useful properties

- a capital goods sector in each region to service investment
- explicit savings in each region, combined with open regional capital accounts that permit savings in one region to finance investment in others
- multiple trading regions, goods and primary factors
- product differentiation by country of origin
- empirically based differences in tastes and technology across regions
- non-homothetic preferences
- explicit transportation costs and indirect taxes on trade, production and consumption.

All individual goods and services entering final and intermediate demand are constant elasticity of substitution (CES) blends of home products and imports. Government spending is also such a composite, though its mix of goods, as between different product groups and between home products and imports, differs from that embodied in private consumption. In turn, imports are CES composites of the products of all regions, the contents of

which depend on regional trading prices. Savings are pooled globally and investment is then allocated between regions from the global pool. Within regions, investment places demands on the domestic capital goods sector, which is also a CES composite of home-produced goods, services and imports in the manner of private consumption and government spending.

Our modifications (Yang and Tyers 2000) make regional governments financially independent by incorporating direct tax regimes. The private saving and consumption decision is represented by a reduced form exponential consumption equation with wealth effects included via the dependence of consumption (and hence savings) on the interest rate. Each region then contributes its total domestic (private plus government) saving, $S_D = S_P + S_G$, to the global pool from which each region's corresponding investment is derived.[4] These relations imply the balance of payments identity at the regional level, which sets the current account surplus equal to the capital account deficit: $X - M = S_P + S_G - I$.[5]

From the global savings pool, investment is allocated across regions and it places demands on capital goods sectors in each region. A high level of global 'capital' mobility is assumed.[6] The allocation to region j (net investment in that region) depends positively on the long-run change in the average rate of return on installed capital, r_j^e, which, in turn, rises when the marginal product of physical capital is increased.[7] This allocation falls when the opportunity cost of financing capital expenditure, the region's real interest rate, r_j, rises. This depends, in turn, on a global capital market clearing interest rate, r^w, calculated such that global savings equals global investment :$\Sigma_j S_j^D = \Sigma_j I_j(r_j^e, r_j)$. Here I_j is nominal gross investment in region j.[8] The region's home interest rate is then $r_j = r^w(1+\pi_j)$ where π_j is a region-specific interest premium, thought to be driven by risk factors not incorporated in this analysis. The investment demand equation for region j then takes the form

$$I_j = \delta_j K_j + I_j^N = \delta_j K_j + \beta_j K_j \left(\frac{r_j^e}{r_j}\right)^{\varepsilon_j} = K_j \left[\delta_j + \beta_j \left(\frac{r_j^e}{r_j}\right)^{\varepsilon_j}\right] \quad (1)$$

where K_j is the (exogenous) base year installed capital stock, δ_j is the regional depreciation rate, β_j is a positive constant and ε_j is a positive elasticity. Critically, investment in any region responds positively to changes

that raise a region's marginal product of physical capital and hence the region's average return on installed capital.[9] Other things equal, then, in the long-run applications in this paper improvements in trans-sectoral efficiency, such as might stem from a trade reform, raise capital returns permanently and hence they raise r_j^e.

The long-run closure adopted for the model in this paper differs from the short-run closure used by Yang and Tyers (2000) and by Rees and Tyers (2002) in that there are no nominal rigidities (no rigidity of nominal wages) and hence full employment is retained and money is neutral;[10] larger production and consumption elasticities are used to reflect the additional time for adjustment;[11] physical capital is not sector specific, it redistributes across sectors to equalise rates of return; China's capital controls are ignored; and changes in government revenue associated with tariff increases are assumed to not be offset via direct (income) tax changes, with the result that the fiscal deficit changes, so that the ratios of government revenue and expenditure to GDP are endogenous while the average direct tax rate is exogenous.[12]

Data and parameters

The regions, primary factors and sectors identified in our analysis are listed in Table A8.1. Considering regions first, we draw on the now well-known GTAP Version 5 global database for 1997, which divides the world into 66 countries and regions. Although this database separates mainland China from Taiwan province, it amalgamates Hong Kong with the mainland.[13] Our further aggregation of mainland China with Taiwan province overlooks effects that are internal to these regions but such effects are not our focus. Instead, we seek to illustrate the strong interaction between self-sufficiency rates, agricultural protection and overall economic performance. These interactions are important for all the economies of East Asia.

Turning to primary factors, skill is separated from raw labour on occupational grounds, with the 'professional' categories of the International Labour Organization (ILO) classification included as skilled.[14] The structure of factor demand has skill and physical capital as complements. This enables the model to represent the links between skill availability, capital returns

and investment that are important in China, which has large skilled and unskilled labour forces that are increasingly mobile between sectors.[15] Finally, the sectoral breakdown we have chosen aggregates the 57 sectors in the database to our more manageable 14, offering the most detail in agricultural and marine products.

The most sensitive parameters in determining the trends in self-sufficiency through time prove to be the elasticities of demand. Our model employs the original GTAP CDE (constant difference of elasticities of substitution) system. Its non-homotheticity is a particular asset for our purpose in that it permits a range of income elasticities to exist, either side of unity. While this system is more general than the homothetic ones often used in such models, it is still restrictive in the width of the range compared to still more general systems. The CDE system is employed here because of its parametric economy.[16] The income elasticities thus embodied in our demand parameters are listed in Table A8.2. Because of the restrictiveness of the CDE system the lower bound for the income elasticity of cereal grains cannot be set below 0.1, despite evidence suggesting that it is now negative (Ito et al. 1991; Peterson et al. 1991). As a result, in our analysis the span between the income elasticities of livestock products and processed foods, which are superior goods, and those of cereal grains is likely to be smaller than the truth. One consequence of this is that our results probably underestimate the relative growth in demand for livestock products and processed foods and hence they underestimate the associated derived demand for cereal feeds and other agricultural inputs. This offers a second downward bias in our estimates of the cost of achieving and maintaining agricultural self-sufficiency. Having said this, we did recalibrate the CDE parameters so as to minimise this downward bias.[17] The span between the income elasticities of livestock products and cereal grains was increased from 0.8, which was based on 1997 numbers in the GTAP Version 5 database, to 1.5. The recalibration involved calculating the new values for the expansion parameter and the substitution parameter in the CDE minimum expenditure function to imply income elasticities close to our target values.

Because the simulations are decade-long projections, it was necessary to use long-run elasticities of substitution in product and service demand. These are listed in Table A8.3. They are larger than the standard GTAP demand elasticities, which are designed for simulations over the medium run.

Constructing the 2010 world economy

As indicated earlier, our numerical analysis originates with the GTAP Version 5 global database for 1997. Rees and Tyers (2002) use a short run version of the above model to examine key changes in the Chinese economy between 1997 and 2001, including substantial trade reforms. We commence with their simulated image of the 2001 world economy and proceed to use it as a base from which to construct a reference projection of the 2010 economy. This latter step is, however, a substantial task in itself. Not only does it require assumptions about the exogenous growth rates of primary factor supplies like labour, skill and physical capital, it also rests importantly on assumptions about the pace of technical change.

The pace of technical change is incorporated by constructing a set of region-wide total factor productivity growth rates that are consistent with forecast changes in populations and labour supplies on the one hand and a set of non-controversial regional GDP growth rates on the other. We do this by making GDP growth rates exogenous in the first simulation and a corresponding set of region-wide total factor productivity growth rates endogenous. In the subsequent counterfactual simulations, GDP is made endogenous in each region but the corresponding total factor productivity growth emerging from the reference simulation is held constant. This ensures that, when subsequent simulations incorporate rising agricultural protection to achieve self-sufficiency, total income growth in each region adjusts. This approach to estimating the effects of new agricultural protection is conservative in that, by making total factor productivity coefficients independent of protection rates we expect to underestimate their contractionary effects.[18] The exogenous population, labour force and capital accumulation rates are listed in Table A8.4, along with the implied rates of total factor productivity growth.

Trends in Chinese agricultural self-sufficiency

The dependence of China's domestic markets on trade is most clearly evident from the ratio of exports to domestic value added in each sector, or the corresponding ratio of competing imports to value added. Estimates of these for 2001 are listed in Table A8.5. They show that the most export-

oriented food-related sector, the 'beverages' group, also faces the greatest level of import penetration. This sector is characterised by differentiated products and intra-industry trade, which, in China's case, appears roughly to balance out. Livestock products, 'processed food' and the 'other crops' group, which includes the key inputs to the livestock products group, grains and soybeans, are less trade-oriented. Importantly, however, they do not enjoy the balance of exports and competing imports that occurs with beverages. They are import competing and therefore sectors in which China is less than self-sufficient.

To track self-sufficiency, we offer a cruder but more widely used measure: domestic output relative to domestic 'disappearance'. For a particular product group we compare the value of output at producers' prices, *Y*, to this value of output supplemented by net imports (*M* - *X*), where the latter are also valued at domestic prices. Our self-sufficiency ratio is then

$$SSR = \frac{Y}{Y + M - X} \tag{2}$$

The values taken by this ratio in the original database of 1997, and the constructed ones for 2001 and 2010, are listed in Table A8.6. Measured in this way, departures from self-sufficiency are largest amongst agricultural products for the beverages group, 'other crops', and the processed food category. Moreover, the shortfall relative to full self-sufficiency is projected to expand through to 2010. Though smaller in magnitude, expansions in this shortfall also occur for marine products and livestock. If self-sufficiency is a policy objective these results suggest increased agricultural protection will be required in order to prevent deterioration in the ratios through time.

Achieving agricultural self-sufficiency through protection

If the Chinese government were to adopt self-sufficiency as an objective, to be achieved through border protection, it might choose to implement a policy regime that would prevent any negative trend in self-sufficiency ratios for product groups that are already import competing. Alternatively, it might seek a regime that would return the economy to self-sufficiency in

all agricultural products. We examine these two possible policy scenarios by constructing alternative simulations of the 2010 global and Chinese economies. In the first, for import-competing agricultural products, the self-sufficiency ratio is held constant at the 2001 level through the implementation of a source-generic tariff in each sector that is additional to existing protection. In the second, these sectors are made to return to full self-sufficiency by 2010 through the more zealous application of such tariffs. The results from these simulations are presented in Table A8.7. To show their power the additional tariffs required are listed in the form of proportional changes to nominal protection coefficients (ratios of domestic post tariff to border prices).

Because the declines in self-sufficiency projected to 2010 are significant, the tariffs necessary to retain 2001 self-sufficiency rates are substantial, particularly for the beverages, 'other crops' and livestock product groups. These taxes on imports are, in fact, taxes on all China's trade which not only reduce food imports. They also reduce China's exports, causing exporting industries to contract. Overall, the increased protection induces a one per cent contraction in GDP along with some restructuring across industrial sectors, favouring the newly protected agricultural industries mostly at the expense of manufacturing.

When the additional tariffs are raised to levels that yield full self-sufficiency in the previously import competing agricultural sectors, further substantial changes occur. The tariffs required by 2010 are very large, particularly on imports in the livestock products, processed food and 'other crops' groups. These distort incentives in the economy substantially, shifting resources into agriculture and contracting both the manufacturing and service sectors, the latter being the primary growth sectors in the economy. Throughout the economy this decline in allocative efficiency reduces returns to installed capital and therefore investment. The level of 2010 GDP is lower by nearly 2 per cent.

The role of the increased tariffs in reducing both imports and exports is clear from Table A8.8. The tariffs that would achieve agricultural self-sufficiency in 2010 also reduce exports from China's growth powerhouse, its light manufacturing industries, by half.[19] While this change is necessary to retain a balance of payments, the mechanism through which it operates is the response of firms and households to the domestic price

and associated real exchange rate changes caused by the tariff increases. Domestic resources are reallocated to the agricultural sector, raising costs in manufacturing and reducing the international competitiveness of China's manufacturing industries. The resulting misallocation of labour is particularly striking (Table A8.9). The higher tariffs cause employment in agricultural and food processing activities to be substantially greater, at the expense primarily of light manufacturing.

The implications of the tariffs for domestic income distribution are indicated by the effects on real unit factor rewards summarised in Table A8.10. Higher agricultural tariffs raise land rents by a considerable margin but reduce real wages and capital returns. In China, rural and urban wages are linked by an, albeit imperfect, labour market (Chang and Tyers 2003). The most labour-intensive sector (light manufacturing) is hurt by the tariffs. In the high tariff scenario, therefore, light manufacturing grows less, so that by 2010, fewer workers are employed in it. Real wages grow less in both agriculture and the modern sector. This is true for both production and skilled workers, and it is also true for the owners of physical capital. Again, the capital losses occur because the industries that are hurt by the tariffs are more capital intensive than agriculture. Indeed, the decline in unit capital rewards is serious for China, since this redirects domestic savings abroad and retards future investment and overall growth. In the end, land holders are the only winners from the tariffs.

We might well ask, then, what is gained by the self-sufficiency. Would food be more readily available in China? No. China's 2010 prices of imported foods would be higher with the increased tariffs by up to 60 per cent and even home-produced food products would be more expensive by at least 10 per cent. The key consequence of political significance would be a reduction in interdependence with the global economy — reduced reliance on global markets. But this cuts two ways. Reduced reliance on food imports means curtailing the principal source of China's overall economic growth since the 1980s — access to foreign markets for its labour-intensive goods. Curtailed exports reduce its capital returns, thereby cutting incentives for investment and, ultimately, the growth rate of its overall economy.

Sensitivity analysis

The simulations presented offer just one representation of the Chinese economy and our point estimates of the effects of higher tariffs are subject to substantial error. As it turns out, our estimates of these effects depend most sensitively on just a few parameters, the most critical being the income elasticity of demand for livestock products. This parameter is most important for two reasons. First, livestock products are superior goods the demand for which can be expected to grow disproportionately with income and hence this sector is particularly likely to lose self-sufficiency. Second, livestock feeds are also imported. The faster the demand for livestock products grows the greater is the derived demand for feed grains and the self-sufficiency rate in the import competing feed grain sector can also be expected to decline. The magnitudes of the tariffs required to stem this decline therefore depend critically on the income elasticity of demand for livestock.

By repeating the simulations in Table A8.7, assuming a smaller value for this elasticity, we have calculated the elasticities of sensitivity of key consequences to the income elasticity of demand for livestock products. The results are displayed in Table A8.11. Each of the elasticities shown in the table indicates the per cent by which the nominated variable changes when the income elasticity of demand for livestock products is raised by 1 per cent. Thus, were the income elasticity of demand for livestock products larger by 10 per cent (1.79 instead of 1.63), without new tariffs 2010 livestock imports would be larger by approximately 18 per cent and feed grain imports would be correspondingly larger by 12 per cent. To achieve agricultural self-sufficiency in 2010 this would mean that the nominal protection coefficient on livestock products would have to be higher by 7 per cent (the home price level would have to rise by 7 per cent relative to the import price). This would result in smaller light manufacturing output, by 7 per cent and smaller light manufacturing exports by 14 per cent. The income elasticity of demand for livestock products is clearly a key parameter — one that should be carefully monitored.

Conclusion

A global comparative static model is used to project the world economy to 2010, noting the trends in the self-sufficiency rates for agricultural products in China. If there is no change in China's trade policy regime, agricultural self-sufficiency rates are shown to decline and this decline is shown to be significant in all agricultural sectors except fisheries. Large changes in protection would be needed to hold the line at 2001 self-sufficiency levels. To achieve full self-sufficiency in all agricultural products by 2010 substantial further new protection would be required. This protection would be both contractionary and redistributive, harming worker households and retarding growth in the modern sector of China's economy. Moreover, it would raise domestic prices of food in China, restricting the availability of food products. This, plus slower growth, seems a high price to pay for a modest reduction in China's interdependence with international markets.

Because livestock products, as a group, are very income elastic, these results prove to be particularly sensitive to their income elasticity of demand. This elasticity has received less attention from the consumption literature than others, particularly that of rice, yet small changes in it lead to substantially different projections of agricultural self-sufficiency rates, the tariffs required to achieve self-sufficiency and the export performance of the modern sector of the economy. Further analysis of the consequences of any move to achieve and maintain agricultural self-sufficiency in China needs to be informed by new and high quality estimates of this and related income elasticities.

Finally, we note two downward biases in our estimation of the economic costs of achieving self-sufficiency. First, the links between productivity growth and trade reform are ignored, so that when new protection is applied with the objective of achieving agricultural self-sufficiency, no associated sacrifice of total factor productivity is imposed. Second, even though we have recalibrated the standard GTAP CDE demand system, the range of income elasticities between the superior food items in 'processed food' and 'livestock products' on the one hand and cereals on the other is still likely to be smaller than in reality. As the sensitivity analysis suggests, the economic costs of a tariff regime to restore self-sufficiency are substantially higher if the income elasticity of demand is raised above

our estimate of 1.63. These two effects lead to an underestimation of the growth in demand for processed food and livestock products as well as a corresponding underestimation of growth in the consumption of their principal intermediate inputs, namely cereals, soybeans, fruits and vegetables. The result is an overestimation of future self-sufficiency ratios and, thus, an underestimation of the cost of raising these to unity via protection.

Notes

1 A detailed description of the original model is provided by Hertel (1997).

2 The nominal side of the model is not used in this analysis, which focuses on long-run changes. No nominal rigidities are introduced and so money neutrality prevails.

3 Our projection employs a similar approach to that used by Ianchovichina and Martin (2002).

4 Private saving is derived as the difference between disposable income (Y-T) and consumption expenditure, where real consumption is determined in a Keynesian reduced form equation that takes the form

$C = \gamma\ r^{\delta}\ [Y - T]^{\mu}$, where *r* is the real interest rate.

5 Note that there is no allowance for interregional capital ownership in the starting equilibrium. At the outset, therefore, there are no factor service flows and the current account is the same as the balance of trade.

6 By which it is meant that households can direct their savings to any region in the world without impediment. Installed physical capital, however, remains immobile even between sectors.

7 rje is the expected rental rate on physical capital, adjusted for depreciation and divided by the price of capital goods to yield a unitless net rate of return.

8 Before adding to the global pool, savings in each region is deflated using the regional capital goods price index and then converted into US$ at the initial exchange rate. The global investment allocation process then is made in real volume terms.

9 This investment relation is similar to Tobin's Q in the sense that the numerator depends on expected future returns and the denominator indicates the current cost of capital replacement.

10 The money and asset markets represented by Yang and Tyers (2000) play no role here, as money is neutral and we report only real quantities or relative prices.

11 The long-run elasticity set used is the same as that employed by Tyers and Yang (2000).

12 When tariff rates are raised to achieve food self-sufficiency, this implies that government revenue increases faster than government spending and there is a small fiscal

contractionary effect which tends to lower interest rates and encourage investment in China.

13 Detailed descriptions of the GTAP database's content and sources as they relate to China are available in Gehlhar (2002), which describes the integration of the data for Hong Kong with that of the mainland and discusses the entrepot nature of some of Hong Kong's trade.

14 See Liu et al. (1998) for the method adopted.

15 For further discussion of the role and representation of skill-capital complementarity, see Tyers and Yang (2000).

16 For a discussion of the CDE system and its more complicated alternatives, see Huff et al. (1997).

17 The method for recalibrating the CDE parameters was provided to us by Dr Yongzheng Yang of the IMF, to whom thanks are due.

18 For analyses of the links between productivity and protection, see Chand et al. (1998), Chand (1999) and Stoeckel et al. (1999).

19 Note that China's comparative advantage in light manufacturing declines through time, as does the level of employment in this sector. This is because the growth rates of China's population and production labour forces are slower than those of its populous Asian neighbours. In the reference simulation its production labour to skill ratio declines substantially by 2010.

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Appendix

Table A8.1 Model structure

Regions
1. China, including Hong Kong and Taiwan
2. Vietnam
3. Other ASEAN
4. Japan
5. Korea
6. Australia
7. United States
8. European Union[a]
9. Rest of World

Primary factors
1. Agricultural land
2. Natural resources
3. Skill
4. Labour
5. Physical capital

Sectors [b]
1. Paddy rice
2. Beverages (product 8 OCR, 'crops nec')
3. Other crops (wheat, other cereal grains, vegetables, fruits, nuts, oil seeds, sugar cane and sugar beet, plant based fibres and forestry)
4. Livestock products (cattle, sheep, goats, horses, wool, silk-worm cocoons, raw milk, other animal products)
5. Fish (marine products)
6. Energy (coal, oil, gas)
7. Minerals
8. Processed food (meat of cattle, sheep, goats and horses, other meat products, vegetable oils and fats, dairy products, processed rice, processed sugar, processed beverages and tobacco products)
9. Light manufacturing (textiles, wearing apparel, leather products and wood products)
10. Other manufacturing (paper products and publishing, petroleum and coal products, chemicals, rubber and plastic products, other mineral products, ferrous metals, other metals, metal products, motor vehicles and parts, other transport equipment, electronic equipment, other machinery and equipment, other manufactures)
11. Transport (sea transport, air transport and other transport)
12. Infrastructure services (electricity, gas manufacturing and distribution, and water)
13. Construction and dwellings
14. Other services (retail and wholesale trade, communications, insurance, other financial services, other business services, recreation, other private services, public administration, defence, health and education)

[a]The European Union of 15.
[b]These are aggregates of the 57 sector GTAP Version 5 database.

Table A8.2 Income elasticities of final demand implied by the model's demand parameters[a]

Merchandise sector	
Rice	0.19
Beverages	0.66
Other crops	0.80
Livestock	1.63
Fish	0.71
Processed food	0.76
Minerals	1.11
Energy	1.24
Light manufacturing	0.85
Heavy manufacturing	1.04
Transport	1.10
Infrastructure services	1.00
Construction	1.05
Other services	1.11

Note: [a] The raw demand parameters are for the CDE (constant difference of elasticities of substitution) system. These income elasticities of demand are implied by those parameters. Note that a major source of demand for all these product categories is as intermediate inputs. These elasticities only characterise the link between the disposable income of households and the final consumption of these product groups.
Source: The original 1997 numbers are aggregated from the 57 commodity categories in the GTAP Version 5 global database, published in 2000. Modifications to the 1997 numbers are detailed in the text.

Table A8.3 Elasticities of substitution in product and service demand[a]

Merchandise sector	Between home goods and generic imports	Between imports according to source
Rice	4.9	9.2
Beverages	4.9	9.2
Other crops	4.9	9.2
Livestock	4.9	9.2
Fish	4.9	9.2
Processed food	4.9	9.2
Minerals	5.6	11.2
Energy	5.6	11.2
Light manufacturing	5.4	11.8
Heavy manufacturing	5.7	11.9
Transport	3.8	7.6
Infrastructure services	3.9	7.6
Construction	3.8	7.6
Other services	4.0	7.7

Note: [a] These long-run elasticities of substitution in product and service demand are larger than the standard GTAP values, reflecting the long-run nature of the simulations.
Source: Values are based on the calibration experiments discussed by Gehlhar, M.J., 1994. Economic growth and trade in the Pacific Rim: an analysis of trade patterns, Unpublished doctoral dissertation, Purdue University and aggregated using the modified GTAP Version 5 database.

Table A8.4 Reference rates of population, labour supply, capital accumulation, productivity and GDP growth, 2001–2010 [a] (per cent/yr)

Region	Population	Production labour	Skilled labour	Physical capital	Total factor productivity [b]	GDP [c]
China	0.84	1.2	2.8	8.8	3.2	8.0
Japan	0.06	-0.19	-0.71	3.0	1.0	2.0
Korea	1.7	2.0	8.9	3.8	0.1	4.0
Vietnam	1.4	2.8	3.1	7.8	2.0	7.0
Other Asia	1.9	2.1	7.2	3.9	3.0	6.5
European Union	0.0	-0.1	0.1	2.7	2.8	4.0
USA	1.1	1.1	1.1	4.1	1.2	3.5
Australia	1.0	1.1	1.0	4.5	1.4	4.0
Rest of world	1.5	1.8	4.8	4.2	.23	3.5

Notes: [a] The rates of growth of population, labour supply and capital accumulation are derived from the sources given below and common to all simulations. In the reference simulation the GDP growth rates are made exogenous targets and the model calculates the sector-generic total factor productivity growth rates consistent with these targets. In the subsequent counterfactual simulations the total factor productivity growth rates are fixed as shown in this table and GDP levels are then endogenous.
[b] Derived in the reference simulation for consistency of factor accumulation and projected GDP growth rates.
[c] These values apply to the reference simulation only. In the subsequent counterfactual simulations GDP is endogenous and departures from these values are reported subsequently.
Source: Factor accumulation rates are drawn from Ianchovichina, E. and Martin, W., 2002. 'Economic impacts of China's accession to the WTO', World Bank, Washington DC, and reference GDP projections from Graham, B. and Tyers, R. 2002. *Global population forecast errors, economic performance and food demand: preliminary simulations*, Working Papers in Economics and Econometrics No. 418. Also presented at the 46th Annual Conference of the Australian Agricultural and Resource Economics Society, Adelaide.

Table A8.5 Trade to value added ratios by industry in 2001[a]

	Exports to value added ratio	Competing imports to value added ratio
Rice	0.01	0.00
Beverages	0.67	0.67
Other crops	0.03	0.11
Livestock	0.04	0.07
Food processing	0.18	0.55
Fish	0.06	0.07
Minerals	0.05	0.21
Energy	0.20	0.58
Light manufacturing	1.58	0.68
Heavy manufacturing	0.94	1.10
Transport	0.24	0.19
Infrastructure services	0.02	0.02
Construction	0.01	0.02
Other services	0.11	0.07

Note: [a] These are quotients of the value of exports or imports at world prices and domestic value added in each industry. They are from the 2001 global database (simulated, based on the trade reforms of 1997–2001 as per Rees, L. and Tyers, R., 2002. *Trade reform in the short run: China's WTO accession*, Working Papers in Economics and Econometrics No. 423, Australian National University. Also presented at the workshop on Agricultural Market Reform in China, Beijing University, 23 September).
Source: The GTAP Version 5 Database, as modified by simulations described in the text.

Table A8.6 Implied Chinese self-sufficiency rates, past and projected, 1997 2001 and 2010 (per cent)[a]

Merchandise sector [b]	1997	2001	2010
Rice	100	100	100
Beverages	98	100	91
Other crops (incl. feed grains)	95	94	89
Livestock	99	99	95
Processed food	92	88	83
Fish	99	99	99
Minerals	95	95	94
Energy	80	80	80
Light manufacturing	123	123	123
Heavy manufacturing	95	95	95

Notes: [a] Self-sufficiency rates are calculated from values of domestic output, Y, imports, M, and exports, X, evaluated at domestic producer prices, from the formula: $SSR=Y/(Y+M-X)$.
[b] The services sectors are represented in the model, as indicated in Table A8.1. Since trade in these is relatively costly, self-sufficiency rates are near unity. They are, in any case, not the focus of this analysis and so they are omitted from this table.
Sources: The original 1997 numbers are aggregated from the 57 commodity categories in the GTAP Version 5 global database, published in 2000. Those for 2001 are based on short run projections from 1997, as conducted by Rees and Tyers (Chapter 9, this volume). For 2010, rates are from the reference simulation discussed in the text.

Table A8.7 Effects of protection to raise agricultural self-sufficiency in 2010

	Reference change, 2001–2010, per cent	Departure from reference 2010, per cent	
		Protection to hold self-sufficiency rates at 2001 levels	Protection to achieve full self-sufficiency
Rise in agricultural nominal protection coefficient			
Rice	-	0.0	0.0
Beverages	-	35.4	50.6
Other crops (incl. feed grains)	-	19.2	72.7
Livestock	-	39.2	78.7
Processed food	-	11.1	67.3
Fish	-	16.1	31.9
Real effective exchange rate	–0.04	2.6	4.3
Terms of trade	–0.38	–0.2	0.3
Return on installed capital	21.2	–0.4	–0.4
Investment	202.6	1.4	1.4
Real gross sectoral output			
Rice	41.4	2.0	8.5
Beverages	61.6	7.1	7.3
Other crops	56.5	3.7	8.9
Livestock	95.2	0.4	0.3
Processed food	52.5	3.8	15.6
Fish	53.0	1.2	2.8
Minerals	108.1	–1.5	–2.2
Energy	78.5	–1.1	–1.7
Light manufacturing	74.7	–22.7	–25.0
Heavy manufacturing	115.5	–3.4	–4.7
Transport	97.7	–1.7	–2.3
Infrastructure services	103.8	–1.6	–1.7
Construction	185.0	1.5	1.4
Other services	92.2	3.9	3.3
GDP	99.9	–1.0	–1.7

Source: Model simulations described in the text.

Table A8.8 Effects of protection to raise agricultural self-sufficiency in 2010 on imports and exports

	Reference change, 2001–2010, per cent	Departure from reference 2010, per cent	
		Protection holds self-sufficiency rates at 2001 levels	Protection to achieves full self-sufficiency
Imports			
Rice	70	0	19
Beverages	101	-75	-87
Other crops (incl. feed grains)	159	-49	-90
Livestock	260	-80	-97
Processed food	99	-28	-87
Fish	65	-43	-67
Minerals	117	-3	-3
Energy	83	-5	-6
Light manufacturing	71	-12	-10
Heavy manufacturing	124	-1	1
Transport	105	3	4
Infrastructure services	80	-1	-1
Construction	208	2	3
Other services	130	-4	-2
Exports			
Rice	-24	-30	-55
Beverages	4	-54	-71
Other crops	-24	-37	4
Livestock	-35	-91	-100
Processed food	25	-32	-59
Fish	36	-41	-58
Minerals	39	-3	-4
Energy	53	3	3
Light manufacturing	53	-51	-53
Heavy manufacturing	79	-14	-17
Transport	66	-14	-17
Infrastructure services	113	-5	-7
Construction	128	-4	-7
Other services	-99	-99	-99

Source: Model simulations described in the text.

Table A8.9 Effects on the employment of production workers of additional protection to raise agricultural self-sufficiency in 2010

	Reference change, 2001–2010, per cent	Departure from reference 2010, per cent	
		Protection to hold self-sufficiency rates at 2001 levels	Protection to achieve full self-sufficiency
Rice	0.4	2.9	11.2
Beverages	6.9	11.0	14.4
Other crops	10.0	4.5	10.7
Livestock	36.8	2.0	3.8
Processed food	3.5	6.8	23.9
Fish	5.7	2.3	4.8
Minerals	32.3	-1.4	-2.3
Energy	6.9	-1.3	-2.2
Light manufacturing	-17.7	-43.0	-45.3
Heavy manufacturing	12.6	-6.1	-8.8
Transport	-14.3	-2.8	-4.7
Infrastructure services	-37.0	-5.4	-6.7
Construction	82.5	4.0	3.5
Other services	-8.9	11.2	9.6

Source: Model simulations described in the text.

Table A8.10 Effects on factor income distribution of protection to raise agricultural self-sufficiency in 2010

	Reference change, 2001–2010, per cent	Departure from reference 2010, per cent	
		Protection to hold self-sufficiency rates at 2001 levels	Protection to achieve full self-sufficiency
Unit factor rewards CPI deflated			
Land	136	7.2	17.1
Unskilled labour (those employed)	39	-1.7	-3.2
Skilled labour	43	-0.8	-2.6
Physical capital	15	-1.8	-3.5
Natural resources	164	-1.8	-2.4

Source: Model simulations described in the text.

Table A8.11 Elasticities of sensitivity to the income elasticity of demand for livestock products

	2010 projection without protection increase	2010 projection with protection to achieve self-sufficiency
Imports		Nominal protection coefficient
Beverages	0.76	0.75
Other crops (including feedgrains)	1.18	0.51
Livestock products	1.83	0.66
Processed food	0.79	0.42
Exports		
Light manufactures	-0.38	
Heavy manufactures	-0.36	
Real gross output		
Rice	-0.03	
Beverages	0.18	
Other crops (including feedgrains)	0.06	
Livestock products	0.37	
Processed food	0.02	
Light manufacturing	-0.65	
Heavy manufacturing	-0.10	
GDP	-0.02	
Imports		
Beverages	-1.56	
Other crops (including feedgrains)	-0.71	
Livestock products	-1.71	
Processed food	-0.72	
Exports		
Light manufactures	-1.41	
Heavy manufactures	-0.72	
Unit factor rewards CPI deflated		
Land	0.43	
Unskilled Labour (those employed)	0.00	
Skilled Labour	-0.01	
Physical capital	-0.02	
Natural Resources	0.04	

Source: To construct these elasticities a small deviation in the income elasticity of demand for livestock products is introduced and the standard simulations repeated. Elasticities are deduced from the comparison of simulation results.