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Achieving food security in China: implications of World Trade Organization accession

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Chunlai Chen and Ron Duncan

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Foreword

China's accession to the World Trade Organization (WTO) in 2001, after 15 years of difficult negotiations, was a momentous event for China and for the world economy. In its accession commitments, China agreed to substantially reduce its barriers to imports and become a much more open economy. Surprisingly, and very pleasingly, China's commitments to reduce import barriers against agricultural imports were very substantial. Given the enormous size of its economy and the rapid rate at which it is growing, the opening of China's agricultural market presents huge opportunities for efficient exporters of agricultural products, such as Australia. At the same time, because reducing trade barriers will help China's agricultural sector to become more efficient, China will also increase its agricultural exports.

However, China's accession to the WTO did not have unanimous approval within the country. There was significant concern within China about the prospect of the country becoming more dependent upon food imports, particularly grain imports. Some of this concern is legitimate, because international food embargoes have been used in the past—although they have never been very effective. Other concerns were about maintaining 'food self-sufficiency', which is more a means of lobbying for support of the agricultural sector—particularly to maintain inefficient industries. There were also concerns about the increase in income inequality between rural and urban households and the fear that this inequality would increase as the economy opened up to agricultural imports.

This report is the culmination of several years of economic research, funded by the Australian Centre for International Agricultural Research (ACIAR), into the effect of China's WTO accession commitments on its agricultural sector. In large part through the use of general equilibrium models—of global trade between countries and of trade between regions within China—the researchers have examined the likely effects of China's accession to the WTO in many areas, including production and trade, by commodity and by region; income inequality between rural and urban households, both within and between regions; labour mobility between the agricultural sector and other sectors and between rural and urban areas; the influence of different macro-economic policies on the effects of accession on the agricultural sector; and the economic costs of trying to maintain grain self-sufficiency at existing levels.

The results of the research show that trying to maintain the existing level of food self-sufficiency would be extremely costly for China. It also shows that attempting to reduce rural–urban income inequality through tariffs, subsidies or other methods of support to agriculture, would also be very costly to the welfare of China's society as a whole. It appears that WTO accession will mean that the agricultural sector will have to make substantial adjustments—in particular, moving out of land-intensive activities, such as grain production, and into labour-intensive activities, such as horticultural products and agricultural product processing, where its comparative advantage lies. The significant shifts in China's agricultural trade since 2001 indicate that structural adjustments are already taking place.

The structural adjustments in agriculture will inevitably benefit some households and hurt others. However, as history shows, it is never a viable option to try to resist such changes. China's policymakers are best advised to devise policies to make the transition easier. This will often mean taking actions that do not directly concern agriculture but that have important effects indirectly. As the research reported here has shown, actions to assist the necessary structural adjustments and reduce the rural–urban income gap include promoting the development of more medium to large sized cities and further freeing up the movement of labour from agriculture into other sectors.

This research project has been a very productive partnership between researchers in Australia and researchers in China. ACIAR will continue to work collaboratively with Australian and Chinese research agencies, to develop well-analysed agricultural policy options for consideration by decision-makers in the future.

Peter Core
Chief Executive Officer
ACIAR

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Acknowledgments

In 1998 the Australian Centre for International Agricultural Research (ACIAR) funded a multi-year research project (ADP/1998/128) to examine the effects of China's WTO accession on its agricultural sector. The project was jointly undertaken by researchers in the Crawford School of Economics and Government at The Australian National University (ANU), Canberra, and the China Center for Economic Research (CCER), Peking University, Beijing. During an extension of the project, researchers in the Center for Chinese Agricultural Policy (CCAP) of the Chinese Academy of Sciences (CAS) joined the research team.

The original project researchers from the then National Centre for Development Studies (NCDS) of the Asia Pacific School of Economics and Management (APSEM) at ANU (now the Crawford School of Economics and Government) were Ron Duncan, Yiping Huang and Yongzheng Yang. The staffing of the project was reorganised with the departure of Yiping Huang and Yongzheng Yang. Rod Tyers, Chunlai Chen, Xiaolu Wang and Tingsong Jiang, all of ANU, joined Ron Duncan to complete the project. During the application and early implementation of the project extension, Christopher Findlay from ANU, now with the University of Adelaide, also joined the research team.

The main collaborators in China were Justin Yifu Lin, Wen Hai, and Feng Lu of the CCER at Peking University. Other researchers in China included Shi Li and his colleagues at the Institute of Economic Research at the Chinese Academy of Social Sciences (CASS), and Weiming Tian and his team at the China Agricultural University, Beijing. During the project extension period, Jikun Huang and Jun Yang from CCAP joined the team.

We gratefully acknowledge the support of ACIAR's Ray Trewin and Trish Andrew in the management of the project. For constructive suggestions on method, output, marketing, and project extension we also thank Associate Professor Robert Scollay from the APEC Study Centre of the University of Auckland, New Zealand, and Professor Fang Cai from the Institute of Population and Labour Economics of the Chinese Academy of Social Sciences, China, who reviewed the project for ACIAR.

Acronyms

ACIAR	Australian Centre for International Agricultural Research
ANU	The Australian National University
APEC	Asia Pacific Economic Cooperation
APSEM	Asia Pacific School of Economics and Management
CAS	Chinese Academy of Sciences
CASS	Chinese Academy of Social Sciences
CCAP	Center for Chinese Agricultural Policy
CCER	China Center for Economic Research
CDE	Constant Difference of Elasticities of Substitution
CERD	[A CGE Model of the] Chinese Economy with Regional Dimensions
CES	Constant Elasticity of Substitution
CET	Constant Elasticity of Transformation
CGE	Computable General Equilibrium
CIF	Cost, Insurance and Freight
CPI	Consumer Price Index
EV	Equivalent Variation
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GEMPACK	General Equilibrium Modelling Package
GTAP	Global Trade Analysis Project
HOS	Heckscher-Ohlin-Samuelson
OECD	Organisation for Economic Cooperation and Development
PCI	Production Concentration Index
R&D	Research and Development
RMB	Chinese Currency – yuan (renminbi)
SOEs	State-Owned Enterprises
TFP	Total Factor Productivity
TVEs	Township and Village Enterprises
yuan	Unit of Chinese Currency
WTO	World Trade Organization

Overview

This report summarises the results of a study of the implications of World Trade Organization (WTO) accession for China's agricultural sector. The project began three years prior to China's accession to the WTO, but it was anticipated that the accession application would be successful. It was important, therefore, to understand fully the effects that the accession commitments could have within China. There was a concern to see that Chinese policy makers appreciated the benefits that would flow from trade liberalisation. At the same time, it was understood that the trade reforms would lead to structural adjustments involving the reduction of some activities, with an ensuing loss of employment and asset values. It was desirable for policy makers to have an understanding of these consequences, as this would reduce the chances of the adoption of poor policies in response to any perceived or actual adverse impacts. Another objective of the project was to analyse various policy options, to offer input into China's policy-making process.

This technical report is the output of the joint research project. Section 1 presents the main results from simulations of the Computable General Equilibrium (CGE) Model of the Chinese Economy with Regional Dimensions (CERD), a regional model of the Chinese economy that was developed as part of the project. Section 2 summarises the main research findings of the project. Section 3 contains policy implications drawn from the research project. Finally, Section 4 outlines the structure of the CERD Model.

China made substantial commitments to freer trade in agriculture in its accession agreement. Underlying these commitments, therefore, is a substantial shift away from its previous basic agricultural policy position, which had an emphasis on food 'self-sufficiency'. As might be expected, there remains strong support in favour of the idea of food self-sufficiency. Therefore, one of the aims of the research project was to demonstrate the high costs of food self-sufficiency policies, to reduce the chances of any move back towards such policies.

The analysis carried out in this project has confirmed that structural change, driven by productivity growth—which the trade reforms will promote—will lead to agriculture becoming a smaller and smaller part of the economy. As incomes increase, consumption patterns will change, the share of agriculture will shrink, and China will become less self-sufficient in many commodities. However, because it has such a large population, China will always have to produce most of the foods that it consumes.

Major findings of the project are that there should be a welfare gain from the WTO trade liberalisation for the Chinese economy as a whole. However, there will be some sectors in agriculture, and in other parts of the economy, that will be losers, e.g. land-intensive agricultural industries, such as grains, and the motor vehicle and transport sector. Labour-intensive agricultural activities, such as horticultural production, and agricultural processing and industrial activities, such as apparel, textiles and electronics, will gain most.

From a regional perspective, the eastern, coastal region will see greater benefits from the reforms than the inland regions. This regional disparity will lead to an increase in income inequality between the coastal and inland regions and also between rural and urban households within and between the regions. The coastal region will see greater enhancement of rural household incomes because of the increased opportunities for off-farm work for rural household members.

As the modelling in this project has shown, trying to hold this development at bay by raising import barriers on agricultural products would have exorbitant costs. No doubt, however, there will continue to be resistance to the reforms in agriculture. The large proportion of the population that is still supported by agriculture can be a significant political weapon. Unfortunately, resistance to reforms can prevent the sector from realising its potential, thus providing further ammunition for arguments to continue government support. It is important, therefore, that the economic arguments against 'food self-sufficiency' policies be made repeatedly.

The focus of food policy should be food security, not food self-sufficiency. Food security policy considers whether people have sufficient income to provide a reasonable diet, not whether food is produced domestically or imported. Poverty in China is primarily to be found in rural households. However, as this project has shown, non-farm income becomes a more and more important component of rural household incomes as development proceeds. Rural household incomes will not be increased by keeping out food imports so that domestic production increases. Agricultural protection raises the cost of food for everyone, reduces the extent of non-farm development in the economy, and reduces the opportunities for rural households to earn off-farm income. The best policy for China is to continue to reduce protection in agriculture, while simultaneously reducing the barriers to movement of people out of farming into the industrial and service sectors. The research project was designed to pay particular attention to the differences among regions and households. China is a very large country with significantly different sub-economies, each having different patterns of factor endowments and therefore different comparative advantages. There are also large differences between the regions' stages of development. Agricultural policy reform (and other policy changes) will therefore impact differently on the different sub-economies and regions. Likewise, the urban and regional households with different factor endowments and different income levels will be affected differently by the policy reforms.

The overall research project had a strong general equilibrium focus, which has been followed through the use of global and China-specific CGE models and analysis of the effects of all of China's WTO accession commitments, not only its agricultural commitments. The focus on general equilibrium research has two related justifications. First, when analysing the effects of agricultural policies, we should look beyond the agricultural sector because agricultural policies will have economy-wide effects. Analogously, trade policy initiatives in other sectors will have effects on the agricultural sector. Further, the effect of macro-economic policies on particular sectors can be as important, if not more important, than sector-specific policies. Second, it is clear from recent experience in developing countries that, ultimately, incomes of rural households are increased more by increases in off-farm income earned by household members than by increases in on-farm income. Therefore, in examining the welfare implications of trade liberalisation for farm households, it is important to examine all the ways in which farm household incomes may be affected through the structural adjustments produced by trade reforms.

The project has four dimensions. First, there is the commodity dimension—the analysis of which agricultural industries gain, and which lose, from trade liberalisation. Second, there is the household dimension. The concern for food security must relate to household incomes, not individual incomes. Moreover, as rural poverty will be largely overcome through the earning of off-farm income by households, there has to be an economy-wide approach to this issue. The growing gap between urban and rural incomes is a matter of great concern in China. Therefore, the analysis allowed for differentiation of representative rural and urban households, to study the effects of policies on both. Third, as noted above, the regional dimension is important in the examination of commodity effects and income effects. Finally, the problems within the agricultural sector will not necessarily be resolved through agricultural policies. Problems such as rural poverty and the increasing urban–rural income gap may be best overcome through macro-economic policies or through policies affecting other sectors, such as industrial, education or internal migration policies.

The most important message from the study is that macro-economic and other policies not directly aimed at the agricultural sector, can do much to improve the outcome for rural households and improve food security. These policies include the promotion of urban development in inland areas and gradual reform of monetary policy. However, agricultural policies also need further reform, including: abandoning of price support and regional self-sufficiency policies; reform of monopolistic agricultural marketing and distribution activities; and reform of the state grain storage system. Hopefully, WTO membership will assist in the implementation of these reforms.

Main results of the CERD modelling

Modelling of WTO accession and regional development

Regional income disparity in China has been worsening since 1991. Among the three regions,[1] the richest, the eastern coastal region, experienced the fastest economic growth over the past two decades. Jiang (2003a) used the computable general equilibrium model of the Chinese economy with regional dimensions (CERD), developed in this project, to simulate the effect of WTO accession on regional development. In particular, he examined the impact of different scenarios on regional income disparities.

Tariff cuts

It is difficult to accommodate all of China's WTO commitments in one simulation. Rather, this study investigated the effect of the most obvious and simplest commitment: the required tariff cut. China's import tariffs are often subject to exemption and reduction under special arrangements that make the effective tariff rates significantly different from the statutory rates. For example, the average statutory tariff rate was 16.4% in 2000, while tariff revenue accounted for only 4.03% of the value of imports (State Statistical Bureau 2001).

The model database represents the Chinese economy in 2000, with the average tariff rate being 16.2%, which is close to the statutory tariff rate.[2] The tariff rates used in this study are mainly drawn from the Global Trade Analysis Project Database 5, with some revisions based on other studies.[3] The WTO tariff rates are only approximately consistent with the actual commitments (Annex 8: Schedule CLII of Protocol on the Accession of the People's Republic of China).

Two closures were used in the simulation:

- No control on the trade balance. In this closure, the nominal exchange rate is fixed, the trade balance is endogenous, and foreign capital flows automatically match the balance.
- No change in the trade balance. In this closure, a floating exchange rate regime is assumed so that the change in the trade balance can be exogenously fixed at zero.[4]

The first closure involved only tariff cuts in the simulation. However, it required some other policy changes to validate the closure. For example, it required capital inflows to match the trade deficit at whatever level the model generates, implying that there is no control on foreign investment. This is clearly not the case. But as it is expected that foreign investment will increase after WTO accession (Chen 2002), and zero change seems too extreme, one would expect that the real situation lies somewhere between the two closures, although, perhaps, closer to the first one.

Simulation results of the tariff cuts are reported in Tables 1 and 2. Table 1 reports the macro-economic effects of tariff cuts under different closures, and Table 2 reports the effect of tariff cuts on regional output, imports and exports of aggregated commodities or sectors.

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[1] It is commonly accepted that mainland China can be divided into three regions according to natural and economic conditions. The eastern coastal region includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi and Hainan; the central region includes Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan; and the western region includes the remaining six provinces, three autonomous regions and one municipality. The eastern region is the most populous and richest region, while the western region is the poorest.

[2] Although this is higher than the effective rate, it may represent the actual protection level if considering non-tariff barriers. Moreover, the effective rate tends to underestimate the actual protection level as it is weighted by import volumes.

[3] For example, Wang (2000), Ianchovichina and Martin (2001), and Anderson, Huang and Ianchovichina (2002).

[4] It could be set at any level, but zero change is an obvious target.

No Control on the Trade Balance

It can be seen from Table 1 that China has a net gain from WTO accession. Cutting tariff rates, as committed to in its WTO accession, enables China's real Gross Domestic Product (GDP) to increase by 0.56%, utility increases by 0.86%, and the equivalent variation, a welfare indicator, reaches 63.69 billion yuan. The higher welfare comes from higher real incomes, and thus higher real consumption and saving. But the tariff cuts have an adverse effect on the trade balance and the terms of trade. China's trade balance declines by 42.55 billion yuan, because imports increase more than exports, and the terms of trade decline by 0.46%. This is because the tariff cuts do not affect the border price. However, Chinese exports become cheaper because tariff cuts help to lower production costs.

It can be seen from Table 2 that the effect will not be evenly distributed. The motor vehicle and other transport equipment sector is the biggest loser, with output declining by 16.37%. The food and tobacco processing, machinery and chemicals sectors are the next largest losers, with output declining more than 3%. The effect on the agricultural sectors is not as severe as some studies have suggested. Crops output declines by 1.2% and total agricultural output is reduced by less than 0.1%. This is in line with the results of Ianchovichina and Martin (2001). The smaller decline in agricultural output may be partly due to the smaller extent of the tariff cuts. It may also be partly attributed to the aggregation of agricultural sectors. If the crop sector could be disaggregated to individual crops, it may be that the output of some crops would be seen to decline significantly.

The changes in imports and exports are consistent with the changes in output. Imports of other agricultural products, processed food and tobacco, motor vehicles and other transportation equipment, are

Table 1. Macro-economic effects of tariff cuts

Indications	No control on trade balance				No change in trade balance			
	Eastern	Central	Western	National	Eastern	Central	Western	National
Real GDP(%)	0.87	–0.06	0.33	0.56	0.85	–0.07	0.33	0.54
GDP deflator(%)	–1.90	–2.03	–2.79	–2.07	3.35	3.04	2.28	3.11
CPI (%)								
Rural households	–2.66	–2.50	–3.11	–2.7	2.42	2.51	1.90	2.35
Urban households	–2.56	–2.27	–2.77	–2.53	2.55	2.82	2.33	2.57
Government	–0.67	–1.30	–1.33	–0.95	4.72	3.98	3.97	4.40
Regional average	–2.61	–2.40	–2.95	–2.62	2.48	2.64	2.1	2.45
Total utility (%)								
Rural households	0.67	0.22	0.17	0.46	0.35	0.01	0.02	0.20
Urban households	1.85	1.16	1.36	1.62	1.30	0.69	1.05	1.13
Government	0.49	–1.94	–2.47	–0.37	1.41	–2.01	–2.54	0.23
Regional average	1.19	0.30	0.48	0.86	0.98	0.02	0.25	0.63
Equivalent variation (EV) (billion yuan)								
Rural households	11.86	2.32	0.83	15.01	6.23	0.13	0.1	6.46
Urban households	38.68	7.89	9.79	56.35	27.08	4.66	7.53	39.26
Government	5.57	–6.84	–6.40	–7.67	15.97	–7.07	–6.58	2.32
Regional sum	56.11	3.36	4.22	63.69	49.28	–2.28	1.04	48.04
Savings (nominal, %)								
Rural households	–1.47	–2.03	–2.64	–1.76	3.58	2.97	2.28	3.26
Urban households	–0.14	–1.07	–1.04	–0.48	5.29	4.25	4.29	4.91
Government	–3.45	–3.26	–3.78	–3.44	1.63	1.85	1.32	1.64
Regional average	–1.02	–1.66	–1.41	–1.22	4.24	3.47	3.84	4.01
Nominal exchange rate				0.00				5.45
Change in trade balance (billion yuan)				–42.55				0.00
Terms of trade (%)				–0.46				–0.47

Source: Jiang (2003a).

more than doubled after WTO accession and imports of crops increase by around 88%.[5] Increases in exports of apparel, textiles, and electronics are of smaller magnitude. In general, these changes reflect the comparative advantages and disadvantages of Chinese industries.

The simulation results show that the eastern coastal region gains more from WTO accession than the inland regions. The order of increase in total utility and equivalent variation is eastern, central and western. This suggests that regional income disparity will worsen after the accession, although all regions may gain. The eastern region gains most of the benefit from the expanding sectors. For example, apparel output in the eastern region increases by over 17%, while this sector's outputs in the central and western regions increase by only 0.3% and 1.5%, respectively. Similarly, textile output in the eastern region increases the most, while it decreases in the central region.

[5] Note, however, that China's crop imports account for only about 1.3% of total imports in the baseline; after the 88% increase, crop imports are still small in absolute terms.

Table 2. Effect of tariff cuts on regional output, exports and imports (%)

Sector	No control on trade balance				No change in trade balance			
	Eastern	Central	Western	National	Eastern	Central	Western	National
Output								
agri	0.00	–0.13	–0.08	–0.06	–0.06	–0.17	–0.12	–0.10
mine	–1.73	1.24	2.60	–0.03	–1.88	1.40	2.76	–0.02
fprc	–4.20	–1.71	–5.35	–3.59	–4.33	–1.80	–5.53	–3.71
lind	7.68	0.04	2.79	5.86	7.77	0.20	3.37	6.00
chem	–2.02	–0.96	–0.75	–1.63	–2.04	–0.90	–0.69	–1.63
motr	–17.88	–14.87	–11.54	–16.37	–18.05	–14.58	–11.10	–16.36
mche	–3.86	–0.95	0.29	–2.76	–3.92	–0.75	0.49	–2.73
elen	5.72	–0.85	3.10	4.98	5.75	–0.76	3.38	5.03
cnst	0.46	1.09	1.18	0.72	0.43	1.11	1.20	0.72
svce	0.82	–0.13	0.15	0.52	0.87	–0.22	0.07	0.52
Exports								
agri	17.19	15.07	17.41	16.56	20.21	17.83	19.90	9.44
mine	1.73	8.15	9.24	4.74	1.83	8.78	9.76	5.05
fprc	9.58	9.67	6.92	9.19	10.95	11.09	7.85	10.50
lind	21.70	8.87	19.21	20.03	22.37	9.93	21.78	20.82
chem	4.89	5.97	6.65	5.15	5.16	6.49	7.20	5.48
motr	–10.31	–5.47	0.80	–7.86	–10.37	–4.81	1.59	–7.70
mche	1.20	5.82	7.47	2.60	1.32	6.45	8.01	2.84
elen	14.94	5.68	12.77	14.39	15.23	6.16	13.50	14.72
cnst	2.53	5.26	5.37	3.04	2.58	5.54	5.59	3.11
svce	2.83	4.06	4.90	3.32	2.86	4.29	5.11	3.41
Imports								
agri	47.47	39.20	63.54	47.97	44.21	36.35	60.84	44.82
mine	–4.45	–4.95	–4.38	–4.53	–4.72	–5.14	–4.53	–4.77
fprc	155.48	173.44	158.17	158.30	151.10	169.02	154.93	154.15
lind	22.54	11.02	5.03	19.02	21.96	9.85	4.02	18.31
chem	22.45	19.27	20.82	21.75	22.17	18.85	20.41	21.44
motr	110.89	107.67	87.98	106.08	110.06	106.43	87.27	105.17
mche	12.55	13.41	12.59	12.69	12.30	13.05	12.33	12.42
elen	6.63	3.88	4.39	5.93	6.31	3.40	4.03	5.58
cnst	–2.19	–4.06	–4.03	–3.17	–2.31	–4.34	–4.25	–3.36
svce	–2.18	–4.93	–5.14	–3.44	–2.31	–5.37	–5.52	–3.70

Note: Sector code: agri: agriculture; mine: mining; fprc: food processing; lind: light industry; chem: chemicals; motr: motor vehicle and other transportation equipment; mche: machinery and equipment; elen: electronics and electric equipment; cnst: construction; svce: services.
Source: Jiang (2003a).

The results show that the output level in the central region may decline after WTO accession. This result seems surprising because it is generally perceived that the western region is the least developed region and should be affected the most. However, the result may be explained in the following way. First, the western region has the cheapest labour, which helps in the development of labour-intensive sectors. Second, the western region has relatively abundant resource endowments, which lead to its comparative advantage in resource-intensive products. Finally, the industrial base in the western region may not be as poor as people think. The Chinese government has made huge investments in the so-called 'third line' program, which brought about development in some sectors.

Although the western region experiences a higher increase in output than the central region, its welfare gains are smaller. This is because government revenues in the western region decline after WTO accession. Therefore, private households in the region receive lower transfers from the government, although their real revenues from returns on factors increase.

WTO accession also worsens rural–urban income inequality—a feature common to all regions. Rural households experience a smaller increase in utility and welfare. This is understandable because rural households receive part of their income from agricultural sectors, which decline in all regions after WTO accession.

No change in the trade balance

This closure has a similar effect on regional economies, despite some differences in the macro-economic dimensions. The fixed exchange rate in the previous closure brings about domestic deflation. In this example, the fixed trade balance with a floating exchange rate leads to depreciation of the currency by 5.5%, which in turn causes domestic inflation of 2.45%. In both cases, the real exchange rate increases, but in the current closure the increase is slightly greater—3.0% versus 2.6%.

This closure has a smaller welfare gain than the previous one because it restrains the gains from trade by fixing the trade balance. Moreover, it causes an even wider welfare gap. In the previous closure, the eastern region's share in the total equivalent variation was 88%. In the current closure, all the gains are absorbed by the eastern region, while the inland regions have a net loss. The income gap between rural and urban households also widens. Urban households' share in the total household welfare gain increases from 79% to 86%.

Policy simulations

Some argue that simulating tariff cuts alone tends to underestimate the effect of trade liberalisation (Kehoe 2002). Therefore, other policy options were also simulated: additional protection to the agricultural sectors (reducing tariff cuts), domestic market liberalisation, and government transfer payments to inland regions.

Additional protection to agricultural sectors

Many studies of China's WTO accession have projected that agriculture would be one of the hardest hit sectors. The simulation results above confirm that agriculture will be adversely affected, which leads directly to worsening regional disparities as the inland regions have a higher proportion of agricultural activities in their economic structure. The Chinese government and the academic community have been worrying about this issue and the government has adopted measures to anticipate detrimental outcomes.[6,7] These measures provide additional protection to agriculture, being equivalent to smaller tariff cuts applied to the agricultural sectors.

To capture this additional protection to agriculture, the simulations presented above were revised, with the tariff cuts in agricultural sectors being only half of the level in the above simulations, other things being equal. The results of the simulation with smaller tariff cuts are reported in Table 3 and Table 4. Several points are evident from these results.

First, such policy actions would provide some cushioning of the agricultural sector. The increase in agricultural imports is smaller, falling from 47.3% to 15.2% with the closure of no control on the trade balance, and from 44.2% to 13.1% with the closure of no change in the trade balance. Consequently, agricultural output declines by only 0.03% and

6 The problem of so-called *San Nong* (agriculture, farmers and rural development) has been a popular topic.

7 For example, the newly implemented reporting requirement for genetically modified food is interpreted as an important tool to protect China's traditional soybean growing areas in the northeast region against competition from the United States. However, these practices have been learnt from other countries. China often complains that its exports face even stricter technical barriers.

0.07%, respectively. Second, because the central region is the major agricultural production area, this protection helps it achieve higher welfare (up from 3.36 billion yuan to 4.12 billion yuan) with the closure of no control on the trade balance, and a lower welfare loss (from –2.28 billion yuan to –0.50 billion yuan) with the closure of no change in the trade balance. Third, it also helps to ease the worsening rural–urban inequality. Rural households have a higher growth in utility than in the previous scenario, while urban households have a lower growth. Fourth, the negative impact on the trade balance and the terms of trade is now smaller. Finally, however, the total welfare gain is smaller than for the full tariff cuts set by the WTO agreement.

Domestic market reform

It is often argued that China's domestic economy is not well integrated and heavy regional protection exists. One well-known example is the restriction on the movement of people. Also, the use of land in many regions is controlled by governments. It is also frequently reported that local governments erect various barriers to bar products from other regions. However, there are no complete and accurate data to enable the calculation of tariff-like protection in Chinese regions. For this reason, a hypothetical scenario is constructed to investigate this issue. Specifically, a set of elasticities was chosen to imitate domestic market reforms.

Elasticities of transformation or substitution usually describe the difference between two goods or factors. However, they may also reflect how easily one good or factor can be transformed into, or substituted for, another. For example, a higher elasticity of transformation between rural and urban labour also describes the higher mobility of labour from rural to urban areas. In this sense, therefore, the

Table 3. Macro-economic effects of WTO tariff cuts with agricultural protection

Indicators	No control on trade balance				No change in trade balance			
	Eastern	Central	Western	National	Eastern	Central	Western	National
Real GDP (%)	0.77	–0.10	0.28	0.48	0.75	–0.10	0.27	0.46
GDP deflator (%)	–1.74	–1.82	–2.53	–1.89	2.50	2.27	1.56	2.29
CPI (%)								
Rural households	–2.24	–2.12	–2.62	–2.28	1.86	1.92	1.42	1.79
Urban households	–2.23	–2.05	–2.51	–2.24	1.89	2.05	1.60	1.88
Government	–0.77	–1.39	–1.44	–1.04	3.57	2.86	2.83	3.27
Regional average	–2.24	–2.09	–2.57	–2.26	1.87	1.98	1.50	1.83
Total utility (%)								
Rural households	0.91	0.44	0.49	0.70	0.64	0.27	0.36	0.48
Urban households	1.58	0.91	1.09	1.35	1.14	0.53	0.84	0.96
Government	0.24	–1.92	–2.42	–0.53	0.99	–1.97	–2.48	–0.04
Regional average	1.10	0.33	0.44	0.81	0.93	0.10	0.25	0.62
Equivalent variation (billion yuan)								
Rural households	16.02	4.68	2.34	23.04	11.34	2.85	1.71	15.89
Urban households	33.05	6.20	7.84	47.08	23.72	3.60	6.03	33.36
Government	2.67	–6.76	–6.28	–10.36	11.19	–6.95	–6.44	–2.19
Regional sum	51.75	4.12	3.89	59.76	46.25	–0.50	1.31	47.06
Savings (nominal, %)								
Rural households	–1.03	–1.59	–1.98	–1.30	3.05	2.44	2.00	2.75
Urban households	–0.30	–1.19	–1.19	–0.64	4.07	3.08	3.10	3.70
Government	–3.59	–3.32	–3.84	–3.58	0.50	0.80	0.27	0.51
Regional average	–0.97	–1.46	–1.38	–1.14	3.26	2.67	2.84	3.07
Nominal exchange rate				0.00				4.39
Change in trade balance (billion yuan)				–34.42				0.00
Terms of trade (%)				–0.42				–0.43

Source: Jiang (2003a).

domestic market reform can be represented by increases in selected elasticities.

With the new values for elasticities, the inter-regional factor and commodity flows become more intensive. For example, in the closure of no control on the trade balance, the price of migrant labour declines by 0.18% when the elasticities are higher, while it increases by 0.18% with the old elasticities. Consequently, migrant labour supply increases by 1.47% (previously the increase was only 0.25%). The migrant labour supply increases in all regions, with the western region increasing the most (1.98% versus 0.31%), followed by the central region (1.68% versus 0.26%) and the eastern region (0.83% versus 0.20%). Similar changes can be observed in the inter-regional trade in commodities. These results are understandable and do not need more explanation. It is more important to look at the welfare implications. The summary results are reported in Table 5.

It can be seen from the table that with the new values for parameters, WTO accession leads to higher welfare gains. Total welfare gain increases from 63.69 billion yuan with the closure of no

Table 4. Effect on output, exports and imports of WTO tariff cuts with agricultural protection

Sector	No control on trade balance				No change in trade balance			
	Eastern	Central	Western	National	Eastern	Central	Western	National
Output								
agri	0.00	–0.06	–0.05	–0.03	–0.05	–0.09	–0.07	–0.07
mine	–1.49	1.24	2.78	0.12	–1.62	1.37	2.91	0.12
fprc	–5.33	–1.80	–5.41	–4.24	–5.42	–1.87	–5.55	–4.33
lind	7.35	–0.22	1.34	5.47	7.43	–0.08	1.81	5.59
chem	–1.92	–0.95	–0.75	–1.57	–1.94	–0.91	–0.69	–1.56
motr	–17.62	–14.71	–11.12	–16.10	–17.76	–14.48	–10.76	–16.09
mche	–3.61	–0.90	0.49	–2.56	–3.66	–0.73	0.65	–2.54
elen	6.43	–0.79	3.49	5.61	6.44	–0.71	3.73	5.65
cnst	0.44	1.04	1.16	0.69	0.42	1.06	1.17	0.69
svce	0.75	–0.13	0.14	0.48	0.80	–0.21	0.08	0.48
Exports								
agri	11.45	10.88	12.57	11.39	13.88	13.11	14.6	13.72
mine	2.63	8.55	10.06	5.48	2.69	9.05	10.48	5.73
fprc	5.25	7.75	5.08	5.86	6.38	8.92	5.86	6.95
lind	20.99	8.12	14.57	19.14	21.53	8.98	16.6	19.79
chem	5.25	6.29	6.89	5.50	5.47	6.71	7.33	5.76
motr	–9.64	–4.95	1.71	–7.17	–9.70	–4.42	2.36	–7.04
mche	1.92	6.32	8.21	3.29	2.01	6.83	8.65	3.48
elen	16.33	6.14	13.8	15.72	16.55	6.53	14.39	15.97
cnst	2.85	5.50	5.67	3.35	2.88	5.73	5.85	3.41
svce	3.05	4.29	5.17	3.54	3.08	4.47	5.33	3.62
Imports								
agri	15.25	11.36	20.17	15.21	13.08	9.42	18.43	13.11
mine	–4.86	–5.37	–4.76	–4.93	–5.07	–5.52	–4.88	–5.12
fprc	161.79	177.93	162.41	163.94	158.03	174.18	159.65	160.40
lind	22.54	11.45	5.62	19.15	22.06	10.49	4.78	18.56
chem	22.27	19.05	20.63	21.57	22.05	18.71	20.30	21.32
motr	109.31	106.26	86.76	104.61	108.68	105.28	86.20	103.90
mche	12.11	12.86	12.06	12.22	11.92	12.58	11.86	12.01
elen	6.33	3.31	3.88	5.57	6.07	2.93	3.60	5.28
cnst	–2.64	–4.44	–4.45	–3.60	–2.72	–4.66	–4.62	–3.73
svce	–2.54	–5.21	–5.45	–3.77	–2.64	–5.56	–5.76	–3.98

Note: Sector code: agri: agriculture; mine: mining; fprc: food processing; lind: light industry; chem: chemicals; motr: motor vehicle and other transportation equipment; mche: machinery and equipment; elen: electronics and electric equipment; cnst: construction; svce: services.
Source: Jiang (2003a).

control on the trade balance, and 48.04 billion yuan with the closure of no change in the trade balance, to 69.04 and 56.79 billion yuan, respectively. Although the worsening of the regional income disparity is still observed, its magnitude becomes smaller when factors and commodities are allowed to move more freely. Every region has a higher welfare gain than before, and the shares of inland regions in the total gain increase from 12% to 14%. The increase in rural households' utility and welfare after WTO accession is higher with the new parameters than with the old ones, while the increase in urban households' utility and welfare is now smaller, implying reduced rural–urban inequality.

Transfer payments

A policy of increasing transfer payments to inland regions was also simulated. The rationale behind this policy option is that because the economy as a whole benefits from WTO accession, there is the possibility of transferring income from one group to another to make all better off. The simulation simply involves a 10% increase in the central government's transfer payments to the central and western regions. The results are reported in Table 6.

The simulation gives a similar result to the scenario of halving the cut in agricultural tariffs. The improvement in regional and rural–urban household income disparity is achieved at the cost of lower overall welfare gains—a 1% smaller welfare gain than the full tariff cut scenario (very small). This could happen because increasing transfers to the inland regions are made possible through penalising the coastal regions that have a higher rate of return. The results of this policy simulation imply that any transfer payment scheme should be carefully designed to avoid further distortions in resource allocation.

Table 5. Macro-economic effects of WTO tariff cuts: higher elasticities

Indicators	No control on trade balance				No change in trade balance			
	Eastern	Central	Western	National	Eastern	Central	Western	National
Real GDP (%)	0.93	–0.12	0.29	0.57	0.91	–0.12	0.28	0.56
GDP deflator (%)	–1.88	–1.76	–2.47	–1.94	2.52	2.53	1.82	2.41
CPI (%)								
Rural households	–2.37	–2.14	–2.70	–2.36	1.93	2.13	1.56	1.92
Urban households	–2.34	–2.05	–2.53	–2.31	1.97	2.25	1.77	2.00
Government	–0.84	–1.39	–1.39	–1.07	3.63	3.01	3.03	3.37
Regional average	–2.35	–2.10	–2.62	–2.34	1.95	2.18	1.66	1.96
Total utility (%)								
Rural households	1.02	0.46	0.51	0.77	0.81	0.33	0.43	1.92
Urban households	1.65	0.93	1.16	1.41	1.15	0.50	0.87	2.00
Government	0.62	–1.80	–2.33	–0.24	1.41	–1.83	–2.37	3.37
Regional average	1.24	0.36	0.50	0.91	1.07	0.13	0.31	0.72
Equivalent variation (billion yuan)								
Rural households	17.97	4.93	2.41	25.32	14.22	3.54	2.05	19.81
Urban households	34.42	6.34	8.35	49.11	23.94	3.37	6.23	33.54
Government	7.03	–6.36	–6.05	–5.39	16.02	–6.44	–6.15	3.43
Regional sum	59.42	4.92	4.71	69.04	54.18	0.47	2.13	56.79
Savings (nominal, %)								
Rural households	–1.00	–1.58	–2.02	–1.29	3.32	2.69	2.22	3.01
Urban households	–0.30	–1.17	–1.12	–0.62	4.20	3.25	3.32	3.85
Government	–3.36	–3.20	–3.70	–3.36	0.89	1.09	0.57	0.90
Regional average	–0.94	–1.45	–1.33	–1.11	3.47	2.89	3.06	3.28
Nominal exchange rate				0.00				4.56
Change in trade balance (billion yuan)				–36.74				0.00
Terms of trade (%)				–0.47				–0.48

Source: Jiang (2003a).

Table 6. Macro-economic effects of WTO tariff cuts: with transfer payments

Indicators	No control on trade balance				No change in trade balance			
	Eastern	Central	Western	National	Eastern	Central	Western	National
Real GDP (%)	0.88	–0.07	0.28	0.55	0.85	–0.07	0.27	0.54
GDP deflator (%)	–1.93	–1.98	–2.72	–2.07	3.22	2.99	2.26	3.01
CPI (%)								
Rural households	–2.67	–2.48	–3.10	–2.69	2.32	2.43	1.82	2.26
Urban households	–2.57	–2.25	–2.75	–2.53	2.44	2.75	2.25	2.48
Government	–0.70	–1.27	–1.28	–0.95	4.59	3.92	3.93	4.31
Regional average	–2.62	–2.39	–2.94	–2.61	2.38	2.56	2.02	2.36
Total utility (%)								
Rural households	0.69	0.22	0.17	0.47	0.38	0.02	0.02	0.21
Urban households	1.84	1.23	1.42	1.64	1.30	0.76	1.11	1.16
Government	0.04	–1.38	–1.89	–0.49	0.95	–1.45	–1.97	0.10
Regional average	1.11	0.40	0.58	0.85	0.91	0.11	0.36	0.62
Equivalent variation (billion yuan)								
Rural households	12.15	2.35	0.82	15.33	6.62	0.21	0.10	6.93
Urban households	38.50	8.33	10.24	57.07	27.11	5.16	8.01	40.28
Government	0.47	–4.86	–4.91	–9.31	10.73	–5.10	–5.10	0.52
Regional sum	51.12	5.82	6.15	63.09	44.45	0.26	3.01	47.72
Savings (nominal, %)								
Rural households	–1.47	–2.01	–2.62	–1.03	3.49	2.89	2.21	4.13
Urban households	–0.16	–0.97	–0.95	–1.60	5.17	4.24	4.29	3.43
Government	–3.43	–2.68	–3.16	–1.33	1.56	2.37	1.87	3.82
Regional average	–1.75	–0.46	–3.39	–1.20	3.18	4.83	1.60	3.93
Nominal exchange rate				0.00				5.35
Change in trade balance (billion yuan)				–41.79				0.00
Terms of trade (%)				–0.46				–0.47

Source: Jiang (2003a).

Conclusions

Using the CERD model, the study finds that, while total welfare increases, regional income disparities will be increased rather than eased by the WTO accession. The eastern coastal region will have much higher gains than the inland regions. The two inland regions will have similar gains, with the central region being only marginally better off than the western region. Rural–urban inequality will be worsened in all regions by the WTO accession commitments.

The results are robust whether the trade balance is fixed or not. However, keeping the trade balance unchanged leads to a smaller overall welfare gain and a wider regional income gap than leaving the trade balance endogenous.

Lowering the tariff cuts in agriculture reduces total welfare gains, although it modifies the worsening inequality between rural and urban households and between regions. Increasing government transfer payments from the coastal region to inland regions also reduces overall welfare gains, although regional disparity may be reduced. This is because the coastal region has higher returns than the inland regions. Domestic market reform, allowing freer movement of factors and commodities across regions, could improve the regional and rural–urban inequality and achieve higher total welfare gains.

Modelling of WTO accession and food security

China's commitments in agriculture are more far-reaching than those in manufactured goods. China agreed to reduce the average statutory tariff rate for agricultural products from 22% to 15% by January 2004. It also agreed to adopt a tariff rate quota system for key agricultural products, such as wheat, rice and corn. Within the specified import quota,

which is scheduled to increase over time, the tariff rate for these three grain products is only 1%.

However, these commitments will not necessarily lead to significant adverse effects on agricultural production in China, as it already had relatively low protection on agriculture. This was partly due to the history of taxing agriculture to subsidise industrial development and partly due to efforts to reduce protection during the WTO accession negotiations.

Overall effects of WTO accession

Jiang (2003b) used the CERD model to simulate the effect of WTO accession on food security. The simulation of WTO accession was carried out by using the closure of no control on the trade balance; that is, the exchange rate is fixed and the trade balance is endogenous. The macro-economic effects of China's WTO accession are summarised in Table 7. Several points can be drawn from the simulation results.

First, China gains from WTO accession. Real GDP, consumption and the utility level increase by 0.4%, 1.0% and 0.8%, respectively. The welfare improvement amounts to 58.2 billion yuan, when measured by the equivalent variation (EV).

Second, the tariff reductions lead to lower prices for imports, which, in turn, result in lower overall prices. The consumer price index (CPI) and GDP deflator decline by 2.2% and 1.8%, respectively. Because of the cheaper domestic prices, the terms of trade decline by 0.4%.

Third, both imports and exports increase after the tariff cut—by 19.0% and 11.1%, respectively. As imports increase more than exports, the trade balance declines by about 34 billion yuan.

Fourth, the effects of WTO accession are not evenly distributed. Crops, food processing, motor vehicles and parts, and the machinery sectors are all adversely affected, while the other sectors benefit from accession. The motor vehicles and parts sector is the hardest hit, while the light industry sector benefits the most.

In regional distribution, almost all the benefits go to the eastern coastal region. This is because the eastern region has the highest proportion of booming sectors. This pattern implies that the regional income disparity worsens after WTO accession.

Table 7. Macro-economic effect of WTO accession

	Eastern	Central	Western	National
Real GDP (%)	0.703	–0.114	0.275	0.436
Real consumption (%)	1.694	0.190	0.218	1.021
Utility (%)	1.093	0.317	0.402	0.790
EV (billion yuan)	51.397	3.627	3.179	58.203
CPI (%)	–2.118	–2.019	–2.477	–2.157
GDP deflator (%)	–1.673	–1.783	–2.500	–1.831
Changes in trade balance (billion yuan)				–33.955
Terms of trade (%)				–0.416
Imports (%)				19.042
Exports (%)				11.096
Sectoral output				
Crops	–0.674	–0.294	–0.399	–0.490
Other agriculture	0.637	0.257	0.466	0.487
Mining	–1.484	1.270	2.943	0.160
Food processing	–5.679	–1.751	–5.332	–4.404
Light industry	7.188	–0.217	1.129	5.341
Chemicals	–1.922	–0.931	–0.680	–1.556
Motor vehicles and parts	–17.612	–14.658	–10.814	–16.035
Machinery	–3.590	–0.865	0.641	–2.516
Electronic and electrics	6.549	–0.736	3.736	5.737
Construction	0.426	1.033	1.162	0.687
Services	0.774	–0.159	0.132	0.481

Source: Jiang (2003b).

Effect of WTO accession on agriculture and food security

The effects of WTO accession on production, exports, imports and self-sufficiency in agricultural products are reported in Tables 8–11. Although agricultural imports and exports change significantly, the imported volume is still within the quota and the contraction of production is limited. For most grains, the reduction in production is less than 1%. Consequently, the impact on grain and food self-sufficiency is also limited and the target rate of 95% self-sufficiency is likely to be achieved.

Grains production in the eastern region declines the most, while that in the central region declines the least. This result is in line with the comparative advantage of agricultural production in each region. Compared to the eastern region, the central region has a relatively abundant labour force and land resources. Compared to the western region, the central region has more favourable weather conditions, and arable land resources are also relatively abundant.

However, food security may still be an issue, even if the self-sufficiency target is achieved, because the benefits and costs of accession are not evenly distributed across regions and households. Even if the overall benefits are larger than the costs for those engaged mainly in the contracting sectors, food insecurity caused by the reduction in income may be

Table 8. Effect of WTO accession on agricultural production (%)

	Eastern	Central	Western	National
Rice	–0.318	–0.169	–0.227	–0.242
Wheat	–1.072	–0.367	–0.523	–0.690
Corn	–1.800	–0.563	–0.813	–1.072
Pulses	–1.125	–0.379	–0.544	–0.588
Other grains	–1.136	–0.385	–0.549	–0.720
Cotton	–1.226	–0.327	–0.499	–0.624
Oilseeds	–1.981	–0.537	–0.801	–1.313
Vegetables and fruits	–0.019	0.006	–0.024	–0.015
Other crops	–0.478	–0.127	–0.205	–0.356
Forestry	0.696	0.768	0.854	0.753
Livestock	1.523	0.298	0.555	0.892
Fishery	–0.989	–0.228	–0.100	–0.798
Other agriculture	0.223	0.222	–0.243	0.126
Processed food	–5.679	–1.751	–5.332	–4.404

Source: Jiang (2003b).

Table 9. Effect of WTO accession on agricultural exports (%)

	Eastern	Central	Western	National
Rice	9.253	9.629	10.787	9.511
Wheat	9.898	10.037	11.357	10.118
Corn	10.075	9.994	11.475	10.201
Pulses	9.913	10.028	11.367	10.143
Other grains	9.888	10.008	11.339	10.134
Cotton	9.955	10.018	11.344	10.193
Oilseeds	10.209	10.051	11.546	10.187
Vegetables and fruits	9.574	10.027	11.090	9.740
Other crops	9.741	10.048	11.210	9.915
Forestry	8.018	8.247	9.740	8.219
Livestock	11.295	10.169	11.981	10.937
Fishery	11.477	9.894	11.253	10.868
Other agriculture	9.013	9.240	11.394	9.405
Processed food	3.931	7.377	4.739	4.938

Source: Jiang (2003b).

a problem. This is especially important for rural households in inland regions. For example, the real wage in agricultural sectors in the central region declines after WTO accession (see Table 12).[8] Table 12 also shows that rural household income increases by a smaller magnitude than urban household income; i.e., the rural–urban income inequality worsens after WTO accession.

[8] This seems a puzzle at first glance as the central region has the smallest reduction among the three regions in almost all agricultural sectors. However, as the magnitude of effect varies across sectors and the sectoral composition differs across regions, it turns out that the central region becomes the hardest hit region in the agricultural sector as a whole.

Policy implications and conclusion

Although overall food sufficiency is not significantly affected, food security may still be an issue for households in inland regions whose only income source is agricultural production.

Several approaches to increasing food security or self-sufficiency have been discussed. A direct response may be to provide support to agricultural sectors and farmers. Support can be provided in many forms, with some conforming to WTO rules and others not. Earlier work in this project considered a scenario where the level of tariff cut on agricultural commodities is halved because of various forms of new barriers, such as labelling requirements, reporting procedures, and so on.

Table 10. Effect of WTO accession on agricultural imports (%)

	Eastern	Central	Western	National
Rice	–7.908	–7.743	–8.635	–7.969
Wheat	31.737	33.813	32.069	32.055
Corn	66.536	71.405	68.605	67.630
Pulses	32.460	34.700	32.904	33.142
Other grains	32.521	34.760	32.970	32.880
Cotton	53.627	56.787	54.684	54.474
Oilseeds	83.812	90.133	86.939	84.771
Vegetables and fruits	–7.466	–7.576	–8.326	–7.543
Other crops	15.097	15.871	14.705	15.099
Forestry	–4.753	–4.531	–5.692	–4.730
Livestock	2.255	0.647	–0.857	1.702
Fishery	–7.215	–2.421	–4.781	–6.632
Other agriculture	325.428	323.875	307.226	324.185
Processed food	163.876	179.087	163.574	165.720

Source: Jiang (2003b).

Table 11. Effect of WTO accession on food self-sufficiency

	Base rate (%)	Change (%)	Post-accession rate (%)
Rice	97.6	0.282	97.9
Wheat	91.5	–0.162	91.3
Corn	95.7	–0.553	95.2
Pulses	110.0	–0.122	109.9
Other grains	94.7	–0.197	94.6
Oilseeds	75.9	–0.983	75.1
Vegetables and fruits	100.9	0.349	101.3
Other crops	99.7	–0.002	99.7
Livestock	97.8	0.158	97.9
Fishery	111.4	0.105	111.5
Processed food	93.3	–4.333	89.3
Total grain	95.1	–0.063	95.0
Total food	96.9	–1.548	95.4

Source: Jiang (2003b).

Table 12. Changes in household income and welfare after WTO accession (%)

Indicators	Eastern	Central	Western
Real wages			
Agricultural labour	0.042	–0.103	0.148
Non agricultural labour	2.528	0.675	1.163
Real income			
Rural household	1.196	0.539	0.681
Urban household	1.772	0.742	1.174
Utility			
Rural household	0.972	0.520	0.615
Urban household	1.502	0.834	1.003

Source: Jiang (2003b).

The simulation of this scenario, using CERD, indicates that although such a policy may provide some cushioning effects to agricultural sectors and help to ease the worsening trend of rural–urban income inequality, the overall welfare gain from WTO accession is smaller. The equivalent variation is 6% less than that of the full tariff cut of the WTO accession commitments.

Support in the form of a production subsidy is considered; using the assumption that the government subsidises farmers to keep the grain self-sufficiency rate constant after WTO accession. Simulation shows that it would cost 7.2 billion yuan to make up for the tiny reduction of 0.06% in the grain self-sufficiency rate. If the target were to restore the total food self-sufficiency rate (down by 1.5%), the cost would be as high as 180 billion yuan.

Increasing transfer payments to inland regions was also simulated in earlier work of this project. However, the simulation gives a similar result to halving the cut in agricultural tariffs. The improvement in regional and rural–urban household income disparity is achieved at the cost of lower overall welfare gains—1% lower welfare gain than the full tariff cut scenario. This could happen because increasing transfers to the inland regions are made possible through penalising the coastal regions that have a higher rate of return. The results of this policy simulation imply that any transfer payment scheme should be carefully designed to avoid further distortions in resource allocation.

Another policy option is to increase agricultural research and development (R&D) to improve agricultural productivity in China, as suggested by many authors, for example: Fan, Fang and Zhang (2001), and Hazell and Haddad (2001). Simulations were conducted to find out how much productivity improvement is required to keep the grain and food self-sufficiency rates constant after WTO accession. It was found that the required productivity improvements are 0.32% and 2.85%, respectively, for constant grain and total food self-sufficiency rates. To give an idea of what these figures mean, agricultural total factor productivity (TFP) in the past may be used as a benchmark. According to Fan (1997), agricultural TFP was 5.1% and 3.91% per annum respectively during the periods 1978–84 and 1984–96. A 2.85% productivity improvement implies that China should almost double the agricultural R&D level.

Agricultural productivity may also be improved through other channels. One such approach could be reforming the current land tenure system. It is often argued that the average farm size in China is too small to take full advantage of economies of scale. Without well-defined land ownership, farmers are reluctant to invest in land, and the lack of a land market impedes needed adjustments in China's rural economy (Lohmar and Somwaru 2002). However, secure land tenure is also important for low-income farmers to achieve food security. Zhou (1998) finds that China's 'dual land system'[9] is superior in avoiding the generation of more landlessness and inefficient land-holding. Ho (2001) finds that many Chinese farmers prefer the current system, especially in poor villages, as it guarantees households access to land. FAO (2002) also shows that the poverty index is negatively related to land holding,

[9] Land is divided into self-sufficiency land and responsibility land. Self-sufficiency land, or grain-rations land, was equally contracted to households on a per capita basis mainly for planting grains for self-consumption. The responsibility land was contracted subject to fulfilling state output quotas and paying agricultural taxes and fees.

and productivity is negatively related to farm size, i.e. smaller farms have higher productivity. These findings may prompt second thoughts about the popular idea of increasing farm size, especially in poor regions.

Finally, further liberalisation is also an option. The earlier simulation work of this project suggested that domestic market reform, characterised by freer movement of primary factors and commodities, may both enhance overall welfare and improve regional income disparity. In addition, China should promote trade liberalisation globally. China has made significant commitments to trade liberalisation on agricultural products and its protection of agriculture is among the lowest in the world. This puts China in a good position in the new round of trade liberalisation negotiations. GTAP simulations show that the removal of agricultural protection in Organisation for Economic Cooperation and Development (OECD) countries improves the competitiveness of Chinese agricultural products in the world market and increases the grain self-sufficiency rate (Yu and Frandsen 2002).

Summary of other major research findings

Food self-sufficiency and food security

Maintenance of grain self-sufficiency has long been a major plank of China's agricultural policy. As recently as 1996, the Vice-Minister of Agriculture, Wan Baorui (1996), announced that the grain self-sufficiency rate was to be maintained at above 95%. Along with the widening of per capita income disparities between rural and urban areas, the rhetoric of food self-sufficiency is the most prominent weapon of China's protectionists. There has been a concern that China will go the way of Japan, Korea and Taiwan and protect its agricultural sector as the sector shrinks in relative importance and national per capita incomes increase. China's accession to the WTO may reduce this likelihood. However, while WTO accession lessens the risk that the protectionists will succeed, the agriculture ministry has been assigned a prominent role in trade policy formation and negotiation. It has the power to press for further agricultural protection on both self-sufficiency and distributional grounds (Anderson et al. 2002; Tong 2003).

That genuine concern for food self-sufficiency in China exists is understandable. Widespread famines have been experienced, although, in hindsight, these were probably more the result of bad policies than bad weather. Concern over the possibility of food trade embargoes can also be understood; although, again, experience has shown that trade embargoes are very difficult to implement (Lu 1997; Yang 2000). The difficulty of financing large volumes of food imports would also have been a legitimate concern in the past. However, this is no longer the case. In 2000, China's total export revenue was around US$250 billion. Imports of 22 million tonnes of grain (the WTO import quota commitment) would cost US$3–4 billion, only a small fraction of total export earnings.

Food self-sufficiency is not the same as food security. Food security is a matter of whether households have sufficient income to maintain an adequate diet. The important question for China on food self-sufficiency is the extent to which it is prepared to rely upon the international market for the gap between domestic production and its effective demand. China is such a large country that, inevitably, most of the goods and services consumed have to be produced domestically.

To illustrate the economic costs of adopting policies that aim to maintain grain self-sufficiency near the present level, or to increase it, protectionist scenarios were modelled by Duncan et al. (2003). They used an adaptation of the GTAP model[10], a global, multi-region, multi-product general equilibrium model. Following Yang and Tyers (2000), independent representations of governments' fiscal regimes were added to the standard GTAP base, including: direct and indirect taxation, separate assets in each region (currency and bonds), and monetary policies with a range of alternative targets.

In an earlier analysis, Yang and Tyers (1989) used a global agricultural sector model to examine the effect of rapid income growth in China on the composition of food consumption and its implications 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 redistribution and economy-wide effects of the protection needed to maintain self-sufficiency. The use of the GTAP model overcomes these limitations.

The modelling first projects the base case to 2010 under conservative output and productivity growth assumptions and then asks two questions. First, if China's present 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 full food self-sufficiency by 2010 and what would be the economy-wide and distributional effects of this protection? Consistent with Yang and Tyers (1989), the

[10] A detailed description of the original model is provided by Hertel (1997).

base case projection to 2010 shows substantial declines in Chinese food self-sufficiency (see Table 13), particularly for beverages, livestock products and feed grains (basically as the result of income growth). This means that substantial increases in protection are needed to maintain the 2001 levels. To achieve self-sufficiency in all agricultural products by 2010, considerable additional protection would be required. In both cases this protection would be contractionary and redistributive, and it would retard growth in other sectors. The sensitivity analysis shows the strength of the results rests quite heavily on some parameters, particularly the income elasticity of demand for livestock products.

Table 13. Food self-sufficiency in China, 2001 to 2010 (%)

Commodity	2001	2010
Rice	100	100
Beverages	99	91
Other crops	94	89
Livestock	99	95
Processed food	88	83
Fish	99	99

Source: Duncan, et al (2003).

The model employs the original GTAP CDE (constant difference of elasticities of substitution) system. Its non-homotheticity is an asset 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 parameter range compared to still more general systems. The CDE system is employed here because of its parametric economy. Because of the restrictiveness of the CDE system, the lower bound for the income elasticity of rice cannot be set below 0.1, despite evidence suggesting that it is now negative (Ito et al. 1989; Peterson et al. 1991). As a result, the differences between the model's income elasticities for livestock products and processed foods, which are superior goods, and those for grains, are likely to be smaller than they actually are. One consequence of this is that the results probably underestimate the growth in demand for livestock products and processed foods; hence they underestimate the associated derived demand for cereal feeds and other agricultural inputs. This means it is likely there is a downward bias in the estimates of the cost of achieving and maintaining agricultural self-sufficiency.

Because the declines in self-sufficiency in the base case projection 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 (see Table 13). These taxes on imports are, effectively, taxes on all China's trade. Thus they also reduce China's exports, causing exporting industries to contract. Overall, the increased protection induces a 1% contraction in GDP, along with some restructuring across industrial sectors. The more heavily protected agricultural industries are favoured, mostly at the expense of manufacturing, particularly light manufacturing.

The additional tariffs required to achieve full food self-sufficiency by 2010 are very large, particularly on imports in the livestock products, processed food and other crops groups (see Table 14). These tariff increases distort incentives in the economy substantially, shifting resources into agriculture and contracting both the manufacturing and service sectors. Throughout the economy this decline in allocative efficiency reduces returns to installed capital and

Table 14. Changes in tariffs required for food self-sufficiency by 2010

Commodities	Extra protection to hold self-sufficiency rates at 2001 levels	Extra protection to achieve full self-sufficiency
Rice	0.0	0.0
Beverages	35.4	50.6
Other crops	19.2	72.7
Livestock	39.2	78.7
Processed food	11.1	67.3
Fish	16.1	31.9

Source:Duncan, et al (2003). The changes in protection are shown as proportional changes to nominal protection coefficients.

therefore investment. The level of 2010 GDP is reduced by nearly 2%. The tariffs that would achieve agricultural self-sufficiency in 2010 reduce exports from China's growth powerhouse, its light manufacturing industries, by one-half. 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. The higher tariffs cause employment in agricultural and food processing activities to be substantially greater, mainly at the expense of light manufacturing.

Higher agricultural tariffs raise land rents by a considerable margin but reduce real wages and capital returns. 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. The capital losses occur because the industries hurt by the tariffs are more capital intensive than agriculture. In the end, landholders are the only winners from the tariffs.

We might well ask: what is gained by self-sufficiency? Would food be more readily available in China? No! China's 2010 prices for imported foods would be increased by up to 60% through the higher tariffs. Even prices for home-produced food products would be increased by at least 10%. The key consequence of political significance would be a reduction in interdependence with the global economy. 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 capital returns, thereby cutting incentives for investment and, ultimately, the growth rate of its economy.

Commodity, regional, and household effects of WTO accession

The project examined the likely commodity/regional effects of China's WTO agricultural commitments. This was done through the calculation of 'production concentration indices', which Lu (2001) defined as the ratio of the sown area (or output) of the commodity per capita of the agricultural population of a region, divided by the same ratio for the country. The interpretation of the index is that a region has a comparative advantage (disadvantage) in the commodity if the production concentration index (PCI) is greater (less) than one (analogous to the use of the export concentration index as a measure of 'revealed' comparative advantage).

The calculations show relatively high PCIs for the labour-intensive commodities (vegetables, fruit, meat, and fish products) in the eastern region, relatively low PCIs for these commodities in the western region, and values in between for the central region. On average, the eastern region has comparative advantage in all four labour-intensive commodity groups. The central region has comparative advantage in vegetables and meat products but not in fruit and fish products. The western region does not have comparative advantage in any of the four labour-intensive product groups.

PCIs for the land-intensive products (grains, oil seeds, cotton, and sugar) are relatively high for the western region, relatively low for the eastern region, and in between for the central region. The western region has comparative advantage in all four land-intensive commodity groups, while the central region has comparative advantage in grains, oil seeds and sugar. In the eastern region, only sugar has a comparative advantage.

In assessing the adjustment effects of the reduction in protection for agricultural commodities, Lu (2001) argues that, in line with China's perceived comparative advantage, liberalisation will strengthen the tendency towards imports of land-intensive commodities and encourage exports of labour-intensive commodities. The export promotion effect is expected to follow closely the regional distribution of comparative advantage of labour-intensive commodities. For the negative import-substitution effect, the study postulates two possibilities: one is that imports of land-intensive products will largely substitute for domestic production in the regions with relatively high domestic production costs for these commodities. The second is that imports will substitute for domestic production in proportion to the existing regional concentration of the commodities.

The two possibilities will have different implications for regional adjustment costs. The first is to be preferred, as it allows the principle of comparative advantage to play a larger role in resource allocation. The second, less desirable, possibility is in line with the policy stance that has emphasised provincial grain self-sufficiency. Under the first scenario, those provinces with comparative advantage in both labour- and land-intensive commodities will have relatively small adjustment costs. Those provinces without compara-

tive advantage in those commodities are likely to be worst off; they will benefit least from the export expansion and have to bear the largest adjustment costs. The eastern region is likely to be the major beneficiary from export expansion of labour-intensive products, while the inland regions are expected to have much smaller benefits. On the other hand, the coastal region may experience a larger share of the adjustment costs from the import growth, while inland provinces may have less adjustment.

Under the second scenario, the regional distribution of the import-substitution effects changes considerably. A large share of the adjustment costs may be incurred by the central and western regions; i.e. they are likely to have a combination of small export-promoting effects and large adjustment costs. This could result in an increase in the income gap between the coastal and inland regions.

To maximise the likelihood for scenario one to materialise, agricultural policies should be changed in a more market-oriented manner. There should be a move away from the emphasis on regional self-sufficiency. The state monopolies in domestic marketing and distribution of bulk agricultural commodities, and in transport, should also be removed to allow goods to flow more freely across provincial borders.

One of the project studies (Jiang 2002b) examined the growing income gap between the coastal and inland regions over the period 1978–2000. This study found that the gap was unchanged, or had even declined, during 1978–90—the period in which China undertook major agricultural reforms and experienced high growth in the agricultural sector. This development favoured the poorer regions that have higher agricultural shares in total output. However, in the period 1991–2000, which followed the major industrial reforms, the eastern region benefited most from growth of foreign investment and development of the private sector. During this time the regional income gap between the coastal and inland regions widened considerably. However, the income disparity within the regions declined.

The increasing gaps between rural and urban incomes, and between incomes in coastal and inland regions, are of considerable concern in China. The likelihood of WTO accession increasing these disparities was a major factor behind resistance to accession. The project modelled (Jiang 2003a) how WTO accession is likely to affect these income disparities using the CERD model.

In simulations of the WTO accession commitments, the crops, food processing, motor vehicles and parts, and machinery sectors are adversely affected by the accession, particularly the motor vehicles and parts sector. Other sectors benefit, particularly the light manufacturing sector. Agricultural production declines most in the eastern region and least in the central region. The study results show the usefulness of general equilibrium analysis, which has taken account of a higher return to labour-intensive activities outside of agriculture in the eastern region. The eastern region does by far the best in overall terms because it realises most of the gains in allocative efficiency. Hence, there is an increase in regional income disparity. Rural household incomes increase most in the eastern region because they have the best opportunities for earning off-farm income. However, across the regions rural household incomes increase less than urban household incomes.

The project (Jiang 2003b) also undertook some simulations to examine the results of policies that may be adopted to mitigate these adverse effects on farm incomes. One policy option tested was the use of a production subsidy. It was found that if agriculture were to be subsidised to maintain the pre-accession grain self-sufficiency rate, the subsidy would be 7.2 billion yuan. If the target were to maintain the food self-sufficiency rate, the subsidy would be 180 billion yuan. Another policy option tested was an increase in agricultural R&D to improve agricultural productivity. It was estimated that China would have to almost double the level of agricultural R&D to maintain the food self-sufficiency rate.

Surplus agricultural labour

Another of the project studies (Wang 2002), argued that a major reason for the widening rural–urban income gap since 1991 is the excess supply of labour in agriculture. This excess supply results in low labour productivity—much lower than in the industrial and tertiary sectors—and slower growth in incomes. As a result of the slower productivity growth and the excess of labour in agriculture, the agricultural share of GDP fell from 51% in 1952 to only 14% by 2002. Meanwhile, the share of agricultural workers in the total work force only declined from 84% in 1952 to 50% in 2002. The share of the rural population in the national total declined even more slowly—from 85% in 1953 to 61% in 2002. The excess supply of labour in agriculture has been attrib-

uted, in large part, to the restrictions on the movement of people from rural areas to the cities, accompanied by discrimination in the form of denial of access to housing, education, job training and health facilities.

Because of the development of rural industries, the sources of rural household income have changed remarkably. In 1990 the agricultural share of rural household incomes was 74%. By 2002, this share had fallen to 47%. The development of the rural industrial sector, particularly the township and village enterprise (TVE) section of it, was very important in providing opportunities for diversification of rural household incomes. Employment in the TVE sector increased from 28 million to 135 million in the period 1978–96, accounting for more than one-quarter of the rural labour force (Wang and Duncan 2003). Despite this, the number of farmers has increased and there appears to be more surplus agricultural labour than ever. The diversification of rural household incomes varies greatly between the major geographical regions, with the share of off-farm income in rural households in the coastal region around 75%, but only around 25% in the western region. Moreover, the rural–urban income disparity has widened most in the western region: between 1980 and 2000 the rural/urban income ratio fell from 54.4% to 43.2% in the eastern region, from 49.5% to 40.1% in the central region, and from 44.9% to 30.4% in the western region (Wang and Duncan 2003).

Development of rural industries slowed in the late 1990s, mainly due to greater market competition, the unfavourable location of rural enterprises, difficulties in accessing external finance, and lack of infrastructure, technical inputs, and human resources. Meanwhile, urbanisation accelerated and larger numbers of rural labourers moved to urban areas in search of jobs. In 2001, the urbanisation rate (the ratio of urban to total population) in China reached 38%, compared to 26% in 1990 and 19% in 1980.

Restrictions on migration

In spite of the acceleration of urban development, the urbanisation rate in China is, on average, 10–20 percentage points lower than in other countries at a similar income level—even allowing for the so-called 'floating population' (Wang and Xia 1999). In particular, there are relatively few medium and large cities. In 2001, 121 million people, only 9.6% of the population, lived in cities of more than 0.5 million people. In the less-developed western region, only 5.6% of the population lived in cities of that size. If China had an urbanisation rate similar to that of other countries of a similar income level, an additional 120–240 million people would be living in urban areas. This number may be thought of as the excess number of people in the rural economy.

Wang and Duncan (2003) noted that there are positive correlations between rural industrialisation (measured as the share of TVE employment in rural labour) and rural incomes and between the urbanisation rate and rural incomes. They therefore undertook a causality test of the relationship between urbanisation and regional economic growth. Because both urbanisation and rural incomes may be a function of economic growth, the causality test was carried out within an endogenous growth model.

The results from the modelling indicate that each percentage point increase in the urbanisation rate increases provincial economic growth by 0.37 percentage points above the, already high, 7–10% growth rate, i.e. urbanisation has a long-run effect on economic growth. When regional dummies are introduced, there are seen to be significant effects from urbanisation on economic growth in both the eastern and central regions, but the effect is insignificant in the western region. There may be two reasons for this latter result: first, the rate of urbanisation in the western region has been low and, second, the urban economy in the western provinces has not experienced much restructuring and is therefore less market-oriented and less efficient.

Macro-economic implications of WTO accession

Most other studies of China's WTO accession have focussed on its medium and long-run effects. However, there are important short-run issues, in particular those relating to the macro-economic policy environment in which the reforms take place. The study by Tyers and Rees (2002) therefore examined the short-run effects of the reforms under scenarios of capital controls, fixed and floating exchange rate regimes, and alternative fiscal policies.

An adaptation of the GTAP model, similar to that used in Duncan, Rees and Tyers (2003), was used for the analysis. Because of the inclusion of independent representation of governments' fiscal regimes (with inclusion of both direct and indirect

taxation) and monetary policies with a range of targets, it is possible to study a range of policy regimes. To be representative of short-run conditions, the model also allows for labour market rigidity and departures from full employment.

Before undertaking the short-run analysis, a simulation of the long-run effects of the accession commitments was first carried out. The results allowed for a derivation of investors' expectations, on the assumption that they take changes in long-run returns on installed capital into account in determining short-run changes in their investment behaviour. The results from the long-run simulation show the expected allocative efficiency gains from the trade reform. These are reflected in increased GDP and increased returns on installed physical capital that induce greater investment and larger net inflows on the capital account. Anticipation of an increased average long-run return on installed capital is therefore part of investors' short-run expectations and so tends to increase the level of investment in the short run—even if capital controls are maintained. The trade reforms also cause consumption to switch away from home-produced goods and a fall in the relative prices of those goods; hence there is a real depreciation. There is also an increase in export competitiveness, and exports increase.

Manufacturing, particularly light manufacturing, is the main beneficiary of trade liberalisation, together with the transport sector. This result, which is contrary to intuition from the trade model of Heckscher–Ohlin-Samuelson (HOS), derives from the model's departure from the HOS model in two ways—first, there is extensive use of intermediate inputs from the same sector (intra-industry trade) and, second, competing imports are differentiated from home products. Under these assumptions, the tariff reductions on imported intermediate inputs have a direct effect on the home industry's total cost. The indirect effect of the reductions in tariffs on competing, but differentiated, products depends upon the elasticity of substitution between imports and home produced goods. For manufacturing, the input-cost effect of tariff reductions is considerably greater than the effect of the loss of protection against competing imports. Cost reductions of similar origin are the reason for the gains accruing to the domestic transport sector.

As the reforms cause the most substantial reductions in protection in China's food processing sector, and therefore lead to long-run contractions in rice and other crops, there is substantial relocation of employment from agriculture to manufacturing, energy, and the transport and other services sectors.

Simulations of short-run effects

For the short-run base-case simulation, China is assumed to maintain a fixed exchange rate against the US dollar and rigid capital controls, while nominal wages are 'sticky'. The other regions specified in the model have inflation and CPI targeting, no capital controls, full short-run nominal wage rigidity in the industrial countries and fully flexible nominal wages elsewhere. Government spending in all regions is assumed to absorb a fixed proportion of GDP and the rates of direct and indirect taxes are constant, so that government deficits vary in response to shocks.

Five different macro-economic regimes were simulated to study the impact of the trade reforms:

1. rigid capital controls and fixed tax rates; monetary policy targets the CPI; and the exchange rate floats;
2. fixed exchange rate and fixed tax rates; there are no capital controls;
3. fixed tax rates; monetary policy targets the CPI; the exchange rate floats; and capital controls are removed;
4. rigid capital controls and a fixed exchange rate; the direct tax rate adjusts to maintain the government deficit as a fixed proportion of GDP; and
5. the closure is the same as (4), however, capital controls are removed.

The short-run effects of trade reform vary considerably under the different macro-economic regimes. When capital controls are in place and the exchange rate is fixed, the allocative gains from the tariff reductions are insufficient to offset the contractionary effects of the deflation from the increase in the relative prices of foreign goods. When capital controls are weak, trade liberalisation attracts increased inflows on the capital account and mitigates the real depreciation and associated domestic price deflation. The real volume of investment increases irrespective of the target of monetary policy, as does the level of GDP. However, the choice of monetary policy still matters, with CPI targeting leading to a smaller GDP price deflation, more modest gains in the real production wage, and better short-run GDP gains.

As with monetary policy, the impact of the different fiscal policies depends on the strength of

capital controls. Given tight capital controls, if tax rates are held constant and the fiscal deficit expands, domestic interest rates rise and private investment is crowded out. Where income tax increases to compensate for the tariff cut, there is less pressure on the domestic capital market and the interest rate increase is less, as is the fall in investment. In the absence of effective capital controls, the case of no increase in the tax rates performs better than the alternative policy. The increased government borrowing draws in international savings at international interest rates and does not crowd out private investment. However, both fiscal policies give superior results in the absence of capital controls.

The key determinant of the short-run structural adjustment resulting from trade liberalisation is the size of the real depreciation, which is larger when capital controls are in place. Traded goods sectors, such as light manufacturing, are advantaged while non-traded sectors are not. When there are no capital controls, the manufacturing gains are smaller and the non-traded services sectors also benefit. Across the board, however, for the same reasons as in the long-run simulation, agriculture and food processing are disadvantaged by the reforms. It is important to note that some relaxation of the monetary policy regime can reduce the adverse effects of trade reform on the agricultural sector. When capital controls are in place and the exchange rate is fixed, almost the entire agricultural sector is hurt. Where capital controls are in place but the exchange rate is floated, the other crops, livestock and fisheries sectors expand.

Employment in food processing falls regardless of the macro-economic policy regime. Significant structural change is required in the short run with the movement of employment from agriculture to manufacturing; however, in the long run, the size of the employment shift is smaller. Under either fiscal regime, the greatest contraction of employment in food processing occurs when capital controls are tight and monetary policy targets the nominal exchange rate. Unlike the effect in the long run, employment in the other agricultural sectors is not necessarily contractionary—the outcome is dependent upon the macro-economic policy regime.

In summary, if capital controls are too tight and the fixed nominal exchange rate is retained, the reforms are deflationary. If the labour market is slow to adjust, employment growth will slow and the reform package will be contractionary. To obviate this, the government has to allow sufficient net inflow on the capital account to at least maintain the level of domestic investment. If it does not do this, a small nominal depreciation would achieve the same result. The fiscal policy response to the loss of import revenue has comparatively little influence over China's economic performance in the short run. Regardless of whether government spending or the government deficit is held constant, the optimal macro-policy environment is a floating exchange rate with no capital controls.

Macro-economic impacts on migration

In a follow-up study to Tyers and Rees (2002), Chang and Tyers (2003) analyse the slow-down in China's income growth since the Asian financial crisis. In particular, they examine the slow-down in rural income growth and the widening urban–rural income gap and ask to what extent this is due to: (1) the remaining obstacles to rural–urban migration (as suggested by Ianchovichina and Martin 2002), (2) the WTO trade reforms (as suggested by Anderson et al. 2002), or (3) restrictive macro-economic policies. Using the GTAP model adaptation of Tyers and Rees (2002)[11], the researchers test the extent to which China's fixed exchange rate and capital controls, and its WTO accession commitments, have contributed to the relatively poor performance in the rural sector.

The Asian crisis was seen as leading to a large (largely illegal) outflow of capital. This capital flight and the trade reforms are hypothesised to have led to a real depreciation in the exchange rate. The pegging of the yuan to the US dollar has therefore necessitated a deflation. If wages are 'sticky' and fall more slowly than prices, employment declines. It is hypothesised that the resulting real wage increase in the modern sectors has reduced labour demand and hence 'bottled up' workers in the rural sector and reduced rural per capita incomes.

Analysis of the data shows that while restraints on rural–urban migration have been relaxed to some extent, the migration flow has decreased rather than increased. The simulation results support the hypothesis that the fixed exchange rate and the

[11] The key difference between the long-run analysis in this paper and that in Tyers and Rees (2002) is that in the model used for the simulations reported in this paper there is an assumed positive relationship between the trade reforms and productivity growth.

capital controls have restricted the flow of workers from the rural sector. The model shows the rate of migration into the manufacturing sector falling by at least one percentage point per year and into the services sector by at least two percentage points per year. In all sectors there is a stark contrast between employment growth under tight capital controls and a fixed exchange rate regime on the one hand, and an open capital account and floating currency regime on the other. Indeed, with an expansionary macroeconomic policy and optimistic assumptions about the productivity effects associated with the WTO accession reforms, simulated worker relocation demands from the reforms exceed the average of China's recent rural–urban performance. This suggests that there is ample scope for a more rapid rate of migration of labour out of the rural sector, which would help reduce the rural–urban income gap.

Summary and discussion

The wide range of analysis carried out in this project consistently shows that the trade reforms China adopted to accede to the WTO will mean substantial structural changes within the agricultural sector. When looked at from a partial equilibrium agricultural perspective, the reforms result in substantial negative impacts across the sector and a worsening of food security, through reduced access to income. However, it cannot be stated too strongly that the outcomes of the reform have to be analysed from an economy-wide perspective. In China, as in other rural-based countries, the main factors behind reductions in rural poverty will be the scope for rural households to earn off-farm income and for people to move from rural areas into industrial and services activities in urban centres. Therefore, to a very large extent, the success of the trade reforms will depend upon policies outside agriculture.

There was considerable internal resistance to China joining the WTO, with concern over food security (more commonly seen in China as food self-sufficiency) and the perceived adverse effects on the agricultural sector. The analysis carried out in this project has confirmed that structural change driven by productivity growth—which the trade reforms will promote—will lead to agriculture becoming a smaller and smaller part of the economy. As incomes increase, consumption patterns change, and the share of agriculture shrinks, China will become less self-sufficient in many commodities. However, because it has such a large population, China will always have to produce most of the foods that it consumes.

As the modelling has shown, trying to hold this development at bay, or reverse it, would have exorbitant costs. No doubt, however, there will continue to be resistance to the reforms in agriculture. The large proportion of the population that is still supported by agriculture can be a significant political weapon. Unfortunately, resistance to reforms can prevent the exploitation of the potential for incomes to increase, thus providing further ammunition for arguments seeking government support for the sector. It is important, therefore, that the economic arguments against 'food self-sufficiency' be made repeatedly.

The gap between urban and rural incomes has widened over the past decade or so. Partly, this is an outcome of the very rapid growth of the urbanised industrial and services sectors, but also of a slowing in the growth of rural incomes. This is partly the result of the slowdown in the growth of the TVE sector and fewer opportunities for rural households to earn off-farm incomes. Incomes in the agricultural sector have not grown as rapidly as they could because of poor agricultural policies, such as: ineffective and costly price support policies, regional self-sufficiency policies, and monopolistic marketing and distribution of bulk commodities, fertilisers and seeds. China's accession to the WTO should help to maintain pressure to bring about reforms in these areas.

The current government grain reserve system is inefficient in many respects and very costly. It is run by different government agencies at the central, provincial and municipal levels, each with different interests and not very clearly defined roles. These arrangements give rise to conflicting interests in operations dealing with market instability and cannot serve the goal of food security well. A smaller, well-managed, grain reserve system with a clear, single objective, would better serve this goal. However, it should be understood that grain markets will never operate efficiently while there is a government-run storage system, as it will crowd out efficient private storage.

The restrictions on rural–urban migration and constraints on the development of urban centres, have also restricted opportunities to reduce the rural–urban income gap. The research shows that urbanisation has significant positive effects on rural incomes and regional economic growth. The devel-

opment of urban centres, particularly in inland regions, appears to be a matter of high priority. The 'keep them down on the farm' policy of China (and many other developing countries) seems to be partly due to a concern about problems associated with urban development, such as congestion and pollution. However, urban centres should be seen in a positive light. They exist because they provide efficiencies of scale and scope. Problems associated with cities largely derive from a lack of good infrastructure planning, inappropriate property rights to land, and inappropriate taxes and subsidies. China should therefore persist with infrastructure development to promote inland cities, as an offset to the geographical disadvantages of the inland regions. Otherwise, it will face continued pressures for migration to the coastal cities. Removal of the remaining restrictions on rural–urban migration, and the discrimination against rural migrants, should accompany promotion of the development of urban centres.

The results show that rural households in the coastal region will do best from the trade reforms as they have greater opportunities for earning income in off-farm employment. These opportunities arise because the non-agricultural industries in the eastern region benefit most from the trade reforms. This is partly the result of the bulk of private sector development having taken place in this region. The government should reduce its support of State-Owned Enterprises (SOEs) in the inland regions, which crowd out private enterprise.

The modelling has also shown that China's monetary policy regime, of a fixed yuan and capital controls, has increased the rural–urban income gap by raising real wages and reducing employment growth in the non-agricultural sectors. The results show that moving away from this monetary policy regime could lead to a much faster relocation of labour out of agriculture and a reduction in the rural–urban income gap.

A monetary policy regime change could also reduce the adverse impacts of the WTO trade reforms on the agricultural sector. Modelling with capital controls in place and a fixed exchange rate, results in almost the entire agricultural sector being adversely affected by the tariff reductions. Even partial relaxation of the monetary policy regime may reduce this adverse impact. For example, when capital controls are in place but the exchange rate is floated, the other crops, livestock and fisheries sectors expand.

However, the government is right to undertake any change in its monetary policy regime gradually and cautiously, as shown by the Asian financial crisis. Adoption of a floating exchange rate would be premature, considering the underdeveloped state of China's financial sector, its only partially reformed banking sector, and its still-vulnerable state-owned enterprises. The priority at this stage should be to accelerate the reforms in each of these areas.

Policy implications

China: food security or food self-sufficiency?

The analysis in this project has confirmed that structural change will lead to agriculture becoming a smaller and smaller part of the economy. The modelling has shown that trying to hold this development at bay by raising import barriers on agricultural products would have exorbitant costs. No doubt, however, there will continue to be resistance to agricultural reforms.

Poverty in China is primarily to be found in rural households. However, as this project has shown, non-farm income becomes a more and more important component of rural household incomes as development proceeds. Rural household incomes will not be increased by keeping out food imports so that domestic production increases.

Agricultural protection only raises the cost of food for everyone, reduces the extent of non-farm development in the economy, and reduces the opportunities for rural households to earn off-farm income. The best policy for China is to continue to reduce protection in agriculture, while simultaneously reducing the barriers to the movement of people out of farming into the industrial and service sectors.

WTO accession: exploiting China's comparative advantage

China is a very large country, with significantly different sub-economies that have different factor endowment patterns and therefore different comparative advantages. Moreover, there are large differences among regions in their stages of development. Consequently, agricultural policy reform (and other policy changes) will affect the various sub-economies and regions differently. Likewise, urban and regional households with different factor endowments and different income levels will be affected differently by the WTO trade liberalisation. Therefore, a key objective of the project was to assess the impact of WTO accession commitments on commodities, regions and households, and to suggest policy directions best suited to the different regional comparative advantages in this very large country.

China's economic development in the post-reform period is a good example of the productive, integrated roles that the different sectors—agriculture, manufacturing and services—can play. Writers such as Lewis (1954), Johnston and Mellor (1961), Mellor (1966), and Hazell and Roell (1983) highlighted the important backward and forward linkages from productivity growth in the agricultural sector in low-income countries. They argued that increasing agricultural output, through increasing land and labour productivity, reduces the price of food for both rural and urban consumers, which increases real incomes (this is particularly important for the poor, who spend 50–80% of their incomes on food).

The increased agricultural productivity also increases the incomes of farmers, despite the fall in output prices. It also increases rural employment (this is particularly important where there are substantial numbers of landless poor). The increased incomes of farmers raise their savings, which can be used to fund investment on the farm or in non-farm rural and urban activities. The higher incomes of farmers make them more important markets for domestically produced manufactures and services, including forward linkages to rural services, such as agricultural processing, and backward linkages to fertiliser and marketing services. The non-farm investment increases the opportunities for off-farm employment and leads to growth in the share of off-farm income in the incomes of rural households (for example, now 35–50% in countries such as China and Vietnam).

Countries that are relatively better endowed with labour than land, such as China, should focus on yield-increasing technologies. This increases labour productivity, but also increases the demand for labour and for modern intermediate inputs. In later stages of development, as employment opportunities outside agriculture increase, labour moves out

of agriculture and wages for farm labour increase. Labour productivity must continue to increase, and agricultural production change, if it is to retain its comparative advantage. So we observe, for example in the eastern regions of China, movement into higher value agricultural commodities, which are also labour-intensive.

Movement of labour out of agriculture into labour-intensive industries and shifting of agricultural production towards higher-value products, have been prominent features of China's development process. These trends illustrate the operation of the principle of comparative advantage.

The WTO accession commitments provide great opportunities for reforming China's agricultural sector; reforms that could lead to positive long-run effects on farmers' incomes. The liberalisation should push agricultural activity towards China's comparative advantages, leading to higher efficiency. There are indications that these changes are happening. For example, in 2002 the area sown to grain fell by 2% but grain output increased by 1%. Output of other agricultural products increased significantly. Sugarcane and beetroots together increased by 16 million tons in 2002, a 19% increase from 2001. Tea and fruit increased by 6% and 4% respectively. These developments indicate that further increases in efficiency in agricultural production are possible in response to the WTO challenge.

The gap between urban and rural incomes has widened over the past decade or so. Partly, this is an outcome of the very rapid growth of the urbanised industrial and services sector. But it is also the result of a slowing in the growth of rural incomes. This partly stems from the slowdown in the growth of the TVE sector and the reduced opportunities for rural households to earn off-farm incomes. However, incomes in the agricultural sector have not grown as rapidly as they should have because of poor agricultural policies, such as ineffective and costly price support policies, regional self-sufficiency policies, and monopolistic storage, marketing and distribution of bulk commodities, fertilisers and seeds (Lu 2001; Wang and Duncan 2003). China's accession to the WTO should help to maintain pressure to bring about reforms in these areas.

The analysis shows that among rural households, those in the coastal region will do best from the trade reforms; they have the greatest opportunities for earning income in off-farm employment. Their opportunities arise because the non-agricultural industries in the eastern region benefit most from the trade reforms; partly because the bulk of private sector development has taken place in this region. The government should therefore reduce its support of SOEs in the inland regions, which crowd out private enterprise. However, the private sector needs government to provide infrastructure to overcome the geographical disadvantages of the inland regions.

To improve incomes in all regions, agricultural policies should become more market-oriented and take full advantage of the differences in comparative advantage across China. Land-intensive and labour-intensive activities could then take place in those regions most suitable for these activities. There should be a move away from the emphasis on regional food self-sufficiency, as this goes against the principle of comparative advantage and reduces the efficiency of production in each region. The state monopolies in domestic marketing and distribution of bulk agricultural commodities, and in transport, should also be dismantled to allow goods to flow more freely across provincial borders.

China: monetary policy and the rural–urban income gap

Most other studies of China's WTO accession have focussed on its medium-term and long-run effects. However, there are important short-run issues, in particular those about the macro-economic policy environment in which the reforms take place. The study by Tyers and Rees (2002) in this project therefore examined the short-run effects of the reforms under macro-economic scenarios of capital controls, fixed and floating exchange rate regimes, and various fiscal policies.

The modelling has shown that China's monetary policy regime, of a fixed yuan and capital controls, has increased the rural–urban income gap by raising real wages and reducing employment growth in the non-agricultural sectors. The results show that moving away from this monetary policy regime could lead to a much faster relocation of labour out of agriculture and promote a reduction in the rural–urban income gap.

A monetary policy regime change could also reduce the adverse effects of the WTO trade reforms on the agricultural sector. Modelling with capital controls in place and a fixed exchange rate, results in almost the entire agricultural sector being adversely

affected by the tariff reductions. Even partial relaxation of the monetary policy regime may reduce this adverse effect. For example, when capital controls are in place but the exchange rate is floated, the other crops, livestock and fisheries sectors expand.

China: the need for increased urbanisation

One of the issues of most concern to Chinese policy makers in recent years, is the widening gap between rural and urban incomes and between regional incomes. Therefore, the researchers were very concerned to examine the effect of WTO accession on income disparities between rural and urban households and between households in China's major regions.

In economics it is important to always keep in mind that the causes of economic problems, particularly sectoral problems, are often to be found not in policies relating directly to the sector itself, but in policies directed at other sectors or even in macroeconomic policies. For example, agricultural export performance can be significantly affected by macroeconomic policies, such as exchange rate policy, or by industrialisation policies, such as import barriers, that restrict the movement of labour out of the agricultural sector. Therefore, the solution to rural problems may also be found in policies not directly related to that sector.

Rural industrialisation and urbanisation have increased since the adoption of market-oriented reforms. Such developments have provided close to 200 million additional, non-agricultural jobs to farmers in rural and urban areas since 1978. Still the number of farmers has increased and there appears to be more surplus agricultural labour than ever before.

Restrictions on migration within China—particularly the movement of people from rural areas to urban centres—have been an integral part of economic policy for many years. The concern of policy makers has been to manage the growth of urban centres and to avoid the problems of infrastructure bottlenecks and pollution that are widespread in rapidly growing cities.

However, slowing down rural–urban migration involves a trade-off between the costs of building the necessary infrastructure for rapidly growing cities, and the income foregone by the rural people who have not been allowed to take advantage of employment in urban centres. Therefore, one of the areas of research in the project was to examine the impact of the restrictions on rural–urban migration and how speeding up urban growth may assist in reducing the rural–urban income gap.

In 2001, the urbanisation rate (the urban population as a percentage of total population) in China reached 38%, whereas it was only 26% in 1990 and 19% in 1980. This was certainly a very rapid growth rate, reflecting, in part, the relaxation of central government controls over the growth of cities. It was also a result of the fact that the development of rural industries slowed in the late 1990s, mainly due to greater market competition, the unfavourable location of rural enterprises, difficulties in obtaining external finance, and lack of infrastructure facilities, technical inputs, and human resources.

Some of the restrictions on migration have been removed over the past decade or so. However, rural–urban migration is still partially restricted by the urban household registration system, job entry barriers, and non-access (or harder access) to services such as: housing, schooling, health care benefits, and public security protection for rural migrants. The low level, or lack, of rural education, job training, and employment information services are also barriers against rural–urban migration. Policy changes to remove these restrictions, to improve rural education, and to provide government services in job training and employment information services, are essential for accelerating urbanisation.

In their research for the project, Wang and Duncan (2003) noted that there is a positive relationship between rural industrialisation (measured as the share of TVE employment in rural labour) and rural incomes, and between the urbanisation rate and rural incomes. They therefore undertook a causality test of the relationship between urbanisation and regional economic growth. Because both urbanisation and rural incomes may be a function of economic growth, the causality test was carried out within an endogenous growth model. The results from the modelling indicate that: each percentage point increase in the urbanisation rate increases provincial economic growth by 0.37 percentage points above the already high 7–10% growth rate, i.e. urbanisation has a long-run beneficial effect on economic growth. When regional differences are taken into account, there are significant effects from urbanisation on economic growth in both the eastern and central regions, but the impact is insignificant in

the western region. There may be two reasons for this latter result: the rate of urbanisation in the western region has been low, and the urban economy in the western provinces has not experienced much restructuring and is, therefore, less market-oriented and less efficient.

Currently, urban economies provide limited opportunities for rural migrants because the number of cities is limited and the average size of cities is small. Expansion of the urban economy will provide more employment opportunities, especially in China's under-developed services sector, which accounts for a significantly higher percentage of GDP in the urban sector than in the rural sector. It is the government's responsibility to improve urban planning, and to provide urban infrastructure and public utilities, to promote urban development. With these changes, many small cities and towns can be expected to become large or medium sized cities.

The restrictions on rural–urban migration and constraints on the development of urban centres have also restricted opportunities for reduction of the rural–urban income gap. The research shows that urbanisation has significant positive impacts on rural incomes and regional economic growth. The development of urban centres, particularly in inland regions, appears to be a matter of high priority.

The concerns in China (and many other developing countries) about the development of urban centres seem to arise partly from a concern about problems associated with urban development, such as congestion and pollution. However, urban centres should be seen in a positive light. They exist because they provide efficiencies of scale and scope. Problems associated with cities largely derive from the lack of good planning of infrastructure, inappropriate property rights to land, and inappropriate taxes and subsidies. China should therefore persist with infrastructure development to promote inland cities as an offset to the geographical disadvantages of the inland regions. Otherwise, it will face continued pressures for migration to the coastal cities. Removal of the remaining restrictions on rural–urban migration, and the discrimination against rural migrants, should accompany the promotion of the development of urban centres.

China's adoption of trade liberalisation should push its agricultural production towards activities that are in accord with its comparative advantage, i.e. more labour-intensive activities. China's agricultural production has already seen a marked shift towards higher value-added products, such as fruit and vegetables and ornamental plants and flowers. Higher value-added products are more labour-intensive and should increase farm incomes and employment. Thus, WTO accession should also act to reduce the pressures for rural–urban migration.

The structure of the CERD model: a CGE model of the Chinese Economy with Regional Dimensions[1]

Introduction

Many general equilibrium models of the Chinese economy have been constructed (for examples see Lloyd and Zhang 2001). However, few models have included regional details due to data limitations. Yang and Huang (1997) used representative types of households to approximate the regional impacts of trade liberalisation. Diao, Fan and Zhang (2002) presented a general equilibrium model with partial disaggregation, i.e. distinguishing nine regions within agricultural sectors. The PRCGEM model (Fan and Zheng 2000, 2001) distinguished 124 commodities and 31 regions within China. However, strictly speaking, it is not a multi-regional model as it follows the tops-down approach, like the MONASH model (Peter et al. 1996). Moreover, the sectors are not sufficiently detailed to carry out food policy analysis.

This document describes the construction of the CERD general equilibrium model, which is based on the 1997 provincial input–output tables and therefore provides the best possible regional disaggregation of the Chinese economy.

Overview of CERD

As the name CERD suggests, it is a multi-regional model of the Chinese economy. It identifies 28 regions, with each region corresponding to one province, autonomous region, or municipality in mainland China. However, there are some exceptions, as Hainan, Ningxia and Tibet are included in Guangdong, Gansu and Qinghai respectively. Multi-regional models have generally followed the so called 'tops-down' approach, where a central model is solved and then the regional distribution is undertaken using the shares of the various regions, as, for example, in the MONASH model. By contrast, CERD uses the 'bottoms-up' approach. Each region in CERD is treated as an open economy with its own agents and behavioural functions, which are mainly drawn from the model presented in Yang and Huang (1997). As shown in Figure 1, agents in each region make their decisions on the demand for, and supply of, commodities and primary factors, and regional economies are linked through commodity and factor flows.

The diagram shows that CERD mimics a global model of multiple regions, like GTAP (Hertel 1997). However, it has some special features. First, the regional links in CERD are more intensive than in a global model, especially for the movement of primary factors. For example, in a global model labour is usually immobile across countries, while CERD

[1] This section is based on Jiang (2002a).

allows partial mobility across regions within China. Second, CERD assumes perfect mobility of capital across domestic regions and sectors.

As labour and capital can move across regional boundaries, it is important to distinguish between the use and ownership of these factors, to better calculate regional household income and consumption. This makes CERD superior to other CGE models.

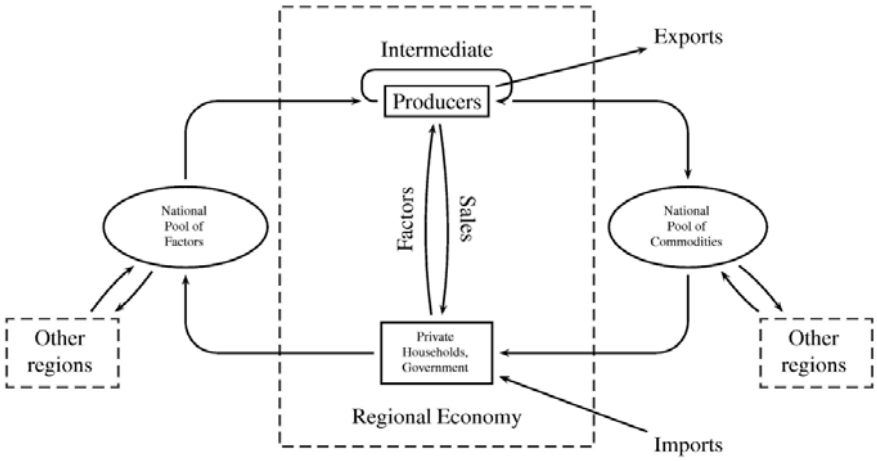

Figure 1. Structure of CERD

Another feature of CERD is that rural and urban households are distinguished in each region according to their possession of primary factors. This feature is very important, and appropriate, for the analysis of the Chinese economy where rural and urban areas are still separated to some extent because of several restrictions, although significant improvements have been made in reducing these restrictions. For example, the household registration system, which identifies a person as a rural or urban resident, is still in effect and prevents people from freely moving across regions, especially from countryside to cities.

Another difference between CERD and global models, or other China models, is its treatment of regional links. Ideally, inter-regional flows of commodities and factors would be presented in the model. However, such information is not available, as there are no 'customs posts' in each province to register 'imports' from, and 'exports' to, other provinces. To avoid arbitrary decisions in creating the database, CERD models inter-regional trade indirectly via a national pool of commodities and factors. Each region sells its excess supply to, and buys excess demand from, the national pool (Figure 1).

CERD also distinguishes regional and national governments, which allows the analysis of transfer payments between governments.

Finally, CERD has a fairly detailed representation of commodities. There are 51 sectors in the model, among which are 12 agricultural sectors, 25 industrial sectors, one construction sector, and 13 service sectors (see Table 27). The three most important food grains, wheat, paddy rice and corn, are separately identified.

Conventions

Variables

Each variable has two forms: in levels and percentage change. The former is represented by upper-case letters and the latter by lower-case letters. The relationship between these two representations is defined as:

$$x = \Delta X/X \times 100$$

In most cases, a variable is a vector or a matrix. For example, regional sectoral output, X or x, is a matrix with two dimensions: sector and region. Therefore, the range of arguments should be included in the variable name, e.g. $X(j, r)$ or $x(j, r)$, $j \in IND$, $r \in RGN$, where *IND* and *RGN* are, respectively, collections of sectors and regions called *sets*. If a specific value of the variable is concerned, e.g. wheat output in Jiangsu Province, it can be written as X("*wheat*", "*jiangsu*").

The following is an incomplete list of the most frequently used arguments in the discussion:

i commodity *j* sector *r* region *v* factor *d* destination *h* household *s* source.

The definitions of all variables used in CERD can be found in Table 28.

Equations

Most of the equations in CERD are expressed in linear form and conform to the General Equilibrium Modelling Package (GEMPACK) syntax as closely as possible. Below is a listing of the linear form of some basic functions:

Level form		Linear form
$Z = X \bullet Y$	$\Rightarrow$	$z = x + y$
$Z = X/Y$	$\Rightarrow$	$z = x - y$
$Z = X^a$	$\Rightarrow$	$z = \alpha \bullet x$
$Z = X + Y$	$\Rightarrow$	$Z. \bullet z = X \bullet x + Y \bullet y$ or $z = (X/Z)x + (Y/Z)y$

where X, Y and Z are level variables, x, y and z are the corresponding linear variables, and α is a parameter.

Coefficients and parameters

The above linear transformation has explicitly shown parameter α. Note that X, Y and Z appear in the last linear function. The purpose of linearising functions is to form a system of linear functions, so that a computer package (e.g. GEMPACK) can solve it. Therefore the values of X, Y and Z should be pre-set during each step of the simulation, that is, they cannot be treated as variables but are treated as *coefficients*. However, as they are associated with those level variables, their values should be updated after each step of the simulation (Harrison and Pearson 2002). In contrast, the value of parameter α does not change from one step of the simulation to another. Therefore, coefficients and parameters are different. To distinguish them, coefficients are denoted by upper-case letters and parameters by Greek letters.

As seen from the above discussion, there are two types of coefficients: absolute values, e.g. X, Y and Z, and shares, e.g. X/Z and Y/Z. To avoid excess notation, an absolute value

coefficient is given a name the same as its associated level variable in this document[2]. The names of share coefficients normally begin with "S", "SH" or "SHR".

Sets

As introduced above, a *set* defines the domain of a variable's argument. It is denoted by upper-case letters, e.g. *IND* and *RGN*, while its elements are usually denoted by lower case and put in quotation marks when referred to, e.g. "*wheat*" and "*jiangsu*". Table 29 lists all sets used in CERD.

Regional economies

There are three types of agents in each region: firms, private households and governments. This section describes the behaviour of these agents.

Firms

Demand for primary factors

Each sector in each region is represented by a firm producing a single commodity. Perfect competition and constant returns to scale are assumed for all firms. Production is modelled by a nest of technologies (Figure 2).

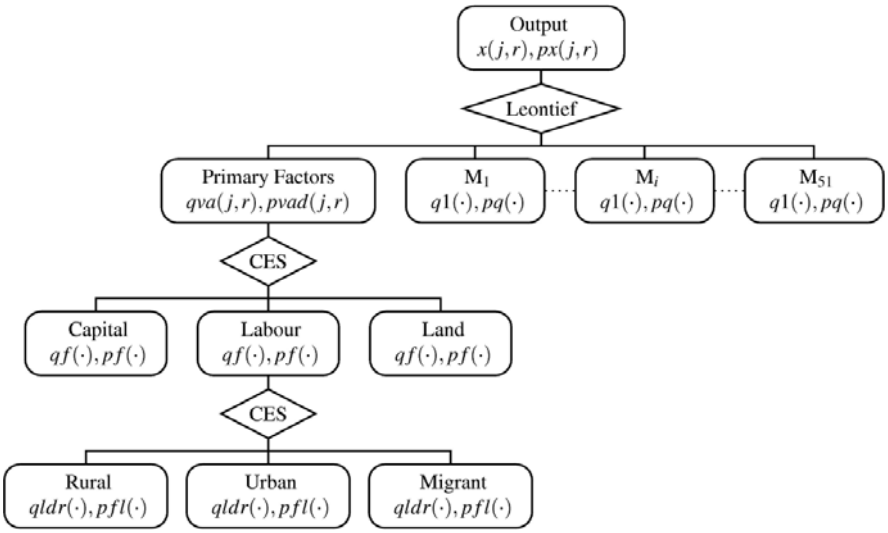

Figure 2. Production nesting

At the first tier of the nest, the technology is Leontief, that is, the production of a good, $X(j, r)$, requires fixed proportions of intermediate inputs, $Q1(i, j, r)$, and aggregated primary factors, or value added, $QVA(j, r)$:

[2] The treatment in the computer coding is different. As GEMPACK does not distinguish between upper and lower case letters, coefficients are given a name different to associated linear variables.

$$QI(i,j,r) = \frac{SQ(i,j,r) \cdot X(j,r)}{AO(j,r) \cdot AI(i,j,r)} \qquad \forall i \in COM, j \in IND, r \in RGN$$

$$QVA(j,r) = \frac{SVA(j,r) \cdot X(j,r)}{AO(j,r) \cdot AVA(j,r)} \qquad \forall j \in IND, r \in RGN$$

where $SQ(i, j, r)$ and $SVA(j, r)$ are, respectively, shares of intermediate inputs and value added in output; $AO(j, r)$, $AI(i, j, r)$ and $AVA(j, r)$ are, respectively, output-, input-, and value added-augmenting technical changes. The linearised versions of these two equations are represented by equations (1) and (2) in Table 15. The shares do not appear in the linearised equations because they are fixed, by definition.

At the second tier, the value added is an aggregation of labour, capital, and land with constant elasticity of substitution (CES):

$$QVA(j,r) = AF(j,r)\left[\sum_{v \in FAC} (SF(v,j,r))^{\frac{1}{\sigma_p(j)}} (QF(v,j,r))^{\frac{\sigma_p(j)-1}{\sigma_p(j)}}\right]^{\frac{\sigma_p(j)}{\sigma_p(j)-1}}$$

where $AF(j, r)$, $SF(v, j, r)$ and $\sigma_p(j)$s are, respectively, the technological shifters, the shares of individual factors, and the elasticities of substitution between factors. A profit maximising firm's demand for primary factors is determined by:

$$QF(v,j,r) = SF(v,j,r)\left[AF(j,r)\right]^{\sigma_p(j)-1} QVA(j,r)\left[\frac{PVAD(j,r)}{PF(v,j,r)}\right]^{\sigma_p(j)}$$

where $PVAD(j, r)$ and $PF(v, j, r)$ are, respectively, prices of value added and individual primary factors. The linearised demand function is represented by equation (3) in Table 15. Equation (4) states that the price of the value added is the average of factor prices.[3]

The demand for intermediate inputs, combined with the demand of households and government and other demands, will be discussed later. The demand is a CES aggregation of commodities from different sources.

At the third tier, demands for different types of labour are determined. The labour demand by non-agricultural sectors is a CES aggregation of rural, urban and migrant labour, while agricultural sectors demand only rural labour. Therefore, there are four types of labour in the demand side: "*agri*" labour, which is rural labour used in agricultural sectors; and "*rural*", "*urban*" and "*migrant*" labour, which are used in non-agricultural sectors (see Figure 3).

[3] This form of average is true for CES and CET functions. Suppose Q is a CES aggregation of Q_1 and Q_2. The price of Q is determined by $PQ = P_1Q_1 + P_2Q_2$. Taking the total differential of this equation and dividing both sides by PQ gives:

$$p + q = \frac{P_1Q_1}{PQ}(p_1 + q_1) + \frac{P_2Q_2}{PQ}(p_2 + q_2) \ .$$

Applying the relations $q_1 = q + \sigma(p - p_1)$ and $q_2 = q + \sigma(p - p_2)$ into the above equation and collecting items gives:

$$p = \frac{P_1Q_1}{PQ} p_1 + \frac{P_2Q_2}{PQ} p_2 \ .$$

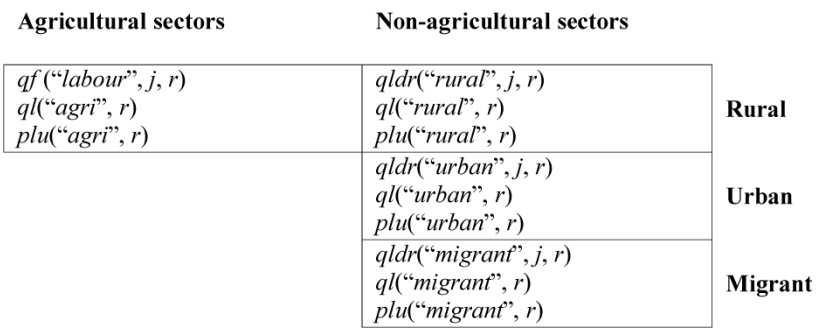

Figure 3. Demand for different types of labour

Equation (5) in Table 15, which has a form similar to equation (2), determines the demand for "*rural*", "*urban*", and "*migrant*" labour in each of the non-agricultural sectors. Equation (6) aggregates the prices of these three types of labour. Equations (7) and (8) assign labour prices, which imply that each type of labour has the same price even when being employed in different sectors. Equations (9) and (10) calculate the total demand for each type of labour in a region.

Sales of products

Commodities produced by firms are sold to three destinations: local (regional) market, other regions in China, and overseas (exports). The sales to each destination are modelled as a process with a constant elasticity of transformation (CET). Equation (11) in Table 16 shows that the sales to a destination are determined by the amount of the commodity concerned, $com(i, r)$, the relative price of the commodity in each destination, $pp(i, r, d) - px(i, r)$, and the elasticity of transformation, σ_t. Equation (12) states that the commodity price is an aggregation of prices in every destination.

Households

There are two types of households, rural and urban, in each region. They are classified according to their possession of primary factors. Rural households own all primary factors used in agricultural sectors and part of the factors used in non-agricultural sectors. The share of rural households in non-agricultural factors is drawn from the share of township and village enterprises (TVEs) in different sectors.

Supply of primary factors

Each household owns an endowment of primary factors, $QFAH(v, h, r)$, and allocates the endowment to different uses according to the CET process. The factor supply functions are grouped in Table 17.

Labour is divided into rural and urban labour. Labour supplied by the rural household can be used in all sectors in its own region as well as in other regions, i.e. as migrant labour. By contrast, labour supplied by the urban household can be used only in non-agricultural sectors in its own region (Figure 4). These assumptions are based on the fact that currently there is a huge amount of surplus labour in rural areas and that urban households are not willing to engage in agricultural activities.

Equation (13) in Table 17 determines rural households' supply of the different types of labour in a region, *qlrh*(*l*, *r*), $l \in LU1$ = {"*agri*", "*nagr*", "*migrant*"}, in a typical CET format. The supply of each type of labour is determined by each rural household's endowment of labour, *qfah*("*labour*", "*rural*", *r*), the relative price of the particular type of labour, *pl*(*l*, *r*) – *plr*(*r*), and the elasticity of transformation, δ_1. Note that a slack variable, *qlslack*(*l*, "*rural*", *r*), is also included in order to model unemployment in some model closures.

	Rural household *qfah("labour","rural", r)* *plr(r)*	**Urban household**
Agricultural sectors	*qlrh("agri",r)* *pl("agri",r)*	
Non-agricultural sectors	*qlrh("nagr",r)* *pl("nagr",r)*	*qfah("labour","urban",r)* *pl("urban",r)*
Other: Migrant	*qlrh("migrant",r)* *pl("migrant",r)*	

Figure 4. Supply of different types of labour

Equation (14) determines the aggregated price of labour supplied by the rural household, *plr*(*r*), in a form explained in footnote (3). Migrant labour moves into a national pool, which is discussed in the regional linkage section.

It is assumed that capital is perfectly mobile across regions and sectors, and there is no difference between capital owned by rural households and that owned by urban households. Therefore, there is no specific transformation function governing the supply of capital to each sector in each region. Only a summation equation (15), is needed to calculate the total supply of capital, which will be equal to total demand set by the market clearing condition (equation 50). Capital in every region has the same price, as suggested by equation (16).

Land is owned only by rural households. It is not mobile across regions, but is partly mobile across agricultural sectors. The imperfect mobility of land reflects both natural and policy restrictions on land uses. No land is used in non-agricultural sectors. Similarly, the supply of land to each (agricultural) sector, *qas*(*j*, *r*), is determined by a CET process described by equation (17)—exactly the same as the GTAP model—depending on the household's endowment of land, *qfah*(*"land"*,*"rural"*, *r*), the relative price of land in the sector concerned, *pas*(*j,r*) – *pf*a(*"land"*, *r*), and the elasticity of transformation, $\delta_4(r)$. Equation (18) aggregates sectoral land prices into a single regional price.

Household income

Table 18 describes the calculation of household income. The primary source of household income is returns to factors. Incomes are calculated separately for rural and urban households. Rural household gross income, *y_g*("*rural*", *r*), is the sum of revenues from supplying land, capital and labour (equation 19), while urban household gross income, *y_g*("*urban*", *r*), is the sum of revenues from supplying capital and labour (equation 20). Each household's net income, *y_n*(*h*, *r*), is its gross income net of income taxes (equation 21), while each household's disposable income, *y_d*(*h*, *r*), is net income plus government transfer payments, *transf_r*(*h*,*r*) (equation 22).

It should be noted that, in equations (19) and (20), each household's income is calculated according to its possession of primary factors *qfah*(*v*, *h*, *r*), rather than the use of them. This is necessary for the accuracy of regional income calculations because of the mobility of labour and capital. This specification might lead to some bias in the calculation because of migrant labour. Specifically, it may underestimate (overestimate) income, and thus the consumption, of regions with net inflows (outflows) of migrant labour. However, most migrant labourers are seasonal workers and send most of their earnings back to their households. In this sense, the current approach is more accurate than that based on the use of factors. If it is found that more migrants choose to reside in their work place permanently, the calculation could be adjusted by changing *qfah*(*"labour"*, *h*, *r*) in the current framework.

Household saving and consumption

Each household allocates its disposable income to savings and consumption. Saving is a fixed proportion of disposable income, determined by the marginal propensity to save, *save_p*(*h* , *r*), (equation 23 in Table 19). The remaining disposable income, *y_c*(*h*, *r*), is for consumption (equation 24).

Household consumption is modelled by a constant difference in elasticity (CDE) system. CDE functions are more flexible than CES functions in modelling consumer behaviour, and are used by the GTAP model (Hertel 1997). The relationship between per capita utility, *uc*(*h*, *r*), and per capita real consumption expenditure, *y_c*(*h*, *r*) – *cpi*(*h*, *r*) – *pop*(*h*, *r*), is given by equation (25), and the consumption demand for individual commodities, *q*3(*i*, *h*, *r*), is given by equation (26). With this CDE system, the cross-price and income elasticities, *EP* (*i*, *k*, *h*, *r*) and *EY* (*i*, *h*, *r*) are not constant, as suggested by equations [b] and [c] in Table 19. Other equations in the table show some necessary calculations of coefficients for the system, including the Engel summation, *ENGEL* 0(*h*, *r*), in equation [a], and the Allen partial elasticity of substitution between commodities, *APE* (*i*, *k*, *h*, *r*) in [d1] and [d2].

Government

There are two levels of government: regional and central. To simplify the treatment, it is assumed that tax collections (except import tariffs and export taxes), government saving, and consumption are made by regional governments, while the central government serves only to transfer payments to regional governments.[4] Therefore, each regional government's revenue, calculated by equation (27) in Table 20, is the sum of consumption, production and income taxes and the transfers from the central government, while the central government collects import tariffs and export taxes, as suggested by equation (28). The behavioural equations of the central government could be suppressed in the model so long as its budget constraint (29) is imposed.

Each regional government's saving and consumption behaviour (shown in Table 21) is similar to that of private households (see Table 19). First, a fixed proportion of total government revenue, *save*("*gov*", *r*), is saved according to the government's propensity to save, *save_p*("*gov*", *r*), as suggested by equation (30). The remaining revenues are then

[4] If the central government was allowed to consume, it would also make decisions about where the commodities are bought and spent. This would unnecessarily increase the burden of computation as this activity can been embodied in the decision-making process of individual regional governments.

allocated to consumption, *govconv*(*r*), or transferred to individual private households in the region, *transf_r*(*h*, *r*). The transfer payment is a policy instrument and set exogenously; therefore the government's consumption expenditure can be determined by equation (31).

Once the expenditure on consumption is determined, the government's utility from consumption, *uc*("*gov*", *r*), is determined by equation (32), which, in turn, determines government demand for each commodity, *q*5(*i*, *r*), through equation (33). The demand function (33) implies that government's utility is a Cobb-Douglas function of the consumed commodities.

Other demands

Investment

Equations (34)–(36) in Table 22 describe regional investment demand. Regional aggregate real investment, *ir*(*r*), is determined by the relative prices of returns to capital, *pfa*("*capital*", *r*), the price of investment goods, *ip*(*r*), and the elasticity of investment, $\gamma(r)$ (equation 34). The commodities used in the production of this aggregate investment, *q2*(*i*, *r*), are given by equation (35), which implies that the aggregate investment is a Cobb-Douglas function of individual commodities. Equation (36) aggregates the prices of individual commodities into the price of investment. National investment is the sum of regional investments, which is discussed in the regional linkage section.

Demand for exports

Equations (37) and (38) determine the world demand for exports.

$\sum_{s \in WLD} S1(i,s) \cdot pe(i,s)$ shows the average export price of commodity *i*, and

$\sum_{l \in COM} \sum_{s \in WLD} S2(l,s) \cdot pe(l,s)$ the average export price of all commodities.

Therefore, world demand for exports of a commodity, *qw*4(*i*), is determined by the relative price of commodity *i* in the world market, and the elasticity of export, $\beta(i)$. The world demand for exports is split into demand for exports from China and demand from the rest of the world, *q*4(*i*, *s*), $s \in WLD = \{$"*chn*", "*row*"$\}$, through a typical CES process.

Regional commodity demand

As shown in Figure 5, regional demand for a commodity, *Q*(*i*, *r*), is the sum of each firm's demand for intermediate goods and services, investment demand, and consumption demand of households and the government:

$$Q(i,r) = \sum_{j \in IND} Q1(i,j,r) + Q2(i,r) + \sum_{h \in HHD} Q3(i,h,r) + Q5(i,r)$$

The linearised form is given by equation (39) in Table 23.

Total demand is a CES aggregation of demands for imported and domestically produced goods; with the latter, in turn, a CES aggregation of goods produced locally, i.e. within the region, and those from other regions, i.e. the national pool. Equations (40)–(43) calculate the user prices of, and demand for, goods from different sources.

This type of demand nesting has a couple of advantages. Firstly, it allows different elasticities of substitution between domestic and imported goods and between goods from different domestic regions. This reflects the usual perception that the domestic market is more

integrated than the global market. Secondly, as almost all models distinguish domestic and foreign products, this nesting permits the use of parameters drawn from other models.

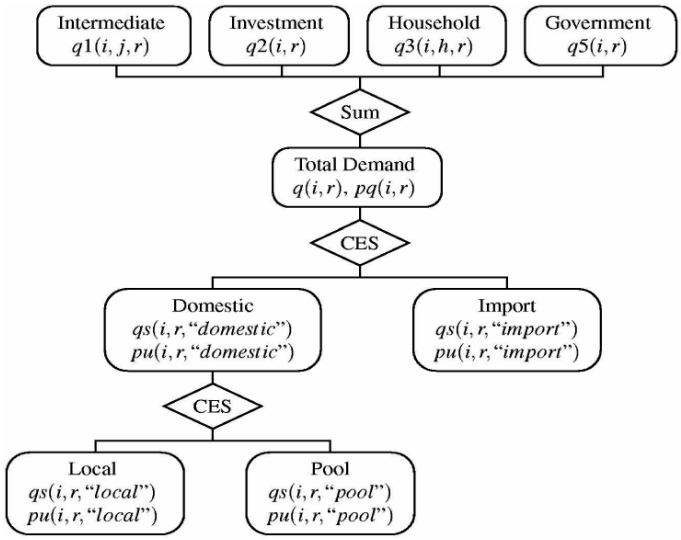

Figure 5. Regional commodity demand

Regional linkages

This section describes the links between regions and between domestic and world markets. The regional market equilibrium conditions are also introduced in this section, as they involve demand and supply from outside the region.

Factor markets

As shown in Figure 3, there are four types of labour in the demand side: rural labour used in agricultural sectors, *ql*("*agri*", *r*); and rural, urban and migrant labour used in non-agricultural sectors, *ql*("*rural*", *r*), *ql*("*urban*", *r*) and *ql*("*migrant*", *r*). There are also four types of labour in the supply side as shown in Figure 4: agricultural and non-agricultural labour supplied by rural households, *qlrh*("*agri*", *r*) and *qlrh*("*nagr*", *r*); labour supplied by urban households, *qfah*("*labour*", "*urban*", *r*); and migrant labour supplied by rural households, *qlrh*("*migrant*", *r*). The markets for the first three types of labour in each side can be equated within one region, as presented by equations (44)–(46) in Table 24, while the migrant labour market clearing conditions are more complicated.

As illustrated in Figure 6, migrant labour in the national pool is the sum of migrant labour supplied by each region; they are then allocated to each region to meet the demand according to a CET process. Equations describing these processes are given by equations (47) and (48) in Table 24. Equation (49) calculates the national price of migrant labour, *plms*. It should be noted that *plms* is the aggregation (or average) of the user price of migrant labour in each region, *plu*("*migrant*", *r*), rather than the average of the supply price, *pl*("*migrant*", *r*). This

may reflect the fact that the migrant labour market is to some extent a buyer's market. The supply of migrant labour in rural households depends on its perceived price, or the price from the hypothetical national pool, which is a mixture of user prices in all regions.

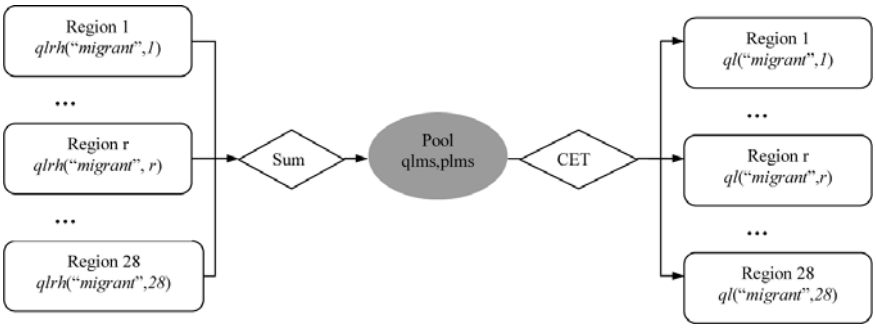

Figure 6. National migrant labour market

Because capital is perfectly mobile across regions and sectors, the market clearing condition (equation 50) simply equates the total demand and supply. On the other hand, land is partly mobile across agricultural sectors within a region, therefore, its supply and demand should be matched for each (agricultural) sector in each region, as stated by equation (51), similar to the structure of GTAP.

Commodity markets

Commodity market clearing conditions are grouped in Table 25. Equation (52) equates the supply of, and demand for, locally produced commodities. Equation (53) calculates the world supply of imports to China, *qms*(*i*), which depends on the elasticity of import supply, ε(*i*), and the world price, *pm*(*i*). In equation (54) this import supply satisfies the total demand for imports from all regions.

Equation (55) presents the market clearing condition for the export market, in which total exports equal the sum of exports from the regions.

Equations (56)–(58) describe the market clearing conditions for commodity markets in the national pool in a similar manner to the market clearing for migrant labour. First, the amount of a commodity in the national pool, *cdo*(*i*), is a sum of the supply of that commodity from all regions, *cd*(*i*, *r*, "*pool*"), as stated by equation (56). Then *cdo*(*i*) is allocated to individual regions to meet their demand according to a CET process given by equation (57). The allocation depends on the elasticity of transformation, $\sigma_d(i)$, and the price of the commodity in each region, *por*(*i*, *r*), relative to the price in the pool, *po*(*i*). Equation (58) aggregates regional prices into the national price.

Price linkages

The price linkage equations are given in Table 26. Equation (59) is the zero pure profit condition, which determines the producer's price of commodity *i* in region *r*, *pps*(*i*, r). Since the firms are assumed to maximise profits, the quantity changes drop out when the net profit equation is totally differentiated in the neighbourhood of an optimum (see, e.g. Varian 1978). This leaves an equation relating the input price and the output price, where

these percentage changes are weighted by value for the agent's price. For computational convenience we use different variables to refer to the firm's prices for composite intermediate inputs (*pq*) and endowment commodities (*pf*).

Most of the remaining equations in Table 26 describe the relationship between supply and demand prices of a commodity or a primary factor. The difference between supply and demand prices arises from various taxes and transaction costs.

Equation (60) defines producer price including indirect tax. The power of indirect tax (*ti*) is defined in equation (74).

Equation (61) describes the linkages between market prices and agents' purchase prices of commodities produced locally. The price difference is caused by commodity taxes (*tca* and *tc*). These commodity taxes can potentially vary, not only across commodities, but also across regions. However, the tax on a commodity from different sources (local, imports, or other domestic regions) in the same region has the same value.

Equations (62) through (64) refer to the procedures for importing commodities from overseas into the national import commodity pool, and then from the national import commodity pool to the regional markets. These equations show the effects of import tariffs (*tm*), defined by equation (73), exchange rates (*phi*), transportation costs (*tmtr*) and commodity taxes on the import price in each region.

Equation (65) links the commodity price in the pool to the agents' purchase price by adding commodity taxes and transport costs (*totr*).

Equation (66) links the export price in specific regions (*pp*) to the national export commodity pool (*ppex*). Equation (67) shows the relationship between prices in the national export pool (*ppex*) and China's export price valued in foreign currency (*pe*).

Equations (68) through (72) link the demand and supply prices of land, capital and labour. As labour is of four types (i.e. agricultural labour, rural labour in the non-agricultural sector, migrant labour, and urban labour), and the CERD model allows the labour supply tax (*tfl*) to differ by region and labour type, there are four equations to reflect such relationships.

Figures 7 and 8 illustrate the commodity price and factor price linkages in the CERD model.

Data

Input–output data

A feature of CERD is that its database was compiled on the basis of the provincial 44-sector input–output tables for 1997.[5] The 44-sector classification follows the 40-sector classification in the 1997 national input–output table (National Accounts Department 1999), with the agricultural sector further disaggregated into five sections. There are 28 provincial tables available.[6] These provincial input–output data were aggregated in the model into three regions. The eastern coastal region includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Guangxi and

[5] China's 1997 provincial input–output tables are the latest tables available for this project. The 2002 national and regional input–output tables for China have not been officially released. The database of the CERD model can be updated if the new provincial input–output tables become available.

[6] Input–output tables for Hainan, Ningxia and Tibet are not available.

Hainan; the central region includes Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan; and the western region includes Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Ningxia, Qinghai, Tibet and Xinjiang.

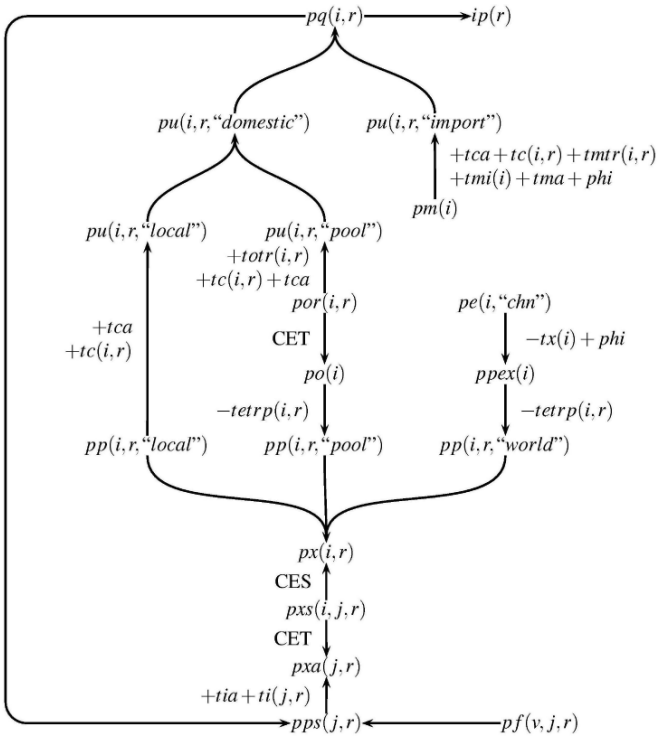

Figure 7. Commodity price linkages

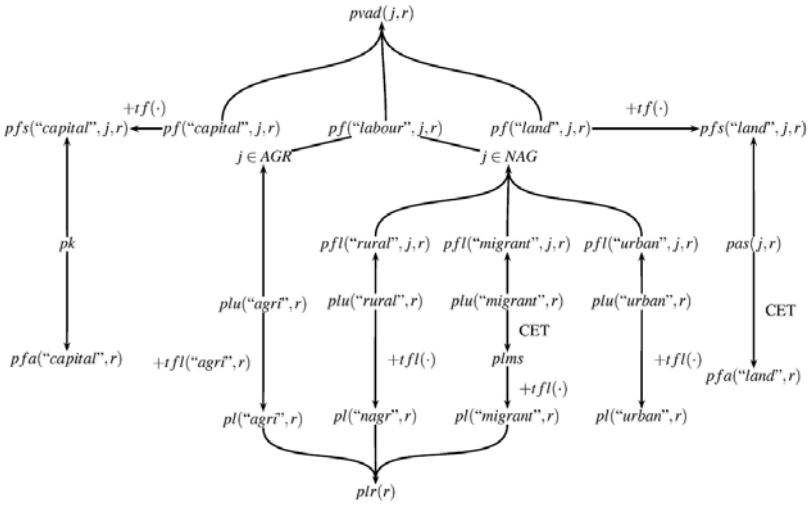

Figure 8. Factor price linkages

To analyse the impact of China's WTO accession on the agricultural sector in more detail, the crops sector in the original 44-sector table was split into nine sectors: rice, wheat, corn, pulses, other grains, cotton, oilseeds, vegetables and fruits, and other crops. The split was based on the provincial crops production database (Ministry of Agricultural and State Planning Commission 2001, unpublished data).

Other data and parameters were drawn from GTAP database 5, Yang and Huang (1997) and the China Statistical Yearbook series.

Regional trade

Five provinces (Anhui, Chongqing, Guizhou, Heilongjiang and Shandong) have data on net exports only.

An ideal way to model inter-regional trade would be to identify each region's inflows from, and outflows to, each of the other regions. However, such data are not available. Therefore, two alternative ways could be offered. First, a probability model is used to predict the trade between two regions, which is then adjusted by a gravity model. The distance between the two regions adversely affects trade.

$$Trade = f(DS)$$

Second, inter-regional trade is modelled via a national pool. There is no direct trade between the two regions. The national pool serves as an intermediary for regional trade. CERD models inter-regional trade indirectly via a national pool of commodities and factors. Each region sells its excess supply to, and buys excess demand from, the national pool. These relationships have been described above.

Model closure

Endowments of primary factors are exogenous. There are labour-slack variables to allow for unemployment. But in the simulations described above these slack variables are set at zero, leaving wages to adjust for full employment.[7]

All tax rates including tariff rates and technological shifters are set exogenously. Exogenous tax rates imply that government revenues will change along with changes in production, income and trade. The share of transfer payments from central government to regional governments does not change; that is, payments to each region change at the same rate.

The marginal propensities to save are fixed, although they vary across households and regions. The difference between national savings and aggregate investment is the net capital inflow, which is equal to the trade deficit. The model allows two closures to simulate the effects of trade liberalisation: no control on the trade balance, and forcing the change in the trade balance to be zero.

[7] The treatment here implies no change in the employment (or unemployment) level embodied in the database.

Table 15. Firms' demand for intermediate and primary factors

(1) Intermediate demand

$$ql(i,j,r) = x(j,r) - ao(j,r) - ai(i,j,r) \qquad \forall i \in COM, j \in IND, r \in RGN$$

(2) Value-added demand

$$qva(j,r) + ava(j,r) = x(j,r) - ao(j,r) \qquad \forall j \in IND, r \in RGN$$

(3) Primary factors demand

$$qf(v,j,r) = qva(j,r) - af(v,j,r) - \sigma_p(j) \cdot [pf(v,j,r) - af(v,j,r) - pvad(j,r)] \qquad \forall v \in FAC, j \in IND, r \in RGN$$

(4) Aggregated value-added price

$$pvad(j,r) = \frac{\sum_{v \in FAC} IF(v,j,r) \cdot [pf(v,j,r) - af(v,j,r)]}{\sum_{v \in FAC} IF(v,j,r)} \qquad \forall j \in IND, r \in RGN$$

(5) Demand for different types of labour by non-agricultural sectors

$$qldr(l,j,r) = qf("labour",j,r) - \sigma_l(j) \cdot [pfl(l,j,r) - pf("labour",j,r)] \qquad \forall l \in LS1, j \in NAG, r \in RGN$$

(6) Demand prices for labour by non-agricultural sectors

$$pf("labour",j,r) = \frac{\sum_{l \in LS1} [LR(l,j,r) \cdot pfl(l,j,r)]}{\sum_{l \in LS1} LR(l,j,r)} \qquad \forall j \in NAG, r \in RGN$$

(7) Labour prices in agricultural sector are equal

$$pf("labour",j,r) = plu("agri",r) \qquad \forall j \in AGR, r \in RGN$$

(8) Labour prices used by different non-agricultural sectors are the same

$$pfl(l,j,r) = plu(l,r) \qquad \forall l \in LS1, j \in NAG, r \in RGN$$

(9) Demand for agricultural labour by agricultural sectors

$$ql("agri",r) = \frac{\sum_{j \in AGR} [IF("labour",j,r) \cdot qf("labour",j,r)]}{\sum_{j \in AGR} IF("labour",j,r)} \qquad \forall r \in RGN$$

(10) Demand for different types of labour by non-agricultural sectors

$$ql(l,r) = \frac{\sum_{j \in NAG} [LR(l,j,r) \cdot qldr(l,j,r)]}{\sum_{j \in NAG} LR(l,j,r)} \qquad \forall l \in LS1, r \in RGN$$

Coefficients:

$$IF(v,j,r) = PF(v,j,r) \cdot QF(v,j,r) \qquad \forall v \in FAC, j \in IND, r \in RGN$$

$$LR(l,j,r) = PFL(l,j,r) \cdot QLDR(l,j,r) \qquad \forall l \in LS1, j \in NAG, r \in RGN$$

Table 16. Firms' supply of products

(11) Sale to different destinations (Demand by different destinations)

$$cd(i,r,d) = com(i,r) + \sigma_t(i) \cdot [pp(i,r,d) - px(i,r)] \qquad \forall i \in COM, r \in RGN, d \in DST$$

(12) Aggregated price of different destinations

$$\sum_{d \in DST} DSP(i,r,d) \cdot px(i,r) = \sum_{d \in DST} DSP(i,r,d) \cdot pp(i,r,d) \qquad \forall i \in COM, r \in RGN$$

Coefficients:

$$DSP(i,r,d) = PP(i,r,d) \cdot CD(i,r,d) \qquad \forall i \in COM, r \in RGN, d \in DST$$

Table 17. Households' supply of primary factors

(13) Supply of different types of labour by rural households

$$qlrh(l,r) = qfah("labour","rural",r) + \delta_1[pl(l,r) - plr(r)] - qlslack(l,"rural",r) \qquad \forall l \in LU1, r \in RGN$$

(14) Aggregated price of labour supplied by rural households

$$plr(r) = \sum_{l \in LU1} SHRLABR(l,r) \cdot pl(l,r) \qquad \forall r \in RGN$$

(15) Market clearing equation for capital

$$qk = \sum_{r \in RGN} \sum_{h \in HHD} SHCAP(h,r) \cdot qfah("capital",h,r)$$

(16) Capital is perfectly mobile between regions

$$pfa("capital",r) = pk \qquad \forall r \in RGN$$

(17) Supply of land to different agricultural sectors

$$qas(j,r) = qfah("land","rural",r) + \delta_4(r) \cdot [pas(j,r) - pfa("land",r)] \qquad \forall j \in IND, r \in RGN$$

(18) Aggregated price of land

$$pfa("land",r) = \sum_{j \in IND} SHLAND(j,r) \cdot pas(j,r) \qquad \forall r \in RGN$$

Coefficients:

$$SHRLABR(l,r) = \frac{PL(l,r) \cdot QLRH(l,r)}{\sum_{l \in LU1} PL(l,r) \cdot QLRH(l,r)} \qquad \forall l \in LU1, r \in RGN$$

$$RF("labour","rural",r) = PLR(r) \cdot QFAH("labour","rural",r) \qquad \forall r \in RGN$$

$$RF("labour","urban",r) = PL(r) \cdot QFAH("labour","urban",r) \qquad \forall r \in RGN$$

$$RF("capital",h,r) = PK \cdot QFAH("capital",h,r) \qquad \forall h \in HHD, r \in RGN$$

$$RF("land",h,r) = PFA("land",r) \cdot QFAH("capital",h,r) \qquad \forall h \in HHD, r \in RGN$$

$$SHCAP(h,r) = \frac{RF("capital",h,r)}{\sum_{r \in RGN} RF("capital",h,r)} \qquad \forall h \in HHD, r \in RGN$$

$$SHLAND(j,r) = \frac{PAS(j,r) \cdot QAS(j,r)}{\sum_{j \in IND} PAS(j,r) \cdot QAS(j,r)} \qquad \forall j \in IND, r \in RGN$$

Table 18. Household income

(19) Rural household gross income

$$INCOMES\_G("rural",r)\cdot y\_g("rural",r)$$
$$= RF("land","rural",r)\cdot\left[pfa("land",r)+qfah("land","rural",r)\right]$$
$$+ RF("capital","rural",r)\cdot\left[pk+qfah("capital","rural",r)\right]$$
$$+ RF("labour","rural",r)\cdot\left[plr(r)+qfah("labour","rural",r)\right] \qquad \forall r\in RGN$$

(20) Urban household gross income

$$INCOMES\_G("urban",r)\cdot y\_g("urban",r)$$
$$+ RF("capital","urban",r)\cdot\left[pk+qfah("capital","urban",r)\right]$$
$$+ RF("labour","urban",r)\cdot\left[pl("urban",r)+qfah("labour","urban",r)\right] \qquad \forall r\in RGN$$

(21) Household net income

$$y\_n(h,r)=y\_g(h,r)-tya-ty(h,r) \qquad \forall h\in HHD, r\in RGN$$

(22) Household disposable income

$$INCOMES\_D(h,r)\cdot y\_d(h,r)=INCOMES\_N(h,r)\cdot y\_n(h,r)$$
$$+RTRANSF(h,r)\cdot transf\_r(h,r) \qquad \forall h\in HHD, r\in RGN$$

Coefficient:

$$INCOMES\_G(h,r)=\sum_{v\in FAC}RF(v,h,r) \qquad \forall h\in HHD, r\in RGN$$
$$INCOMES\_N(h,r)=INCOMES\_G(h,r)-TAXINC(h,r) \qquad \forall h\in HHD, r\in RGN$$
$$INCOMES\_D(h,r)=INCOMES\_N(h,r)+RTRANSF(h,r) \qquad \forall h\in HHD, r\in RGN$$
$$RTRANSF(h,r)=TRANSF\_R(h,r) \qquad \forall h\in HHD, r\in RGN$$

Table 19. Household saving and consumption

(23) Household saving

$$save(h,r) = save\_p(h,r) + y\_d(h,r) \qquad \forall h \in HHD, r \in RGN$$

(24) Households' expenditure for consumption

$$INCOMES\_D(h,r) \cdot \left[y\_d(h,r) + bgtslack(h,r) \right]$$
$$= CON(h,r) \cdot y\_c(h,r) + SAVINGS(h,r) \cdot save(h,r) \qquad \forall h \in HHD, r \in RGN$$

(25) Private consumption utility

$$y\_c(h,r) = cpi(h,r) + ENGEL0(h,r) \cdot uc(h,r) + pop(h,r) \qquad \forall h \in HHD, r \in RGN$$

(26) Consumption demand for individual commodities by household

$$q3(i,h,r) = \sum_{k \in COM} EP(i,k,h,r) \cdot pq(k,r)$$
$$+ EY(i,h,r) \cdot \left[y\_c(h,r) - pop(h,r) \right] + pop(h,r) \qquad \forall i \in COM, h \in HHD, r \in RGN$$

Coefficients and Parameters:

$$SAVINGS(h,r) = SAVE(h,r) \qquad \forall h \in HHD, r \in RGN$$

$$CONS(i,h,r) = PQ(i,r) \cdot Q3(i,h,r) \qquad \forall i \in COM, h \in HHD, r \in RGN$$

$$CON(h,r) = \sum_{i \in CMM} CONS(i,h,r) \qquad \forall h \in HHD, r \in RGN$$

[a] $$ENGEL0(h,r) = \sum_{i \in CMM} SHRC(i,h,r) \cdot \gamma(i,r) \qquad \forall h \in HHD, r \in RGN$$

[b] $$EP(i,k,h,r) = \left[APE(i,k,h,r) - EY(i,h,r) \right] \cdot SHRC(k,h,r) \qquad \forall i,k \in COM, h \in HHD, r \in RGN$$

[c] $$EY(i,h,r) = \frac{\beta(i,h) \cdot \gamma(i,h) + \sum_{m \in COM} SHRC(m,h,r) \cdot \gamma(m,h) \cdot \alpha(m,h,r)}{\sum_{m \in COM} SHRC(m,h,r) \cdot \gamma(m,h)}$$
$$+ \alpha(i,h,r) - \sum_{m \in COM} SHRC(m,h,r) \cdot \alpha(m,h,r) \qquad \forall i \in COM, h \in HHD, r \in RGN$$

[d1] $$APE(i,k,h,r) = \alpha(i,h,r) + \alpha(k,h,r)$$
$$- \sum_{m \in COM} SHRC(m,h,r) \cdot \alpha(m,h,r) \qquad \forall i,k \in COM, h \in HHD, r \in RGN$$

[d2] $$APE(i,i,h,r) = 2\alpha(i,h,r) - \frac{\alpha(i,h,r)}{SHRC(i,h,r)}$$
$$- \sum_{m \in COM} SHRC(m,h,r) \cdot \alpha(m,h,r) \qquad \forall i \in COM, h \in HHD, r \in RGN$$

$$SHRC(i,h,r) = \frac{CONS(i,h,r)}{CON(h,r)} \qquad \forall i \in COM, h \in HHD, r \in RGN$$

$$\alpha(i,h,r) = 1 - \beta(i,h) \qquad \forall i \in COM, h \in HHD, r \in RGN$$

Table 20. Government revenues

(27) Regional government revenue

$$GREV(r)\cdot govrev(r)=\sum_{i\in COM}\{DSU(i,r,"local")\cdot[pu(i,r,"local")+qs(i,r,"local")]$$
$$-DSP(i,r,"local")\cdot[pp(i,r,"local")+qs(i,r,"local")]$$
$$+DSU(i,r,"pool")\cdot[pu(i,r,"pool")+qs(i,r,"pool")]$$
$$-DPM(i,r)\cdot[por(i,r)+qs(i,r,"pool")]\}$$
$$+\sum_{j\in IND}\{PAYA(j,r)\cdot[pxa(j,r)+x(j,r)]-PAYB(j,r)\cdot[pps(j,r)+x(j,r)]\}$$
$$+\sum_{h\in HHD}[INCOMES\_G(h,r)\cdot y\_g(h,r)-INCOMES\_N(h,r)\cdot y\_n(h,r)]$$
$$+CTRANSF(r)\cdot transf\_c(r) \qquad \forall r\in RGN$$

(28) Central government revenue

$$CGREV\cdot cgovrev=\sum_{i\in COM}\{TMM(i)\cdot[pmm(i)+qms(i)]-TMB(i)\cdot[pm(i)+phi+qms(i)]$$
$$+TXB(i)\cdot[pe(i,"chn")+phi+q4(i,"chn")]-TXP(i)\cdot[ppex(i)+q4(i,"chn")]\}$$

(29) Budget constraints on central government transfers

$$CGREV\cdot[cgovrev+cbgtslask]=\sum_{r\in RGN}CTRANSF(r)\cdot transf\_c(r) \qquad \forall r\in RGN$$

Coefficients

$$DSU(i,r,s)=PU(i,r,s)\cdot QS(i,r,s) \qquad \forall i\in COM, r\in RGN, s\in SRC$$
$$DPM(i,r)=POR(i,r)\cdot QS(i,r,"pool") \qquad \forall i\in COM, r\in RGN$$
$$PAYA(j,r)=PXA(j,r)\cdot X(j,r), \quad PAYB(j,r)=PPS(j,r)\cdot X(j,r) \qquad \forall j\in IND, r\in RGN$$
$$TMM(i)=QMS(i)\cdot PMM(i), \quad TMB(i)=QMS(i)\cdot PM(i)\cdot PHI,$$
$$TXB(i)=Q4(i,"chn")\cdot PE(i,"chn")\cdot PHI, \quad TXP(i)=Q4(i,"chn")\cdot PPEX(i) \qquad \forall i\in COM$$
$$GREV(r)=\sum_{i\in COM}[DSU(i,r,"local")-DSP(i,r,"local")+DSU(i,r,"pool")-DPM(i,r)]$$
$$+\sum_{j\in IND}[PAYA(j,r)-PAYB(j,r)]+\sum_{h\in HHD}[INCOMES\_G(h,r)-INCOMES\_N(h,r)]$$
$$+CTRANSF(r) \qquad \forall r\in RGN$$
$$CGREV=\sum_{i\in COM}[TMM(i)-TMB(i)+TXB(i)-TXP(i)]$$
$$CTRANSF(r)=TRANSF\_C(r) \qquad \forall r\in RGN$$

Table 21. Government savings and consumption

(30) Government savings

$$save\_p("gov",r) = save("gov",r) - govrev(r) \qquad \forall r \in RGN$$

(31) Government expenditure on consumption

$$GREV(r)\cdot\left[govrev(r) + bgtslack("gov",r)\right] = CON("gov",r)\cdot govconv(r) + SAVINGS("gov",r)\cdot save("gov",r) + \sum_{h\in HHD} RTRANSF(h,r)\cdot transf\_r(h,r) \qquad \forall r \in RGN$$

(32) Nominal government consumption

$$govconv(r) = uc("gov",r) + cpi("gov",r) \qquad \forall r \in RGN$$

(33) Government consumption of different commodities

$$q5(i,r) = uc("gov",r) - \left[pq(i,r) - cpi("gov",r)\right] \qquad \forall i \in COM, r \in RGN$$

Coefficients:

$$CON("gov",r) = \sum_{i\in COM} CONS(i,"gov",r) \qquad \forall r \in RGN$$

$$CONS(i,"gov",r) = PQ(i,r)\cdot Q5(i,r) \qquad \forall i \in COM, r \in RGN$$

$$SAVINGS("gov",r) = SAVE("gov",r) \qquad \forall r \in RGN$$

$$RTRANSF(h,r) = TRANSF\_R(h,r) \qquad \forall h \in HHD, r \in RGN$$

Table 22. Investment and export demand

(34) Regional aggregated real investment

$$ir(r) = \gamma(r)\cdot\left[pfa("capital",r) - ip(r)\right] \qquad \forall r \in RGN$$

(35) The production of investment goods

$$q2(i,r) = ir(r) - \left[pq(i,r) - ip(r)\right] \qquad \forall i \in COM, r \in RGN$$

(36) Price of investment

$$\sum_{i\in COM} INVE(i,r)\cdot ip(r) = \sum_{i\in COM} INVE(i,r)\cdot pq(i,r) \qquad \forall r \in RGN$$

(37) World demand for exports

$$qw4(i) = \beta(i)\cdot \sum_{s\in WLD} S1(i,s)\cdot pe(i,s) - \sum_{i\in COM}\sum_{s\in WLD} S2(l,s)\cdot pe(l,s) \qquad \forall r \in RGN$$

(38) Demand for exports from China

$$q4(i,s) = qw4(i) - \sigma_w(i)\cdot\ pe(i,s) - \sum_{k\in WLD} S1(i,k)\cdot pe(i,k) \qquad \forall i \in COM, s \in WLD$$

Coefficients:

$$INVE(i,r) = Q2(i,r)\cdot PQ(i,r) \qquad \forall i \in COM, r \in RGN$$

$$S1(i,s) = EXPORTS(i,s) / \sum_{j\in WLD} EXPORTS(i,j) \qquad \forall i \in COM, s \in WLD$$

$$S2(i,s) = EXPORTS(i,s) / \sum_{k\in COM}\sum_{j\in WLD} EXPORTS(k,j) \qquad \forall i \in COM, s \in WLD$$

$$EXPORTS(i,s) = Q4(i,s)\cdot PE(i,s) \qquad \forall i \in COM, s \in WLD$$

Table 23. Regional commodity demand

(39) Market clearing condition for commodities

$$\sum_{j\in IND} INTER(i,j,r) + INVE(i,r) + \sum_{h\in HHG} CONS(i,h,r) \cdot q(i,r)$$
$$= \sum_{j\in IND} INTER(i,j,r)\cdot q1(i,j,r) + INVE(i,r)\cdot q2(i,r)$$
$$+ \sum_{h\in HHD} CONS(i,h,r)\cdot q3(i,h,r) + CONS(i,"gov",r)\cdot q5(i,r) \qquad \forall i\in COM, r\in RGN$$

(40) Aggregated price of domestic and imported products

$$\sum_{s\in SRC1} DSU(i,r,s)\cdot pq(i,r) = \sum_{s\in SRC1} DSU(i,r,s)\cdot pu(i,r,s) \qquad \forall i\in COM, r\in RGN$$

(41) Aggregated price of local products and inflows from other domestic regions

$$\sum_{S\in SRC2} DSU(i,r,s)\cdot pu(i,r,"domestic") = \sum_{s\in SRC2} DSU(i,r,s)\cdot pu(i,r,s) \qquad \forall i\in COM, r\in RGN$$

(42) Demand for domestic and imported products

$$qs(i,r,s) = q(i,r) - \sigma_m(i)\cdot\left[pu(i,r,s) - pq(i,r)\right] \qquad \forall i\in COM, r\in RGN, s\in SRC2$$

(43) Demand for local products and inflow from other domestic regions

$$qs(i,r,s) = qs(i,r,"domestic")$$
$$-\sigma_d(i)\cdot\left[pu(i,r,s) - pu(i,r,"domestic")\right] \qquad \forall i\in COM, r\in RGN, s\in SRC2$$

Coefficient

$$INTER(i,j,r) = PQ(i,r)\cdot Q1(i,j,r) \qquad \forall i\in COM, j\in IND, r\in RGN$$

Table 24. Primary factors market clearing conditions

(44) Market clearing for agricultural labour

$$ql("agri",r) = qlrh("agri",r) \qquad \forall r \in RGN$$

(45) Market clearing for rural labour in non-agricultural sectors

$$ql("rural",r) = qlrh("nagr",r) \qquad \forall r \in RGN$$

(46) Market clearing for urban labour in non-agricultural sectors

$$ql("urban",r) = qfah("labor","urban",r) - qlslack("urban","urban",r) \qquad \forall r \in RGN$$

(47) Total migrant labour

$$qlms = \sum_{r \in RGN} SLM\_S(r) \cdot qlrh("migrant",r)$$

(48) Market clearing for migrant labour

$$ql("migrant",r) = qlms + \delta_1 \cdot [plu("migrant",r) - plms] \qquad \forall r \in RGN$$

(49) Aggregated price for migrant labour used by different regions

$$plms = \sum_{r \in RGN} SLM\_D(r) \cdot plu("migrant",r)$$

(50) Market clearing for capital

$$qk = \sum_{r \in RGN} \sum_{j \in IND} SHCAPD(j,r) \cdot qf("capital",j,r)$$

(51) Land supply equal to demand

$$qas(j,r) = qf("land",j,r) \qquad \forall j \in IND, r \in RGN$$

Coefficients:

$$SLM\_S(r) = QLRH("migrant",r) / \sum_{S \in RGN} QLRH("migrant",s) \qquad \forall r \in RGN$$

$$SLM\_D(r) = \frac{PLU("migrant",r) \cdot QL("migrant",r)}{\sum_{s \in RGN} PLU("migrant",s) \cdot QL("migrant",s)} \qquad \forall r \in RGN$$

$$SHCAPD(j,r) = \frac{IF("capital",j,r)}{\sum_{i \in IND} \sum_{r \in RGN} IF("capital",i,r)} \qquad \forall j \in IND, r \in RGN$$

Table 25. Commodity market clearing conditions

(52) Supply equal to demand for locally produced commodities

$$cd(i,r,"local") = qs(i,r,"local") \qquad \forall i \in COM, r \in RGN$$

(53) China's import demand

$$qms(i) = \varepsilon(i) \cdot pm(i) \qquad \forall r \in RGN$$

(54) Market clearing condition for imported goods

$$qms(i) = \sum_{r \in RGN} SHRIMP(i,r) \cdot qs(i,r,"import") \qquad \forall i \in COM$$

(55) Market clearing condition for export goods

$$\sum_{R \in RGN} EXP(i,r) \cdot q4(i,"chn") = \sum_{r \in RGN} \left[EXP(i,r) \cdot cd(i,r,"world") \right] \qquad \forall i \in COM$$

(56) Aggregated "national pool" commodities

$$cdo(i) = \sum_{r \in RGN} \left[SHRPO(i,r) \cdot cd(i,r,"pool") \right] \qquad \forall i \in COM$$

(57) Distribution of "national pool" commodities

$$qs(i,r,"pool") = cdo(i) + \sigma_d(i) \cdot \left[por(i,r) - po(i) \right] \qquad \forall i \in COM, r \in RGN$$

(58) Aggregated "national pool" price

$$po(i) = \sum_{r \in RGN} SHRPOR(i,r) \cdot por(i,r) \qquad \forall i \in COM$$

Coefficients:

$$SHRIMP(i,r) = IMB(i,r) / \sum_{s \in RGN} IMB(i,s) \qquad \forall i \in COM, r \in RGN$$

$$IMB(i,r) = QS(i,r,"import") \cdot PM(i) \cdot PHI \qquad \forall i \in COM, r \in RGN$$

$$EXP(i,r) = CD(i,r,"world") \cdot PP(i,r,"world") \qquad \forall i \in COM, r \in RGN$$

$$SHRPO(i,r) = CD(i,r,"pool") / \sum_{s \in RGN} CD(i,s,"pool") \qquad \forall i \in COM, r \in RGN$$

$$SHRPOR(i,r) = DPM(i,r) / \sum_{s \in RGN} DPM(i,s) \qquad \forall i \in COM, r \in RGN$$

$$DPM(i,r) = POR(i,r) \cdot QS(i,r,"pool") \qquad \forall i \in COM, r \in RGN$$

Table 26. Price linkage and zero profit conditions

(59) Zero profit condition

$$\left\{\sum_{i\in COM} INTER(i,j,r)+\sum_{v\in FAC} IF(v,j,r)\right\}\cdot\left[pps(j,r)+ao(j,r)+profitslack(j,r)\right]$$
$$=\sum_{i\in COM} INTER(i,j,r)\cdot\left[pq(i,r)-ai(i,j,r)\right]$$
$$+\sum_{v\in FAC} IF(v,j,r)\cdot\left[pf(v,j,r)-af(v,j,r)-ava(j,r)\right] \qquad \forall j\in IND, r\in RGN$$

(60) $pxa(j,r)=pps(j,r)+tia+ti(j,r)$ $\forall j\in IND, r\in RGN$

(61) $pu(i,r,"local")=pp(i,r,"local")+tca+tc(i,r)$ $\forall i\in COM, r\in RGN$

(62) $pu(i,r,"import")=pmmr(i,r)+tca+tc(i,r)$ $\forall i\in COM, r\in RGN$

(63) $pmm(i)=pm(i)+tm(i)+tma+phi$ $\forall i\in COM$

(64) $pmmr(i,r)=pmm(i)+tmtr(i,r)$ $\forall i\in COM, r\in RGN$

(65) $pu(i,r,"pool")=por(i,r)+totr(i,r)+tca+tc(i,r)$ $\forall i\in COM, r\in RGN$

(66) $pp(i,r,"world")=ppex(i)-tetrp(i,r)$ $\forall i\in COM, r\in RGN$

(67) $ppex(i)=pe(i,"chn")-tx(i)+phi$ $\forall i\in COM$

(68) $pfs(v,j,r)=pf(v,j,r)+tf(v,j,r)$ $\forall v\in FAC1, j\in IND, r\in RGN$

(69) $pl("agri",r)=plu("agri",r)+tfl("agri",r)$ $\forall r\in RGN$

(70) $pl("nagr",r)=plu("rural",r)+tfl("rural",r)$ $\forall r\in RGN$

(71) $pl("migrant",r)=plms+tfl("migrant",r)$ $\forall r\in RGN$

(72) $pl("urban",r)=plu("urban",r)+tfl("urban",r)$ $\forall r\in RGN$

(73) $tm(i)=TARIFF(i)/[100+TARIFF(i)]\cdot tm\_r(i)$ $\forall i\in COM$

(74) $ti(j,r)=TAX\_IND(j,r)/[100+TAX\_IND(j,r)]\cdot ti\_r(j,r)$ $\forall j\in IND, r\in RGN$

Coefficients:

$INTER(i,j,r)=PQ(i,r)\cdot Q1(i,j,r)$ $\forall i\in COM, j\in IND, r\in RGN$

$TARIFF(i)$:tariff rate $\forall i\in COM$

$TAX\_IND(j,r)$:indirect tax rate $\forall j\in IND, r\in RGN$

Table 27. Sectoral classification in the model

Sectors in the model	Code*	Sectors in the model	Code*
Agriculture			
01. Wheat	001	08. Vegetables and fruits	001
02. Paddy rice	001	09. Other crops	001
03. Corn	001	10. Forestry	002
04. Pulses	001	11. Livestock and livestock products	003
05. Other grains	001	12. Fishery	004
06. Cotton	001	13. Other agricultural products	005
07. Oilseeds	001		
Industry and construction			
14. Coal mining and processing	006	27. Metal products	061
15. Crude petroleum and natural gas products	007, 008	28. Machinery and equipment	062–066
		29. Transport equipment	067–072
16. Metal ore mining	009, 010	30. Electric equipment and machinery	073–075
17. Non-metal mineral mining	011–013	31. Electronic and telecommunication equipment	076–079
18. Manufacture of food products and tobacco processing	014–021	32. Instruments, meters, cultural and office machinery	080, 081
19. Textile goods	022–027		
20. Wearing apparel, leather, furs, down and related products	028, 029	33. Maintenance and repair of machine and equipment	082
21. Sawmills and furniture	030, 031	34. Other manufacturing products	083, 084
22. Paper and products, printing and record media reproduction	032–035	35. Scrap and waste	085
		36. Electricity, steam and hot water production and supply	086, 087
23. Petroleum processing and coking	036, 037		
24. Chemicals	038–047	37. Gas production and supply	088
25. Non-metal mineral products	048–054	38. Water production and supply	089
26. Metals smelting and pressing	055–060	39. Construction	090
Services			
40. Transport and warehousing	091–097	48. Health services, sports and social welfare	115–117
41. Post and telecommunications	098, 099		
42. Wholesale and retail trade	100	49. Education, culture and arts, radio, film and television	118–119
43. Eating and drinking places	101		
44. Passenger transport	102–105	50. Scientic research	120
45. Finance and insurance	106, 107	51. General technical services	121–123
46. Real estate	108	52. Public administration and other sectors	124
47. Social services	109–114		

* The 124–sector code in 1997 input–output table (National Accounts Department 1999).

Table 28. Definitions of variables

Variable	Argument	Definitions
absp(r)	r∈RGN	Real aggregate final absorption in region r
abspi(i,r)	i∈COM, r∈RGN	Real final absorption of good i in region r
af(v,j,r)	v∈FAC, j∈IND, r∈RGN	Factor-augmenting technical change
ai(i,j,r)	i∈COM, j∈IND, r∈RGN	Input-augmenting technical change
ao(j,r)	j∈IND, r∈RGN	Output-augmenting technical change
ao_avg(r)	r∈RGN	Sector-generic value added-augmenting technical change
ao1(j,r)	j∈IND, r∈RGN	Output-augmenting technical change in industry j
ava(j,r)	j∈IND, r∈RGN	Value added-augmenting technical change in industry j
bgtslack(h,r)	h∈HHG, r∈RGN	Household income slacks
bt		Ratio of EXPORTS to IMPORTS
cbgtslack		Central government budget constraint
cd(i,r,d)	i∈COM, r∈RGN, d∈DST	Supply of good i in region r for destination d
cdo(i)	i∈COM	Aggregate supply of domestic good used by other regions
cgovrev		Hypothetical central government revenue (tariff and export tax revenues only)
com(i,r)	i∈COM, r∈RGN	Regional output of commodity i
comi(i,j,r)	i∈COM, j∈IND, r∈RGN	Output of commodity i by industry j in region r
conr(r)	r∈RGN	Regional aggregate (private household and government) consumption
cpi(h,r)	h∈HHG, r∈RGN	Consumer price indexes for private household and government in region r
cpia(r)	h∈HHG, r∈RGN	Aggregate consumer price in region r
DelBOT		Change in balance of trade (million yuan)
EV(h,r)	h∈HHG, r∈RGN	Equivalent variation (million yuan)
EV_AGG(r)	r∈RGN	Aggregate equivalent variation (million yuan)
gdpr(r)	r∈RGN	Regional real GDP – expenditure side
gdpv(r)	r∈RGN	Regional nominal GDP – expenditure side
gov_gdp(r)	r∈RGN	Ratio of government revenues to GDP
govconv(r)	r∈RGN	Nominal government consumption
govrev(r)	r∈RGN	Regional government revenues
hhdconr(h,r)	h∈HHD, r∈RGN	Real household consumption
ip(r)	r∈RGN	Price of investment goods
ir(r)	r∈RGN	Aggregate real investment
iv(r)	r∈RGN	Aggregate nominal investment
out(l,r)	l∈LU2, r∈RGN	Regional output by sector
pas(j,r)	j∈IND, r∈RGN	Price of land supply
pe(i,d)	i∈COM, d∈WRD	Foreign currency price of exports
pf(v,j,r)	v∈FAC, j∈IND, r∈RGN	Unit return to primary factors
pfa(v,r)	v∈FAC, r∈RGN	Price of aggregate primary factors
p(l,j,r)	l∈LS1, j∈NAG, r∈RGN	Demand price for different types of labour
pfs(v,j,r)	v∈FAC1, j∈IND, r∈RGN	Supply prices of primary factors
pgdp(r)	r∈RGN	Regional GDP deflator
phi		Exchange rate
pk		Price for capital

Table 28. (cont'd) Definitions of variables

Variable	Argument	Definitions
pl(l,r)	l∈LU0, r∈RGN	Supply price of different types of labour
plr(l,r)	l∈LU2, r∈RGN	Real wages
plms		National supply price of migrant labour
plr(r)	r∈RGN	Aggregate price of labour supplied by rural sector
plu(l,r)	l∈LS0, r∈RGN	Demand price of labour
pm(i)	i∈COM	Foreign currency prices of imports
pmm(i)	i∈COM	Market prices of imports in national pool
pmmr(i,r)	i∈COM, r∈RGN	Regional market prices of imports
po(i)	i∈COM	Price of aggregate supply of goods to be used by other regions in pool
pop(h,r)	h∈HHG, r∈RGN	Population
por(i,r)	i∈COM, r∈RGN	Regional producer price of goods to be supplied to other regions
pp(i,r,d)	i∈COM, r∈RGN, d∈DST	Producer price
ppex(i)	i∈COM	Aggregate producer price of exports
pps(j,r)	j∈IND, r∈RGN	Producer price by industry excluding tax
pq(i,r)	i∈COM, r∈RGN	Price for absorption
protslack(j,r)	j∈IND, r∈RGN	Zero profit slack
pu(i,r,s)	i∈COM, r∈RGN, s∈SRC0	User price
pvad(j,r)	j∈IND, r∈RGN	Price of value added by industry
px(i,r)	i∈COM, r∈RGN	Aggregate producer price of good
pxa(j,r)	j∈IND, r∈RGN	Producer price by industry including tax
pxs(i,j,r)	i∈COM, j∈IND, r∈RGN	Producer price by goods and industry
q(i,r)	i∈COM, r∈RGN	Total absorption of good i in region r
q1(i,j,r)	i∈COM, j∈IND, r∈RGN	Intermediate demand for i by j in r
q2(i,r)	i∈COM, r∈RGN	Fixed investment demand for i in r
q3(i,h,r)	i∈COM, h∈HHD, r∈RGN	Household demand for i by h in r
q4(i,d)	i∈COM, d∈WLD	Export demand for i from d
q5(i,r)	i∈COM, r∈RGN	Government demand for i in r
qas(j,r)	j∈IND, r∈RGN	Total supply of land in region r
qash(j,h,r)	j∈IND, h∈HHD, r∈RGN	Supply of land by households in region r
qex		National export volume
qex_agg(j,r)	j∈IND_AGG, r∈RGN	Aggregated exports
qf(v,j,r)	v∈FAC, j∈IND, r∈RGN	Demand for primary factor v by industry j in region r
qfah(v,h,r)	v∈FAC, h∈HHD, r∈RGN	Supply of aggregate primary factors by household
qfh(v,j,h,r)	v∈FAC, j∈IND, h∈HHD	Factor demand by industry and households
qim		National import volume
qim_agg(j,r)	j∈IND_AGG, r∈RGN	Aggregated imports
qk		Total supply of capital
ql(l,r)	l∈LS0, r∈RGN	Demand for labour type l by region r
qldr(l,j,r)	l∈LS1, j∈NAG, r∈RGN	Demand for labour type l by industry j in region r
qlrh(l,r)	l∈LU1, r∈RGN	Supply of labour type l by rural household h in region r
qlms		National total supply of migrant labour
qlmsr(r)	r∈RGN	Regional supply of migrant labour
qlslack(l,h,r)	l∈LU0, h∈HHD, r∈RGN	Labour supply slack

Table 28. (cont'd) Definitions of variables

Variable	Argument	Definitions
qms(i)	i∈COM	Total supply of import i from rest of world
qs(i,r,s)	i∈COM, r∈RGN, s∈SRC0	Demand for good i in region r from source s
qva(j,r)	j∈IND, r∈RGN	Demand for composite value added by industry j in region r
qw4(i)	i∈COM	Excess world demand for export i
rqex(r)	r∈RGN	Regional export volume
rqim(r)	r∈RGN	Regional import volume
rvex(r)	r∈RGN	Regional export value
rvim(r)	r∈RGN	Regional import value
save(h,r)	h∈HHG, r∈RGN	Household and government saving
Save_p(h,r)	h∈HHG, r∈RGN	Household propensity to save
tabsp		National real aggregate final absorption
tabspi(i)	i∈COM	National real final absorption of commodities
tc(i,r)	i∈COM, r∈RGN	Power of commodity tax
tca		Economy wide power of commodity taxes
tconr		National aggregate consumption
tcpi(h)	h∈HHG	National consumer price index
tcpia		National aggregate consumer price index
tetrp(i,r)	i∈COM, r∈RGN	Power of transportation cost
tf(v,j,r)	v∈FAC, j∈IND, r∈RGN	Power of factor tax
t(l,r)	l∈LS0, r∈RGN	Tax on labour supply
tgdpr		National real GDP
tgdpv		National nominal GDP
tgovconv		National nominal government consumption
thhdconr(h)	h∈HHD	National real household consumption
ti(j,r)	j∈IND, r∈RGN	Power of indirect tax
ti_r(j,r)	j∈IND, r∈RGN	Ad valorem rate of indirect tax
tia		Economy wide power of indirect taxes
tm(i)	i∈COM	Power of tariff
tm_r(i)	i∈COM	Ad valorem rate of tariff
tma		Economy wide power of tariff
tmtr(i,r)	i∈COM, r∈RGN	Power of transport cost moving import i from port to region r
tot		Terms of trade
totr(i,r)	i∈COM, r∈RGN	Power of transport cost from pool to regions
totrp(i,r)	i∈COM, r∈RGN	Power of transport cost from regions to pool
tout(l)	l∈LU2	National output by sector
tpgdp		National GDP deflator
tqex_agg(j)	j∈IND_AGG	Aggregated exports
tqim_agg(j)	j∈IND_AGG	Aggregated imports
transf_c(r)	r∈RGN	Central government transfer to regional government
transf_r(h,r)	h∈HHD, r∈RGN	Regional government transfer to households
tsave(r)	r∈RGN	Total savings
tx(i)	i∈COM	Power of export tax
tx_agg(j)	j∈IND_AGG	Aggregated industrial output
ty(h,r)	h∈HHD, r∈RGN	Power of household income tax

Table 28. (cont'd) Definitions of variables

Variable	Argument	Definitions
tya		Economy wide power of income taxes
u(h,r)	h∈HHG, r∈RGN	Total utility by household
uc(h,r)	h∈HHG, r∈RGN	Utility from consumption
vex		National export value
vim		National import value
x(j,r)	j∈IND, r∈RGN	Total output of industry j in region r
x_agg(j,r)	j∈IND_AGG, r∈RGN	Aggregated industrial output
y_c(h,r)	h∈HHD, r∈RGN	Household consumption expenditure
y_d(h,r)	h∈HHD, r∈RGN	Household incomes after tax
y_g(h,r)	h∈HHD, r∈RGN	Household incomes before tax
y_n(h,r)	h∈HHD, r∈RGN	Net household income (after income tax)

Table 29. Definitions of sets

Sector	Definition
AGR	Agricultural sectors
COM	Commodities, each corresponds to a sector as classified in Table 27.
DST	Destinations of sales: {"local", "pool", "world"}
FAC	Primary factors: {"land", "labour", "capital"}
FAC1	Primary factors: {"land", "capital"}
HHD	Private households: {"rural", "urban"}
HHG	Private households and government: {"rural", "urban", "gov"}
HHM	Private households and migrant: {"rural", "urban", "migrant"}
IND	Sectors classified in Table 27.
IND_AGG	Aggregate sectors for report purposes
INO	Sectors and "other"
LU0	Labour uses: {"agri", "nagr", "migrant", "urban"}
LU1	Rural labour uses: {"agri", "nagr", "migrant"}
LU2	Labour uses: {"agri", "nagr"}
LS0	Labour sources: {"agri", "rural", "urban", "migrant"}
LS1	Labour sources in non-agricultural sectors: {"rural", "urban", "migrant"}
NAG	Non-agricultural sectors
RGN	Provinces, autonomous regions and municipalities under central government in China
SRC	Sources of commodity supply: {"local", "pool", "import"}
SRC0	Sources of commodity supply: {"domestic", "import", "local", "pool"}
SRC1	Sources of commodity supply: {"domestic", "import"}
SRC2	Sources of commodity supply: {"local", "pool"}
WLD	China or rest of the world: {"chn", "row"}

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