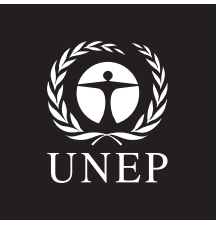

Integrated Assessment of the Impact of Trade Liberalization

A Country Study on China's Rice Sector

First edition 2005

ISBN: 92-807-2536-X

Foreword

Over the last two decades, China has undergone a series of market-oriented reforms that have resulted in China's dramatic economic growth in all sectors. In line with these market reforms, China's foreign trade market has, generally speaking, opened up, especially since the early 1990s. China joined the World Trade Organization (WTO) at the end of 2001, signifying further trade liberalization.

China's WTO membership will require trade-policy adjustments in line with WTO rules. China has agreed to reduce tariff rates, limit its domestic support to farmers to 8.5 per cent of production value (compared to 10 per cent for other developing countries), and eliminate agricultural export subsidies. For rice, a global tariff-rate quota of 2.66 million tons in 2002 will rise in annual increments to 5.32 million tons in 2005, at a 1 per cent tariff rate. At the same time, its out-of-quota bound tariff rate will fall from 114 per cent to 65 per cent. All these changes related to trade liberalization will have an impact on China's rice sector. Faced with new opportunities and challenges in trade liberalization, China's rice sector may benefit from a larger foreign market and an increase in technology transmission. However, it could also face more intensive competition from the world rice market.

Rice is one of the most significant crops in China's agricultural production, and the rice economy plays an important role in China's agricultural economy. Rice production is widely distributed across the country, and the rice growing area represents about 30 per cent of the total grain sown area. Consequently, changes in the rice sector will have an impact on most local economies and households in rural areas.

Rice production is closely related to the rural environment. Fertilizers, pesticides and films are all necessary chemical inputs in rice production, but they can also cause serious environmental damage. Methane emissions from rice paddy aggravate the greenhouse effect. In addition, rice production requires large quantities of irrigation water, which puts pressure on water resources.

However, with the introduction of some changes to the rice sector, trade liberalization could benefit the economy, rural society and rural ecologies.

Given the background described above, the goal of this project is to identify the positive and negative impacts of trade liberalization, enhance the country's understanding of the implications of multilateral trade rules, and improve its negotiating capacity. The ultimate goal is to formulate policies and policy packages to eliminate the identified negative impacts of liberalized trade and to maximize the positive ones through economic and regulatory instruments as well as through the application of voluntary private-sector initiatives, particularly in the context of the Agreement on Agriculture (AoA).

Acknowledgements

The research work for this integrated assessment study was carried out under the instruction of the Chinese State Environmental Protection Administration (SEPA) and the report is the result of cooperation among a number of organizations and individual experts. The finalisation of this report would not have been possible without the full support of Mr. Yue Ruisheng, Deputy Director General, Department of International Cooperation, SEPA; Mr. Tu Ruihe, Director, Division of International Organizations, Department of International Cooperation, SEPA; and Dr. Xia Guang and Dr. Ren Yong, Director and Deputy Director of the Policy Research Center for Environment and Economy (PRCEE), SEPA. The project was coordinated under the overall supervision of Prof. Hu Tao, Project Coordinator and Team Leader, PRCEE, SEPA, Prof. Huang Jikun, Director and Team Leader of CCAP team, Center for Chinese Agricultural Policy, Chinese Academy of Sciences, and Prof. Mao Xianqiang, Environmental Economics and Environmental Science, Team Leader of BNU team, School of Environment, Beijing Normal University. Members of the research team were Dr. Xu Zhigang, Center for Chinese Agricultural Policy, CAS, Dr. Scott Rozelle, Dept. of Agriculture and Resource Economics, University of California, Davis, Dr. Li Ninghui, Institute of Agricultural Economics, Chinese Academy of Agri. Sciences, Dr. Zhan Lingyun, Environmental Economics and Environmental Sciences, School of Environment, Beijing Normal University, Dr. Tu Yingyan, Environmental Economics and Environmental Sciences, School of Environment, Beijing Normal University, Dr. Xiao Yang, Geographical Information System (GIS) and Environmental Sciences, Dr. Zhang Sheng, Environmental Economics and Environmental Sciences, Department of Environmental Protection Enforcement & Inspection, SEPA, Dr. Dong Wenguang, Agricultural Environment Protection, Beijing Station of Agricultural Environmental Monitoring, and Dr. Li Xianqiang, Environmental Management, Beijing Institute of Petrochemical Technology.

Besides the stakeholders, a number of institutions and individuals have contributed to the study. Sincere acknowledgements are extended to them. They are Prof. Li Shantong and Mr. He Jianwu, Senior Research Fellows, Development Research Center of State Council, Mr. Ni Hongxing, Division Director/Negotiator on Agriculture Sector, Ministry of Agriculture, Dr. Guo Dongmei, Technical Adviser for China's negotiations on trade and environment with WTO, Dr. Yu Hai, PRCEE, SEPA, Dr. Ke Binsheng, Director General, Agricultural Policy Research Center, Ministry of Agriculture, Prof. Tian Weiming, Professor of China Agriculture University and Adviser for China's agriculture negotiations with WTO, Prof. Zhou Shudong, Nanjing Agriculture University, Prof. Xin Xian, China Agriculture University, Prof. Tian Zhihong, China Agriculture University, and Prof. He Xiurong, China Agriculture University.

Special Acknowledgements are extended to those persons who provided assistance during the field surveys in Heilongjiang and Hubei provinces, including Mr. Du Changhe, Director, Heilongjiang Station of Agricultural Environment Monitoring, Mr. Li Zhanjun, Heilongjiang Station of Agricultural Environment Monitoring, Mr. Li Youjun, Director, Spread Station of Agricultural Technology in Qing'an county, Heilongjiang province, Mr. Zhang Du, Spread Station of Agricultural Technology in Qing'an county, Heilongjiang province, Mr. Luo Lan, Party Branch Secretary of Shayang county Government, Hubei province, Ms. Zhang Li, Shayang county Government, Hubei province, Mr. Zhang Chao, Secretary

of Tongcheng county Government, Anhui province, Mr. Dai Xiangqian, Director of Tongcheng county Agricultural Bureau, Anhui province.

At UNEP, the project was initiated and led by Hussein Abaza. Sophie Forster Carbonnier and Mariko Hara coordinated and provided technical and logistical support to the project. The country teams prepared the full studies as well as the summaries included in the synthesis report (*Integrated Assessment of the Impact of Trade Liberalization on the Rice Sector, UNEP Country Projects Round III, A Synthesis Report*). Thanks are due to Jan Joost Kessler, Konrad von Moltke and Fulai Sheng for having provided critical reviews of draft reports. This appreciation is also extended to the members of the international working group on rice set up by UNEP to guide and implement the projects and provide comments. The members of this group, who attended the two international expert meetings on 19-20 February and 17-18 November 2003 in Geneva and provided useful contributions and comments on these occasions, are: Tunji Akande, Nigerian Institute of Social and Economic Research; Claude Auroi, IUED (Institut Universitaire d'Etudes du Développement); Luisa Bernal, South Centre; Concepción Calpe, FAO; Céline Charveriat, Oxfam International; Martha Chouchena-Rojas, IUCN; Aliou Diagne, West Africa Rice Development Association; Salah El Serafy, Consultant, USA; Aimée Gonzales, WWF International; Dongmei Guo, SEPA, China; Nestór Gutiérrez, Federación Nacional de Arroceros, Colombia; Mark Halle, IISD; Dimitris Diakosavvas, OECD; Panos Konandreas, FAO; Doug Koplow, Earth Track, Inc.; Hans-Jörg Lehmann, Swiss Federal Office for Agriculture, Bern; Eric Peters, European Commission; Majda Petschen, WTO; Shishir Priyadarshi, South Centre; Sarah Richardson, Maeander Enterprises Ltd., Canada; Abdoulaye Sene, Institut des Sciences de l'Environnement, Dakar; Shefali Sharma, IATP; Miho Shirotori, UNCTAD; Matius Suparmoko, Jenderal Soedirman University, Indonesia; Robert Teh, WTO; Gerard van Dijk, UNEP Regional Office for Europe; Truong van Tuyen, Hue University of Agriculture and Forestry, Viet Nam; Scott Vaughan, (ex-Carnegie Endowment) OAS; Rene Vossenaar, UNCTAD; Alex Werth, ICTSD.

Susan Broomfield edited the final study; however full responsibility for the content remains with the authors. Logistical support was provided by Desiree Leon and Rahila Mughal from UNEP.

Finally, UNEP/ETB wishes to gratefully acknowledge the funding from the Norwegian Ministry of Foreign Affairs, which made this project possible.

United Nations Environment Programme

The United Nations Environment Programme (UNEP) is the overall coordinating environmental organization of the United Nations system. Its mission is to provide leadership and encourage partnerships in caring for the environment by inspiring, informing and enabling nations and people to improve their quality of life without compromising that of future generations. In accordance with its mandate, UNEP works to observe, monitor and assess the state of the global environment, improve the scientific understanding of how environmental change occurs, and in turn, how such change can be managed by action-oriented national policies and international agreements. UNEP's capacity-building work thus centres on helping countries strengthen environmental management in diverse areas that include freshwater and land resource management, the conservation and sustainable use of biodiversity, marine and coastal ecosystem management, and cleaner industrial production and eco-efficiency, among many others.

UNEP, which is headquartered in Nairobi, Kenya, marked its first 30 years of service in 2002. During this time, in partnership with a global array of collaborating organizations, UNEP has achieved major advances in the development of international environmental policy and law, environmental monitoring and assessment, and the understanding of the science of global change. This work also supports the successful development and implementation of the world's major environmental conventions. In parallel, UNEP administers several multilateral environmental agreements (MEAs) including the Vienna Convention's Montreal Protocol on Substances that Deplete the Ozone Layer, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (SBC), the Convention on Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (Rotterdam Convention, PIC) and the Cartagena Protocol on Biosafety to the Convention on Biological Diversity as well as the Stockholm Convention on Persistent Organic Pollutants (POPs).

Division of Technology, Industry and Economics

The mission of the Division of Technology, Industry and Economics (DTIE) is to encourage decision makers in government, local authorities and industry to develop and adopt policies, strategies and practices that are cleaner and safer, make efficient use of natural resources, ensure environmentally sound management of chemicals, and reduce pollution and risks for humans and the environment. In addition, it seeks to enable implementation of conventions and international agreements and encourage the internalisation of environmental costs. UNEP DTIE's strategy in carrying out these objectives is to influence decision-making through partnerships with other international organizations, governmental authorities, business and industry, and non-governmental organizations; facilitate knowledge management through networks; support implementation of conventions; and work closely with UNEP regional offices. The Division, with its Director and Division Office in Paris, consists of one centre and five branches located in Paris, Geneva and Osaka.

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The Economics and Trade Branch (ETB) is one of the five branches of DTIE. Its mission is to enhance the capacities of countries, especially of developing countries and countries with economies in transition, to integrate environmental considerations into development planning and macroeconomic policies, including trade policies. ETB helps countries to develop and use integrated assessment and incentive tools for sustainable development and poverty reduction. The Branch further works to improve the understanding of environmental, social and economic impacts of trade liberalization and the trade impacts of environmental policies, and to strengthen coherence between Multilateral Environmental Agreements and the WTO. Through its finance initiative, ETB helps enhance the role of the financial sector in moving towards sustainability.

In the field of environmental economics, ETB aims to promote the internalization of environmental costs and enhance the use of economic instruments to contribute to sustainable development and poverty reduction, including in the specific context of Multilateral Environmental Agreements. The UNEP Working Group on Economic Instruments serves as an advisory body to UNEP-ETB's work programme on economics and has been instrumental in the preparation of UNEP publications on economic instruments.

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Executive Summary

Rice is the most important food crop in China's agricultural economy. Over the last three decades, the rice growing area has accounted for 27-29 per cent of the total grain cultivation area, and rice represents 42-45 per cent of the country's total grain production. China's rice growing area accounted for nearly one quarter of the world's growing area and more than one third of the world's rice production before the late 1990s. However, in 2003, China's share in the world's rice growing area had dropped to 17 per cent, and after 2000 its share of total world rice production had fallen to less than 30 per cent.

China's rice growing area is widely spread throughout the country and across a variety of natural environments, from low coastal areas in the south-east to high mountain plateaus 2,600 metres above sea level. The rice growing area is divided into two main regions, north and south, and then into six zones according to natural conditions, variety types, farming systems and administrative divisions. More than 85 per cent of the rice growing area lies south of the Qinling Mountain Range and Huaihe River, mainly in the midstream and downstream plain of the Yangtze River, and the basin plain and delta area of the Pearl River. Rice grown in this area is mainly of the low quality indica variety. The rice growing area of the north lies mainly in the north-east where the fertile soils and favourable climate provide the conditions for growing high quality japonica rice.

Rice is particularly important to China's food security, and rice exports account for less than 3 per cent of domestic output. Thus domestic production is determined more by internal policies than by the impacts of trade liberalization.

The overall goal of this project is to enhance understanding of the implications of multilateral trade on national sustainable development and the environment, and to enhance negotiation capacity. The ultimate goal is to formulate policies to correct the identified negative impacts and maximize the positive ones.

The project was initiated in April 2001 when UNEP invited participants from several rice producing countries to a meeting in Geneva to discuss potential studies to assess the economic, social and environmental impacts of the AoA. The project has involved a multitude of stakeholders at all levels. SEPA organized the project, and the project team consisted of experts from the PRCEE of SEPA, the Center for Chinese Agricultural Policy (CCAP) of the Chinese Academy of Science, and the Environment School of Beijing Normal University (BNU). A stakeholder workshop was organized at the beginning of the assessment to review the related studies and collect the relative data for the assessment. All the stakeholders cooperated in the research process to analyse the background of trade liberalization, identify the trade liberalization paths impacting on the rice sector, select methods, and define the research approach. CCAP experts projected the impacts of trade liberalization on the rice sector in 2005 and 2010 at the national and provincial levels. Based on the results, they then assessed the impacts on poverty and chemical input use by region (or by province). Experts from the BNU also assessed the environmental impacts of rice trade liberalization in different regions and conducted field surveys in two provinces, Heilongjiang and Hubei, which are two typical provinces in the north and south rice-growing regions of China respectively. Experts from the PRCEE of SEPA integrated all the results and concluded the final report.

In order to measure the impacts of trade liberalization on China's rice economy, poverty and the rural environment from 2001 to 2010, a quantitative method was developed based on the CCAP's Agricultural Policy Simulation and Projection Model (CAPSiM), which is a partial equilibrium model developed to provide a framework for analysing policies affecting agricultural production, consumption, price and trade at the national level. With the national and regional price transmission models, CAPSiM also simulates the impacts of trade liberalization on production, consumption, poverty and the use of chemicals in the production of rice and other agricultural commodities in each province. Most of the elasticities were estimated using state-of-the-art econometrics.

China has been implementing market-oriented reforms since 1978 and the country's foreign trade market has opened up, especially during the 1990s. Average tariff rates have been reduced from 46.6 per cent in 1992 to 21.2 per cent in 1997. Over two decades, China's foreign trade in agricultural products has increased 14-fold. Between 1980 and 2002, China's rice exports reached record levels for 20 years. Asia and Africa are the main importers of Chinese rice. Most of China's rice imports originate from Thailand (99 per cent in 1999). The country's southern cities constitute the main market for high quality Thai indica rice.

With domestic market reforms, the development of China's agriculture has gradually stepped into a new phase. Over the past 25 years, the country's agricultural production, rural economy and the rural environment have undergone great changes. For example, State Trading Enterprises have undergone radical reforms and no longer have a monopoly on trade.

China continued its market-opening trend by joining the WTO at the end of 2001. Under its market access commitments, China will be required to further lower its tariffs on all agricultural products in 2004, and increase access to its markets for foreign producers by applying tariff rate quotas (TRQ) on some commodities and removing quantitative restrictions on others. In return, China should have better access to foreign markets for her own products. China will also have to adjust her Amber Box policies and enhance Green Box policies based on WTO rules. Currently implemented measures mainly include reducing agricultural taxes, reducing distribution subsidies, implementing direct subsidies for grain production, etc., most of which are aimed at encouraging domestic rice production.

The year after China joined the WTO, imports decreased by 9 per cent and exports increased by 3.2 per cent compared to the previous year. Indeed, because of the importance of rice in national food security, foreign trade in rice could not undergo complete liberalization immediately after WTO accession. Furthermore, the domestic environment is the main factor determining changes in rice production, making it more complicated to identify the direct impacts of trade liberalization on China's rice sector.

The CAPSiM results indicate that under the WTO scenario (compared to a baseline scenario without WTO accession) the average national per capita rice consumption in China will decline gradually from 2001 to 2010 but total rice demand will continue to increase due to population growth. Production will increase slightly more than demand. The rice growing area is expected to reach 28.6 million ha in 2005, which is 1 per cent higher than that in the baseline scenario, and rice production is expected to reach 28.3 million tons in 2010, which is 1.4 per cent higher than in the baseline.

It should be noted, however, that the impacts of trade liberalization differ across regions. The higher quality japonica rice production zones will benefit from trade liberalization and are likely to expand, whereas the zones that produce lower quality indica rice are expected to shrink in the face of increased competition. Trade liberalization is likely to facilitate China's exports of japonica rice to East Asian countries. Super quality indica rice imports are also expected to rise, though the domestic market for this variety will remain limited. Overall net exports are expected to rise by 4 per cent by 2010. As long as the price of indica rice does not fall, increased exports are expected to cause an increase in the average

domestic rice price, which would act as an incentive for farmers to increase rice production. However, an increase in the price of rice is also likely to result in a decline in domestic per capita consumption, although this would have the advantage of increasing China's self-sufficiency rate in rice production.

The estimated impacts on rural households were made on the basis of income group and region. The analysis predicts that, under trade liberalization, the aggregate agricultural output value of the average farm would increase slightly, although the poor farmers gain much less than the richer ones. Furthermore, provinces that produce mainly exportable commodities will gain whilst those that produce importable commodities are likely to experience negative impacts. Food expenditures would also increase, but to a lesser extent, though this also depends on whether the foods consumed are importable or exportable commodities, since importable foods are likely to be priced lower than exportable ones.

Environmental impacts focused mainly on chemical inputs, greenhouse gas emissions and water resources. Rice cultivation accounts for the largest proportion of fertilizer and pesticide use in China. Under trade liberalization, fertilizer use is expected to increase, in view of the anticipated lower price of fertilizer and increased rice production motivated by the higher price of rice, particularly in the major rice production zones. Overuse of fertilizers may cause eutrophication of surface waters, deterioration of soil quality, and air pollution. The accumulation of films forms an obstructive layer in the soil, preventing ventilation, permeation, etc. The impacts on pesticide use are even greater under trade liberalization, particularly in view of the expected increase in imports of cheaper pesticides, and again the higher price of rice acting as an incentive to production.

Structural changes in the rice growing areas as a result of free trade is favourable, on the whole, to decreasing greenhouse gas emissions, with reductions in the south offsetting increases in the north. Similarly with water resources, overall water requirements do not change much with the structural changes in the rice growing area, however the pressure on water resources in northern areas will be greater as a result of production expansion in these areas. Finally, the "Return croplands to wetlands" project will be negatively affected in areas where production is expected to expand, but it will benefit from production decreases in other areas.

Two case study sites were chosen for comparative purposes. Heilongjiang province is the largest rice-producing province in the north and the main polished japonica rice export zone in China. Hubei province is traditionally an indica rice growing region and lies in the middle reaches of the Yangtze River valley. The study revealed that fluctuations in rice production in both areas mainly depended on adjustments of domestic support policies according to WTO regulations rather than on trade liberalization directly. Changes in farmers' incomes mainly originated from changes in the price of rice and adjustments in domestic policies. Ecological impacts relate to changes in the use of chemical inputs, although inputs per unit area remained stable so the total change in chemical input use was mostly based on fluctuations in the crop area. The optimisation of rice production and the development of green production are helpful in improving environmental quality. On the other hand, rural taxation reforms could have a negative impact on the implementation of rural environmental protection projects.

On the whole, the conclusion from this study is that the positive impacts from China's WTO accession are greater than the negative ones. Higher prices encourage farmers to adapt their production to commodities with a greater comparative advantage, such as rice, and adjustments in support policies are helpful in improving farmers' incomes from rice. However, again the impacts differ across regions and China's policy makers will need to pay more attention to enhancing competitive capacity in indica rice growing areas, for example by accelerating the shift to more competitive crops, improving rice quality and promoting green food production.

In dealing with the excessive use of chemical inputs, the Government has several alternatives, such as encouraging wider application of Integrated Pest Management (IPM), new technologies and site-specific nitrogen management (SSNM), although the latter requires investments in training and agricultural extension services. The use of genetically modified (GM) crops can also substantially reduce pesticide use. Another option includes increasing the price of chemical inputs and converting financial support to other production factors such as super seeds, machines and accelerating green production. In order to reduce pressure on water resources it is suggested that the Government increase the price of irrigation water in the north to encourage farmers to adopt water saving irrigation technologies voluntarily. The Government should also take effective measures to limit wetland exploitation to protect habitat and biodiversity.

This report is organized as follows. Sections 1 and 2 briefly describe the background of the project and provide an overview of China's agriculture. The role of rice in China's agriculture and food security is presented in section 3. Domestic market reforms and trade liberalization are explained in section 4. Section 5 covers China's WTO accession and its implications for the country's agriculture. Methodologies, assumptions and scenarios applied in this study are covered in Section 6. The results of the impacts of WTO accession on China's agriculture and rice, and their successive impacts on households and poverty, and environmental impacts on fertilizer, pesticides, water resource uses and methane emissions are presented in sections 7, 8 and 9. Section 10 concludes the study and enumerates policy implications. Detailed explanations on the CAPSiM model and reports on the case studies are provided in the appendices.

Abbreviations and acronyms

AIC	Agricultural Inputs Corporation
AMS	Aggregate measure of support
AoA	Agreement on Agriculture
BNU	Beijing Normal University
Bt	Bacillus thuringiensis
CAM	Comparative advantage magnitude
CAPSiM	CCAP's Agricultural Policy Simulation and Projection Model
CAS	Chinese Academy of Sciences
CCAP	Center for Chinese Agricultural Policy
CCICED	China Council for International Cooperation on Environment and Development
CES	Constant elasticity of substitution
CIF	Cost, insurance and freight
COFCO	China National Cereals, Oils and Foodstuffs Import & Export Corporation
DRC	Domestic resource cost
DRCC	Domestic resource cost coefficient
FAO	Food and Agriculture Organization of the United Nations
FOB	Free on board
GDP	Gross domestic product
GM	Genetically modified
Ha	Hectare
HRS	Household responsibility system
JGIEC	Jilin Grain Group Import and Export Company
mm	Millimetres
MOA	Ministry of Agriculture
MOFTEC	Ministry of Foreign Trade and Economic Cooperation
Mu	Land measurement unit (1mu=1/15hectare)
NCBED	National Centre of Biological Engineering Development
NDRC	National Development and Reform Commission
NPR	Nominal protection rate
NSBC	National Statistical Bureau of China
NTB	Non-Tariff Barrier
PPP	Purchasing power parity
PRCEE	Policy Research Center for Environment and Economy
RDRCC	Ration of Domestic Resource Cost Coefficient
SEPA	State Environmental Protection Administration
SSNM	Site-specific nitrogen management
TFP	Total factor productivity
TRQ	Tariff rate quotas
UN	United Nations
UNEP	United Nations Environment Programme
VAT	Value added tax
WTO	World Trade Organization

1. Background to the project

1.1 Performance of the economy

China's leaders implemented the various reform measures that have stimulated economic growth over the past 25 years. The initiation of economic liberalization and structural change in 1978 has resulted in substantial growth in China's economy. The annual gross domestic product (GDP) growth rate was nearly 9 per cent in 1979-2002 (Table 1-1).

Although reform has pervaded the entire economy since the early 1980s, most of the successive transformations began with, and to some extent depended on, growth in the agricultural sector (Nyberg and Rozelle, 1999). After 1978, decollectivisation, price increases and the relaxation of local trade restrictions on most agricultural products accompanied the growth of the agricultural economy. The average annual growth rate of agricultural GDP reached nearly 5 per cent in 1979-2000, much higher than the population growth over the same period (Table 1-1).

Economic growth has led to a significant decline in the national poverty rate. In the two and half decades since 1978, based on China's official poverty line, more than 230 million Chinese rural residents have escaped poverty, and the absolute poverty level has fallen from 260 million in 1978 to less than 30 million in 2002 (Table 1-2). The incidence of rural poverty has fallen equally fast, plunging from 32.9 per cent in 1978 to less than 3 per cent in 2002. The greatest reductions in poverty came in the early years immediately after the

Table 1-1: The annual growth rates (%) of China's economy, 1970-2002

	Pre-reform	Reform period				
	1970-1978	1979-1984	1985-1995	1996-2000	2001	2002
GDP	4.9	8.5	9.7	8.2	7.5	8.0
Agriculture	2.7	7.1	4.0	3.4	2.8	2.9
Industry	6.8	8.2	12.8	9.6	8.4	9.8
Service	Na	11.6	9.7	8.2	8.4	7.5
Foreign trade	20.5	14.3	15.2	9.8	7.5	21.8
Imports	21.7	12.7	13.4	9.5	8.1	21.3
Exports	19.4	15.9	17.2	10.0	6.8	22.4
Grain production	2.8	4.7	1.7	0.03	-2.16	0.38
Oil crops	2.1	14.9	4.4	5.6	-3.04	1.13
Fruits	6.6	7.2	12.7	8.6	6.95	4.42
Red meats	4.4	9.1	8.8	6.5	3.88	4.02
Fishery	5.0	7.9	13.7	10.2	2.40	4.18
Population	1.80	1.40	1.37	0.90	0.70	0.65
Per capita GDP	3.1	7.1	8.3	7.1	6.7	7.2

Note: The GDP figure for 1970-1978 is the growth rate of national income in real terms. Growth rates are computed using the regression method. Growth rates of individual and groups of commodities are based on production data; sectoral growth rates refer to value added in real terms.

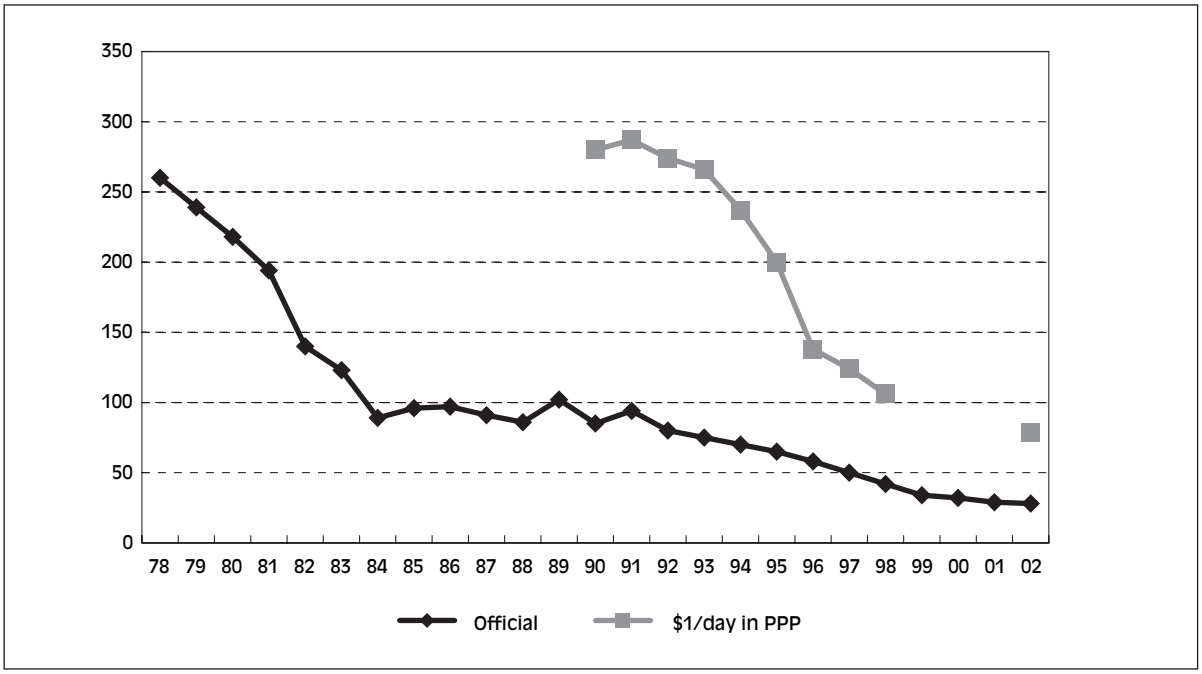
Source: National Statistical Bureau of China (NSBC), Statistical Yearbook of China, various issues; MOA, China Agricultural Yearbook, various issues.

Table 1-2: Rural poverty in China, 1978-2002

Year	Poverty based on China's official poverty line			Poverty based on international standards ($1/day in PPP)	
	Poverty line (Yuan/year)	Number of poor (million)	Poverty incidence (%)	Number of poor (million)	Poverty incidence (%)
1978		260	32.9		
1979		239	30.2		
1980		218	27.6		
1981		194	24.4		
1982		140	17.5		
1983		123	15.3		
1984	200	89	11.0		
1985	206	96	11.9		
1986	213	97	11.9		
1987	227	91	11.2		
1988	236	86	10.4		
1989	259	102	11.6		
1990	300	85	9.4	280	31.3
1991	304	94	11.0	287	31.7
1992	317	80	8.8	274	30.1
1993	350	75	8.3	266	29.1
1994	440	70	7.7	237	25.9
1995	530	65	7.1	200	21.8
1996	580	58	6.3	138	15.0
1997	640	50	5.4	124	13.5
1998	635	42	4.6	106	11.5
1999	625	34	3.9		
2000	625	32	3.4		
2001	630	29	3.2		
2002	627	28	3.1	78.6	8.7

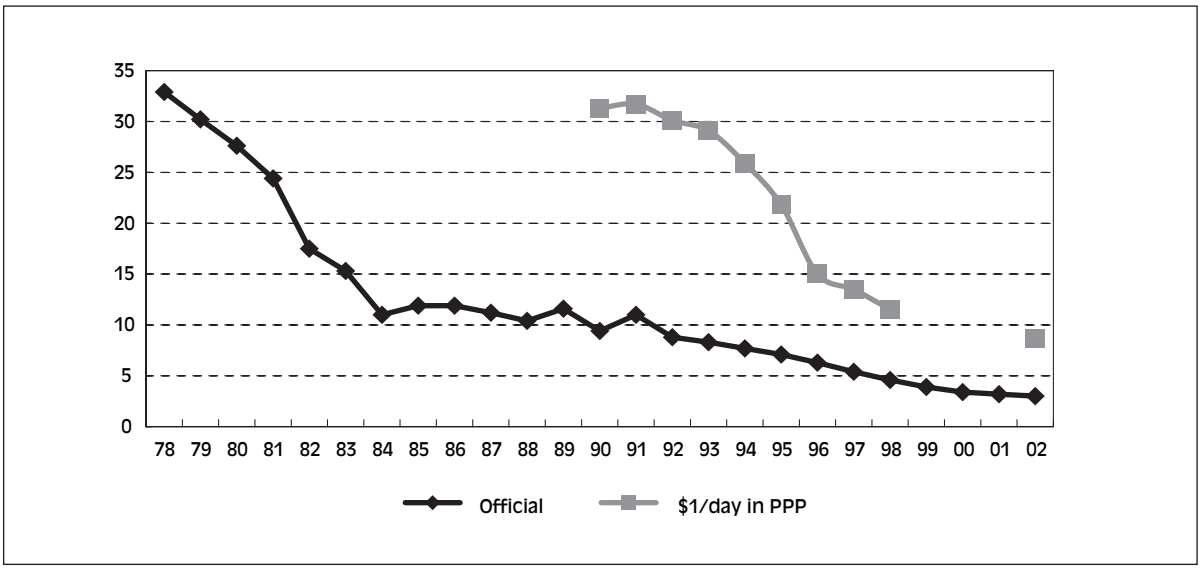
reforms and during most of the 1990s. Even based on international standards of what constitutes the poverty line, i.e. one dollar per day in purchasing power parity (PPP) terms, the number of poor and the incidence of poverty have fallen equally fast (Table 1-2 and Figures 1-1a and 1-1b).

Figure 1-1a: Rural poverty in China, 1978-2002: number of rural poor (million)



Sources: Huang, Zhang and Rozelle, 2005.

Figure 1-1b: Rural poverty in China, 1978-2002: poverty incidence (%)



Sources: Huang, Zhang and Rozelle, 2005.

1.2 Challenges

While economic growth and the reduction of rural poverty have been impressive in the past, there are still great challenges ahead. In terms of agricultural production, the growth rate declined from more than 7 per cent in the early reform period (1979-1984) to less than 3 per cent recently (Table 1-1). High input levels in many areas of China and diminishing marginal returns mean that increasing inputs will not lead to large increases in outputs. Water shortages and increasing competition for water resources for industry and domestic use do not provide much hope for large gains in area and yield from the expansion of irrigation. Institutional change often provides only one-time shifts and has been shown to be largely exhausted in China (Huang and Rozelle, 1996). In the future, many have predicted that almost all gains will have to come from second and third generation Green Revolution technologies that could significantly improve agricultural productivity.

It is particularly worth noting that past agricultural growth has occurred at high environmental cost. For example, increases in agricultural and food production were achieved by increasing the intensity of farming systems and chemical use, especially chemical fertilizers and pesticides. The concerns on agricultural non-point pollution have been rising.

The economic growth was also accompanied by large income disparities. The income gap between regions, urban and rural households, and households within the same location has been increasing continuously since the mid-1980s (Rozelle, 1996). The rural/urban income ratio now exceeds 3.4 (NSBC, 1981-2003). Income disparities have risen within rural areas. The rising Gini coefficients, which increased from 0.24 in 1980 to 0.35 in 2000 and 0.32 in 2001, indicate the rising income disparity in rural areas (NSBC, 1991-2003).

Although there has been a significant reduction in the poverty rate in China, there are still nearly 30 million rural people living below the national poverty line and an even larger number according to international poverty line standards (Figures 1-1a and 1-1b). If we apply the World Bank's poverty line (US$ 1/day measured in PPP), the number of rural poor reached nearly 9 million, which represents about 9 per cent of the rural population in 2002 (Table 1-2). Moreover, the pace of rural poverty reduction has slowed down significantly since the late 1990s as the poverty levels fell (Figures 1-1a and 1-1b).

Trade liberalization further challenges China's agricultural and rural economy. Agriculture has been at the centre of discussions regarding China's accession to the WTO, partly due to the vulnerability of segments of the rural economy but also to the importance of agriculture in the political economy of a number of developed nations with whom China negotiated its accession to WTO. However, the likely shifts in China's future agricultural policy and their impacts are not well understood, and debates on the future of China's agriculture continue. Some argue that the impact of WTO accession on China's agriculture will be substantial, adversely affecting hundreds of millions of farmers (Carter and Estrin, 2001; Li *et al.*, 1999). Yet others believe that, although some impacts will be negative and even severe in specific areas, the overall effect on agriculture will be modest (Anderson and Peng, 1998; Anderson *et al.*, 2004). In part, the confusion regarding the ultimate impact of WTO accession on agriculture can be traced to a general lack of understanding of the policy changes that WTO accession will engender (Martin, 2002). However, the lack of clarity in the debate can be traced, in perhaps an even greater way, to a lack of understanding of the fundamental facts regarding the nature of the distortions to China's economy on the eve of joining the WTO.

1.3 Issues and objectives

Despite the importance of China's move to join the WTO to both world trade and the Chinese domestic food economy, little empirical work has sought to answer basic questions regarding the expected effects on the environment and poverty of China's WTO accession. Huang, Li and Rozelle (2003) showed that, on balance, China's WTO accession helps rural residents and improves incomes. They also demonstrated that, since households in most parts of China are fairly well integrated into national markets, the effects of trade liberalization that start at China's ports–both those that raise and lower domestic prices–are diffused rapidly throughout the economy (Huang, Rozelle and Chang, 2004).

However, in previous modelling efforts, researchers rarely tried to closely track the way in which different types of households have been affected and, as far as we know, there is no study in China that analyses the impacts of trade liberalization on the environment. Likewise few have tried to assess the effects of the trade policy changes on the different types of crops and the households in different regions of the country that produce them. Without this type of analysis, it is difficult to assess household and environmental impacts, since each category of farmer (e.g. richer or poorer) living and farming in different regions produces a variety of crop types to which different levels of fertilizer and pesticides are applied.

UNEP has been supporting the SEPA in the implementation of this project on the impacts of trade liberalization on the agriculture sector and the environment with specific focus on the rice sector. The overall goal of the project is to enhance the country's understanding of the implications of multilateral trade rules and trade liberalization on sustainable national development and the environment and to strengthen negotiating capacity. The ultimate objective is to formulate policies and policy packages to correct the identified negative impacts of liberalized trade and maximize the positive ones through economic and regulatory instruments as well as through the application of voluntary private sector initiatives, particularly in the context of the AoA.

More specifically, within the overall project this study aims to examine the effects of China's WTO accession on its economy, society and the environment in general and on the rice sector in particular. The agricultural impacts are analysed by commodity at the national and regional levels (i.e. in major provinces). The impacts are simulated for the poor and non-poor households in the representative provinces. For the environmental impacts, the focus is on the changes in chemical fertilizer and pesticide use due to trade liberalization in the various rice production regions.

2. Overview of China's agriculture

Remarkable progress has been achieved in China's economic performance. The average annual growth of agriculture was about 5 per cent throughout the entire reform period (Table 1-1). Despite the expansion of agriculture, the even faster growth of the industrial and service sectors during the reform era has begun to transform the rural economy from one based on agricultural production to one focused on industry.

2.1 Changing role of agriculture in the economy

Successive transformations of China's economic reform are based on agricultural growth (Nyberg and Rozelle, 1999). During this transformation process, the share of agriculture in the national economy declined significantly. Whereas agriculture accounted for more than 30 per cent of the GDP prior to the economic reforms in 1979, by 2002 the share of agriculture had fallen to less than 15 per cent (NSBC, 1981-2003). Agriculture has made important but declining contributions to national economic development in terms of gross value added, employment, capital accumulation, urban welfare and foreign exchange earnings.

Economic changes can also be seen in employment. Agriculture employed 81 per cent of labour in 1970, but 50 per cent after 2001 (NSBC, 1981-2003). Off the farm, more than 40 per cent of rural residents have employment, and about 100 million of them have migrated to urban areas for employment (Rozelle *et al.*, 2002). With such sharp changes in the employment structure, China is moving from a rural-based to an urban-based society.

The declining importance of agriculture is historically common to all developing economies. China is densely populated; farm sizes averaged less than one hectare as early as the 1950s. Population growth and limited land resources will cause China to shift from its comparative advantage in land-intensive economic activities such as agriculture to labour-intensive manufacturing and industrial activities (Anderson, 1990).

2.2 Agricultural production

The growth of agricultural production in China since the 1950s has been one of the main accomplishments of the country's development and national food security policies. Except during the famine years of the late 1950s and early 1960s, the country has enjoyed production growth rates that have outpaced population growth.

After 1978, de-collectivisation, price increases and the relaxation of trade restrictions on most agricultural products accompanied the rapid growth of China's food economy. Between 1978 and 1984, grain production increased by 4.7 per cent per year; the output of fruit rose by 7.2 per cent (Table 1-1). The highest annual growth rates came in the oilseed, livestock and aquatic products sectors. These sectors expanded in real value terms by 14.9 per cent, 9.1 per cent and 7.9 per cent, respectively.

However, as these one-time efficiency gains resulting from the shift to the household responsibility system (HRS) were essentially reaped by the mid-1980s, the growth rate of the food and agricultural sectors decelerated (Table 1-1). The declining growth trend was most pronounced for grain crops. However, although the growth rate generated in both the pre-reform and early reform periods dropped, the production of most agricultural commodities continued to expand after 1985 (Table 1-1).

The earliest empirical studies have already demonstrated that institutional changes contributed to the largest agricultural growth in the early reform period. These studies focused on measuring the contribution of the institutional innovations and concluded that most of the rise in productivity was a result of the HRS, a policy that gave individual farmers control and income rights in agriculture (McMillan *et al.*, 1989; Fan, 1991; Lin, 1992).

More recent studies show that since the HRS was completed in 1984 several factors simultaneously contributed to agricultural growth since the mid-1980s. Technological change has been the primary engine of agricultural growth (Huang and Rozelle, 1996; Fan, 1997; Fan and Pardey, 1997; Huang *et al.*, 1999). The results of these studies show that further reforms outside of de-collectivisation also have high potential for affecting agricultural growth. Price policies have been shown to have had a notable influence on the growth (and deceleration) of both grain and cash crops during the post-reform period. A deteriorating price ratio caused by slowly increasing output prices in the face of sharply rising input prices was an important factor behind the slowdown in agricultural production in the late 1980s and early 1990s. Rising wages and the higher opportunity cost of land have also held back the growth of grain output throughout the period and that of cash crops since 1985. Irrigation has played a critical role in establishing the highly productive agronomic systems in China, however, rising demand for water for domestic and industrial uses poses a serious threat to irrigated agriculture, and increasing water scarcity has come to be seen as a major threat to the future food security and well-being of people, especially in the northern region (Wang, 2000).

Trends in environmental degradation, including overuses of fertilizer and pesticides, erosion, salinization and the loss of cultivated land suggest that there may be considerable stress being put on the agricultural land base and environment. Erosion and salinization have increased since the 1970s. The overuse of fertilizers and pesticides has generated considerable pollution in rural areas (Zhang *et al.*, 2004 forthcoming; Huang *et al.*, 2000). These factors have been shown to affect the output of rice and other grains and agricultural products in a number of recent studies (Huang and Rozelle, 1995 and 1996).

2.3 Changing structure of agricultural production

Rapid economic growth, urbanization and the development of the food market have boosted demand for meat, fruit and other non-staple foods. These changes have stimulated sharp shifts in the agricultural structure (Huang and Bouis, 1996; Huang and Rozelle, 1998). For example, the share of livestock output value more than doubled from 14 per cent to 31 per cent between 1970 and 2002 (Table 2-1). Aquatic products rose at an even faster rate. The other significant sign of structural changes in the agricultural sector is that the share of the crop sector in total agricultural output fell from 82 per cent to 55 per cent. Moreover, the largest decline in crop-specific growth rates has been experienced in the grain sector (Table 2-1).

Within the crop sector, the importance of the three major crops (rice, wheat and maize) grew and then weakened. The area share of these three cereals increased from 50 per cent in 1970 to a peak level of over 57 per cent in 1990 and then gradually declined again to less that 50 per cent after 2000 (Table 2-1), mostly due to a decrease in the wheat growing area and, to a lesser extent, the rice growing area. In contrast, the maize growing area grew by about 50 per cent between 1970 and 2002 (Table 2-1). Maize is China's main feed grain and the rise in its growing area correlates in no small way to the rapid expansion of livestock production during the same period.

Major cash crops such as vegetables, edible oil crops, sugar crops and tobacco have all experienced rapid growth. In the 1970s, vegetables accounted for only about 2 per cent of the total crop area; by 2001, the share had increased more than five-fold (Table 2-1). The area share of edible oil crops (excluding soybeans) also multiplied three to four times. The most significant area expansion occurred in the fruit sector that increased five-fold over 20 years.

Table 2-1: Changing structure of the agricultural economy, 1970-2002

	1970	1980	1985	1990	1995	2000	2001	2002
				Agricultural output value share (%)				
Crop	82	76	69	65	58	56	59	55
Livestock	14	18	22	26	30	30	26	31
Fishery	2	2	3	5	8	11	11	11
Forestry	2	4	5	4	3	4	4	4
				Crop growing area shares (%)				
Cereal grains								
– Rice	22.1	23.1	21.9	22.3	20.5	19.2	18.5	18.2
– Wheat	17.4	19.7	20.0	20.7	19.3	17.1	15.8	15.5
– Maize	10.8	13.7	12.1	14.4	15.2	14.8	15.6	15.9
Subtotal	50.3	56.5	54	57.4	55	51.1	49.9	49.6
Soybeans	5.5	4.9	5.3	5.1	5.4	6.0	6.1	5.6
Rapeseed	1.0	1.9	3.1	3.7	4.6	4.8	4.6	4.6
Peanuts	1.2	1.6	2.3	2.0	2.5	3.1	3.2	3.2
Sugar	0.4	0.6	1.0	1.2	1.3	1.0	1.1	1.2
Cotton	3.4	3.4	3.5	3.8	3.6	2.6	3.1	2.7
Tobacco	0.2	0.3	0.9	0.9	0.9	0.8	0.8	0.8
Vegetables	2.0	2.2	3.2	4.3	6.3	9.7	10.5	11.2
Others	41.6	34.5	34.3	30.6	31.2	34	35.1	35.8
Total	100	100	100	100	100	100	100	100
				Tea and fruit growing areas (1,000 hectares)				
Tea		1041	1077	1061	1115	1089	1141	1134
Fruit		1783	2736	5179	8098	8932	9043	9098

Sources: NSBC, Statistical Yearbook of China, various issues; NSBC, China Rural Statistical Yearbook, various issues; NSBC, China Rural Household Survey Yearbook, various issues.

2.4 Agricultural trade

While agricultural production was expanding fast, agricultural trade was growing even faster. Agricultural imports and exports almost tripled from 1980 to 1995 (Table 2-2), although exports rose faster than imports. Since the early 1980s, China has been a net food exporter.

In the same way that trade liberalization has affected growth in the domestic economy (Lardy, 2001), changes in the external economy have affected the nature of China's trade patterns (Huang and Chen, 1999). Whereas the share of primary (mainly agricultural) products in total exports was over 50 per cent in 1980, it fell to only 10 per cent in 2002 (NSBC, 1981-2003). Over the same period, the share of food in total exports fell from 17 to 5 per cent and the share of food imports fell from 15 to 2 per cent.

Disaggregated, crop-specific trade trends show equally sharp shifts and suggest that exports and imports are increasingly moving towards products in which China has a comparative advantage and that have therefore also facilitated the structural changes in agriculture (Table 2-2 and Figure 2-1). The net exports of land-intensive bulk commodities such as grains, oilseeds and sugar crops have fallen; exports of higher-valued, more labour-intensive products, such as horticultural and animal (including aquaculture) products, have risen. The proportion of grain exports, which represented about 20 per cent of total agricultural exports in the 1990s, is less than half what it was in the early 1980s. By the late 1990s horticultural products and animal and aquatic products accounted for about 80 per cent of agricultural exports (Huang and Chen, 1999). These trends are even more evident when we reorganize the trade data and group them on the basis of factor intensity (Figure 2-1).

Table 2-2: China's food and feed trade (million US$), 1980-2002

	1980	1985	1990	1995	2000	2001	2002
Exports:							
Live animals and meat	745	752	1221	1822	1628	1976	1008
Dairy products	71	57	55	61	188	192	194
Fish	380	283	1,370	2,875	3705	4231	4690
Grains, oils and oilseeds	481	1,306	1,237	1,608	2667	1835	2422
Horticulture	1074	1260	2293	3922	4367	4931	6402
Sugar	221	79	317	321	173	156	227
Sum of above foods	**2,972**	**3,737**	**6,493**	**10,609**	**12,728**	**13,340**	**14943**
Imports:							
Live animals and meat	6	24	68	115	696	659	706
Dairy products	5	31	81	60	218	219	274
Fish	13	44	102	609	1212	1319	1558
Grains, oils and oilseeds	2,472	1,065	2,535	6,760	4163	5343	5825
Horticulture	104	92	113	259	677	866	838
Sugar	316	274	390	935	177	376	238
Sum of above foods	**2,916**	**1,530**	**3,289**	**8,736**	**7,143**	**8,782**	**9439**
Net exports:							
Live animals and meat	739	728	1153	1707	932	1317	302
Dairy products	66	26	-26	1	-30	-27	-80
Fish	367	239	1,268	2,266	2493	2912	3132
Grains, oils and oilseeds	-1991	241	-1298	-5152	-1496	-3490	-3403
Horticulture	970	1168	2180	3663	3690	4065	5564
Sugar	-95	-195	-73	-614	-4	-220	-11
Sum of above foods	**56**	**2,207**	**3,204**	**1,873**	**5,585**	**4,558**	**5504**

Source: Data for 1980-1995 are taken from Mathews, 2001, based on UN COMTRADE statistics; data after 1995 were taken from NSBC, 1981-2003 and MOFTEC, 2002-2003.

Figure 2-1: Agricultural trade balance by factor intensity (million US$), 1985-2003

Note: Land intense products include grain, oils, sugar, cotton and wool. Labour intense products include livestock, fish, horticulture and beverages.

Source: Huang and Chen, 1999 and MOFTEC, 2002-2003.

3. China's rice economy

3.1 Importance of China's rice sector

Rice is the most important food crop in China's agricultural economy. Over the last three decades the rice growing area represented about 27–29 per cent of the country's total grain growing area and rice production accounted for 42–45 per cent of total grain production (Table 3-1). Moreover, rice makes up 40 per cent of the national calorie intake (Huang and Rozelle, 1996).

Rice produced in China is also the largest component of the world rice economy. Before the late 1990s, China's rice growing area represented nearly one quarter of the world's growing area and Chinese rice production accounted for more than a third of total world production (Table 3-1). However, China's shares in the world's rice growing area and production have declined significantly since the late 1990s (see next subsection for details). China's share in the world's rice growing area dropped from 23 per cent in 1990 to 19 per cent in 2000 and 17 per cent in 2003. Its share in world rice production declined from 38 per cent in 1990 to less than 30 per cent after 2000 (Table 3-1).

The rise in rice production in China during the 1970s and 1980s is one of the most remarkable success stories in science, technology and policy-making. Several factors contributed to the sharp increase in production (Huang and Rozelle, 1996; Fan, 1991). Technology changes, increasing availability of water, and chemical fertilizer and pesticide use all contributed to growth in rice production exceeding population growth. As for the remainder of the agricultural sector, institutional changes stimulated production, particularly in the early reform period, 1979-1984 (Huang and Rozelle, 1996).

China's rice economy is also facing a number of challenges and opportunities in production, consumption and trade. A careful examination of China's rice economy suggests that the sector remains difficult to predict since it defies categorization (i.e. conventional and hybrid rice, indica and japonica rice). The potential for future productivity increases is difficult to gauge by studying other developing countries since a larger proportion of China's rice growing area is irrigated than in any other main rice-producing nation. Furthermore, the demand structure has been changing. All of this will have a significant effect on rice production, farmers' incomes and rice trade.

Table 3-1: Importance of China's rice economy (%), 1970-2003

	1970	1980	1990	2000	2003
Rice in China's grain economy					
Area	27	29	29	28	27
Production	45	44	42	46	42
China's rice in the world rice economy					
Area	24	23	23	19	17
Production	36	38	38	31	27

Sources: NSBC, 1981-2003 and FAO, 2003.

3.2 Rice production

3.2.1 Natural conditions and geographical distribution of China's rice production

The distribution of rice growing areas in China tends to be regionalized and discontinuous because of topography and weather conditions. In south-east China, high temperatures and adequate rainfall provide an ideal environment and long growing period for rice cultivation. The region south of the Qinling Mountain Ranges and the Huaihe River covers nearly 30 million ha, i.e. over 90 per cent of the total rice growing area.

In north-west China, low temperatures, a short growth period, little rainfall and lack of water limit the rice growing area. South of the Huang-huai-hai Plain is a larger rice-growing area, but it is often limited by volatile rainfall between spring and summer. The Bohai Bay region, the lower reaches of the Liaohe River and the Songhua River basin are other vast rice growing areas in the eastern high latitude region. There are also scattered rice-growing areas in the arid and semi-arid regions of north-west China.

A shrinking land base for agriculture is the primary production constraint. On average, China's population is increasing by 13 million/year while the cultivated land area is shrinking by some 300,000 ha/year. In the past 40 years, China's cultivated land area per capita has shrunk from 0.18 ha to 0.085 ha, a decrease of 53 per cent. Relatively serious water loss, soil erosion, expanding desertification, increased salinization and decreasing organic matter content in the soil pose grave difficulties for sustained agricultural development.

At present there is not much land left than can be reclaimed so China's increasing demand for grain has to be met by raising yields. There is great potential for raising yields, especially on some 26 per cent of the total rice growing area that has medium-to-low productivity.

Droughts, floods, water logging, severe cold periods and insects affect 20-50 million ha of agricultural land throughout the country. Salinity and toxicity affect some more recent rice fields, but nutrient deficiency is the more general constraint. Water shortages often reduce the irrigated area and frequency of irrigation, resulting in rice production losses as high as 1-2 million tons in some years.

The main task of Chinese rice scientists in the near term is to ensure the sustainability of gains achieved thus far. Over the longer term, increased production is expected through improved rice varieties and soil fertility, greater efficiency in fertilizer use, integrated management of low-to-medium-yielding rice fields, insect pest management, disease and weed control, mechanization, improved post-harvest processing, and more efficient irrigation and water conservation.[1]

China's rice growing area is spread over a wide area that reaches Hainan Island in the south (18° 9‘ N), Heihe River in Heilongjiang (52° 29‘ N) in the north, Taiwan in the east, and Xinjiang Uygur Autonomous Regions in the west. Rice growing areas can also be found at low altitudes on the coastal tide fields in the south-east, and at higher altitudes up to the Yunnan-Guizhou plateau 2,600 metres above sea level. More than 90 per cent of the rice growing area lies south of Qinling Mountains and Huaihe River, and mainly in the midstream and downstream plain of the Yangtze River, the basin plain and the delta area of the Pearl River. The sand plains of Yunnan and Guizhou, the strand plains of the coastal area of Zhejiang and Fujian, and Taiwan west plain are also important rice producing regions of China.

In 1957, Professor Ding Ying divided Chinese rice growing zones into two major rice rice growing regions, north and south, and six rice zones according to natural conditions, variety types, farming systems and administrative divisions, as shown in Map 3-2 and Table 3-2.

[1] http://www.riceweb.org/countries/china.htm.

Map 3-1: Precipitation isoline of China in 1999 (mm)

Source: Water Resources Ministry, 2000.

Map 3-2: Distribution of China's rice production areas and zones

Table 3-2: Characteristics of China's rice growing areas and zones

Rice area	North rice growing area			South rice growing area		
Rice zone	**North rice zone**	**North-east rice zone**	**North-west drought rice zone**	**South rice zone**	**Central rice zone**	**South-west high-land rice zone**
Range	Bordered by Qinling Mountain Range-Huaihe River in the south and the Great Wall in the north	To the north of the Great Wall and east of the Great Xinganling Mountain Range	To the west of Hexi corridor and the north of Qilian Mountain Range	To the south of Nanling Mountain Range	To north of Nanling Mountain Range and south of Qinling Mountain Range and Huaihe River	Yunnan, Guizhou, Tibet and west Sichuan province
Degree of rice paddy drought	2~6	1	>6	<1	1	>1
Rice growth period (month)	5~7	4~5	5~6	9~12	7~9	7~10
Average temperature in growth period (°C)	19~22.6	16.6~20	18.3~21.8	22~26	20~22 or higher	20 or lower
Rotation	Spring rice and wheat	Spring rice	Spring rice	Two rice harvests per year	Rice and wheat or two rice harvests	Rice and wheat
Rice type	High land middle japonica rice	Early japonica rice	Early japonica rice	Early, middle and late indica type rice	Indica and japonica rice	Indica rice in lower land, Japonica rice in higher land

Source: Chinese Committee for Agricultural Regional Planning, 1987.

3.2.2 Growth trends

Rice production in China has grown steadily throughout the last several decades except for recent years (Table 3-3). In the 1970s, rice yields increased about 2 per cent annually. The growth rate accelerated to 5.1 per cent in the early reform period (1978-1984). Although the growth rate slowed somewhat after the mid-1980s, rice yields are still among the highest in the world, reaching 6.3 ton/ha by the late 1990s (NSBC, 2001 issue). These successes have depended on the Government's continuous efforts to modernize the nation's rice economy (Hu *et al.*, 2000). However, unlike maize (the growing area of which increased after the mid-1980s), the rice growing area shrank by nearly 0.6 per cent per year from 1970 to 2000. Rice production and yield growth rates fell behind the overall average for grain in each of the sub-periods since the mid-1980s.

After reaching a historical high in 1997-1998, rice production declined after 1998. In recent years (2001-2003) the average annual decline of rice production amounted to 4.8 per cent, which was much higher than the declining rate of grain production (1.7 per cent) in the same period (Table 3-3). The decline in rice production was mostly due to the switch from rice to other crops in response to market price changes. The rice-growing area decreased by 3.8 per cent annually in 2001-2003. A drop in the price of rice also resulted in a reduction in the amount of inputs used in rice production and, consequently, lower crop yields in recent years. The annual yield growth rate has been negative (-1 per cent) since 2000.

The decline in grain production has led to renewed concern among national leaders regarding China's grain security after prices rose between the autumn of 2003 and spring of 2004. In response to these

concerns the Government recently launched several policies to promote grain (mainly rice, wheat and maize) production. For example, an income transfer scheme of 100 billion Yuan was implemented in 2004 through a direct subsidization programme that is supposed to involve the distribution of cash payments to farmers in major grain producing areas. Perceiving part of the problem to be a fall in the cultivated area, leaders imposed strict controls on the conversion of cultivated land to non-agricultural uses.

Government officials and academics have differing views on the current policies. Huang (2004) shows that China's grain production and stock in the late 1990s were so high that they led to constant decreases in grain prices. As a natural consequence of the laws of supply and demand, production gradually fell during this time. By early 2003, the excess supplies of grain in storage (Government stocks and household reserves) that had threatened China's grain markets over the previous several years gradually disappeared and grain prices began to stabilize. The increase in grain prices at the end of 2003 and throughout the early months of 2004 was a normal and expected market reaction resulting from successive years of low prices.

High grain prices in late 2003 and early 2004 incited farmers to produce more, and have in fact already led to higher production of rice, wheat and maize in 2004. Recent surveys by the Ministry of Agriculture (MOA) and the NSBC showed that both the grain growing areas and yields increased, and production is expected to rise by more than 5 per cent in 2004.

3.2.3 Structural changes in production

A yield increase has been the central goal of the policy on rice research and technology. China developed and extended its first fertilizer-responsive, semi dwarf rice varieties in the early 1960s before the rest of the world had been introduced to Green Revolution technology. By the early 1980s, more than 98 per cent of China's rice growing area was planted with improved varieties, both conventional high-yielding varieties and hybrid rice cultivars (Huang and Rozelle, 1996). Disease-resistant varieties were developed and extended throughout the late 1970s and 1980s.

One of the largest breakthroughs in rice yield is the development of hybrid rice. Hybrid rice was developed by a group of breeders led by Yuan Longping in the early 1970s. In 1976, China began to extend F1 hybrid rice varieties for use by farmers. With a potential 15-20 per cent yield advantage over conventional high-yielding varieties, the area under hybrid rice expanded rapidly

Table 3-3: Growth rates (%) of rice and total grain production, growing area and yields in China, 1970-2003

Commodity	Pre-reform 1970-1978	Reform period 1978-1984	1984-1995	1996-2000	2001-2003
Grain					
Production	2.8	4.7	1.7	0.03	-1.7
Growing area	0.0	-1.1	-0.1	-0.14	-2.7
Yield	2.8	5.8	1.8	0.17	1.1
Rice					
Production	2.5	4.5	0.6	0.3	-4.8
Growing area	0.7	-0.6	-0.6	-0.5	-3.8
Yield	1.8	5.1	1.2	0.8	-1.0
Wheat					
Production	7.0	8.3	1.9	-0.4	-4.5
Growing area	1.7	0.0	0.1	-1.4	-5.9
Yield	5.2	8.3	1.8	1.0	1.5
Maize					
Production	7.4	3.7	4.7	-0.1	3.3
Growing area	3.1	-1.6	1.7	0.8	1.4
Yield	4.2	5.4	2.9	-0.9	1.8

from 4.3 million hectares in 1978 to 15.9 million hectares in 1990, increasing from 12.6 per cent of the rice growing area to 41.2 per cent (Huang and Rozelle, 1996). The share of hybrid rice in the total rice growing area reached a historical high in the early 1990s (Table 3-4) when more than half of the rice grown in China was hybrid rice.

However, the high-yield goal of research and extension policies has faced increasing challenges since the early 1990s. After 1993, when the rice retail market was liberalized, the use of hybrid rice fell because of concerns regarding quality. Estimates show that the share of hybrid rice declined from its peak level of 54 per cent in 1991-1992 to about 50 per cent in recent years (Table 3-4). Increasing demand for high-quality rice is also believed to have had a significant effect on rice production by region and type of rice (indica and japonica) (Table 3-4). The rice growing area expanded rapidly in north China, a major japonica production area. North China's share of the overall rice growing area expanded from less than 6 per cent before the 1980s to 10 per cent in 1990 and 15 per cent in 2003. Several provinces that were traditionally indica rice producers in the lower part of the Yangtze River Basin, such as Jiangsu, Zhejiang, Shanghai and Anhui, have now become major new japonica producers. Rising rice production in north China and shifting rice production from indica to japonica cultivars in the Yangtze River Basin have raised the share of the japonica rice growing area from 11 per cent in 1980 to 16 per cent in 1990 and 30 per cent in 2003 (Table 3-4).

3.2.4 The nature of technological change in the past

Breeders in China have turned out a constant stream of modern rice varieties. Since 1982, rice farmers in China have used about 400 major varieties each year (Table 3-5)[2], which implies that farmers in each province use about 25 major rice varieties annually. However, this number varies greatly across regions, ranging from less than 10 in Hebei to about 50 in Guangdong. Hu *et al.* (2000) showed that historic investment priority, fortunate breakthroughs and the availability of international germ plasm have all contributed to the activities of plant breeding programs and the spread of rice varieties in China.

China's breeding efforts have also enhanced the quality of the country's seed stock. Based on experiment-station yields of each major variety during the year that the variety was certified, two quality measures were developed: a "yield frontier"

Table 3-4: Structural changes (%) in rice production in China, 1980-2003

	Area shares by variety		Shares by region		Hybrid rice area share
Year	Indica	Japonica	South	North	
1980	89	11	94	6	14
1985	88	12	93	7	26
1990	84	16	90	10	49
1995	79	21	89	11	52
2000	73	27	86	14	51
2003	70	30	85	15	50

Note: The hybrid rice growing area reached a peak in 1991-1992, and accounted for about 54 per cent of the total rice growing area. The conventional (non-hybrid) rice growing area share = 100 per cent - hybrid rice growing area share.
Sources: Unpublished data provided by Jikun Huang and Ruifa Hu, Center for Chinese Agricultural Policy, Chinese Academy of Sciences.

[2] A "major" variety in our sample is any variety that covers at least 10,000 mu (or 667 ha) in a province. Since our database is built on this concept, we do not have full coverage. In fact, the proportion of area covered by "major" varieties exceeds 90 per cent in each province.

Table 3-5: Major variety, yield frontier, total factor productivity (TFP) of rice in 16 major rice growing provinces and agricultural research investment in China, 1981-1995

	16 major rice growing provinces			National average for all 31 provinces				
	Rice variety number	Average increases in yield frontier [a] (kg/ha)	Adopted yield potential [b] (kg/ha)	Output index [c]	Material input index [c]	Labour input (days/ha) [c]	Total input index [c]	TFP index [c]
1980				99	103	567	97	109
1981				100	101	485	93	120
1982	379	460	402	112	108	393	87	138
1983	333	468	414	118	111	364	87	146
1984	380	509	415	122	113	345	84	156
1985	424	512	424	115	116	330	80	154
1986	419	515	431	117	119	325	79	157
1987	373	552	438	117	124	317	78	158
1988	381	577	449	115	136	318	80	151
1989	365	590	455	123	141	315	82	158
1990	412	595	463	127	143	312	82	163
1991	395	595	465	123	144	296	78	165
1992	403	601	476	121	144	290	74	169
1993	392	603	475	117	142	285	70	179
1994	416	605	476	116	167	271	74	169
1995	391	611	483	121	170	287	77	170

a: The yield frontier is the highest experiment station yield of a variety that has been extended to the field. The variable is non-decreasing in the sense that if in some subsequent year the highest yielding variety has a lower yield, the previous period's yield is maintained.
b: Adopted yield potential is the average experiment-station yields of all varieties adopted by farmers.
c: The base year of all indexes is 1979 (1979 = 100).
Sources: Hu *et al.,* 2000.

variable and an "adopted yield potential" variable[3]. The yield frontier, which is defined based on the highest yield of any one major variety in the field in each province during a given year, is a measure of the ultimate yield potential of the current technology used by farmers in each province. The adopted yield potential is the average of the experiment-station yields of all major varieties adopted by farmers.

According to the above two measures, China's research system has created a steady stream of high-quality technology (Table 3-5). The yield frontiers for rice increased 2.3 per cent per year from 1980 to 1995, most likely because of the development of hybrid cultivars. However, farmers have not always chosen (or perhaps not been able to choose) the highest-yielding varieties. The average adopted yield potential of major varieties in the sample area rose at the annual rate of 1.4 per cent during the reforms (Table 3-5). This represents a difference of 31 per cent compared to farmers' actual yields in 1980, a gap that is not high by developing countries' standards (Pingali *et al.*,

[3] "Yield frontier" is defined as non-decreasing. If a major variety (defined in note 2) used by farmers in the field has the highest yield one year, it is assumed that the yield frontier in that province has reached that yield level and will not fall, even in the rare case that farmers have stopped using that variety and all other varieties have lower certified yields in the following years.

Table 3-6: Experiment station yields (yield frontier and adopted yield potential), actual yields, and yield gaps in 16 major rice-growing provinces, 1980-1995

	1980 (tons/ha)	1995 (tons/ha)	Annual growth rate (%)
Yield frontier	6.6	9.1	2.3
Adopted yield potential	6.1	7.2	1.4
Actual yield	4.2	6.2	2.1
Percentage gap between adopted yield potential and actual yields	31%	14%	

Source: Hu *et al.,* 2000.

1997). Reflecting in part the rapid rise in material inputs (see discussion above), the gap fell from 31 per cent to 14 per cent from 1980 to 1995.

The gap between the adopted yield potential and the actual yield for rice is small compared to other rice producing countries. In 1987, China's gap was only 1.0 ton/ha (or 15 per cent). Similar (although not exactly comparable) gaps ranged from 5 tons/ha (or 65 per cent) in the Philippines and 3.5 tons/ha (or 58 per cent) in India (Pingali *et al.,* 1997). Relatively low yield gaps may imply that further gains in realized TFP of rice in China may be more difficult since most of them must come from increases in the creation and adoption of new varieties.

The gap between the yield frontier and adopted yield potential has widened (Table 3-6). This has several different implications for China's future yield growth. On the one hand high-yielding varieties may not be moving out into the field because of some physical, policy or infrastructure constraint. On the other hand it could be that farmers are finding other varieties with lower yields that are more effective in increasing their profits. Considerable changes in the rice market (Rozelle *et al.*, 2000; Luo, 1999) and increasing demand for high-quality rice (there is a trade-off between high yield and better quality) may partially explain the fact that the gap between the yield frontier and adopted yield potential has grown substantially.

Rice output increased 21 per cent in 1979-1995 (Table 3-5). Division indices of aggregate inputs, including land, labour, fertilizer and other material inputs (see Hu *et al.,* 2000), actually fell, but this is mainly due to the decline in labour in the early reform period and in the growing area later. Material inputs including fertilizer, pesticides and other factors rose sharply. Aggregate data show that the material inputs index increased by 170 in 1979-1995 (Table 3-5).

Although the mobilization of inputs has been a major part of the increase in rice output during the last 20 years, China may not be able to rely on inputs as much as in the past to ensure future increases in rice output. High levels of fertilizer and pesticide use in many regions of the country mean that expansion of these inputs in the future may not be expected. When countries approach input plateaus, further growth in output must rely more on technological change. This increases the importance of our understanding of the record of TFP in the past and the factors that have contributed to its rise.

3.2.5 Growth of TFP

The TFP of rice was at about the same level in 1990 as it was in 1984. There is a great deal of discussion in China over what caused the slowdown in yields during this period. The debate usually focuses on land rights, commodity pricing policy, the availability and price of inputs and the structural transformation of the rural economy (i.e. the expansion of rural industries, rising wages and rural income diversification). Regardless of the ultimate reason for the slowdown, policymakers aware of food security were concerned. TFP began to rise again in the 1990s and the productivity of rice rose by more than 20 per cent from 1990 to 1993, but fell in the mid-1990s.

3.2.6 Biotechnology

China has invested heavily in agricultural biotechnology, which it considers as a strategically significant tool for raising agricultural productivity (Huang *et al.,* 2002). GM cotton has been widely adopted and the list of GM technologies in trials is impressive in China. At the same time there is an active debate regarding when China should commercialise its GM food crops, particularly rice, due the lack of clarity on their impacts on biosafety and the economy.

Bt cotton is the most successful case of China's agricultural Bt activities. By 2003, more than five million farmers had adopted Bt cotton and nearly 60 per cent of the cotton growing area was planted with it. Based on unique data from an empirical microlevel study in China, a series of studies by Huang and colleagues indicates that the adoption of Bt cotton increased output per hectare by nearly 10 per cent and reduced pesticide use by 35 kg (or about 60 per cent), which significantly improves the income of small farmers. They also provide evidence that farmers have less health problems because of reduced pesticide use.

Technologically, China's GM rice is also ready for commercialisation. Transgenic hybrid and conventional GM rice varieties (e.g. Bt rice varieties), resistant to rice stem borer and leaf roller were approved for environmental release in 1997 and 1998 (Zhang *et al.,* 1999). The transgenic rice variety that is resistant to the rice plant hopper has been tested in field trials. Through the culture of anthers, the CpTi gene and the Bar gene were successfully introduced into rice, which expressed resistance to rice stem borer and herbicide (NCBED, 2000). Transgenic rice with Xa21, Xa7 and CpTi genes resistant to bacteria blight or rice blast has also been approved for environmental release since 1997 (NCBED, 2000). Furthermore, significant progress has been made with transgenic rice plants that desmonstrate drought and salinity tolerance; these have been used in field trials since 1998. Genetically modified nitrogen fixing bacteria for rice was approved for commercialisation in 2000. Technically, several types of GM rice are ready for commercialisation. However, the commercialisation of GM rice production has not yet been approved. Instead, China allowed scientists to conduct a "pre-production" evaluation at the farm level before GM rice is formally approved for commercialisation.

Based on a unique dataset collected from rice farms in 2001-2003 of the pre-production stage, Huang *et al.* (2005 forthcoming) evaluated the impacts of insect resistant GM rice in farms, and their study shows that the performance of GM rice is impressive. Insect resistant GM rice can reduce pesticide use by 17 kg per hectare (or about 80 per cent), which is a promising alternative that could reduce pesticide use in China's rice production and improve the rural environment. Their econometric analyses also show a yield increase of about 5 per cent with GM rice. With the findings from the farms and a modified Global Trade Analysis Project (GTAP) model, their economy-wide assessments indicate that the development of Bt has an important impact on China's agricultural (particularly rice) production, trade and welfare. Annual welfare gains in China would reach US$ 5 billion from Bt cotton (US$ 1 billion) and GM rice (US$ 4 billion) by 2010 if China could commercialise its GM rice now. The gains far outweigh the public Bt research expenditures.

3.3 Rice consumption

3.3.1 Consumption growth trend

Annual per capita consumption in China was about 93 kg in the 1990s, but this declined significantly after the mid-1990s, particularly in recent years (Table 3-7). However, the average annual per capita consumption among rural consumers is about 100 kg, which is much higher than in urban regions where the average annual per capita consumption was about 65 kg in the 1990s.

After reaching a record level of 81 kg in the early 1980s, the trend in urban per capita rice consumption has been continuously declining (Table 3-7). Prior to 2000, rural rice consumption continued to increase, but this trend slowed in the mid-1980s

and stagnated after the mid-1990s. Because per capita consumption in rural areas is much higher than in urban areas, the share of urban consumption has, on average, declined since the late 1990s. Therefore, the total increase in demand for rice is mainly driven by population growth and structural changes in the economy such as urbanization and food market expansion in rural areas as well as changes in food consumption patterns that increasingly favour meat over staple foods such as rice (Huang and Rozelle, 1998).

3.3.2 Structure of rice consumption

Rice has been widely used as feed in many areas of south China. Feed accounts for 6-7 per cent of total rice use in China. It is expected that this share will decline slightly in the future, but not significantly since China still has an important production of hog, a major livestock that is fed on early indica rice (poor quality) and food (rice) residues. Seed use, industry demand and waste in post-harvest processes together account for about 10 per cent of total rice consumption. The share of direct and indirect food (i.e. processed food such as rice cakes and noodles) consumption accounted for 84 per cent of rice consumption (Table 3-7).

3.3.3 Demand changes

Income changes and demand. On the demand side, changes in the urban economy have made urban consumers almost entirely dependent on free markets for their consumption needs since the early 1990s. In this sector, prices and income changes have been and will most likely continue to be the fundamental forces driving consumption pattern changes. Urban incomes have risen steadily by about 7 per cent per year over the past 25 years. Rising incomes meant an increasing demand for most food products, though not always for rice in most periods.

At the average level of income for most urban residents before the 1990s, rice consumption increased only marginally, and even declined in large cities, with new increments in income (Liu, 2003). The income elasticity of urban rice demand was about 0.10 in the mid-1990s (Fan *et al.*, 1995; Huang and Bouis, 1996) and is expected to have approached zero and below in recent years (Liu, 2003).

Although rural income has grown slowly since the mid-1980s, demand for rice has increased over time (Fan *et al.,* 1995; Halbrendt *et al.,* 1994). The

Table 3-7: Average annual rice supply and utilization food balance sheet in China, 1980-2003

	Units	1980-1984	1985-1989	1990-1994	1995-1999	2000-2003
Area harvested	1000 ha	33312	32232	31654	31283	27841
Yield	Tons/ha	3.33	3.75	4.04	4.38	4.29
Production	1000 tons	110961	121023	127794	136957	122620
Stock change	1000 tons	-1652	-2297	-2865	4272	-2608
Net imports	1000 tons	-621	-288	-803	-906	-2101
Imports	1000 tons	159	518	183	646	260
Exports	1000 tons	780	806	986	1552	2361
Consumption	1000 tons	111992	123032	129855	131779	123128
Food use	%	83	84	84	84	84
Feed use	%	7	7	7	7	7
Seed use	%	3	2	2	2	2
Industry use	%	2	2	2	2	2
Waste	%	6	6	5	5	5
Per capita food	kg/person	92	95	94	90	81
Urban	kg/person	81	74	67	60	54
Rural	kg/person	95	102	104	104	97
Self-sufficiency	%	99	98	98	104	100

Source: From CAPSiM database and authors' estimates.

rice demand expenditure elasticity estimated by the authors was 0.15 for rural residents, which was slightly higher than that for urban dwellers. However, our work shows that, as incomes rise in cross-section samples, the elasticities of urban and rural residents fall (Huang and Bouis, 1996, Huang and David, 1993). It is expected that the income of urban and rural populations will increase over the next several decades and that the growth rate in demand for rice will decrease and eventually become negative.

Rural market liberalization. Rural food consumption markets are less developed. Farmers in some areas face limited choices in their consumption decisions, even as their incomes rise, since many of the products they desire on a daily basis, such as meat and fresh fruit, are not always available. In a sample of households drawn from the authors' national household income and expenditure survey a strong and significant correlation was found between the level of consumption of primarily purchased goods such as meat and fruit, and the level of market development holding income and prices constant (Huang and Rozelle, 1998). Discontinuous free markets, lack of refrigeration and generally high transaction costs for procuring food affect the consumption patterns of rural consumers. While changes in rural markets have been rapid, in 1999-2001 Chinese farmers still purchased about 60 per cent of the food they consumed (Liu, 2003). As markets develop and activity in rural consumption markets increases, consumption patterns will be affected and rice consumption will decline, irrespective of changes in income and prices.

Population growth. The annual growth rate of China's population declined considerably over the past two decades from about 1.5 per cent in the 1980s to less than 1 per cent recently (NSBC, 1981-2003). The family planning policy apparently contributed to this decline. An estimation of population growth by the United Nations indicates that the annual growth rate of China's population will fall further to about 0.65 per cent in 2010 and that China will reach zero population growth by 2030 or thereabouts (United Nations, 2000).

Urban migration. Across Asia, as countries urbanize consumer behaviour changes dramatically (Huang and Bouis, 2001; Huang and David, 1993; Bouis, 1989). China's urban dwellers consume much less rice and other staples (especially those that require intensive preparation) and more convenience foods. Hence, as people in China migrated from rural to urban areas, rice consumption typically fell.

The ratio of urban to rural residents in China is changing rapidly; the share of the urban population in the total population increased from 19 per cent in 1980 to 36 per cent in 2002 (NSBC, 1981-2003). Huang and Bouis (1996) have documented the impact of this population migration on food grain demand in China. Since rural demand for rice currently exceeds urban demand, China's future migrations will cause overall rice consumption to fall.

3.4 Rice trade

Between 1980 and 2002 China recorded net rice exports for 20 years, but net imports in 1989, 1995 and 1996. Annual rice exports averaged 740,000 tons in the 1980s, and 1,100,000 tons in the 1990s, i.e. 5-6 per cent of the world total. Exports were historically high in 1998 with 3,750,000 tons (equal to 19 per cent of the year's world total), and the year's net exports were 3,510,000 tons. The following years, rice exports reached 2,710,000 tons in 1999, 2,950,000 tons in 2000 and 1,860,000 tons in 2001 (Table 3-8).

Asia and Africa are the major export markets for Chinese rice. Asia represents 57 per cent of China's rice export market, Africa 30 per cent, North America 7 per cent and Europe 6 per cent. The most important Chinese rice importers are Indonesia, the Philippines, Japan and Korea in Asia; Côte d'Ivoire and Libya in Africa; Russia and Romania in Europe; Cuba, USA and Canada in North America. China's import market is much simpler. Most of China's rice imports originate from Thailand (99 per cent in 1999). China's southern large and medium cities are the major markets for Thai high quality indica rice.

Table 3-8: China's rice imports and exports (10^4t)

Year	Rice imports (10^4t)	Rice exports (10^4t)	Net exports (10^4t)
1991	14	69	55
1992	1	95	94
1993	–	143	143
1994	51	152	101
1995	164	5	-159
1996	76	26	-50
1997	33	94	61
1998	24	375	351
1999	17	271	254
2000	24	295	271
2001	27	186	159
2002	24	199	175

Source: NSBC (2003) Rural Statistical Yearbook of China.

Figure 3-1: China's rice exports and trade balance, 1991-2002

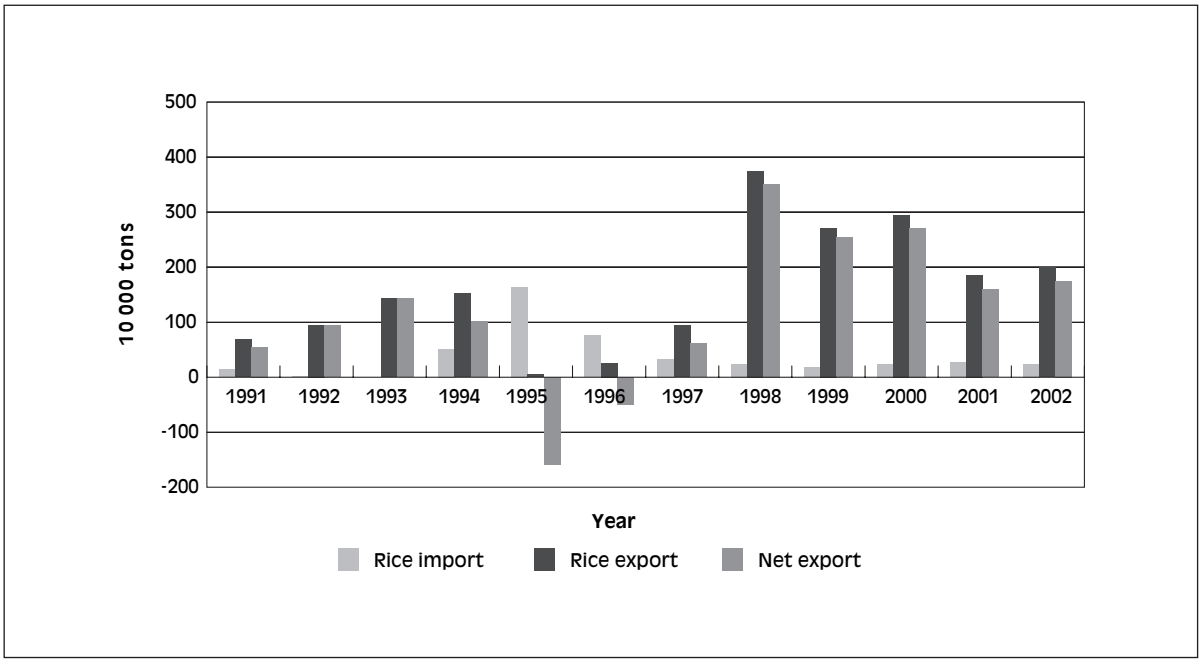


Table 3-9: China's rice imports by country (1,000 tons)

Year / Country	1996	1997	1998	1999	2000	2001	2002	2003	2004 (Jan - Mar)
Thailand	605	323	243	168	238	268	231	257	156
Vietnam	13	0	–	–	–	–	0	0	0
USA	2	1	1	1	0	0	–	–	–
Burma	1	1	–	–	–	–	0	–	0
Others	140	1	1	0	0	0	5	0	0
Total	761	326	245	169	239	269	236	257	156

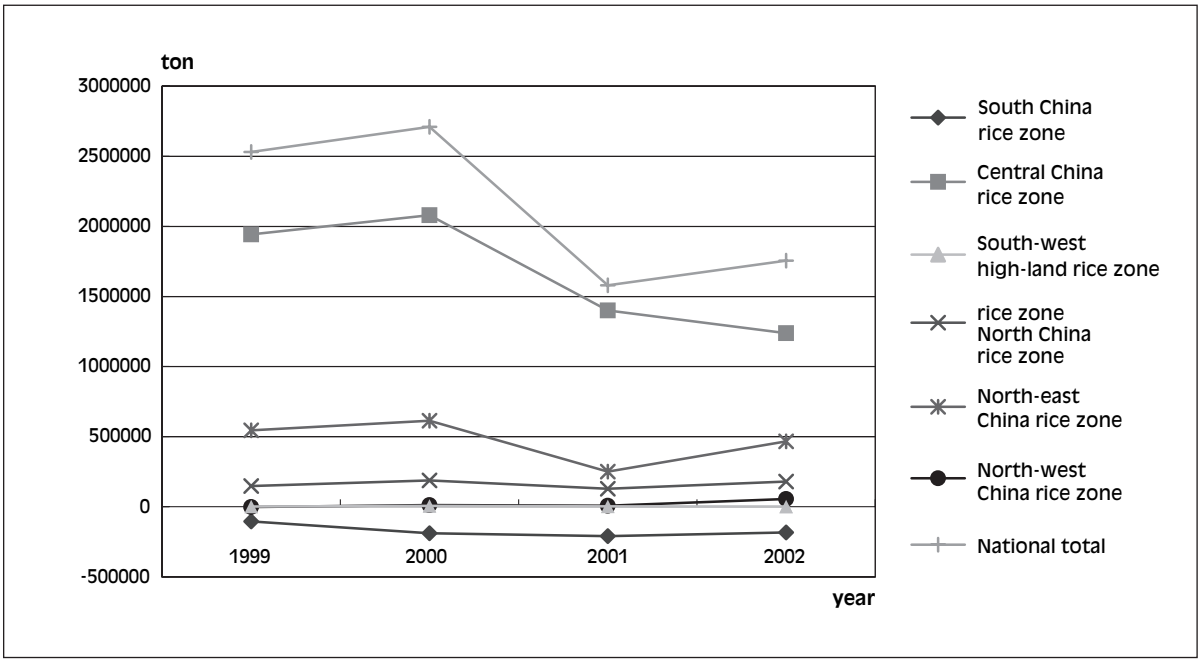
Source: National Food and Oil Information Center.

Table 3-10: China's rice exports by country (1,000 tons)

Year / Country	1996	1997	1998	1999	2000	2001	2002	2003	2004 (Jan - Mar)
Philippines	–	184	1375	181	64	1	26	1	–
Indonesia	–	10	1363	734	542	0	243	126	–
North Korea	45	92	78	86	53	89	73	115	25
Korea	68	14	75	116	131	76	71	87	55
Japan	34	36	81	76	66	103	97	122	56
Iraq	–	124	99	103	169	110	–	–	–
Côte d'Ivoire	–	100	180	421	870	898	740	1016	202
Cuba	0	85	145	227	226	196	216	–	–
Others	118	294	350	760	827	375	500	1123	362
Total	265	939	3746	2704	2948	1848	1965	2589	700

Source: National Food and Oil Information Center.

Figure 3-2: Net rice exports in China's rice zones



After WTO accession, although the TRQ for 2002 was 3,990,000 tons, with supply larger than demand in China's domestic market, the import of foreign rice did not change substantially. In the first 11 months of 2002, the first year of WTO accession, China imported just 180,000 tons of rice, a 9 per cent decrease compared to the previous year, while rice exports reached 1,638,500 tons, a 3.2 per cent increase compared with the previous year. Net exports increased by 5 per cent.

Although China's net exports have represented less than 1 per cent of domestic production, its share of total world rice exports typically ranges from 10 to 20 per cent. The future performance of China's rice sector is of critical importance to the welfare of China's population and could have pervasive effects on world rice markets.

4. Market reform and trade liberalization

4.1 Output market reform

Price and market reforms are key components of China's development policy shift from a socialist to a market-oriented economy. The reforms have been implemented gradually from non-strategic commodities (vegetables, fruits, fish and livestock) to national strategic commodities (sugar, edible oils, cotton and grains). The aims of the early reforms were to raise farm level prices and gradually liberalize the market. As the right to private trading was extended to include surplus output of all categories of agricultural products after fulfilment of contractual obligations to the state, the foundations of the state marketing system began to be undermined (Rozelle *et al.*, 1997).

After a record growth in agricultural production in 1984 and 1985, a second stage of price and market reforms was announced in 1985 aimed at radically limiting the scope of Government price and market interventions and further enlarging the role of market allocation. Other than for grains and cotton, the intention was to gradually eliminate planned procurement of agricultural products, and Government commercial departments could only continue to buy and sell in the un-intervened market.

Because of the sharp drop in the growth rate of agricultural production and inflation of food prices in the late 1980s, implementation of the reform policy to deepen domestic market liberalization was slowed down. Mandatory procurement of grains, oil crops and cotton was continued. To enhance the incentive for farmers to boost productivity and sell to the Government, contract prices were increased over time. Despite this, the increase in the nominal agricultural procurement price was lower than the inflation rate, and this led to a decline in real farm gate prices.

As agricultural production and prices stabilized in 1990-1992, another attempt was made in early 1993 to abolish the compulsory quota system and the sale at ration prices to consumers. While both the state distribution and procurement systems were substantially liberalized, the policy was reversed in 1995 due to inflation in food prices in 1994-1995. Since then, several policies have been implemented. Government grain procurement once again became compulsory and the provincial governors' "Rice Bag" responsibility system was introduced in 1994.[4]

With record levels of grain production in 1995-1997, almost zero or negative inflation since 1997, rising grain stocks, declining food prices, and a rising financial burden in managing state grain marketing, China was in a position to take a further step towards liberalizing its domestic grain market. However, while the liberalization of other commodities has been continued,[5] the concerns of the central Government on the slow growth of farm income and fiscal stress in financing the State

[4] The "Rice Bag" responsibility system required each provincial Government to take on the main responsibility for balancing the provincial grain (mainly rice, wheat and maize) supply and demand, either through its own production or interregional trade.

[5] Only grain, soybeans, cotton and tobacco were still under heavy intervention from the Government by the mid-1990s. However, soybeans and cotton, two major crops in China, have been liberalized through the elimination of the Government quota procurement since 1999.

grain marketing system led national leaders to initiate a controversial policy in the grain marketing system in 1998.[6]

Under the 1998 policy, individuals and private companies were prohibited from purchasing grain from farmers, but were allowed to operate in wholesale and retail markets. Commercial branches of grain bureaus and the grain reserve system were the only entities allowed to purchase grain from farmers. The Government considered the ban on private grain procurement as a precondition for eliminating the Government's financial burden. Grain quota procurement prices were set not lower than market prices as an agricultural policy measure to increase farmers' incomes. Grain bureaus sold the grain directly to markets or private traders at a higher price than the procurement price to fully cover marketing operation costs and thus avoid losses. However, few economists considered that the policy achieved any of its goals.

The liberalization of the grain sector through elimination of the Government procurement and market price intervention was re-initiated in all grain-deficit provinces in 2001-2002 and gradually expanded to grain-surplus provinces in 2003. In 2004, the central Government formally decreed a policy to completely liberalize its grain market.

In sum, substantial efforts to liberalize the price and market structure of China's agricultural sector have been deployed since the reform started in the late 1970s. By the late 1990s, the Government had phased out its price and marketing interventions in nearly all agricultural commodities. Grain has been a major exception; its market liberalization trend has experienced a cyclical pattern of stop-and-go and the grain market was fully liberalized only after 25 years of reform.

4.2 Fertilizer and pesticide market reform

The reforms in fertilizer, pesticide and other input markets followed China's gradual reform strategy. In the first stage, reformers only implemented measures that provided incentives to sets of individuals, and for less important commodities; they did not alter the institutional structure that was set up to provide abundant and inexpensive food to the urban economy. De-collectivisation and administrative increases for output prices improved farmers' incentives. Leaders, who remained responsible for meeting the same ambitious food sector goals, did little to the rest of the rural economy in the early 1980s, leaving machinery, fertilizer and the seed systems virtually unchanged and heavily planned. From the mid-1980s, market liberalization was gradually implemented, starting with machinery, pesticide and farm films. The meaningful liberalization of strategically important inputs occurred only in the early 1990s for fertilizer and in the late 1990s for the seed industry.

In most years of the 1980s, the Agricultural Inputs Corporation (AIC), State-owned enterprises with local trade and retail sales monopolies, rationed subsidized fertilizer and pesticides and controlled the flow of fertilizer and pesticide into and out of each jurisdiction in almost the same way they had done in the 1970s (Stone, 1988). In the early years of the reforms, however, poorly developed markets often made Government sales agencies the only viable marketing channel for agricultural inputs, and it is doubtful that the input markets would have emerged quickly or effectively even if the sector had been liberalized. Leaders kept the nominal price of subsidized fertilizer constant for the entire 1970s and 1980s, and the State-run system dominated fertilizer markets even when trade was allowed. For example, urea retail prices were about 450 to 500 Yuan per ton between 1970 and 1985. But in real terms, urea prices decreased 50 per cent between 1970 and 1990.

Like the rest of the economy, however, reform gradually spread through input markets (Ye and Rozelle, 1994). The pesticide market was first liberalized in the late 1980s. Fiscal deterioration

[6] The goals of the grain market reform in 1998 were to improve the efficiency of the grain marketing system and to reduce the central Government's fiscal burden in financing grain circulation and the reserve system.

and commercialisation of the State-owned fertilizer industry started in the late 1980s and induced policy makers to liberalize fertilizer markets in the early 1990s. Meanwhile farmers lost access to cheap fertilizer from the State when officials reduced the quantity of subsidized fertilizer, removed price controls and formally allowed private individuals to sell fertilizer.

One of the most important policy reforms was the fundamental shift in incentives provided to the State-owned fertilizer trading and retailing enterprises in the late 1980s and the early 1990s (Xiao and Fulton, 1997). Government officials offered AIC managers and employees use of the system's trucks and warehouses and a share of trading profits in exchange for keeping workers on the payroll, supporting retirees and carrying out a limited number of policy duties such as keeping their local input retail outlets open. Following a similar pattern to the grain marketing reform, a two-tiered price system was implemented. Fertilizer became available at within-quota and above-quota prices. Above-quota fertilizer prices were about twice as much as within-quota prices. The amount of fertilizers that farmers could purchase at within-quota prices depended on the amount of grain farmers sold to Government grain procurement agencies.

Although, at first, there were few traders in the late 1980s, gradually liberalization of the fertilizer market seemed to work well. Private traders multiplied quickly. Fertilizer became available to farmers more than ever before, including to those in poorer areas. Even the presence of the Government in the fertilizer market, which could have dampened the effectiveness of markets to convey demand-driven price signals, did not slow down liberalization. Competition in the sales of out-of-plan fertilizer helped AIC employees learn about operating out of the plan and developing procurement and sales networks (Xiao and Fulton, 1997; Ye and Rozelle, 1994). Soon, AIC-based companies were not only competing against private individuals, but also with each other.

In the early 1990s, two key decisions were perhaps the most far-reaching in terms of their impacts on encouraging the emergence of competitive fertilizer markets that had initially been less developed than grain markets: private trading was authorized and leaders issued a clear central policy document allowing other state-agencies to join in the commercial fertilizer trade. Hence, after the implementation of the policies, with surprisingly little disruption, fertilizer markets supplanted planned distribution networks (Xiao and Fulton, 1997). Rising competition raised the efficiency of markets, made traders more responsive to consumer demands and reduced transaction costs. Fertilizer markets, like those for grain, rapidly saw the entrance of a large number of private firms, and fertilizer availability became less of a concern for farmers.

The only perceived disruption caused by the reforms did not occur until the mid-1990s when the country experienced an imbalance in the supply and demand for food and fertilizer. Fertilizer prices doubled between 1993 and 1996. This was, in part, a result of China phasing out its within-quota fertilizer programme. Subsidies to production units in China were eliminated and factory managers had to raise prices for the fertilizer that was being sold on the market. During this time, the leadership appealed to the commercialised AIC employees to refrain from raising prices on the distribution of goods that fell under their formal areas of Government-designated duty. However, since such policies reduced the profit margins of commercial operations, in most cases policy directives were ignored. Attempts to keep locally produced fertilizers inside a region also met with only partial success as the already fluid markets made it impossible to enforce marketing restrictions.

By the late 1990s, the Government once again officially encouraged fertilizer market integration. After liberalization, fertilizer prices stabilized and declined. At first this was due to rising availability through domestic production and imports. Later, imports levelled off and most of the rise in supply of all but potash fertilizers came from China's own producers. As a sign of the sector's success in

increasing supply, the retail price of urea declined from 2,209 Yuan/ton in 1996 (measured in 2001 constant prices) to 1,361 Yuan/ton in 2001 (based on authors' survey).

4.3 Exchange rate policy

China's open door policy contributed to the rapid growth of its external economy. Expansion of the external economy has become one of the major driving forces of China's economic growth. The growth of trade also results in greater reliance on both domestic and international trade to meet consumer demand.

Historically, overvaluation of the domestic currency for trade protection purposes had reduced agricultural incentives. Real exchange rates remained constant and even appreciated during the 30 years prior to reforms. As a source of tradable commodities, the agricultural sector (including the rice sector) has experienced heavy intervention (Huang and Chen, 1999).

After the reforms, however, the exchange rate depreciated rapidly, with the exception of several years of domestic price inflation during the mid-1980s. From 1979 to 1993, the real exchange rate depreciated more than 400 per cent (Table 4-1). Falling exchange rates have increased export competitiveness and contributed to China's phenomenal export growth record (of non-grain food products) and the spectacular national economic performance of the 1980s. Without depreciation, and if China had applied the official 1979 exchange rate, China's rice price would have been more than three times higher than world prices.

However, the situation has changed since the early 1990s. From 1992 to 1997, the real exchange rate appreciated by about 30 per cent. Moreover, the pressure from major trade partners, particularly the USA, to appreciate the RMB (Chinese Yuan) is growing, but the Chinese Government has insisted on maintaining its current exchange rate policies as the national leaders consider that a stabilized

Table 4-1: Official and swap market exchange rates and the real effective exchange rate indices, 1979-2001

Year	Official exchange rate (/US$) (1)	Black market or swap-centre exchange rate (/US$) (2)	Real effective exchange rate index (1994=100) (3)	Ratio (4)=(2)/(1)
1979	1.56	2.33	397	1.50
1980	1.50	1.95	403	1.30
1981	1.70	2.05	359	1.20
1982	1.89	2.27	343	1.20
1983	1.98	2.39	337	1.21
1984	2.32	2.69	299	1.16
1985	2.94	3.05	254	1.04
1986	3.45	4.03	185	1.17
1987	3.72	4.40	160	1.18
1988	3.72	6.50	133	1.75
1989	3.77	6.60	154	1.75
1990	4.78	6.60	137	1.38
1991	5.32	6.60	121	1.24
1992	5.51	6.92	108	1.26
1993	5.76	8.28	94	1.44
1994	8.61	8.70	100	1.01
1995	8.35	8.50	109	1.02
1996	8.31	8.60	117	1.03
1997	8.29	8.60	123	1.04
1998	8.28	8.60	123	1.04
1999	8.28	8.60	117	1.04
2000	8.28	8.50	118	1.03
2001	8.28	8.40	121	1.01

Source: International Monetary Fund's database.

foreign exchange rate is key to national economic stabilization. Meantime, China has been accelerating the reform of foreign exchange management through further liberalization of foreign exchange demand and supply, and is considering gradually eliminating export tax rebates in order to avoid the sharp rise in its foreign exchange reserve.

4.4 Foreign trade liberalization

The effect of the foreign exchange policy has not been the only important change in the trade environment. The changes in the exchange rate system occurred at the same time as China began to liberalize its international trading system. In the initial years, most of the fall in protection came from a reduction in the commodities that were controlled by single-desk State traders (Huang and Chen, 1999). In the case of many products, competition among non-state foreign trade corporations began to stimulate imports and exports (Martin, 2002). Although several major agricultural commodities were not included in the move to decentralize trade, the moves spurred exports of many agricultural goods. In addition, policy shifts in the 1980s and 1990s changed the trading behaviour of State traders. Leaders allowed the State traders to increase imports in the 1980s and 1990s.

For example, prior to China's WTO accession and even though the import tariff rate was low, leaders did not allow the importation of grains except by agencies and enterprises that held licenses and import quotas. Grain imports within the quota were subject to a 3 per cent tariff rate but for grain imports above the quota the tariff rate was as high as 114 per cent. However, no above-quota grain has entered China because in the case of grain trade, imports have to be arranged by State-traders. For the entire reform period, the China National Cereals, Oils and Foodstuffs Import & Export Corporation (COFCO) was the nation's single-desk State trading company for grain. COFCO also managed the imports of edible oils.

However, COFCO itself has undergone a series of reforms since the late 1990s. Specifically, officials have tried to streamline importing procedures by commercialising COFCO and de-monopolizing the trade of a number of commodities. For example, soybeans have been completely liberalized with a single tariff management scheme, and the effective tariff rate on soybean imports has been only 3 per cent since 1999. For rice and maize, the Jilin Grain Group Import and Export Company (JGIEC), a provincial State trading enterprise established in April 2001, has taken over the import and export responsibilities of COFCO for most maize and rice exports from north-east China. The establishment of JGIEC marked the end of COFCO's complete monopolization of China's grain trade. Moreover, competition has also been introduced within the COFCO network (COFCO has always had branches in each province and key municipality). Better incentives were also given to managers and branch officials to increase their attention to the activities that affect profitability. Also, an agency system has been imposed to implement a payment-for-services policy. COFCO traders are only supposed to trade on behalf of their clients for a fee, not on their own account.

Despite the above efforts in commercialising grain trade and less intervention in rice trade, trade liberalization in maize, and to some extent cotton, is still minimal (Huang, Rozelle and Chang, 2004). For example, China used export subsidies in the years prior to its WTO accession to increase exports of maize and cotton. By providing exporters with payments to encourage the export of maize, leaders have increased the protection of domestic producers by raising the price of domestic commodities. During field interviews in 2001, it was found that maize and cotton exporters received subsidies that averaged 34 per cent and 10 per cent respectively of their export prices. However, China eliminated export subsidies for cotton in 2002 and maize in early 2004.

Moves to relax rights of access to import and export markets were matched by actions to reduce the taxes that were being assessed at the border. After the fall of restrictions on imports and exports of many of China's agricultural commodities, a

new effort began in the early 1990s to reduce the level of formal protection. From 1992 to 1998, the simple average agricultural import tariff fell from 42.2 per cent in 1992 to 23.6 per cent in 1998 and to 21 per cent in 2001 (MOFTEC, 2002).

4.5 Nominal protection rates[7]

4.5.1 Changing trends of nominal protection rates

To analyse the impacts of the marketing reform, trade liberalization and other policies on agricultural incentives, we need to generate some indicators. One of the measures often used for this purpose is called the nominal protection rate (NPR), which is an aggregate measure of combined distortion for all policies. The NPR is generated by comparing China's domestic prices with international ones. The analysis in the case of China, however, is a bit more complicated. Since China has reformed, it has had several prices–a quota price, a negotiated price, and a market price. Hence, three different measures can be calculated, which are illustrated for rice, wheat, maize and soybean. The results are shown in Table 4-2. Table 4-3 uses only market prices (or the State administered price in the case of cotton) to show the protection of cotton and livestock products in more recent years. For inputs, we estimated the NPRs of major fertilizers; these are reported in Table 4-4 (for imported fertilizers) and Table 4-5 (for exported fertilizers).

Based on this analysis it is clear that for most of the early reform period the requirement that farmers submit a mandatory delivery quota of rice, wheat, maize and soybean at below market prices has represented a lump sum tax on farmers and lump sum subsidy to urban consumers who were able to purchase grain from state rationing outlets at below-market value (Table 4-2). Before the mid-1990s the average prices farmers received for compulsorily delivered rice, wheat, maize and soybean were far below the border prices. Although all of China's major crops were affected by the State grain quota procurement policy, wheat – the nation's main imported farm commodity – received favourable treatment relative to rice in most periods. For example, in the early 1990s, its rate of taxation (-14 per cent) was less than that for rice. The same bias appears in the other price categories (columns 5 to 12). The bias is even larger than shown by the within-price category comparisons, since a higher proportion of rice production is procured at the low-quota procurement price than

Table 4-2: NPR for grain, 1978-2002

	Quota procurement price				Negotiated procurement price				Wholesale market price			
	Rice	Wheat	Maize	Soy-beans	Rice	Wheat	Maize	Soy-beans	Rice	Wheat	Maize	Soy-beans
1978-79	-42	15	12	2	-6	72	65	22	10	89	92	40
1980-84	-43	-3	-15	13	2	50	28	25	9	58	46	44
1985-89	-30	4	-13	-13	-5	34	17	15	-4	52	37	39
1990-94	-37	-14	-35	-32	-16	14	-7	7	-7	30	12	26
1995-99	-15	0	4	-1	-9	7	11	20	-4	22	27	24
2000	-4	17	35	38					-5	15	33	20
2001	-3	13	34	na					-3	12	32	17
2002	-3	10	15	na					-3	8	15	16

Note: Border prices are the average prices of exports (rice and sometimes maize) or imports (wheat, soybean and sometimes maize) for the varieties that are comparable with domestic grains. Official exchange rates are used for the conversion of border prices.
Source: Authors' estimates based on CCAP's database.

[7] This section drew heavily from Huang, Rozelle and Chang, 2004.

for wheat, maize or soybeans (Huang, 2001). In the late 1990s, however, there was a marked change in the rate of protection. Quota prices moved closer to border prices, and in some cases rose above them. Examining China's NPRs based on negotiated and market prices between 1995-1999 and 2000-2001, except for rice, China's domestic prices have begun to rise above the border price.

Interestingly, the case of livestock is markedly different (Table 4-3). In all periods, for all major commodities, pork, beef and chicken, the NPRs are negative. Meat producers have received less than they would have if they could have sold their output on domestic and world markets at international prices.

Table 4-3: NPR for cotton and livestock products, China, 1995-2001

Year	Cotton	Pork	Beef	Chicken
1995	17	-14	-14	-22
1996	23	-16	-8	-15
1997	28	-18	-3	-16
1998	18	-25	-15	-16
1999	-3	-13	0	-15
2000	14	-16	-2	-15
2001	14	-21	-11	-17

Note: Export prices of pork, beef and chicken, and import prices of cotton are used as border prices. Domestic prices are those on urban wholesale markets. The cotton wholesale price is estimated as the state procurement price times 1.25. Official exchange rates are used for the conversion of border prices.

Table 4-4: NPR of fertilizer measured in terms of the CIF price in China, 1980-2001

	Urea		Potassium sulphate	
Year	Planned price	Market price	Planned price	Market price
1980-1984	95.7			
1985-1989	63.9			
1990	52.1	195.6	-58.7	-26.7
1991	10.6	110.5	-59.1	-27.6
1992	-0.4	19.5	-50.6	-20.7
1993	16.8	51.3	-47.5	-24.2
1994		2.1		-11.2
1995		-1.9		29.0
1996		12.4		53.3
1997		3.9		18.6
1998		11.7		7.6
1999		8.6		12.2
2000		12.5		
2001		4.3		

Note: Domestic prices are detail prices multiplied by 0.88 to adjust transportation and quality.

Table 4-5: NPR of fertilizer measured in terms of the FOB price in China, 1997-2001

Year	Urea	Potassium sulphate
1997	9.7	23.5
1998	8.6	4.9
1999	14.2	2.8
2000	18.3	na
2001	6.5	na

Note: Domestic prices are detail prices multiplied by 0.88 to adjust transportation and quality.

The liberalization of the fertilizer market has led to an even more substantial change in its protection. For example, in the early 1980s, farmers received urea from AICs at prices that were nearly twice as much as the price of imported urea (Table 4-4). While the protection of planned (or within-quota) urea decreased to about 52 per cent in 1990 due to the depreciation of the domestic currency and increasing supply of domestic fertilizers, the NPR for urea based on the market price was as high as 195.6 per cent in 1990 when China allowed the above-quota urea to be traded in the market (Table 4-4). With domestic market liberalization, planned fertilizer supply was phased out in the early 1990s when both planned and market prices were closer to the border prices.

The nature of protection differs between fertilizers. Contrary to urea, potassium fertilizers were once heavily 'dis-protected' (or taxed) before liberalization of the domestic fertilizer market (Table 4-4). But the extent of taxation declined over time and turned to positive protection in the mid-1990s. Despite the liberalization, farmers still paid more than the price of imported fertilizers by the time China joined the WTO in 2001. Interestingly, China also exported fertilizer recently, though imports exceeded exports most years. The average NPR based on the FOB price was about 11 per cent for urea and even less for potassium sulphate (Table 4-5).

When examining the NPRs for almost all agricultural commodities and inputs over time, as discussed in the previous sections, we can see the experience of China's agricultural trade policy. Before the mid-1980s, the domestic wholesale prices of rice and other grains far exceeded the world price (Table 4-2). For example, China's rice market price was 10 per cent above the world market price (row 1). The nation's wheat and maize prices exceeded the world price by about 90 per cent. However, over the following two decades, the protection rate on rice became negative and for wheat and maize it fell to about 30 per cent. A more significant decline in protection has been experienced in agricultural input, particularly urea (Tables 4-4 and 4-5), a major input in rice and other crop production.

The driving force behind this fall in protection has been the gradual but sustained effort in the implementation of trade liberalization policies over the past two decades (Martin, 2002; Lardy, 1995). Published agricultural tariff rates fell from more than 40 per cent in the early 1990s to only 21 per cent in 2001. Assessed tariff rates have fallen even more. During this period, the intervention by State traders and the use of non-tariff barriers (NTBs) also gradually fell. In the case of some commodities, there has been a sharp rise in the number of trading firms – both exporters and importers. China has tried to gain access to outside markets for some commodities. In sum, distortions have declined significantly in the past 20 years, and based on the timing of China's trade policy efforts, much of the falling protection appears to be due to a number of factors: the liberalization of the exchange rate policy; decentralization of authority and relaxation of licensing procedures for some crops; reduction of the scope of NTBs; relaxation of real tariff rates at the border; and changing quotas (Huang and Chen, 1999).

One immediate effect of lower protection has been the shift in trade patterns. For example, except for rice in the late 1980s and pork in recent years, exports of certain commodities (including, rice, vegetables, pork, poultry and fish) have increased substantially since the late 1980s (Tables 2-2 and 3-7). Imports of commodities including coarse grains, soybeans, edible oils, cotton and sugar (except for late 1990s) and milk have also risen over the same period.

4.5.2 Heterogeneity of rice

Although Tables 4-2 and 4-3 reveal the general trends for each of the commodity groups, within some of the groups there is in fact heterogeneity among commodities or varieties in terms of their trade patterns, and economic shocks have also affected imports from time to time. The degree of heterogeneity varies by commodity group. Non-homogeneity of quality contributes to most of the variations. Rice is a typical case.

In addition to the rising level of rice exports, China also imports some rice. The imported rice varieties, however, are different from the exported varieties. Traders import certain high quality varieties such as Thai Jasmine that are not produced inside China. The quantity of imported rice, however, has been small, averaging less than 0.3 million metric tons annually in the 1980s and early 1990s. The increase in rice imports in the mid-1990s occurred because of rising domestic rice prices and the fear of grain shortages that led to the grain export restrictions in 1995 and 1996. Despite these aberrations, however, rice exports show a general rising trend over time, except for the late 1980s. Exports reached a historical high (3.74 million tons) in 1998 (not shown in Table 3-7).

In estimating rice NPRs great efforts were made to avoid some of the common problems that researchers have encountered in the past. Among other things, we try to understand in a more disaggregated way the level at which China is protecting rice or parts of certain markets (i.e. a certain variety). This analysis should help us assess more accurately the level of rice price protection, comparative advantages and the impacts of trade liberalization on China's rice economy.

For disaggregated NPRs of rice by variety, we estimate the NPRs in October 2001 (the eve of China's WTO accession).[8] Results depend mostly on the collection of a new type of data from the rice trader interviews. In particular, we conducted a set of interviews and surveys with the stated goal of precisely identifying the differences in the prices of specific rice varieties at a precise point in time and at a particular location between a type of imported rice on one side of the border (outside China) and a domestic rice on the other side (inside China). Likewise, we also wanted to identify the same price gap between exportable domestic rice as it leaves the country and the same rice produced in other countries and being traded in international markets.

Traders reported that the price of very high quality rice from Thailand (e.g. Thai super quality rice) was about 17 per cent higher in the domestic markets of China's major ports than when it was sitting on a ship in one of China's ports ready to be brought into the country (Table 4-6). More precisely, according to our data, if 1 ton of imported Thai rice were to be brought across the border at no cost and auctioned off in China's domestic market in October of 2001, on average the competitive bid price would have been 17 per cent higher than the international CIF price. Hence, based on this price gap, one would have to assume that China's protection price is high, and if China were to open its markets completely, China's domestic rice prices would fall and import volumes would rise.

However, the sample traders/users were quick to point out that they did not think that, even with open markets, China's overall rice price would fall

Table 4-6: NPR of rice in China, 2001

Variety or quality	Comparable domestic price		Border prices (US$/ton)		
	Yuan/ton	US$/ton	CIF	FOB	NPR (%)
High quality japonica	2,901	351		398	-12
Average indica	1,693	205			0.9
Thai super quality rice	3,690	446	380		17
Medium quality indica	1,519	184		185	-0.5

[8] While we also estimated the NPRs for other commodities just before China joined the WTO, they are not reported here.

and indeed most of them believed the average rice price will increase with trade liberalization. According to our interviews, the market for high quality Thai rice is relatively small in China, and because of the limited demand for this rice variety and the fact that no farmer produces it in China, the negative impact of liberalizing the rice market to the rest of world is not expected to be big, and the overall price impact in the domestic market would be minimal.

On the other hand, China has been one of the major japonica rice exporters and recently also exported small amounts of medium quality indica. Medium quality indica and high quality japonica rice together account for, by far, the largest proportion of China's production. These varieties are indeed dis-protected (Table 4-6) and their NPRs were both negative in 2001. Our survey found that traders believed if China's high quality japonica rice were sold on the international market in late 2001, it would sell at a price premium of 11 per cent.

4.5.3 NPRs at the eve of China's WTO accession and sources of distortion

NPRs for each commodity are estimated in 2001 when China joined WTO. For commodities that are simultaneously imported and exported to a significant extent, or where the difference between imports and exports has not been large in the past decades, we estimated the NPRs based on both CIF and FOB prices. These commodities include rice, maize, cotton and beef. Because there are differences among major types of any individual agricultural commodity, we weighted them to obtain average NPRs by either their growing area (for crops) or production shares (for meat). Thus, sets of more traditional, by commodity, aggregate NPRs can be created. Wheat, for example, has an NPR of 15 per cent when the individual NPR is weighted by growing area share. On average, the prices of all varieties of domestically produced wheat that are sold in the domestic markets of China's major port cities are 15 per cent above the average CIF price of all types of imported wheat varieties. The results are summarized in Table 4-7.

Our findings show not only that significantly positive rates of protection exist for a number of China's major field crops, but also that they vary according to the position in which China finds itself (as a net importer or as a net exporter). According to exporters, maize prices were, on average, more than 30 per cent above world prices.

Table 4-7: NPR and sources of policy distortion in China, 2001

	Import tariff equivalent				Export subsidy equivalent			
	Tariff rate	VAT	NTB China	NPR	Tax rebate	Subsidy	NTB abroad	NPR
Rice	1	13	3	17	1	0	-9	-8
Wheat	1	13	1	15				
Maize	1	13	8	22	32	0	32	
Other grains	1	13	1	15				
Soybeans	3	13	1	17				
Cotton	3	13	2	18	5	10	0	20
Oilseeds	13	13	21	47				
Sugar crops	25	15	10	50				
Vegetables					1	0	-11	-10
Fruit					1	0	-11	-10
Pork (meat)					5	0	-25	-20
Beef	45	15	0	60	5	0	-13	-8
Mutton					5	0	-10	-5
Poultry (meat)	20	15	0	35	13	0	-30	-17
Eggs					1	0	-5	-4
Milk	50	17	0	67				
Fish					5	0	-20	-15

In other words, traders would have lost more than 30 per cent of the value of their shipment if the Government had not subsidized the transaction. It is interesting to note that the level of protection of maize almost exactly corresponds to total export subsidies and tax rebates that were being paid to exporters of maize during the fall of 2001. However, when considering maize as an import the protection rates differed among regions. For example, traders in the north-east told our survey team that if they were not exporting and foreign maize were to be imported into China the importer could make, on average, 22 per cent.

Table 4-7 also shows that, despite the large increase in the volume of soybean imports in recent years, there is still a difference between the CIF and domestic prices in the port. The average difference between the domestic price and the international price was 17 per cent. In one sense, it is remarkable that there is a remaining price gap given that China imported 20 million tons of soybeans in 2003, the official tariff is only 3 per cent and the commodity can be traded by any foreign trade company (i.e. trading firms do not need to secure a license or quota allocation). On the other hand, the remaining price gap reminds us that there may be other reasons for distortions beyond tariffs and State trading. In fact, the gap between the domestic and international price fully demonstrates the effect of China's policy of assessing a value added tax (VAT) on imported soybeans at the border (13 per cent of the CIF price).

Besides maize, other commodities such as cotton, edible seeds and sugar were also fairly highly protected in October 2001 (Table 4-7). The distortions for these commodities in the autumn of 2001 came from the official tariff rate, VAT and NTB (for sugar and edible oil seeds).

Our results also indicate that there are a number of commodities besides rice that had negative NPRs in 2001. Vegetables, fruit, pork and poultry are facing significant non-trade tariff barriers from the rest of world.

5. Market-oriented reform in China's agricultural sector after WTO accession

5.1 China's commitments in the agricultural sector

In its most basic terms, China's commitments relating to the agricultural sector can be classified into three major categories: market access, domestic support and export subsidies. The commitments on market access will lower the tariffs on all agricultural products, increase foreign producers' access to China's markets for some commodities through TRQs and remove quantitative restrictions on others. In return, China is supposed to gain better access to foreign markets for its agricultural products as well as a number of other indirect benefits. Domestic support and export subsidies are the other two critical issues that arose during the course of negotiations. These commitments, together with a number of other market-access commitments, make China's WTO accession unique among all other developing countries that have been admitted to the WTO's new environment.

Some of the direct import market access commitments that China has made to WTO members do not actually appear to be substantial. Overall, agricultural import tariffs (in terms of its simple average) declined from about 21 per cent in 2001 to 17 per cent by 2004. This is a continuance of earlier trends; the simple average agricultural import tariff fell from 42.2 per cent in 1992 to 23.6 per cent in 1998. Although important when taken in the context of the discussion in the previous section about China's external economy reforms of the last two decades, one would have to conclude that the commitments are merely an extension of China's past changes. In this sense, WTO accession can be thought of as just another step on China's road to opening up its economy.

Except for national strategic products, such as rice, wheat, maize, cotton, edible oil and sugar, other agricultural products (horticulture, livestock, fisheries, wine, tobacco, soybeans and barley) have become part of a tariff-only regime (Table 5-1). For most commodities in this group effective protection fell by varying amounts by January 2002; and for most the tariffs will fall even further by 2004. To the extent that tariffs are binding for some of these commodities, the reductions in tariff rates should stimulate new imports.

It is important to note, however, that although published tariff rates will fall on all of these commodities, imports will not necessarily grow summarily. Indeed, China has a comparative advantage in many commodities under the single tariff regime. For example, lower tariffs on horticultural products and meats might impact only a small portion of the domestic market (e.g. markets that buy and sell only very high quality products – meat for five-star hotels that cater to foreigners). Although tariffs fall for all products, since China produces and exports many commodities at prices below those of the world market, the reductions will not affect producers or traders.

Table 5-1: Import tariff rates (%) on major agricultural products subject to tariff-only protection in China

	Actual tariff rates in 2001	Effective as of 1 January	
		2002	2004
Barley	114 (3) [a]	3	3
Soybeans	3 [b]	3	3
Citrus fruit	40	20	12
Other fruit	30-40	13-20	10-13
Vegetables	30-50	13-29	10-15
Beef	45	23.2	12
Pork	20	18.4	12
Poultry meat	20	18.4	10
Dairy products	50	20-37	10-12
Wine	65	45	14
Tobacco	34	28	10

a: Barley was subjected to licence and import quota; the tariff rate was 3 per cent for imports within the quota and no above-quota barley with 114 per cent tariff was imported in 2001.
b: Tariff rate was as high as 114 per cent before 2000 and lowered to 3 per cent from early 2000.

Source: China's WTO Protocol of Accession, November 2001.

Such movements, however, will almost certainly be (and can legally be) limited for a class of commodities called "national strategic products." China's WTO agreement allows officials to manage the trade of rice, wheat, maize, edible oils, sugar, cotton and wool with TRQs. These commodities are covered under a special set of institutions. As shown in Table 5-1, except for sugar (20 per cent) and edible oils (9 per cent), the within-quota tariff is only 1 per cent for rice, wheat, maize and wool, although imports at these tariff levels are strictly restricted in volume. However, the within-quota volumes are due to increase over a three-year period (2002-2004) at annual rates ranging from 4 to 19 per cent. China does not have to import this quantity, but provisions are in place to allow competition in the import market so that if there is demand within China for the national strategic products at international prices, traders will be able to import the commodity up to the TRQ level.

At the same time there are, theoretically, still ways to import these commodities once the TRQ has been reached. Most poignantly, tariffs on above-quota sales will drop substantially in the first year of accession and fall further between 2002 and 2005. But, during the transition period, most people believe such rates are so high (e.g. 65 per cent for grains and sugar in 2004 and edible oils in 2005) that in the coming years they will not bind (Table 5-2).[9]

Table 5-2: TRQ of agricultural products

	TRQ (million tons)		Tariff (%)		Quota for non-State-owned enterprises (%)
	2002	2005	Within-quota	Above-quota	2000-2005
Wheat	7.3	9.6	1	65	10
Maize	4.5	7.2	1	65	25-40
Rice	2.6	5.3	1	65	50
Cotton	0.743	0.894	-	-	67
Soybean oil	1.7	3.2	9	121	50-90

[9] Although at 65 per cent the above tariff rate seems high, it is important to note that when compared to other countries this is low. In most Asian countries that have a TRQ system, high tariff bindings are two or more times higher than this.

After the first 4 to 5 years of accession, a number of other changes will take place. For example, China agreed to phase out its TRQ for edible oils after 2006. But China is likely to maintain the TRQ for maize after 2005, though the TRQ will certainly be raised. State trading monopolies will also be phased out for wools after 2004 and gradually disappear for most other agricultural products (Table 5-2). Although COFCO will continue to play an important role in relation to rice, wheat and maize, there will be an increasing degree of competition from private firms in the importing and exporting of grains in the future.

In its WTO accession commitments China also agreed to a number of other items, some of which are specific to the case of China. First, China must phase out all export subsidies (most subsidies were applied to maize exports in 2001) and not introduce any such subsidies on agricultural products in the future. Moreover, despite clearly being a developing country, China's *de minimis* exemption for product-specific support is equivalent to only 8.5 per cent of the total value of production of a basic agricultural product (compared with 10 per cent for other developing countries). Some measures, such as investment subsidies for all farmers and input subsidies for the poor and other resource-scarce farmers, that are generally available for policy makers to use in developing countries, are not allowed in China. In other words, China must include any such support as part of its aggregate measurement of support which should be less than 8.5 per cent of agricultural output values.

Because of its Socialist background and the difficulty that the world has had in assessing the scope of the Government's intervention in business dealings of all types, China was forced to accept a series of measures governing the way it will deal with the rest of the world in cases of anti-dumping and countervailing duties. More simply, special anti-dumping provisions will remain in place for 15 years. According to these provisions, in cases of anti-dumping, China will be subjected to a different set of rules that countries can use to prove their dumping allegations. In addition, the methods that countries can use against China to enforce anti-dumping claims when they have won will differ from most of the world. In essence, this set of measures makes it easier for countries to bring, prove and enforce dumping cases against China. However, it should be noted that, although the rules differ from those governing trade among other countries, China would benefit from the same rights in its dealings with other countries, an element that could help it in some cases with its dealings with dumping matters where its partners' exporting behaviour is concerned.

China's WTO commitments and privileges, associated with the measures in other parts of the agreement, will also directly or indirectly affect its agriculture. For example, with regard to agricultural chemicals, China has committed to replace quantitative import restrictions on nitrogen, phosphate and potask fertilizers by TRQs. Tariffs will be cut on accession and further cuts will be phased in by 2005 for almost all industrial products (e.g. tractors and pesticides). Furthermore, China will reduce significantly its non-tariff measures and eliminate all quotas, tendering and import licensing on non-farm merchandise by 2005 at the latest.[10]

5.2 Agricultural supporting policy adjustments after WTO accession

China needs to adjust its domestic agricultural supporting policy according to WTO rules. Generally, the degree of agricultural support is low, so there will not be binding from China's WTO commitment to its agriculture development. In

[10] For textiles and clothing, however, the current 'voluntary' export restraints will not be completely phased out until the end of 2008, meaning that exports may not expand as fast as they would under a less restrictive regime. Substantial commitments to open up service markets in China have also been made.

order to upgrade the international competence of farm products and confront the impact of WTO accession, the domestic agricultural supporting policy should be adjusted actively to keep up with the free-trade process. When increasing progressively the domestic degree of agricultural support due to financial limitations in the long term, the key to choosing an agricultural supporting policy in the short term is to adjust its structure according to WTO rules and ensure its validity.

Following WTO accession, the domestic agricultural support policy adjustment should fully utilize Green Box policy options, strengthen agricultural support services, increase the total amount of support and optimise its structure. For example by: (i) taking direct subsidies, reducing or remitting the agricultural taxation and implementing the direct subsidy on farmers' incomes step by step; (ii) increasing the budget for services to farmers, including market information services, product marketing services, technology extension; (iii) increasing investment in the construction of agricultural infrastructure, scientific research and education and ecological protection; (iv) setting up food subsidies in favour of the low-income group, subsidies for conversion to other industries, regional development assistance and disaster relief; (v) expenditure on grain reserves and food aid.

The Chinese Government should rearrange the emphasis of Amber Box policy support and redirect the subsidies from the distribution sector to the direct subsidisation of agricultural producers, for example by offering price supports and preferential policy for the agricultural means of production, including improved varieties and technical upgrades, agricultural fuel, agricultural machinery, etc., but also by increasing low-interest loans for the construction of agricultural infrastructures as well as technological transformation, marketing, livestock and so forth.

Since China's accession to WTO at the end of 2001, the adjustment and reform of domestic agricultural supporting policies have advanced substantially. The concrete measures are described below.

5.2.1 Rural taxation reform

Since 2000, in response to the problem of the overly heavy farmers' burden, tax reforms have been launched progressively all over the country. From April 2000 Anhui province and some counties of nine other provinces were chosen for the pilot work. This was expanded progressively in 2001-2002 and pursued throughout the country in 2003. Since 2004, eight provinces, municipalities and autonomous regions have cancelled the agricultural tax, and in most other provinces the agricultural tax rates have generally been reduced to less than 5 per cent.

The reduction in rural taxation is regarded as a type of subsidy to farmers which tallies with Green Box policy requirements.

5.2.2 Grain procurement and marketing reform

According to WTO rules, reform of the agricultural support policy should place emphasis on the role of market mechanisms to reduce price supports that distort production and trade and progressively redirect subsidies from the distribution to the production sectors. Even though price supports were needed, China has still been moving step-by-step from the Government's monopoly of purchasing to market-defined prices, but with the help of a Government protective price.

Since WTO accession, China has been exploring new directions for further reform and making new adjustments.

- *Unlocking grain purchasing and selling markets*: From 2004, grain purchasing and selling markets all over the country have been unlocked, and multiple channels are permitted to carry out business related to grain trade. The monopoly position of State-owned grain enterprises will be weakened.
- *Cutting down price supports and purchasing grain at the market price*: The key grain varieties should be purchased at the market price. When the market price is higher than the protective price, it is purchased according to the market

situation by the licensed enterprises. However, when the market price is lower than the lowest protective price, it is designated that the appointed enterprises purchase grain at the protective price to stabilize the grain market price.

- *Redirect subsidies from the distribution sector to the production sector*.

5.2.3 Promoting poverty relief and development

According to the AoA, support to poverty-stricken areas, namely payments according to the regional aid plan, meets with Green Box requirements. In the last 2 years, poverty relief and development has been promoted substantially.

At present in China, the rural population living below the poverty line is mainly concentrated in the central and western areas. Investment in poverty-relief and development increased greatly in recent years. According to the statistics, total anti-poverty funds of all types paid out of the fiscal budget amounted to 31.1 billion Yuan in 2002. At the same time, the related local Government fund has increased by a relatively large extent too. In addition, international anti-poverty cooperation is going well.

6. Methodology

6.1 CAPSiM modelling and scenario formulation

6.1.1 Commodity selection

China's regional productions differ largely due to its vast variations in climate and natural resources. Four provinces in the southern part of the country (Hunan, Jiangxi, Guangxi and Guangdong) produce nearly 40 per cent of the nation's rice, three provinces in the north China plain (Henan, Shangdong and Hebei) produce 44 per cent of the wheat and 30 per cent of the maize, and Heilongjiang province in north-east China accounted for 35 per cent of national soybean production in 2001 (Table 6-1).

A dominant crop in one location could be a minor crop in another part of the country. For example, rice is the most important crop in southern China and accounted for more than half of the crop areas in Jiangxi and Hunan, while wheat is the most important crop in the north China plain (Henan, Shangdong and Hebei) and north-east China (Qinhai, Gangsu, and Ningxia), and soybean was the dominant crop in Heilongjiang (Table 6-2). Eastern China produces more vegetables and fruit than central and western China.

Since there is such great regional heterogeneity, we needed to select a broad basket of commodities for this study, though the discussion focuses mostly on rice. In order to make the analysis manageable, however, we classify all commodities into 12 crops or crop groups and seven livestock products and fish groups. The crop groups include rice, wheat, maize, sweet potato, potato, other course grains (millet, sorghum, barley and other minor coarse grains), soybeans, cotton, edible oil crops, sugar crops (cane and beet), vegetables and fruit. This bundle of crops accounts for about 90 per cent of the total crop growing area in China. Our group of livestock products includes pork, beef, mutton, poultry, eggs and milk. Fish is regarded as an aggregate group, including marine and fresh water fish that are either caught or raised in aquaculture fisheries.

However, even with these groupings there are still too many commodities in many of our analyses. As a result, the presentation of our commodity analyses only shows the results for rice and groups such as exportable and importable commodities. Exportable commodities are those that have negative NPRs and importable commodities are those with positive NPRs (see Table 4-7). Beef and poultry, which are both exported and imported, are included in the exportable category.

6.1.2 An overview of the CAPSiM methodology

In order to evaluate the impact of China's WTO accession in 2001-2005 and further trade liberalization until 2010 on China's rice sector, other agricultural sectors, poverty and chemical-use, a quantitative method has been developed based on the CAPSiM. CAPSiM was developed to provide a framework for analysing policies affecting agricultural production, consumption, price and trade at the national level. CAPSiM is a partial equilibrium model in which most of the elasticities used were estimated using state-of-the-art econometrics and with assumptions that make our estimated parameters consistent with theory. Both demand and supply elasticities change over time since income elasticities depend on the income level, and cross-price elasticities of demand (or supply) depend on the food budget shares (or crop area shares).

Table 6-1: Share of provincial crop growing area in China (%), 2001

Province	Rice	Wheat	Maize	Sweet potato	Potato	Other coarse grains	Soy-beans	Cotton	Oil crops	Sugar crops	Vege-tables	Fruit
Hunan	12.8	0.4	1.1	5.3	2.1	0.9	2.1	3.1	6.2	1.8	5.1	3.8
Jiangxi	9.7	0.2	0.1	3.0	0.0	0.2	1.5	1.5	5.3	1.6	3.7	2.7
Guangxi	8.4	0.1	2.3	5.6	0.0	0.4	2.6	0.0	2.2	34.7	5.7	8.8
Guangdong	8.2	0.0	0.7	7.2	1.0	0.3	0.9	0.0	2.4	9.9	6.9	10.8
Sichuan	7.3	6.1	4.9	15.9	6.6	5.2	2.0	1.4	7.2	1.9	5.7	3.5
Jiangsu	7.0	6.9	1.8	2.7	0.0	4.2	2.6	8.0	6.3	0.4	7.2	1.9
Hubei	6.9	3.0	1.7	4.2	5.0	1.3	2.3	7.2	10.0	1.1	6.7	2.6
Anhui	6.8	8.0	2.4	6.9	0.3	3.2	7.2	7.5	9.7	0.5	3.5	1.0
Heilongjiang	5.5	1.7	8.8	0.0	8.9	5.7	35.1	0.0	2.1	11.0	2.6	1.9
Zhejiang	4.6	0.5	0.2	1.9	1.3	1.1	1.3	0.6	2.1	1.1	3.5	2.8
Fujian	4.0	0.1	0.1	4.9	1.8	0.4	1.0	0.0	0.8	0.9	3.4	6.1
Yunnan	3.8	2.6	4.7	3.2	8.0	6.2	1.3	0.0	1.4	16.3	2.4	2.4
Chongqing	2.7	1.7	2.0	8.6	6.4	1.0	0.8	0.0	1.5	0.2	2.2	1.2
Guizhou	2.6	2.1	3.0	4.2	10.5	1.7	1.5	0.0	3.4	1.1	2.3	1.0
Jilin	2.4	0.2	10.7	0.0	1.9	2.4	4.6	0.0	1.6	2.2	1.6	1.8
Liaoning	1.8	0.4	6.5	1.2	2.3	9.2	3.5	0.2	1.6	1.1	2.5	3.9
Henan	1.4	19.5	9.1	10.4	0.0	3.6	5.9	17.8	9.9	0.3	8.0	3.7
Hainan	1.2	0.0	0.1	2.3	0.0	0.1	0.1	0.0	0.4	3.7	1.0	1.6
Shandong	0.6	14.4	10.3	5.5	2.7	1.7	4.2	15.3	6.9	0.0	11.3	8.1
Shanghai	0.5	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.4	0.1	0.9	0.4
Shaanxi	0.5	5.8	4.1	1.8	5.6	4.7	2.4	1.0	2.0	0.1	1.8	7.4
Hebei	0.3	10.5	10.5	4.1	3.8	10.7	4.0	8.7	4.3	0.6	5.7	11.5
Inner Mongolia	0.3	2.1	6.3	0.1	11.9	10.7	8.0	0.0	4.2	3.5	1.1	0.7
Ningxia	0.3	1.2	0.6	0.0	1.7	2.0	0.3	0.0	0.7	0.0	0.3	0.5
Xinjiang	0.3	3.0	1.7	0.0	0.4	1.1	0.8	23.5	1.5	5.2	0.8	2.5
Tianjin	0.0	0.4	0.6	0.0	0.0	0.4	0.5	0.9	0.1	0.0	0.8	0.5
Gansu	0.0	4.6	1.9	0.0	10.2	7.4	0.9	1.2	2.2	0.7	1.1	3.1
Beijing	0.0	0.3	0.4	0.1	0.0	0.1	0.2	0.1	0.1	0.0	0.7	0.9
Shanxi	0.0	3.3	3.5	0.9	6.2	10.0	2.3	1.9	2.1	0.3	1.5	2.9
Tibet	0.0	0.2	0.0	0.0	0.0	2.8	0.0	0.0	0.1	0.0	0.1	0.0
Qinghai	0.0	0.6	0.0	0.0	1.2	1.0	0.0	0.0	1.2	0.0	0.1	0.1
Total	100	100	100	100	100	100	100	100	100	100	100	100

CAPSiM explicitly accounts for urbanization and market development on the demand side. On the supply side, the analysis accounts for changes in technology, other agricultural investments, environmental trends and competition for labour and land use. Supply, demand and trade respond to changes in both producer and consumer prices. Details of the model description can be found in Huang and Li (2003). A brief discussion of the model is provided in Appendix A of this document.

Because the analysis based on the original CAPSiM framework can only be done at the national level and was designed to be used to simulate the future effects of policy shifts, we have had to make a number of changes for the purposes of this study in order to examine the impacts of trade liberalization on poverty and the environment. The original model had to be modified to allow us to disaggregate the national impacts into household production, consumption and poverty at the provincial level and to assess the impact that trade liberalization has had on households in different income groups in the same provinces. We also had to modify the model to evaluate the impacts of China's WTO accession and further trade liberalization on fertilizer and pesticide use in crop production. Among the changes and new assumptions, work done for this project includes:

- Generation of a database on household food consumption, production, agricultural product farm gate prices and food procurement prices by income group and province. Our original

Table 6-2: Individual crop growing area shares by province in China (%), 2001

Province	Rice	Wheat	Maize	Sweet potato	Potato	Other coarse grains	Soy-beans	Cotton	Oil crops	Sugar crops	Vege-tables	Fruit	Total
Hunan	52.8	1.6	3.9	4.2	1.4	0.7	2.9	2.1	13.1	0.4	11.9	5.1	100
Jiangxi	57.2	0.8	0.4	3.3	0.0	0.2	3.0	1.4	15.8	0.5	12.3	5.0	100
Guangxi	39.0	0.2	9.0	4.9	0.0	0.3	4.0	0.0	5.3	9.2	15.0	13.1	100
Guangdong	41.4	0.2	2.9	6.9	0.8	0.3	1.5	0.0	6.2	2.9	19.6	17.3	100
Sichuan	23.7	17.0	13.6	9.9	3.5	2.9	2.1	0.8	11.9	0.3	10.6	3.7	100
Jiangsu	27.1	23.1	5.8	2.0	0.0	2.7	3.3	5.2	12.5	0.1	15.9	2.4	100
Hubei	28.3	10.5	5.7	3.3	3.4	0.9	3.1	4.9	20.9	0.3	15.5	3.3	100
Anhui	23.9	24.0	7.2	4.6	0.2	1.9	8.3	4.4	17.3	0.1	6.9	1.2	100
Heilongjiang	17.1	4.6	23.1	0.0	4.6	3.0	36.0	0.0	3.3	2.0	4.6	1.8	100
Zhejiang	44.2	4.0	1.7	3.5	2.1	1.7	4.0	0.9	10.1	0.6	18.6	8.6	100
Fujian	39.2	1.0	1.2	9.1	2.9	0.6	3.3	0.0	4.2	0.5	19.0	18.9	100
Yunnan	22.3	13.0	23.1	3.5	7.7	6.0	2.6	0.0	4.0	5.5	7.9	4.5	100
Chongqing	23.4	12.9	15.0	14.4	9.3	1.4	2.4	0.0	6.9	0.1	10.8	3.4	100
Guizhou	19.1	13.3	18.4	5.8	12.6	2.1	3.6	0.1	12.7	0.5	9.5	2.3	100
Jilin	14.7	1.1	55.8	0.0	1.9	2.4	9.2	0.0	5.0	0.8	5.6	3.5	100
Liaoning	12.4	2.4	37.6	1.6	2.6	10.6	8.0	0.2	5.7	0.4	9.9	8.7	100
Henan	3.3	37.9	17.3	4.5	0.0	1.4	4.4	6.8	11.4	0.0	10.3	2.7	100
Hainan	37.8	0.0	1.8	13.5	0.0	0.6	0.9	0.2	5.8	6.5	17.2	15.8	100
Shandong	1.5	30.9	21.8	2.6	1.1	0.7	3.4	6.4	8.8	0.0	16.1	6.5	100
Shanghai	33.2	6.9	1.1	0.2	0.0	2.4	1.0	0.2	13.8	0.3	32.2	8.8	100
Shaanxi	3.0	30.3	21.4	2.1	5.6	4.9	4.9	1.1	6.2	0.0	6.1	14.5	100
Hebei	1.0	27.0	26.6	2.4	1.9	5.4	4.0	4.4	6.6	0.1	9.7	11.0	100
Inner Mongolia	1.8	10.6	31.2	0.1	11.5	10.6	15.5	0.0	12.5	1.2	3.7	1.3	100
Ningxia	8.1	32.7	16.2	0.0	8.9	10.3	2.9	0.0	11.0	0.0	5.2	4.8	100
Xinjiang	2.3	23.5	13.0	0.0	0.7	1.7	2.5	35.7	6.9	2.7	4.0	7.1	100
Tianjin	2.0	19.0	25.1	0.4	0.0	3.4	8.1	8.0	3.6	0.0	23.0	7.4	100
Gansu	0.2	33.2	13.8	0.0	14.3	10.6	2.4	1.7	9.6	0.3	5.5	8.3	100
Beijing	1.6	16.7	23.1	1.4	0.0	1.4	4.6	0.7	3.3	0.0	27.7	19.7	100
Shanxi	0.1	22.6	23.1	1.4	8.1	13.3	6.0	2.5	8.5	0.1	6.8	7.4	100
Tibet	0.5	21.8	1.6	0.1	0.0	63.3	0.3	0.0	7.8	0.0	4.1	0.5	100
Qinghai	0.0	34.2	0.5	0.0	12.5	10.9	0.0	0.0	36.9	0.0	3.9	1.1	100
China	19.4	16.6	16.3	3.7	3.2	3.2	6.4	3.2	9.8	1.1	11.0	6.2	100

database is from NSBC's rural household income and expenditure survey in 2003. In order to link this unique database with CAPSiM, we estimated a similar household database (that was also disaggregated by income group and region) in 2001 (the year China joined WTO and therefore the base-year for this study) by transforming the 2003 household data. The transformation was made by dividing the 2003 production and consumption levels for each subgroup by the changes that occurred at the national level between 2001 and 2003. With this new (estimated) household database in 2001, we then applied CAPSiM to simulate how supply, demand and prices change in 2001-2005 due to China's WTO accession and in 2005-2010 due to future trade liberalization.

- Estimation of a set of demand and supply elasticities for the projection period of 2001-2010. Income elasticities of demand for various foods decline over time. We also assume the decline in food income elasticities as the consumers move from a lower income category to a higher income category.
- Testing market integration and price transmissions from national to regional and household levels, and use the findings of these analyses to adjust the results of impact studies based on CAPSiM simulations.
- Development of a database on fertilizer and pesticide use by crop in 2001. The data are in chemical use per hectare for each crop in each province.

- Development of a database on crop production by province in 2001. This includes individual crop growing area, yield and production.
- Development of fertilizer and pesticide demand models. A brief discussion of fertilizer and pesticide demand models is presented hereafter, whereby Q_i is the total fertilizer or pesticide used in the *i's* crop:

(1) $Q_{it} = A_{it} \, x \, q_{it}$

(2) $Ln(q_{it}) = a_i + b_i \, Ln(P_i) + c_i \, Ln(P_c)$

where A_{it} is the growing area of crop i in year t; q is the per-hectare fertilizer or pesticide use; P_i is crop *i's* output price; P_c is the price of the chemical (fertilizer or pesticide); *a, b*, and *c* are parameters to be estimated.

The above models indicate that the impacts of trade liberalization on chemical use can be simulated through its impacts on the crop areas (since different levels of chemical inputs are applied to different types of crops), and per hectare chemical inputs based on the changes in crop output prices and input prices (e.g. fertilizer and pesticide prices) due to trade liberalization.

6.1.3 Scenario development

To simulate the impact of WTO accession on production, consumption and trade (henceforth known as Y), we begin by assuming that any change in Y from time *t-1* to time *t*, which we define as ΔY_t, can be decomposed into the impacts of WTO accession and other factors:

(3) $Y_t = Y_{t-1} + \Delta Y_{At} + \Delta Y_{Bt}$,

or $\Delta Y_t = \Delta Y_{At} + \Delta Y_{Bt}$ where subscript *B* refers to all factors that affect the economy except for the policy changes related to China's WTO accession (subscript *A*). We then let NPR_{WTO-t} be the level of protection under WTO and NPR_{Base-t} the level that China would enjoy under the scenario if there were no WTO agreement.

With these assumptions and definitions, we build our simulation by constructing two scenarios that vary only by the nation's future NPRs. In Scenario I, we have:

(4) $\Delta NPR_t^I = NPR_t - NPR_{t-1}$;

In Scenario II, we have:

(5) $\Delta NPR_t^{II} = 0 \text{ and } NPR_t \neq 0$,

where ΔNPR is the change in the NPR associated with either scenario I or II.

Table 6-3: NPR (tariffs or tariff equivalents) of major agricultural commodities in 2001 and assumed rates in 2005 and 2010

Commodity	2001	2005	2010
Rice	-3.0	-1.5	-0.8
– Japonica	-12.0	-6.0	-3.0
– Indica	0.9	0.4	0.2
Wheat	16.0	14.0	14.0
Maize	22.0	14.0	14.0
Soybeans	17.0	16.0	14.0
Cotton	18.0	14.0	14.0
Oil crops	47.0	22.5	17.3
Sugar crops	50.0	36.0	25.0
Vegetables	-10.0	-6.7	-4.4
Fruit	-10.0	-6.7	-4.4
Pork	-20.0	-13.3	-8.9
Beef	-8.0	-5.3	-3.6
Poultry	-17.0	-11.3	-7.6
Milk	42.0	28.0	22.5
Fish	-15.0	-10.0	-6.7

In Scenario I, China's NPR moves over the next 10 years in levels that are consistent with the WTO accession agreement (Table 6-3). In Scenario II, China's economy continues to operate during the next 10 years as if there was no trade reform; as shown in equation (3), China's NPRs remain constant. If CAPSiM is used to simulate the two scenarios, once with the conditions in equation (4) imposed, and once with those in equation (5) imposed, the impact of WTO accession can be isolated by taking the difference between the two scenarios.

(6)

$$\Delta Y_{At} = (Y_{At} \mid \underline{\Delta NPRt} = NRPt - NPRt\text{-}1) - (Y_{At} \mid NPRt = NPRt\text{-}1)$$

In other words, equation (6) produces a measure of the impacts of WTO accession on China's agricultural production, consumption and trade (or Y_t) between $t\text{-}1$ and t relative to a scenario in which there is no additional trade reform.

In implementing both the WTO and baseline scenarios we make a number of assumptions. First, we assume that producers in all regions and all income categories have the same demand and supply elasticities. While somewhat restrictive, we believe that, since our interest in this paper is in poor areas, our assumption can be considered *conservative*. Since poor areas are likely to have relatively more farmers only engaged in subsistence production (although even in the poorest areas in China farmers market a part of their crop) and face somewhat less robust markets, supply elasticities are likely to be somewhat lower (in absolute value terms) than for producers and consumers in coastal areas. For demand elasticities, different income and price elasticities are estimated for different income groups to reflect varying food demand due to income and price changes.

The model also assumes that the transmission of price shifts at the national level (e.g. changes at the border due to increased imports) to households in rural areas is 0.85. According to Huang, Rozelle and Chang, transmission coefficients of this size are consistent with the development of China's agricultural markets. Although markets are well integrated, there are still some imperfections (and domestic trade is still subject to substantial transaction costs) that keep the whole price change at the border from being experienced by inland producers. Based on the work, when both producer and consumer prices at the national level change by 1 per cent, CAPSiM assumes that 0.85 per cent of the shift is transmitted to households.

In both Scenarios I and II, we assume that per capita income grows equally fast in all regions, which may not be a bad assumption if remittances are counted in income gains in poor areas and subtracted from income gains in richer areas. Real urban income growth declines from 8 per cent in 2002-2005 to 6 per cent in 2006-2010. The corresponding growth rates in rural areas are 4 per cent. Since these figures are the same in Scenarios I and II, they will not affect our results. The only shortcoming of our analysis is that we do not account for the impacts on consumption from changes in income due to price changes resulting from WTO accession. In other words, if farmers receive a higher price due to increased exports under WTO, although we account for both lower consumption and higher production due to the price rise, we do not account for the fact that the profits (or income) of farmers, as producers, will rise and affect consumption. As a result, to the extent that overall prices in China rise (fall) due to WTO accession, the consumption effects will be under (over) estimated.

6.2 Comparative advantage allocation of impact on changes in the rice growing area by province

6.2.1 Premise of allocation

From our field survey in Heilongjiang and Hubei provinces, we can see that in the same policy and market environment, the degree of impacts on rice production under trade liberalization in different provinces mainly depends on comparative advantage. Domestic rice production's tendency to change is less elastic to import and export changes determi-

ned by comparative advantage than to domestic production support policies and storage of grain.

The above conclusion is the basis of the distribution to each province of national change in the rice growing area caused by trade liberalization. In this part, we will give an index "contribution rate" which can be used to measure the magnitude of the contribution of change in the provincial rice growing area to the nation's total change caused by trade liberalization.

6.2.2 Methodology

CAPSiM applied price transmission models to transmit national prices (e.g. indica and japonica rice price changes at national levels) to individual provinces and simulated the responses of producers (production) and consumers (consumption) to provincial price changes in the corresponding province. Alternatively, we estimate rice area changes in each province by allocating the national total projected by CAPSiM to each province according to the provincial comparative advantage in crop production.

6.2.2.1 Analysis of the comparative advantage of rice production at the provincial level

Related concepts are as follows:

- *Domestic Resource Cost (DRC)*

The DRC theory is widely applied to measure the comparative advantage of a product. The essence of this method is in measuring the opportunity cost of a product, taking into account the border price of inputs and outputs. This index indicates the actual domestic resource consumption caused by increasing exports to earn one unit of foreign exchange or decreasing imports to save one unit of foreign exchange, making allowances for a subsidy factor.

$$DRC_j = DPC_j / NV_j = \frac{\sum_{s=2}^{m} F_{sj} V_s - E_j}{U_j - M_j - R_j}$$

Where:

DRC_j —— DRC of crop j;

DPC_j —— Opportunity cost of domestic resource in the production of the crop j, which means that when input materials, labour, and agricultural products flow among countries, the cost of agricultural production for one unit shadows the income in one country;

NV_j —— The added value of crop j calculated according to the border price;

F_{sj} —— The quantity of No. s input material used in the production of crop j;

V_s —— Per unit opportunity of the No. s input material;

E_j —— External effect of the production of crop j;

U_j —— Total production value of crop j calculated according to the border price in foreign exchange;

M_j —— Total cost of imported input materials calculated according to the CIF price in foreign exchange;

R_j —— The opportunity cost of foreign capital reward in foreign exchange.

- *Domestic Resource Cost Coefficient (DRCC)*

$$DRCC_j = DRC_j \ / \ EX$$

Where:

$DRCC_j$ —— DRCC of crop j;

DRC_j —— DRC of crop j;

EX —— Opportunity cost of foreign exchange (shadow exchange rate).

$DRCC = 1$, indicates that the resource consumption value of domestic production is equal to the import cost or export income, i.e. the production of crop j just maintains the balance in international competition;

$DRCC < 1$, indicates that the resource consumption value of domestic production is lower than the import cost or export income, i.e. the production of crop j is competitive in international competition;

$DRCC > 1$, indicates that the resource consumption value of domestic production is higher than the import cost or export income, i.e. the production of crop j is not competitive in international competition.

- *Comparative advantage magnitude (CAM)*

Subtracting the DRCC from 1, we use the result to describe the CAM of crop j,

$$\text{CAM of crop } j = 1 - DRCC_j$$

$1 - DRCC = 0$, indicates that the production of crop j just maintains balance in international competition;

$1 - DRCC > 0$, indicates that the production of crop j is competitive in international competition;

$1 - DRCC < 0$, indicates that the production of crop j is not competitive under international competition.

6.2.2.2 Estimation of the "contribution rate" of provincial rice area change to the national total

1. Contribution rate index

We set a contribution rate index "W" to measure the magnitude of the contribution to rice production change caused by trade liberalization at the national level.

$$W_{ij} = (1 - DRCC_{ij}) \times a \times b$$

Where:

W_{ij} —— Contribution rate of crop j in province i to national rice production change caused by trade liberalization

$(1 - DRCC_{ij})$ —— CAM of crop j in province i;

a —— Coefficient that describes the proportion of the provincial production area in relation to the national growing area of crop j;

b —— Coefficient that describes the priority of changing the production of crop j to other crops based on the comparative advantage in province i;

2. Coefficients

Coefficient a can be obtained from statistical data. The approach for working out coefficient b is as follows:

Step 1: Estimation of the Ration of Domestic Resource Cost Coefficient (RDRCC)

$$RDRCC_{ij} = DRCC_{ij} / \overline{DRCC_j}$$

Where:

$DRCC_j$: DRCC of crop j in province i;

$\overline{DRCC_j}$: Average $DRCC$ of crop j in nation;

$RDRCC_j$: The ratio $DRCC_j$ of to $\overline{DRCC_j}$, which compares the comparative advantage of crop j in province i with the national average.

Step 2: Based on the $RDRCC$ of all main crop j products in province i, we can give the priority of changing the production of these products in province i.

6.2.3 Results

6.2.3.1 CAM

We work out the CAM based on the results of the $DRCC$ developed by Professor Zhong Funing, Nanjing Agricultural University (Tables 6-4 and 6-5).

Table 6-4: DRCC of crops in China's provinces

Provinces	Japonica DRCC	Early indica DRCC	Middle-season rice DRCC	Late indica DRCC	Wheat DRCC	Corn DRCC	Soya DRCC	Jowar DRCC	Millet DRCC	Cotton DRCC	Rapeseed DRCC
Beijing	1.03				0.96	1.72					
Tianjin	1.02				0.78	1.07					
Hebei	1.04				0.91	0.97	0.91		0.84	0.78	
Shanxi	0.73				0.95	1.22	1.46	0.73	0.77		1.41
Shandong	0.96				1.06	1.18	0.99			1.13	
Henan	0.86		0.78		0.87	1.01	0.79		0.91	0.87	1.55
Shaanxi			0.77		1.04	1.25	1		1.06	0.74	1.17
Ningxia	0.78				0.8	0.82	1.5				
Liaoning	0.79				0.92	1.18	1.04	0.88	0.93	1.11	
Jilin	0.71					1.14	0.88	0.87			
Heilongjiang	0.78				1.09	1.05	1.08	0.69			
Inner Mongolia	0.99				0.89	1.12	1.2	0.87	0.97		0.72
Gansu					0.93	1.07			1.18	0.58	0.89
Xinjiang	0.72				0.72	0.96				0.78	0.85
Fujian		1.19	1.05	1.18	1.44		1.32				
Guangdong		1.13		1.21							
Guangxi		0.99		1.02		1.35					
Hainan		0.87		1.2							
Shanghai	0.88				1.04					1.51	1.77
Jiangsu	0.93		1.14		1.36	1.53	1.43			1.39	1.89
Zhejiang	1.08	1.11		1.04	1.05					1.13	1.83
Anhui	0.76	1.07	0.8	0.93	0.98	1	0.9			0.91	1.59
Jiangxi		1.24		0.94						1.19	1.71
Hubei	1.15	1.26	1.04	1.17	1.75	1.7	1.03			1.37	2.24
Hunan		1.22		1.02		1.05					1.67
Chongqing			0.9		1.39	1.46					1.77
Sichuan			0.91		1.23	1.42				1.45	1.66
Guizhou	0.72		0.67		0.95	1.06					1.1
Yunnan	0.73		0.65		0.99	1.09	0.98				1.01

Table 6-5: DRCC of crops in China's provinces (continued)

Provinces	Peanuts DRCC	Sesame DRCC	Flue-cured Tobacco DRCC	Ramee DRCC	Sugarcane DRCC	Beetroot DRCC	Pod DRCC	Green Tea DRCC	Apples DRCC	Oranges DRCC
Beijing	1.28								0.35	
Tianjin										
Hebei	0.99	1.19							0.2	
Shanxi						1.02	0.25		0.23	
Shandong	1.24		0.92				0.2		0.26	
Henan	1.21	0.86	0.72				0.22	1.95	0.27	
Shaanxi	0.98		1.38				0.19	1.04	0.2	
Ningxia							0.19			
Liaoning	1.1		0.83						0.15	
Jilin			0.74			0.91				
Heilongjiang			0.92			1.21				
Inner Mongolia						0.96				
Gansu			0.5			1.09	0.15		0.29	
Xinjiang						0.89				
Fujian	1.25		0.82		1.24			1.35		
Guangdong	1.3		1.19		0.95		0.3	2.13		0.58
Guangxi	1.13		0.8		0.97		0.16			0.83
Hainan	0.85				0.94					
Shanghai										
Jiangsu	1.64						0.33	1.35		
Zhejiang							0.28	1.94		
Anhui	0.8		0.77				0.19	1.17		
Jiangxi			0.85		0.91		0.22			
Hubei	1.3	1.47	0.98	0.59			0.25	1.24		0.55
Hunan			0.82	0.43			0.23	2.61		
Chongqing			1.25							
Sichuan	1.28		0.79	0.59	0.86		0.22	0.97		0.58
Guizhou	0.87		0.63				0.14	1.12		
Yunnan	1.4		0.6		0.77			1.14		

Note: The data is the average for 1998-2000 to avoid accidental errors.

The results of the CAM of crops in provinces are as follows:

Table 6-6: CAM of crops in China's provinces – North rice growing area

	North rice growing area												
	Beijing	Tianjin	Hebei	Shanxi	Shandong	Henan	Shaanxi	Ningxia	Liaoning	Jilin	Heilong-jiang	Inner Mongolia	Gansu Xinjiang
Japonica	-0.03	-0.02	-0.04	0.27	0.04	0.14		0.22	0.21	0.29	0.22	0.01	0.28
Indica						0.22	0.23						

Table 6-7: CAM of crops in China's provinces – South rice growing area

	South rice growing area													
	Fujian	Guangdong	Guangxi	Hainan	Shanghai	Jiangsu	Zhejiang	Anhui	Jiangxi	Hubei	Hunan	Chongqing	Sichuan	Guizhou	Yunnan
Japonica					0.12	0.07	-0.08	0.24		-0.15				0.28	0.27
Indica	-0.14	-0.17	-0.01	-0.04		-0.14	-0.08	0.06	-0.09	-0.16	-0.12	0.1	0.09	0.33	0.35

6.2.3.2 Contribution rate

This refers to the contribution of change in the rice growing area of each province to the national total caused by trade liberalization.

1. Coefficient b

The following result is the order of crops in each province based on the RDRCC.

Table 6-8: Order of RDRCC of crops by province

Provinces	RDRCC and Rank	Japonica Rice	Indica Rice	Wheat	Corn	Soya	Jowar	Millet	Cotton	Rapeseed	Peanuts
Beijing	RDRCC	1.17		0.92	1.44						1.10
	Rank	3		1	4						2
Tianjin	RDRCC	1.16		0.74	0.90						
	Rank	3		1	2						
Hebei	RDRCC	1.19		0.87	0.81	0.83		0.88	0.73		0.85
	Rank	9		6	2	4		7	1		5
Shanxi	RDRCC	0.83		0.91	1.02	1.33	0.90	0.81		0.97	
	Rank	2		4	8	10	3	1		6	
Shandong	RDRCC	1.09		1.01	0.99	0.90			1.06		1.07
	Rank	9		4	3	1			5		6
Henan	RDRCC	0.98	0.76	0.83	0.85	0.72		0.96	0.82	1.06	1.04
	Rank	9	3	5	7	1		8	4	12	11
Shaanxi	RDRCC		0.75	0.99	1.05	0.91		1.11	0.69	0.80	0.84
	Rank		3	9	10	8		11	1	4	6
Ningxia	RDRCC	0.89		0.76	0.69	1.36					
	Rank	4		2	1	5					
Liaoning	RDRCC	0.90		0.88	0.99	0.94	1.09	0.98	1.04		0.95
	Rank	3		2	8	4	10	7	9		5
Jilin	RDRCC	0.81			0.96	0.80	1.08				
	Rank	2			5	1	6				
Heilongjiang	RDRCC	0.89		1.04	0.88	0.98	0.85				
	Rank	3		5	2	4	1				
Inner Mongolia	RDRCC	1.13		0.85	0.94	1.09	1.08	1.02		0.49	
	Rank	8		2	3	7	6	5		1	

Provinces	RDRCC and Rank	Japonica Rice	Indica Rice	Wheat	Corn	Soya	Jowar	Millet	Cotton	Rapeseed	Peanuts
Gansu	RDRCC			0.89	0.90			1.24	0.54	0.61	
	Rank			5	6			9	1	3	
Xinjiang	RDRCC	0.82		0.69	0.81				0.73	0.58	
	Rank	5		2	4				3	1	
Fujian	RDRCC		1.11	1.37		1.20					1.07
	Rank		4	7		5					3
Guangdong	RDRCC		1.14								1.12
	Rank		4								3
Guangxi	RDRCC		0.98		1.13						0.97
	Rank		4		6						3
Hainan	RDRCC		1.01								0.73
	Rank		3								1
Shanghai	RDRCC	1.00		0.99					1.42	1.21	
	Rank	2		1					4	3	
Jiangsu	RDRCC	1.06	1.11	1.30	1.28	1.30			1.30	1.29	1.41
	Rank	2	3	6	4	6			6	5	9
Zhejiang	RDRCC	1.23	1.05	1.00					1.06	1.25	
	Rank	4	2	1					3	5	
Anhui	RDRCC	0.87	0.91	0.94	0.84	0.82			0.85	1.09	0.69
	Rank	7	9	10	4	3			5	11	1
Jiangxi	RDRCC		1.06						1.12	1.17	
	Rank		4						5	6	
Hubei	RDRCC	1.31	1.13	1.67	1.43	0.94			1.28	1.53	1.12
	Rank	11	6	14	12	3			10	13	5
Hunan	RDRCC		1.09		0.88					1.14	
	Rank		5		2					6	
Chongqing	RDRCC		0.88	1.33	1.22					1.21	
	Rank		1	4	3					2	
Sichuan	RDRCC		0.89	1.17	1.19				1.36	1.14	1.10
	Rank		2	10	11				12	9	7
Guizhou	RDRCC	0.82	0.65	0.91	0.89					0.75	0.75
	Rank	7	2	9	8					4	4
Yunnan	RDRCC	0.83	0.63	0.94	0.91	0.89				0.69	1.20
	Rank	6	1	9	8	7				2	10

Table 6-9: Order of RDRCC of crops by province (continued)

Provinces	Item	Sesame	Flue-cured Tobacco	Ramee	Sugar cane	Beetroot	Pod	Green Tea	Apples	Oranges
Beijing	RDRCC								1.44	
	Rank								4	
Tianjin	RDRCC									
	Rank									
Hebei	RDRCC	1.01							0.82	
	Rank	8							3	
Shanxi	RDRCC					1.01	1.14		0.94	
	Rank					7	9		5	
Shandong	RDRCC		1.07				0.91		1.07	
	Rank		6				2		6	
Henan	RDRCC	0.73	0.84				1.00	1.30	1.11	
	Rank	2	6				10	14	13	
Shaanxi	RDRCC		1.60				0.86	0.69	0.82	
	Rank		12				7	1	5	
Ningxia	RDRCC						0.86			
	Rank						3			
Liaoning	RDRCC		0.96						0.62	
	Rank		6						1	
Jilin	RDRCC		0.86			0.90				
	Rank		3			4				
Heilongjiang	RDRCC		1.07			1.19				
	Rank		6			7				

Provinces	Item	Sesame	Flue-cured Tobacco	Ramee	Sugar cane	Beetroot	Pod	Green Tea	Apples	Oranges
Inner Mongolia	RDRCC					0.95				
	Rank					4				
Gansu	RDRCC		0.58			1.08	0.68		1.19	
	Rank		2			7	4		8	
Xinjiang	RDRCC					0.88				
	Rank					6				
Fujian	RDRCC		0.95		1.31			0.90		
	Rank		2		6			1		
Guangdong	RDRCC		1.38		1.00		1.36	1.42		0.91
	Rank		6		2		5	7		1
Guangxi	RDRCC		0.93		1.02		0.73			1.31
	Rank		2		5		1			7
Hainan	RDRCC				0.99					
	Rank				2					
Shanghai	RDRCC									
	Rank									
Jiangsu	RDRCC						1.50	0.90		
	Rank						10	1		
Zhejiang	RDRCC						1.27	1.29		
	Rank						6	7		
Anhui	RDRCC		0.89				0.86	0.78		
	Rank		8				6	2		
Jiangxi	RDRCC		0.99		0.96		1.00			
	Rank		2		1		3			
Hubei	RDRCC	1.25	1.14	1.10			1.14	0.83		0.87
	Rank	9	7	4			7	1		2
Hunan	RDRCC		0.95	0.80			1.05	1.74		
	Rank		3	1			4	7		
Chongqing	RDRCC		1.45							
	Rank		5							
Sichuan	RDRCC		0.92	1.10	0.91		1.00	0.65		0.91
	Rank		5	7	3		6	1		3
Guizhou	RDRCC		0.73				0.64	0.75		
	Rank		3				1	4		
Yunnan	RDRCC		0.70		0.81			0.76		
	Rank		3		5			4		

Source: Author's calculation.

According to the order results above, we can estimate the priority of changing rice production caused by trade liberalization in each province.

Table 6-10: Priority of changing rice production

Provinces	Comparative advantage order of crops	Priority of changing Japonica production		Priority of changing Indica production	
		Expanding	Shrinking	Expanding	Shrinking
Beijing	Wheat, Peanuts, Japonica, Corn, Apples	3/6	3/6		
Tianjin	Wheat, Corn, Japonica	1/4	3/4		
Hebei	Cotton, Corn, Apples, Soya, Peanuts, Wheat, Millet, Sesame, Japonica	1/10	9/10		
Shanxi	Millet, Japonica, Jowar, Wheat, Apples, Rapeseed, Beetroot, Corn, Pod, Soya	9/11	2/11		
Shandong	Soya, Pod, Corn, Wheat, Cotton, Peanuts, Flue-cured Tobacco, Apples, Japonica	1/10	9/10		

Provinces	Comparative advantage order of crops	Priority of changing Japonica production		Priority of changing Indica production	
		Expanding	Shrinking	Expanding	Shrinking
Henan	Soya, Sesame, Indica, Cotton, Wheat, Flue-cured tobacco, Corn, Millet, Japonica, Pod, Peanuts, Rapeseed, Apples, Green Tea	6/15	9/15	12/15	3/15
Shaanxi	Cotton, Green Tea, Indica, Rapeseeds, Apples, Peanuts, Pod, Soya, Wheat, Corn, Millet, Flue-cured Tobacco			10/13	3/13
Ningxia	Corn, Wheat, Pod, Japonica, Soya	2/6	4/6		
Liaoning	Apple, Wheat, Japonica, Soya, Peanuts, Flue-cured Tobacco, Millet, Corn, Cotton, Jowar	8/11	3/11		
Jilin	Soya, Japonica, Flue-cured Tobacco, Beetroot, Corn, Jowar	5/7	2/7		
Heilongjiang	Jowar, Corn, Japonica, Soya, Wheat, Flue-cured Tobacco, Beetroot,	5/8	3/8		
Inner Mongolia	Rapeseed, Wheat, Corn, Beetroot, Millet, Jowar, Soya, Japonica	1/9	8/9		
Gansu	Cotton, Flue-cured Tobacco, Rapeseed, Pod, Wheat, Corn, Beetroot, Apples, Millet				
Xinjiang	Rapeseed, Wheat, Cotton, Corn, Japonica, Beetroot	2/7	5/7		
Fujian	Green Tea, Flue-cured Tobacco, Peanuts, Indica, Soya, Sugarcane, Wheat			4/8	4/8
Guangdong	Orange, Sugarcane, Peanuts, Indica, Pod, Flue-cured Tobacco, Green Tea			4/8	4/8
Guangxi	Pod, Flue-cured Tobacco, Peanuts, Indica, Sugarcane, Corn, Oranges		4/8	4/8	
Hainan	Peanuts, Sugarcane, Indica,			1/4	3/4
Shanghai	Wheat, Japonica, Rapeseed, Cotton	3/5	2/5		
Jiangsu	Green Tea, Japonica, Indica, Corn, Soya, Rapeseed, Wheat, Soya, Cotton, Peanuts, Pod	10/12	2/12	9/12	3/12
Zhejiang	Wheat, Indica, Cotton, Japonica, Rapeseed, Pod, Green Tea	4/8	4/8	6/8	2/8
Anhui	Peanuts, Green Tea, Soya, Corn, Cotton, Pod, Japonica, Flue-cured Tobacco, Indica, Wheat, Rapeseed	5/12	7/12	3/12	9/12
Jiangxi	Sugarcane, Flue-cured Tobacco, Pod, Indica, Cotton, Rapeseed		3/7	4/7	
Hubei	Green Tea, Orange, Soya, Ramee, Peanuts, Indica, Flue-cured Tobacco, Pod, Sesame, Cotton, Japonica, Corn, Rapeseed, Wheat	4/15	11/15	9/15	6/15
Hunan	Ramee, Corn, Flue-cured Tobacco, Pod, Indica, Rapeseed, Green Tea			3/8	5/8
Chongqing	Indica, Rapeseed, Corn, Wheat, Flue-cured Tobacco			5/6	1/6
Sichuan	Green Tea, Indica, Sugarcane, Orange, Flue-cured Tobacco, Pod, Peanuts, Ramee, Rapeseed, Wheat, Corn, Cotton			11/13	2/13
Guizhou	Pod, Indica, Flue-cured Tobacco, Rapeseed, Peanuts, Green Tea, Japonica, Corn, Wheat	3/10	7/10	8/10	2/10
Yunnan	Indica, Rapeseed, Flue-cured Tobacco, Green Tea, Oranges, Japonica, Soya, Corn, Wheat, Peanuts	5/11	6/11	10/11	1/11

Note: if the order of crops RDRCC in some province is $J_1, J_2, J_3, J_m \ldots J_n$, then the priority of changing J_m production is as follows:

$$\text{Priority of expansion of } J_m \text{ production} = \frac{Expand(J_1 \ldots J_m) + Expand(J_1 \ldots J_{m+1}) + \ldots + Expand(J_1 \ldots J_n)}{Expand(none) + Expand(J_1) + \ldots + Expand(J_1 \ldots J_n)} = \frac{n-m+1}{n+1}$$

$$\text{Priority of shrinkage of } J_m \text{ production} = \frac{Shrink(J_m \ldots J_n) + Shrink(J_{m-1} \ldots J_n) + \ldots + Shrink(J_1 \ldots J_n)}{Shrink(none) + Shrink(J_n) + \ldots + Shrink(J_1 \ldots J_n)} = \frac{m}{n+1}$$

Source: Author's calculation.

2. Contribution rate (W)

Table 6-11: Contribution of the change in the rice growing area of each province to the national total caused by trade liberalization

Provinces	DRCC		1 - DRCC		Coefficient a:		Coefficient b:		W (Contribution rate)	
	Japonica	Indica	Japonica	Indica	Japonica	Indica	Japonica	Indica	Japonica	Indica
Beijing	1.03		-0.03		0.06		0.5		-0.0009	
Tianjin	1.02		-0.02		0.16		0.75		-0.0024	
Hebei	1.04		-0.04		0.49		0.9		-0.0176	
Shanxi	0.73		0.27		0.018		0.82		0.004	
Shandong	0.96		0.04		0.57		0.1		0.0023	
Henan	0.86	0.78	0.14	0.22	0.47	1.11	0.4	0.8	0.0263	0.1954
Shaanxi		0.77		0.23		0.5		0.77		0.0886
Ningxia	0.78		0.22		0.23		0.33		0.0167	
Liaoning	0.79		0.21		1.61		0.73		0.2468	
Jilin	0.71		0.29		1.63		0.71		0.3356	
Heilongjiang	0.78		0.22		5.18		0.63		0.7179	
Inner Mongolia	0.99		0.01		0.38		0.11		0.0004	
Gansu					0.02					
Xinjiang	0.72		0.28		0.24		0.29		0.0195	
Fujian		1.14		-0.14		4.31		0.5		-0.3017
Guangdong		1.17		-0.17		8.34		0.5		-0.7089
Guangxi		1.01		-0.01		7.7		0.5		-0.0385
Hainan		1.04		-0.04		1.24		0.75		-0.0372
Shanghai	0.88		0.12		0.78		0.6		0.059	
Jiangsu	0.93	1.14	0.07	-0.14	4.9	2.64	0.83	0.25	0.497	-0.0924
Zhejiang	1.08	1.08	-0.08	-0.08	3	3	0.5	0.25	-0.216	-0.06
Anhui	0.76	0.94	0.24	0.06	3.53	3.53	0.42	0.25	0.6608	0.053
Jiangxi		1.09		-0.09		9.5		0.57		-0.4874
Hubei	1.15	1.16	-0.15	-0.16	0.7	6.35	0.73	0.4	-0.0662	-0.4064
Hunan		1.12		-0.12		12.82		0.63		-0.9692
Chongqing		0.9		0.1		2.55		0.83		0.2117
Sichuan		0.91		0.09		6.99		0.85		0.5347
Guizhou	0.72	0.67	0.28	0.33	0.24	2.19	0.3	0.8	0.0202	0.5782
Yunnan	0.73	0.65	0.27	0.35	1.79	1.35	0.45	0.91	0.406	0.43
Nation in total	–	–	–	–	–	–	–	–	2.7094	-1.0101

Note: If the CAM > 0, then use the data of expansion priority; otherwise use the data of shrinkage priority.
Source: Author's calculation.

Table 6-12: Change in the rice growing area caused by trade liberalization by province

Provinces	Rice area change caused by trade liberalization in year 2005 (1,000 ha)			Rice area change caused by trade liberalization in year 2010 (1,000 ha)		
	Japonica rice (1,000 ha)	Indica rice (1,000 ha)	Percentage rice change (%)	Japonica rice (1,000 ha)	Indica rice (1,000 ha)	Percentage rice change (%)
Beijing	-0.15		-0.86	-0.21		-1.18
Tianjin	-0.40		-0.80	-0.55		-1.10
Hebei	-2.94		-1.95	-4.05		-2.69
Shanxi	0.67		12.14	0.92		16.72
Shandong	0.38		0.22	0.53		0.30
Henan	4.39	32.61	7.57	6.05	44.91	10.42
Shaanxi		14.79	9.66		20.37	13.30
Ningxia	2.79		3.90	3.84		5.38
Liaoning	41.19		8.31	56.73		11.44
Jilin	56.01		11.13	77.14		15.34
Heilongjiang	119.81		7.51	165.02		10.34

Provinces	Rice area change caused by trade liberalization in year 2005 (1,000 ha)			Rice area change caused by trade liberalization in year 2010 (1,000 ha)		
	Japonica rice (1,000 ha)	Indica rice (1,000 ha)	Percentage rice change (%)	Japonica rice (1,000 ha)	Indica rice (1,000 ha)	Percentage rice change (%)
Inner Mongolia	0.07		0.06	0.09		0.08
Gansu			0.00			0.00
Xinjiang	3.25		4.38	4.48		6.04
Fujian		-50.35	-3.79		-69.35	-5.22
Guangdong		-118.31	-4.60		-162.95	-6.34
Guangxi		-6.43	-0.27		-8.85	-0.37
Hainan		-6.21	-1.62		-8.55	-2.24
Shanghai	9.85		5.09	13.56		7.01
Jiangsu	82.95	-15.42	2.91	114.24	-21.24	4.00
Zhejiang	-36.05	-10.01	-2.49	-49.65	-13.79	-3.43
Anhui	110.28	8.85	5.46	151.89	12.18	7.53
Jiangxi		-81.34	-2.78		-112.03	-3.83
Hubei	-11.05	-67.83	-3.63	-15.22	-93.41	-5.00
Hunan		-161.75	-4.09		-222.78	-5.64
Chongqing		35.33	4.49		48.66	6.19
Sichuan		89.24	4.14		122.91	5.70
Guizhou	3.37	96.50	13.34	4.64	132.90	18.38
Yunnan	67.76	71.76	14.45	93.32	98.84	19.90
Nation in total	452.2	-168.6	1.01	622.8	-232.2	1.39

Note: The calculation is on the invariability assumption of crop's comparative advantage.
Source: Author's calculation.

6.2.3.3 Change in the rice growing area caused by trade liberalization by province

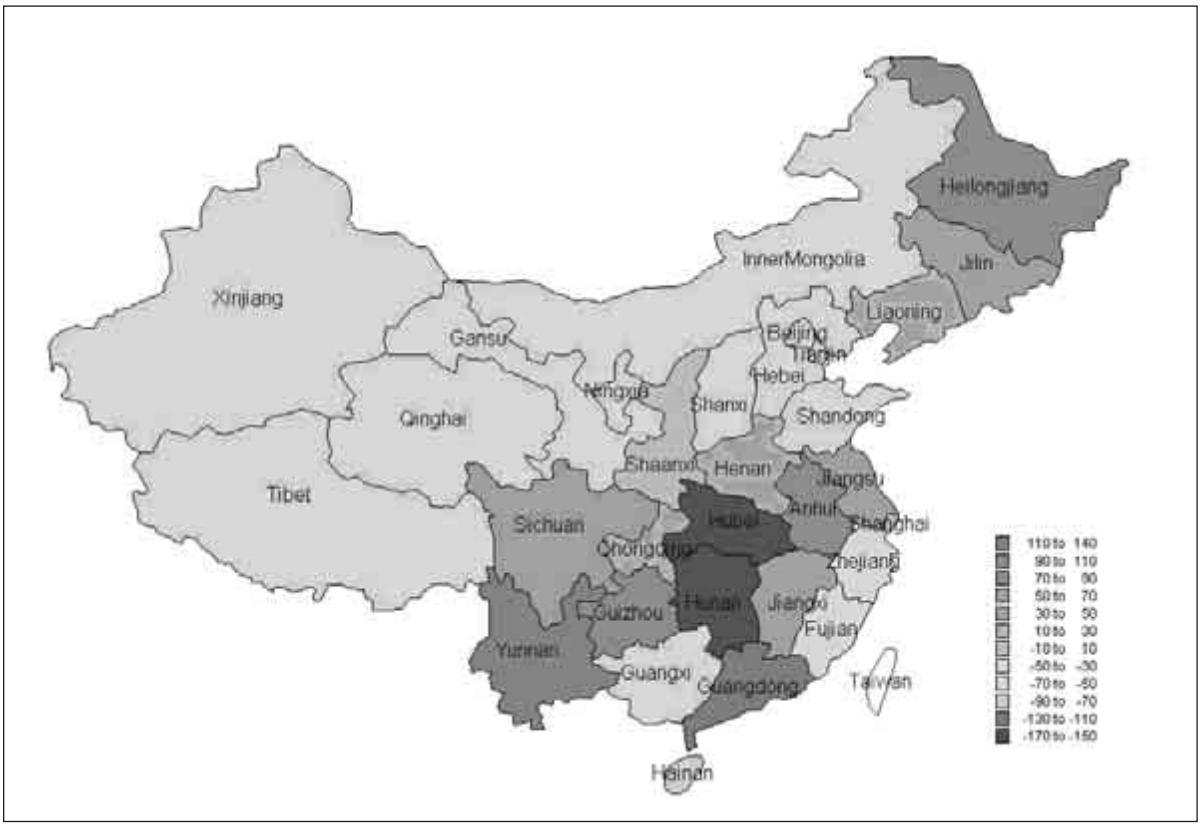
We allocate the national total change in the rice growing area caused by trade liberalization, projected by CAPSiM, to each province (Tables 6-11 and 6-12).

From the results above, we can see that China's japonica rice production will benefit from trade liberalization in general. Most of the area expansion lies in Heilongjiang, Jilin and Liaoning provinces in north-east China, and a few provinces in central and south-west China (e.g. Anhui, Jiangsu and Yunnan).

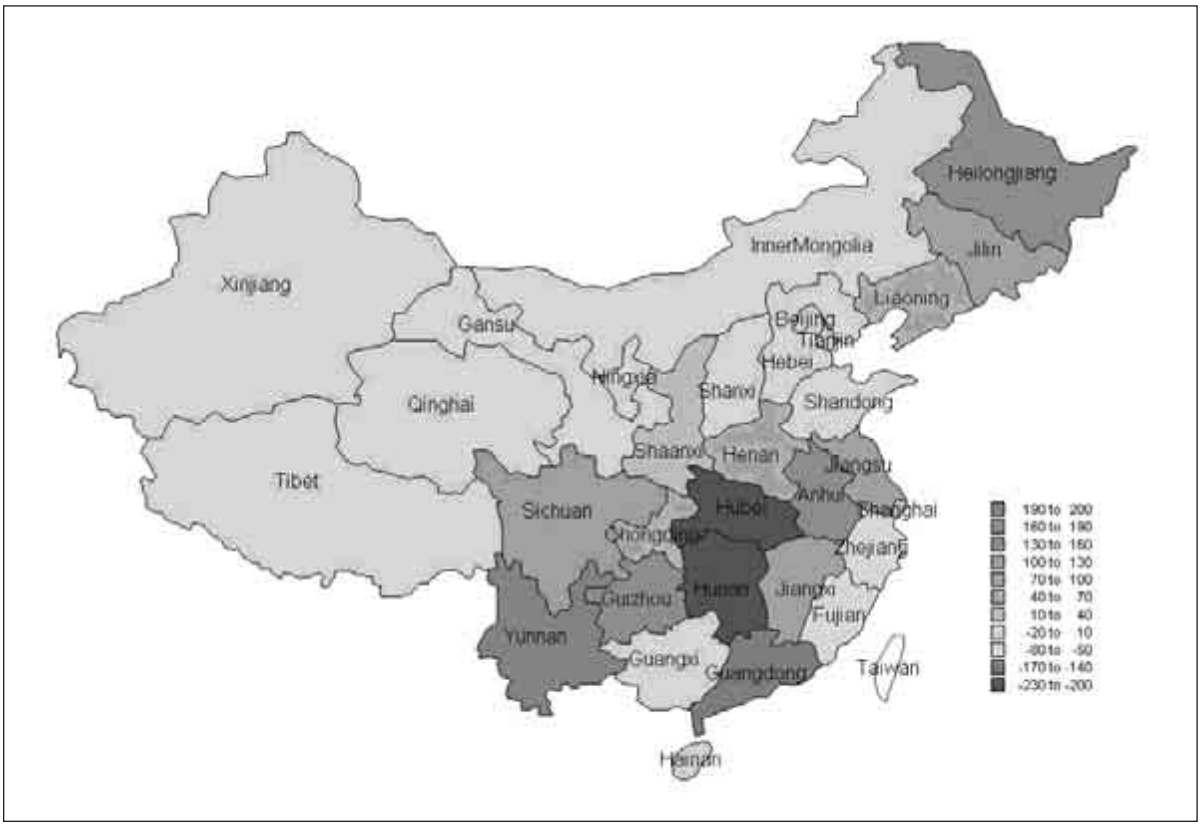
Conversely, indica rice production will shrink under international market competition. Indica rice production areas mainly lie in central China and along the south-eastern coastland. Central China is the major rice growing area in China, but this area has been shrinking in the past few years because of the low quality of the rice produced there. Following China's accession to the WTO, rice production in these areas will face more intensive competition. Economic development in the south-east is fast, so the costs of land and labour are relatively high. If trade liberalization offers opportunities to industries other than agriculture, rice production in these areas will gradually be reduced.

Maps 6-1 to 6-4 summarize the predicted rice growing area changes due to the impacts of free trade, by province, in 2005 and 2010.

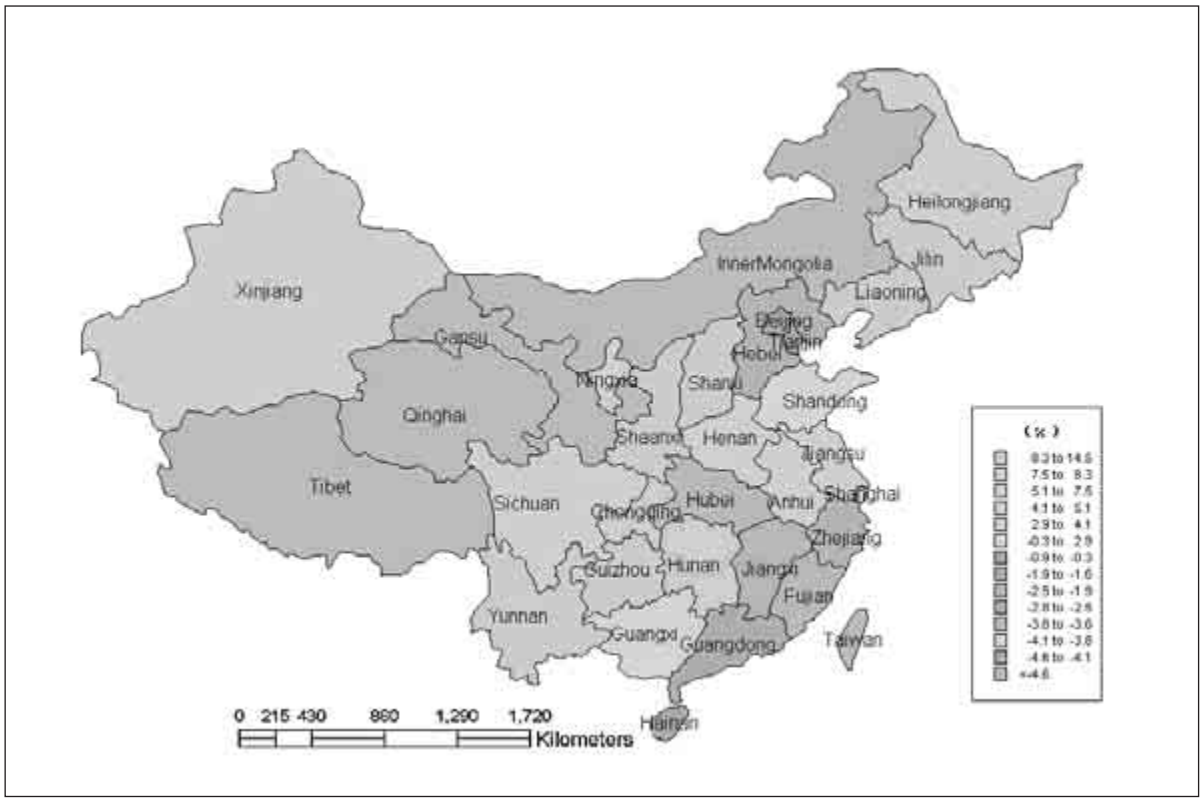
Map 6-1: Change in the rice growing area caused by trade liberalization in 2005 by province (kha)



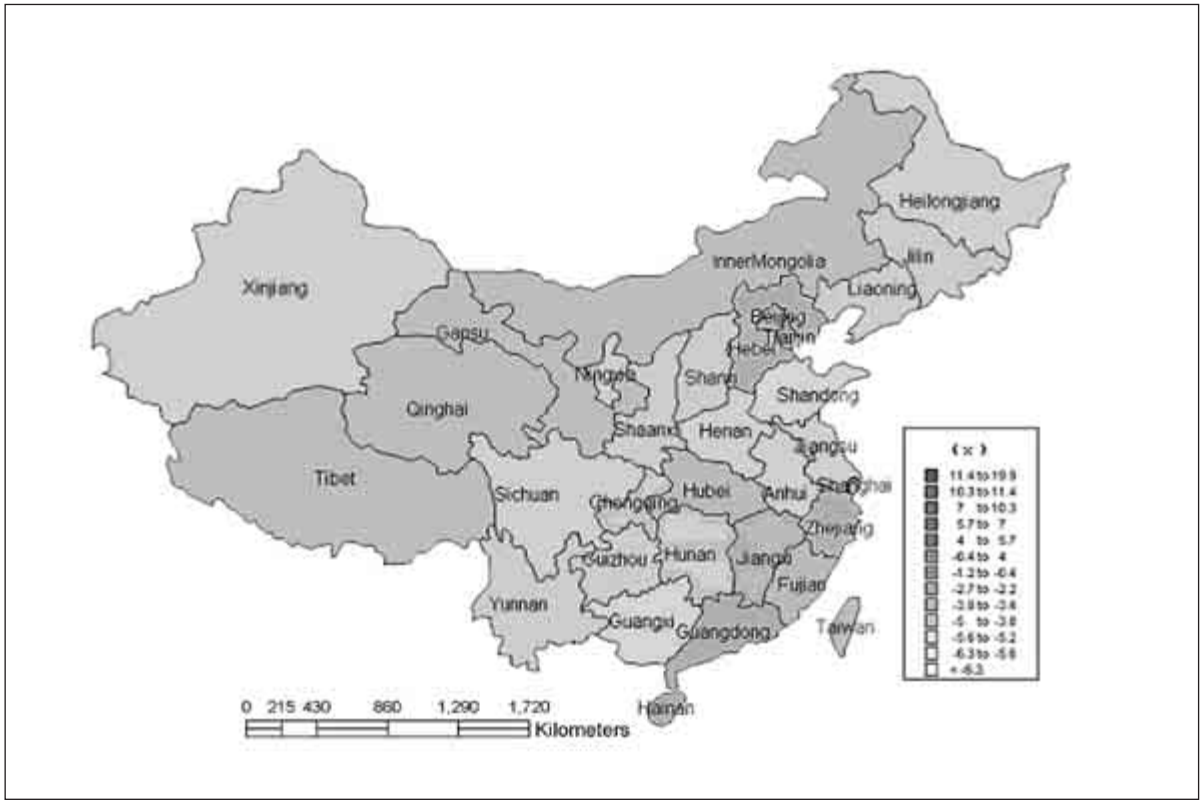
Map 6-2: Change in the rice growing area caused by trade liberalization in 2010 by province (kha)



Map 6-3: Percentage change in the rice growing area caused by trade liberalization in 2005 by province (%)



Map 6-4: Percentage change in the rice growing area caused by trade liberalization in 2010 by province (%)



7. Economic impacts of trade liberalization on the rice sector

7.1 Impacts on national agricultural prices, output and food consumption

7.1.1 Impacts on agricultural prices

According to the analysis, WTO accession will have impacts on the prices for nearly all crop and livestock commodities. Compared with the baseline (i.e. without WTO accession), the prices of most crop commodities decline in the coming decade (Table 7-1). However, for vegetables, fruit, meat and fish the prices increase.

While the decline pattern over time for most crops (except japonica rice, vegetables and fruit) are similar, the extent of price declines due to trade liberalization vary significantly among commodities (Table 7-1). For example, although trade liberalization will affect domestic prices, the extent of the impacts on commodities with small NPRs in 2001 (e.g. indica rice, wheat, coarse grains, soybean and cotton) is much lower than on those with higher NPRs in 2001 (e.g. maize, oil crops and sugar crops). Compared with the baseline, WTO accession will lower the domestic prices of wheat, soybean and cotton by about 2-4 per cent in 2005-2010, whereas the impacts could be as high as 7-20 per cent for maize, oil and sugar crops in the same time period.

On the other hand, trade liberalization will increase the domestic prices of commodities in which China has a comparative advantage in the international market. The expected rise in exports of these commodities increases their domestic prices. For example, we estimate that the prices of vegetables will be about 4-6 per cent higher under the WTO scenario compared to the baseline in 2005 and 2010. Over the same period, the prices of pork and

Table 7-1: Impacts of WTO accession and trade liberalization on agricultural output prices, in percentage changes compared with the baseline, 2005 and 2010

Commodity	2005	2010
Rice	1.5	2.3
– Japonica	6.8	10.2
– Indica	-0.4	-0.6
Wheat	-1.7	-1.7
Maize	-6.6	-6.6
Soybeans	-0.9	-2.6
Cotton	-3.4	-3.4
Oil crops	-16.7	-20.2
Sugar crops	-9.3	-16.7
Vegetables	3.7	6.2
Fruit	3.7	6.2
Pork	8.3	13.9
Beef	2.9	4.8
Poultry	6.8	11.4
Milk	-9.9	-13.7
Fish	5.9	9.8

poultry will rise even more (by 4-14 per cent, Table 7-1). A similar increase pattern will occur in fish prices. Among all animal products, milk is an exception; its domestic price will decline with trade liberalization.

Overall, agricultural produce and food prices are projected to rise slightly over the projection period. The aggregate agricultural (crop + meat + fish) output prices, crop output prices and food consumption prices are generated using a Stone price index (where the prices of individual commodities are aggregated using weights constructed with value shares). While the aggregate crop output price level will fall by 2.26 per cent in 2005 and 2.18 per cent in 2010 under the WTO scenario (compared with the baseline scenario), overall agricultural prices will rise by 0.48 per cent in 2005 and 1.8 per cent in 2010, though the changes are essentially minimal. The reason overall agricultural prices do not fall with more trade liberalization like crop output prices do is simply because the prices of most meats and fish rise with trade liberalization (Table 7-1). For the aggregate food prices, we estimate a higher rate of increase under the WTO scenario because some of the crops with falling prices (e.g. cotton and most of the maize) are not consumed as food. Compared with the baseline scenario, overall food prices under the WTO scenario will rise by 2.36 per cent in 2005 and 4.37 per cent in 2010.

7.1.2 Impacts on agricultural production

The price changes due to trade liberalization mean that the incentives of agricultural producers will change, but unlike sector-wide policies, trade liberalization policies are unique in that they frequently change the relative prices of domestic agricultural commodities because the impacts of trade policies differ from one commodity to another. In general, trade liberalization stimulates domestic production in sectors that are producing commodities in which the nation has a comparative advantage while dampening those in which producers do not have an advantage. As a result, trade policies can lead to different impacts, sometimes negative and sometimes positive. Moreover, because most of the commodities are competing for domestic resources such as land, labour and capital, cross-commodity substitutions could result in a policy that targets one commodity having an effect on another.

Table 7-2 presents the results of our simulations on the impacts of China's WTO accession and further trade liberalization on agricultural production in 2005 and 2010. The analyses show that trade liberalization will affect domestic production moderately. The signs of impacts due to trade liberalization are as expected. Overall, the impact on production is negative for wheat, maize, cotton, oil crops and sugar crops. In contrast, the impact

Table 7-2: Impacts of WTO accession and trade liberalization on agricultural production, percentage change compared with the baseline, 2005 and 2010

Commodity	2005	2010
Rice	1.5	2.3
Wheat	-0.2	-0.1
Maize	-3.5	-3.1
Soybeans	1.0	0.2
Cotton	-0.3	0.1
Oil crops	-7.5	-9.0
Sugar crops	-2.5	-5.6
Vegetables	2.9	4.9
Fruit	3.3	5.4
Pork	7.6	11.0
Beef	3.5	4.8
Poultry	6.9	9.7
Milk	-5.6	-8.4
Fish	4.3	6.6

is positive for those commodities in which China has a comparative advantage such as rice, vegetables, fruit, meat and fish (Table 7-2). An increase in the prices of these commodities due to trade liberalization will stimulate their domestic production.

It is worth noting that the increased price of commodities will not lead to a boost in domestic production in all cases. The production impacts are associated with both own commodity price and cross commodity price substitution impacts. Soybean – a crop with less comparative advantage that was liberalized before China's WTO accession in 2001 – is an interesting case for understanding the impact of trade liberalization. The liberalization of the soybean sector led to a substantial increase in imports and a decline in the domestic price and production prior to China's WTO accession. Imports reached more than 15 million tons, i.e. a level similar to domestic production at the time China joined the WTO. While further trade liberalization after China's WTO accession will result in a decline in the price of soybeans (Table 7-1), the price decrease will be so small that the impacts of own price are less than the impacts due to changes in the prices of substitute commodities such as vegetables, fruit, rice and some coarse grains, and to changes in input prices (e.g. fertilizer and pesticide) in the post WTO era.

As there are both positive and negative impacts resulting from WTO accession on China's agriculture, we estimate the overall impacts on the whole agricultural sector for the average farmer. These are reported in Table 7-3. When examining the overall effects of trade on agricultural production, several facts become clear. In contrast to some of the commodity-specific effects that were presented above, the overall effects of China's WTO accession and further trade liberalization are positive. According to our analysis, the agricultural output value for the average farm will rise by 191 Yuan (about 26 Yuan or US$ 5.6 per person), representing 2.8 per cent of total agricultural output in 2005 (Table 7-3). The net benefits in terms of output values will increase to 460 Yuan in 2010, which represents about 5.6 per cent of household agricultural output values. Among the benefits, about 20-30 per cent is due to the rise in prices and the other 70-80 per cent is due to the growth in real output through the changes in production patterns, namely a shift from agricultural products with a lower comparative advantage to ones with a higher comparative advantage.

The rise in overall production that occurs when imports rise and exports expand demonstrates the importance of accounting for the way in which production responds to changing prices. According to our simulation, producers in China respond to price changes by shifting to the production of commodities that experience price increases and away from those that experience price reductions. At the end of the period we forecast that enough structural change has occurred to cause overall agricultural output to increase. By 2005, while the output value of importable products will decline by

Table 7-3: Impacts of WTO accession and trade liberalization on agricultural output value and food consumption expenditure for average farm households in China compared with the baseline, 2005 and 2010.

	2005		2010	
	Changes in value (Yuan/household)	Percentage change (%)	Changes in value (Yuan/household)	Percentage change (%)
Agricultural output	191	2.8	460	5.8
– Importable sector	-198	-7.2	-264	-8.5
– Exportable sector	389	9.3	723	15.1
Food consumption	44	1.1	102	2.3
– Importable sector	-16	-2.0	-17	-1.9
– Exportable sector	61	1.9	119	3.3

Note: The importable sector includes wheat, maize, all coarse grains, soybeans, edible oil, cotton, sugar and milk. The exportable sector includes rice, vegetables, fruit, all meats and fish.

7.2 per cent under the WTO scenario (compared with the baseline scenario), exportable products will rise by 9.3 per cent (2nd column, Table 7-3).

Between 2005 and 2010, i.e. the fifth and tenth years after WTO accession, the rate in the rise of household agricultural output accelerates (Table 7-3, columns 3 and 4). Because liberalization continues for both products that are protected (especially maize, sugar and edible crops) and those that are exportable (e.g. livestock, fish, vegetables and rice), agricultural output will continue to increase under a more liberalized trade environment in 2005-2010. However, because we have not accounted for the increased production output values that occur due to the greater use of inputs, the increase in agricultural output values should not be considered as an increase in agricultural income. When comparing our results to those of other trade models that have simulated the impact of WTO accession on China's agriculture, our results (which are couched in terms of output rather than income) are fairly consistent (about 2-3 per cent agricultural income changes in 2005-2010; if one takes a fraction of the output – say 50 per cent – as increased profits).

7.1.3 Impacts on food consumption expenditure

As we expected, our simulations show that the per capita food consumption of importable commodities rises as their prices fall with trade liberalization, whereas per capita food consumption of the exportable commodities will decline (Table 7-4). The large impacts are found in edible oils, sugar, vegetables, fruit, livestock products and fish.

The overall effects of trade liberalization on food expenditures for average rural households are summarized in Table 7-3. Compared with production impacts, the overall effects of China's WTO accession on food consumption are more modest (rows 4-6, Table 7-3). By 2005, total household food expenditure will be 1.1 per cent higher under the WTO scenario than under the baseline. The impact will rise to 2.3 per cent in 2010.

Because overall food prices change with trade liberalization, to examine the impacts of WTO accession on food consumption, we need to compare the changes in food expenditure shares with the overall food price changes in the projection period. Because the aggregate food prices will rise by 2.36 per cent in 2005 and 4.37 per cent in 2010 under the WTO scenario (compared with the baseline scenario), this implies that increases in food expenditure due to trade liberalization all derive from the rise in food prices. Indeed, at constant prices, real food consumption will decline by about 1 per cent in 2005 and 2 per cent in 2010 due to trade liberalization.

Table 7-4: Impacts of WTO accession and trade liberalization on per capita food consumption in rural and urban China, percentage changes compared with the baseline, 2005 and 2010

	Rural		Urban	
Commodity	2005	2010	2005	2010
Rice	-0.6	-0.8	-1.0	-1.4
Wheat	0.2	0.2	0.2	0.1
Maize	1.4	1.4	1.9	2.1
Soybeans	0.5	1.1	0.5	0.9
Edible oils	13.7	19.8	13.9	18.0
Sugar	7.4	14.3	6.9	13.1
Vegetables	-1.9	-2.9	-1.6	-2.6
Fruit	-2.7	-4.8	-1.6	-3.0
Pork	-3.9	-6.6	-3.8	-5.9
Beef	-0.8	-2.5	-0.4	-2.3
Poultry	-3.7	-5.5	-3.9	-6.0
Milk	13.4	20.6	8.0	11.4
Fish	-3.2	-6.1	-3.1	-4.5

Table 7-5: Self-sufficiency rate (%) of major crops under the baseline and WTO scenarios in 2010

		2010	
Commodity	**2001**	**Baseline**	**WTO**
Cereal Crops	101	96	93
– Rice	101	103	107
– Wheat	100	97	96
– Maize	105	90	80
Soybeans	53	49	47
Oil crops	83	89	69
Sugar crops	89	80	71
Vegetables	101	100	105
Fruit	100	99	106

7.2 Impacts on national food self-sufficiency

The baseline projection shows that the self-sufficiency of all land-intensive crops, except rice, will fall in the coming decade, and WTO accession will further lower the self-sufficiency levels of these commodities (Table 7-5). For example, under the WTO scenario, cereal imports will rise from 3 million tons in 2001 to 41 million tons in 2010 (Table 7-6). Most of the imports are feed grain. Although exports (mainly rice) will also increase, net imports will reach 32 million tons in 2010, representing about 7 per cent of domestic consumption. In other words, the self-sufficiency level for cereals will fall from 101 per cent in 2001 to only 93 per cent 2010, compared to 96 per cent in 2001-2010 under the baseline scenario.

The self-sufficiency levels of other land-intensive crops (e.g. oil and sugar crops) will fall even more than those of cereal crops. Imports of edible oils will account for 31 per cent (Table 7-5) of domestic consumption under the WTO scenario in 2010, about 20 per cent higher than under the baseline scenario. By 2010, China will also have to import nearly 30 per cent of its sugar from the world market.

On the other hand, China can benefit substantially from trade liberalization for rice and labour-intensive products such as vegetables, fruit, meat and fish. Self-sufficiency of rice will improve by 4 per cent under WTO membership (from 103 per cent to 107 per cent, Table 7-5). China can export 5-6 per cent of its horticultural products to international markets, compared to the baseline of nearly zero net export. Export expansion of meat and fish products will be even larger than that of horticultural products.

In sum, while grain self-sufficiency levels will fall with trade liberalization, food grain (excluding feed grain) and overall food self-sufficiency will rise. Trade liberalization will facilitate China's agricultural diversification and transformation of its agriculture from lower comparative advantage sectors to those with a higher comparative advantage.

7.3 Impacts on the rice economy

Before the impacts of WTO accession on China's rice economy are presented, we analyse the prospects of the rice economy under the WTO scenario in the coming decade. The projected levels of rice consumption, production and trade will provide useful information for judging the impacts that are normally presented in percentage figures. It is also worth noting that the projection results presented in this section are based on a number of assumptions related to consumers' income growth, urbanization, development of the food market on the demand side, and agricultural research and development investments and irrigation expansion on the supply side. Because these assumptions are held in both the WTO and baseline scenarios, they are not critical in assessing the impacts of WTO accession. However, their assumptions do have

significant impacts on the levels of production and consumption under both the WTO and baseline scenarios in the future. Therefore, it is necessary to be cautious when comparing the results presented in Table 7-6 with the results of other projections where the assumptions relating to non-trade policies for both demand and supply differ from this study.

According to the analysis, our study shows that the average national per capita rice consumption in China will decline gradually during the projection period. From a base-year high of 82 kg, per capita rice consumption declines at a very slow rate over the following 10 years (last 3 rows, Table 7-6). The average rural resident will consume greater amounts through 2010. Urban per capita rice consumption peaked in the late 1990s and will decline over the whole projection period. Aggregate per capita rice demand drops despite the rise in rural rice consumption, partly due to rural-urban migration.

Although per capita rice demand falls in the projection period, total rice demand continues to increase through 2010, mainly because of population growth. By the end of the forecast period, aggregate rice demand will reach 128 million tons (Table 7-6). Total grain demand is projected to increase by about 18 per cent (from 366 million tons to 432 million tons, (row 8, Table 7-6) in 2001-2010. Rice will fall from a share of about 34 per cent of total grain consumption in 2001 to less than 30 per cent in 2010.

WTO scenario projections for rice supply show that China's production sector produces slightly more

Table 7-6: Annual cereal and rice supply and utilization of food balance sheet in China under the WTO scenario, 2001-2010

	Units	2001	2005	2010
		Cereals		
Growing area	Million ha	86.1	84.7	83.7
Yield	Tons/ha	4.0	4.3	4.8
Production	Million tons	348	365	401
Stock change	Million tons	-23	9	0.0
Net imports	Million tons	-5	41	32
Imports	Million tons	3	47	41
Exports	Million tons	9	5	10
Consumption	Million tons	366	398	432
Food use	%	57	53	50
Feed use	%	32	36	39
Seed use	%	3	2	2
Industry use	%	4	4	4
Waste	%	5	5	5
Per capita food	kg/person	165	161	159
Urban	kg/person	102	97	92
Rural	kg/person	201	207	214
		Rice		
Growing area	Million ha	28.8	28.6	28.3
Yield	Tons/ha	4.3	4.5	4.9
Production	Million tons	124	129	138
Stock change	Million tons	-1	-2	0
Net imports	Million tons	-1.6	-4.8	-9.6
Imports	Million tons	0.3		
Exports	Million tons	1.9		
Consumption	Million tons	124	125	128
Food use	%	84	83	83
Feed use	%	7	7	7
Seed use	%	2	2	2
Industry use	%	2	2	3
Waste	%	5	5	5
Per capita food	kg/person	82	80	79
Urban	kg/person	56	54	51
Rural	kg/person	97	99	102

than the increase in demand. The surplus rice balance is expected to increase after 2001. Rice production is expected to reach 138 million tons in 2010, which is about 11 per cent higher than in the base year.

Under the projected period, the initial widening gap between the forecast annual growth rate of production and demand implies a rising surplus. Rice exports increase somewhat in 2001-2005 from about 1.6 million tons per year to 4.8 million tons, and reach 9.6 million tons (about 7.5 per cent of domestic consumption or nearly 7 per cent of domestic production) in 2010 (Table 7-6).

Trade liberalization is likely to facilitate China's export of japonica rice to East Asian countries such as Japan, Korea and China Taiwan. Although super quality indica rice imports will also rise, the domestic market for this quality of rice will still be limited in the next 10 years, and will be largely offset by a moderate export of medium quality indica rice from China. Overall, the share of China's net rice exports in domestic production will rise by about 4 per cent in 2010 due to trade liberalization.

Increased rice exports will raise the average domestic rice price by 1.5 per cent in 2005 and 2.3 per cent in 2010 (Table 7-1). Indeed, the rice price would increase a little more if the price of indica rice were not to fall slightly (rows 2 and 3). The rise in the price due to WTO accession provides a better incentive for domestic rice production. Annual total rice production will increase by about 1-2 per cent in the coming years (row 1, Table 7-2). However, per capita rice consumption will decline slightly due to the change in the price of rice. We estimate that per capita rice consumption will decrease by about 1 per cent in 2005-2010 in both rural and urban China (Table 7-4).

The increase in rice production and the decline in its consumption due to China's WTO accession and further trade liberalization under the new round of Doha negotiations will improve China's rice self-sufficiency level. In the base year (2001), China exported about 1 per cent of its rice to the world market. By 2010, net exports will reach about 3 per cent of domestic production under the baseline scenario; the rate will increase to 7 per cent (or 107 per cent of self-sufficiency) under the WTO scenario (Table 7-5). In sum, our analyses show that rice seems to be the only grain that is projected to benefit from China's entry into the WTO.

8. Impacts of WTO accession on China's rural households and poverty

8.1 Characteristics of rural households

Based on geographical location and the level of economic development, China often divides its economy into three regions: west, central and east (Table 8-1). The western region is the least developed area and is characterized by poor infrastructure. About one fifth of China's population lives in the region. Most provinces in the eastern region are located on China's eastern coast and most of these regions are endowed with better infrastructure and a higher population density. About half of the nation's population and 40 per cent of the rural population live in this area. The eastern region is the most developed area. The central region in terms of geography, population and economic development is in between the western and eastern regions. Due to the large number of provinces (31), and although the analyses were conducted for all provinces some of which are presented in maps, the presentation of data in tables only shows a few selected provinces. They are Zhejiang and Guangdong in eastern China; Jilin, Jiangxi and Henan in central China; and Sichuan, Ningxia, Shaanxi and Guizhou in western China.

Because all rural households have access to land, farms in China are small by international standards. For the nation as a whole, the average farm size is 7.9 mu (Table 8-2), or 0.53 hectares (15 mu = 1 ha). Since the eastern region has a higher population density, its average farm size is the smallest (i.e. 2.5 mu in Zhejiang and 3.2 mu in Guangdong). Farmers in most of the central and western regions have more land than those in the east, but the average size is still small. Because the farms are small, households in China have to use their land resources intensively. They use their land to produce both their own staple foods and cash crops for sale to the market.

Despite the increasing rate of non-farm employment, there are significant regional variations in economic activities and sources of income. Income levels in the eastern region are twice as high as those in the west (Table 8-1). Eastern farmers also earned much more income from the non-agricultural sector than from agriculture (Table 8-3). In contrast, the average farmer in most of the west earned more from agriculture in 2003.

Income variations among regions also mean that spending patterns by farmer differ. Western farmers, on average, spent nearly 60 per cent of their total living expenditure on food. In contrast, less than 50 per cent of the budget share of farmers in the east is spent on food. Of the 30 million people living below China's national poverty line, about half are located in the west. The poverty incidence rate is higher in the west and centre than in the east (Table 8-3).

The variations among farmers in China, and even within a region, are surprisingly large. In order to show the variations among farmers in terms of their income levels, we divided the entire sample households surveyed by the NSBC in 2003 into

Table 8-1: Rural income and living expenditure by province, 2003

	Per capita net income (Yuan)	Per capita living expenditure (Yuan)
East		
Shanghai	6687	5670
Beijing	5752	4139
Zhejiang	5431	4287
Tianjin	4655	2320
Jiangsu	4239	2704
Guangdong	4055	2927
Fujian	3825	2757
Shandong	3153	2136
Liaoning	2934	1884
Hebei	2853	1600
Hainan	2588	1645
Guangxi	2095	1751
Central		
Hubei	2567	1802
Hunan	2535	2141
Jilin	2532	1810
Heilongjiang	2514	1663
Jiangxi	2458	1908
Shanxi	2299	1430
Inner Mongolia	2281	1771
Henan	2236	1509
Anhui	2127	1596
West		
Sichuan	2230	1747
Chongqing	2215	1583
Xinjiang	2106	1465
Ningxia	2043	1637
Qinghai	1815	1576
Yunnan	1694	1414
Shaanxi	1675	1455
Gansu	1673	1337
Tibet	1585	1017
Guizhou	1565	1185
National	2704	1949

Source: NSBC's database on rural household income and expenditure survey in 2003. Sustainable rises in rural labour productivity and household income, however, will require more than the average income from farm activities in China. As a result, members of farming households need to find employment in the off-farm sector. In fact, this is what has been happening in rural China since the early 1980s (deBrauw *et al.*, 2002). By 2003, farmers allocated an average of 35.6 per cent of their time to off-farm activities (Table 8-2) and earned 56 per cent of the family's income from the non-agricultural sector (Table 8-3). Most of the off-farm earnings were in the form of wages.

12 groups for China as a whole and also for each province. The household characteristics, earnings and consumption levels of each income group for China as a whole are presented in Table 8-4.

As shown in Table 8-4, there is considerable heterogeneity among income categories in China. This is also the case within the provinces (not shown in this report). For example, the poor in China (and also in each province) have a much higher dependency ratio than those in the rich categories. Even wider variations are found among households when examining human capital and access to off-farm employment. The differences in human capital also seem to have had an impact on farmers' access in different regions to off-farm employment (deBrauw *et al.*, 2002; World Bank, 2001). Table 8-4 also provides this evidence. For example, the poorest of the poor (Poverty I) spent only 21 per cent of their time on off-farm activities, while the richest spent nearly 60 per cent of their time on off-farm activities (Table 8-4).

Table 8-2: Rural household characteristics in the selected provinces by region, 2003

	Family size (persons)	Labour	Off-farm time %	Average farm arable land (mu)
National	4.1	2.8	35.6	7.9
East				
Zhejiang	3.6	2.6	64.9	2.5
Guangdong	5.0	3.3	44.9	3.2
Central				
Jilin	3.7	2.8	35.2	19.4
Jiangxi	4.4	3.1	38.3	5.5
Henan	4.1	2.7	33.4	5.7
West				
Sichuan	3.9	2.7	35.6	3.6
Ningxia	4.6	2.8	28.8	16.9
Shaanxi	4.3	2.7	32.4	7.0
Guizhou	4.4	2.8	29.4	4.6

Note: One hectare = 15 mu.
Source: NSBC's database on rural household income and expenditure survey in 2003.

Table 8-3: Rural household income and expenditure by region, 2003

	Wage income %	Agricultural income %	Poverty I incidence %	Poverty II incidence %
National	37	44	4.0	8.6
East				
Zhejiang	48	19	1.0	1.8
Guangdong	48	32	0.4	1.3
Central				
Jilin	17	75	7.0	11.8
Jiangxi	42	45	3.5	8.7
Henan	28	53	4.2	10.7
West				
Sichuan	34	50	1.4	4.4
Ningxia	29	47	8.0	16.7
Shaanxi	37	44	9.0	18.9
Guizhou	29	53	6.5	18.2

Note: Poverty I and II refer to poverty levels according to the offical national and international (US$ 1/day in PPP) poverty line standards respectively.
Source: NSBC's database on rural household income and expenditure survey in 2003.

Table 8-4: Rural household characteristics by income group in China, 2003

		Poverty		Income groups from lowest (1) to highest (10)									
	Average	I	II	1	2	3	4	5	6	7	8	9	10
Family size	4.1	4.6	4.7	4.7	4.5	4.4	4.3	4.2	4.1	3.9	3.9	3.7	3.4
Labour	2.8	2.9	3.0	2.9	2.9	2.9	2.9	2.8	2.8	2.8	2.8	2.7	2.6
Off-farm time %	35.6	21.4	22.5	22.7	25.5	27.3	30.4	33.2	35.1	37.9	41.1	46.5	57.7
HH arable land (mu)	7.9	11.1	9.8	9.6	8.3	8.0	7.7	7.6	7.8	7.7	7.6	7.8	6.6
Per capita net income	2704	337	572	618	1124	1455	1769	2098	2465	2914	3523	4551	8336
Wage income %	37	38	28	28	27	28	32	35	36	37	39	41	40
Agricultural income %	44	59	64	64	62	60	56	52	50	47	44	39	30
Per capita living exp.	1949	1021	992	1001	1124	1298	1464	1647	1819	2080	2318	2869	4767

Source: NSBC's database on rural household income and expenditure survey in 2003

The sources of income help identify some of the reasons for the discrepancies. When examining the components of total income, wage income contributes more to the variation than other sources of income. For example, poor farmers earn a much smaller proportion of their income from wages and other off-farm activities. If they earned as much as richer farmers, the differences among income groups would be much lower. Table 8-4 shows poor farmers also depend more on agriculture for their income than richer farmers. The share of agriculture in total income ranged from about 60 per cent for the poor to 30 per cent for the richest.

While we examine the impacts of trade liberalization on the national production in the previous section, the aggregate effects could cover up important effects on different groups of farmers in different regions. This is especially true if the structure of household production varies significantly among farmers in the different income groups. In order to assess the impacts of trade liberalization on a household's agricultural production, we first describe the structure of agricultural production by income categories and then by regions.

Our analyses indicate that the poor depend more on agricultural income from commodities of lower comparative advantage than the richer farmers. To show this, we divide all households into ten groups, each with equal sized households, and range them based on their income level (named as 1st decile to 10th decile in Figure 8-1a). Meantime, we also identify all households under the World Bank's poverty line. For each household group, we divide the household agricultural production into two categories: importable and exportable commodities. Then we compute the share of importable commodity production in total production. Importable commodities are those for which the prices will decline with trade liberalization, while the exportable commodities are those for which the prices will rise (or their NPRs were negative in 2001, see previous section for details). The results of this analysis are presented in Figure 8-1a and Figure 8-1b, which show that, as farmers move from the lower (bottom 10 per cent, or 1st decile) to the higher income categories, the share of their importable commodity output in total production declines, or the share of their exportable commodity output increases.

It is interesting to note that the production patterns we have observed by income category for the nation (Figures 8-1a and 8-1b) do not appear in

Figure 8-1a: Agricultural production structure by income group in 2003: Importable output (%)

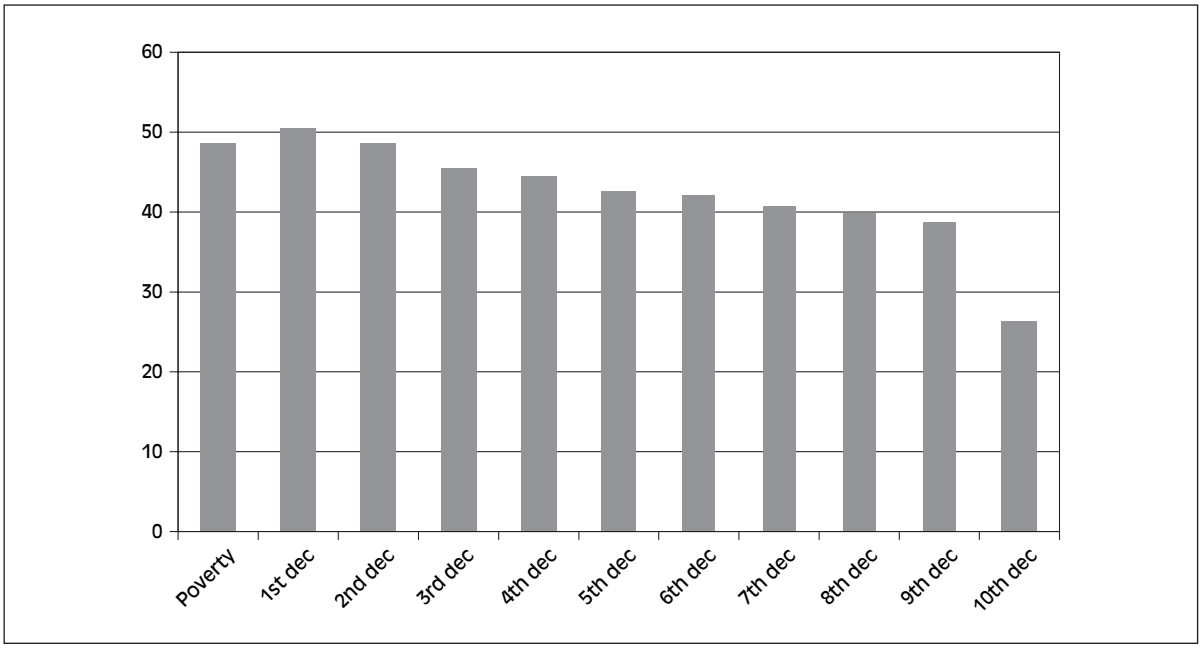
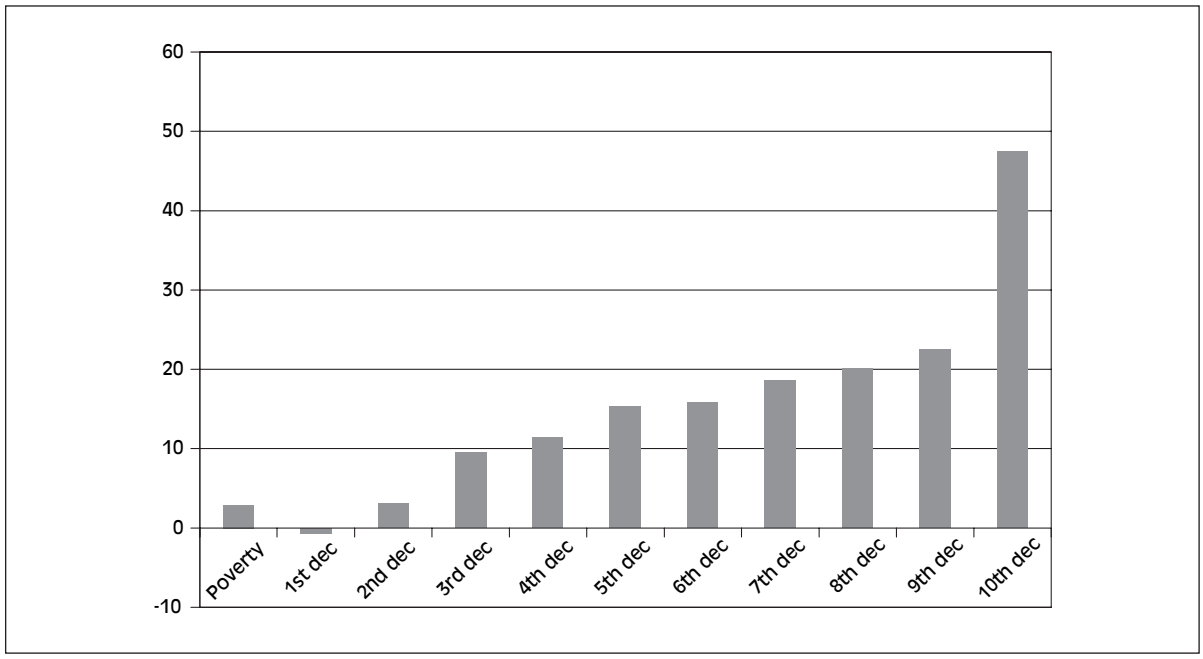
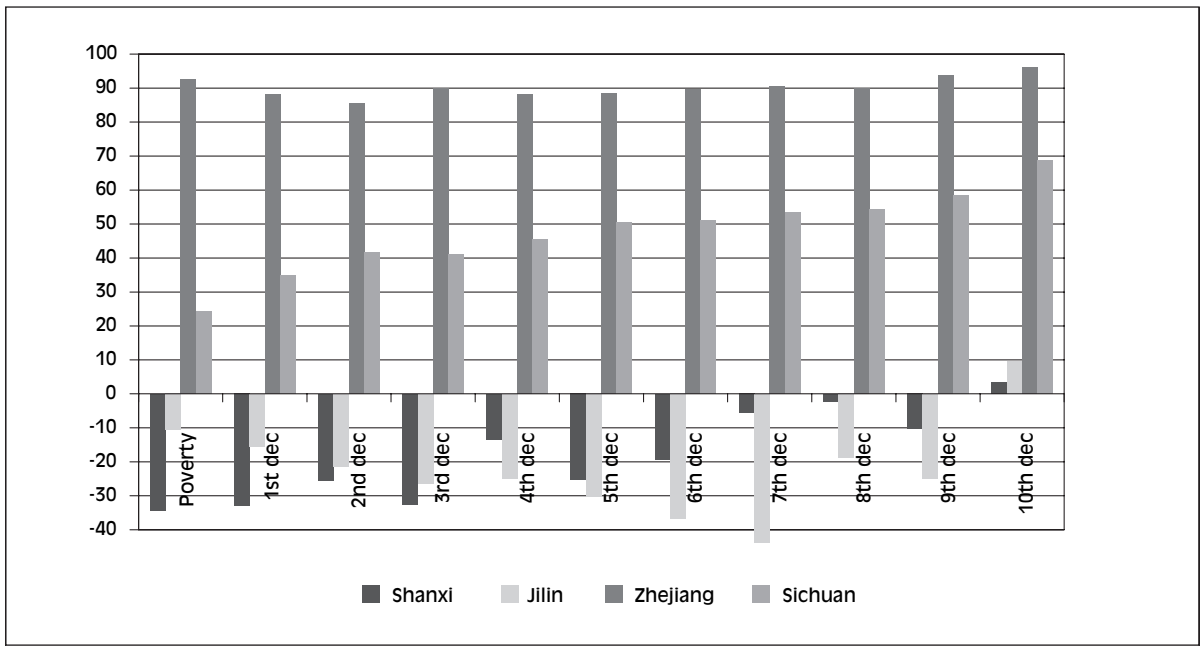


Figure 8-1b: Agricultural production structure by income group in 2003: Exportable % - importable %



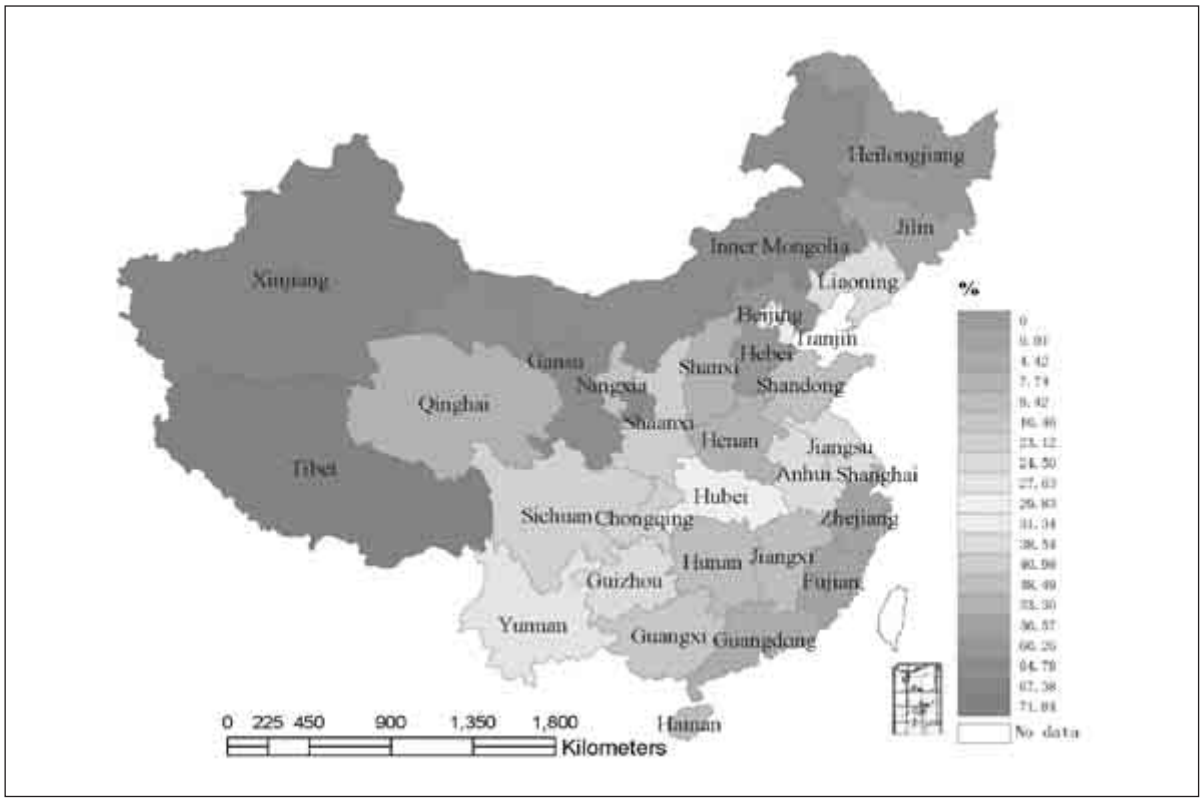
each region. A close analysis of the production of different farmers by province reveals some key differences. For example, in Shanxi and Jilin nearly all farmers (except the richest) produce more commodities in which China has a lower comparative advantage, while the farmers in all categories in Zhejiang province, regardless of whether they are poor or rich, produce mostly products for which the prices will rise with trade liberalization (Figure 8-2). This suggests that future trade liberalization will affect poor farmers negatively in the poor areas since it will invariably lead to lower

Figure 8-2: Agricultural production structure by income group in selected provinces in 2003: Exportable% - importable%

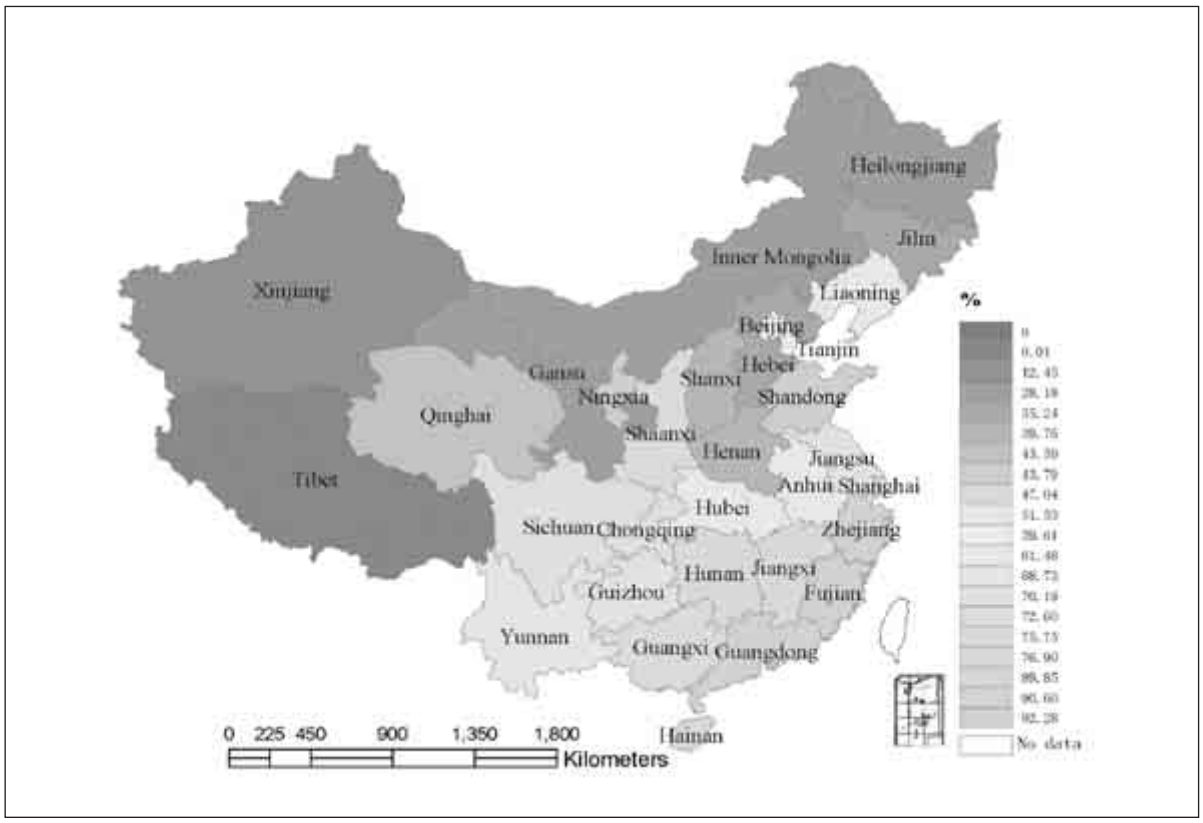


Source: NSBC, 2004.

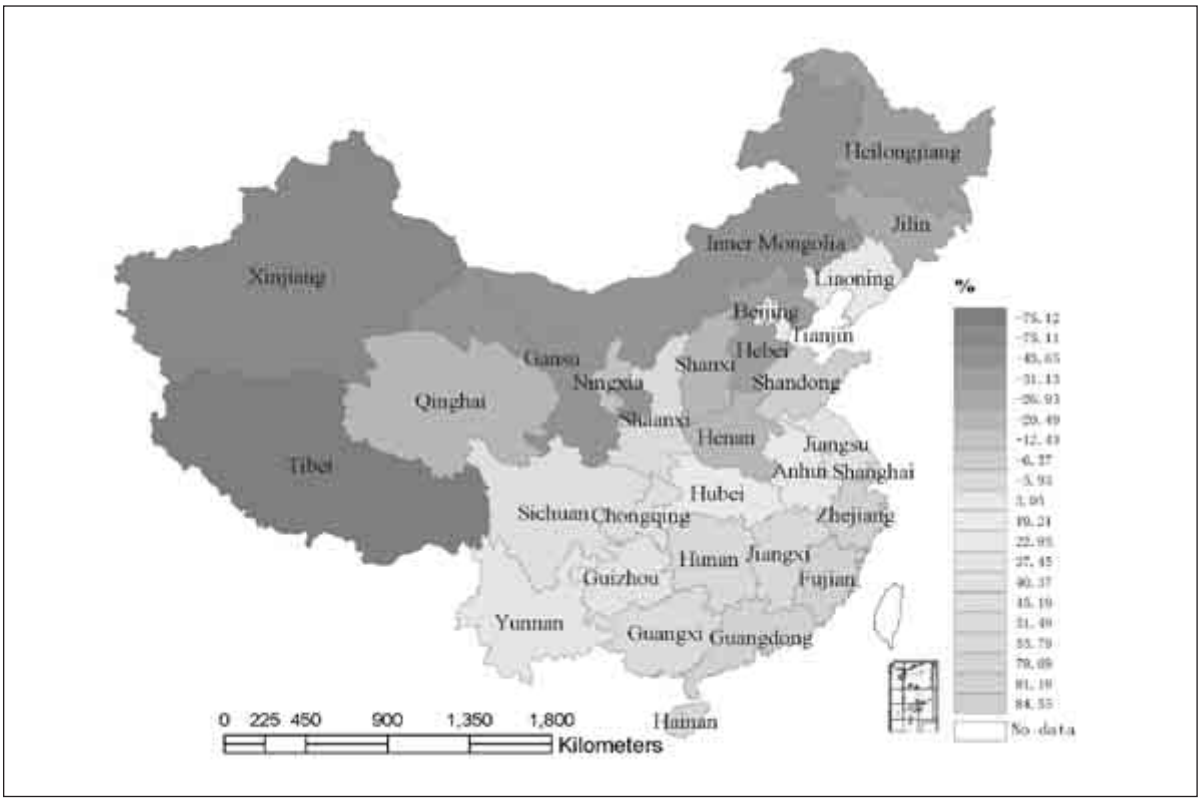
Map 8-1a: Regional agricultural production structure in 2001: importable output share, %



Map 8-1b: Regional agricultural production structure in 2001: exportable output share, %



Map 8-1c: Regional agricultural production structure in 2001: net exportable output share, %



prices for the products on which they rely heavily. On the other hand, both poor and non-poor farmers may gain equally in many coastal and southern provinces as a result of China's WTO accession.

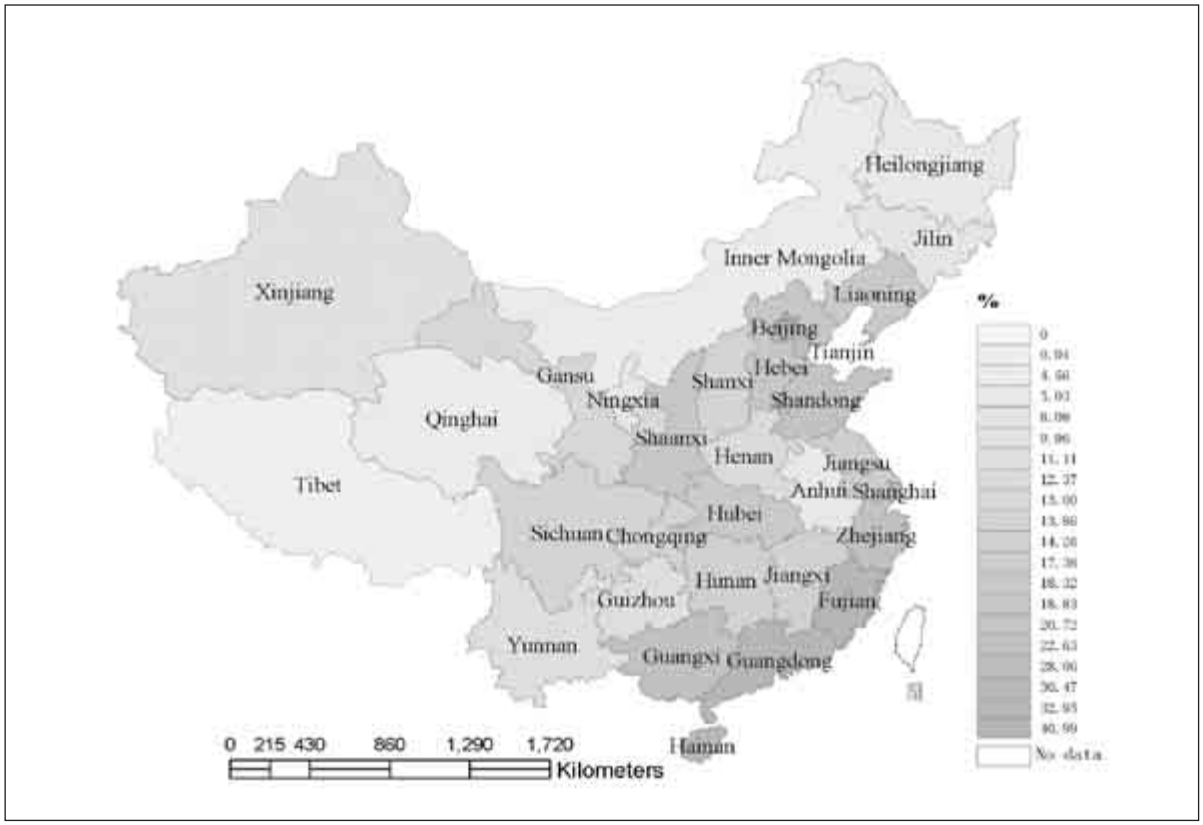
Based on the same approach, Maps 8-1a to 8-1c show that farmers living in southern and coastal areas are expected to benefit from trade liberalization because they produce more exportable commodities than farmers in northern and western China. This implies that the impact analysis based on the national scale presented in the previous section might be misleading for many inland farmers who indeed will face great challenges during trade liberalization.

While it is obvious that coastal farmers will benefit more – or lose less – from trade liberalization than western and northern farmers because the former produce more livestock and aquatic products than the latter, the same pattern is also evidenced within the crop sector. For example, coastal farmers produce a higher proportion of China's rice, livestock and horticulture crops that have driven the nation's rising exports (Maps 8-2a and 8-2b). The yields of these crops in the coastal areas are also higher. In contrast, inland farmers have used a higher proportion of their growing area to produce crops such as maize, wheat, soybean, edible oils, sugar and cotton that present a rise in imports (and the largest drop in NPRs).

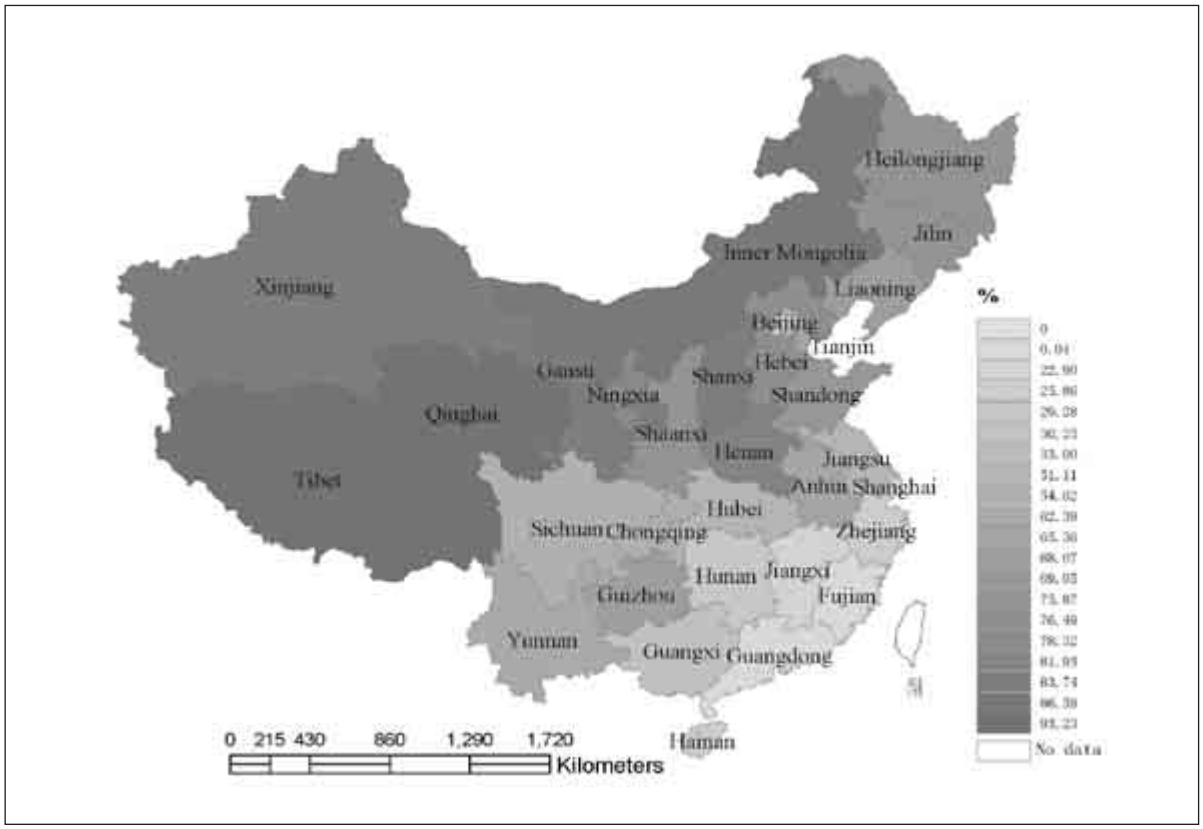
8.2 Impacts on rural households by income group and region

According to the analysis, if China implements its commitments under the WTO agreement, the changes in domestic prices will affect both production and consumption in all rural households (Table 8-5). As discussed above, our simulation analysis predicts that, after 5 years for the average farm, agricultural output value will rise 2.8 per cent (row 4, Table 8-5). During the same period,

Map 8-2a: Regional crop production structure in 2001: horticultural area share, %



Map 8-2b: Regional crop production structure in 2001: importable crop area share, %



food expenditures will rise by 1.1 per cent (row 13, Table 8-5), albeit at a rate lower than the increase in production output value. Aggregate food expenditures also rise as a result of the overall food price increase and the reduction of total food consumption (Table 8-5). For importable commodities, consumption increases as prices fall. The expenditure reduction on importable foods means that consumers gain from both the increase in consumption and the decline in price. For exportable commodities, consumers lose from the rising prices and decline in consumption.

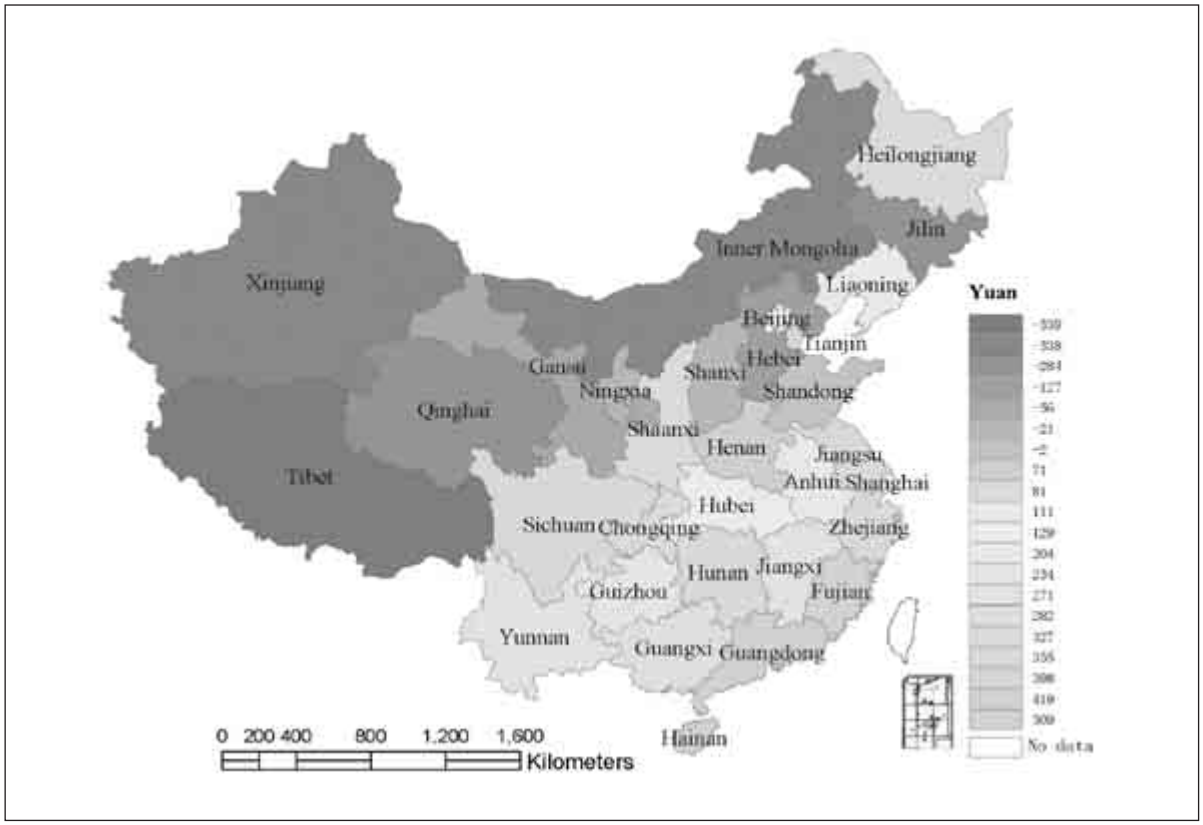
However, not all farm households benefit equally from China's accession to the WTO. Our results show that in 2005 and 2010, the poor gain much less than the average and richer farmers. Agricultural output values for the poor will increase by 77 Yuan per household in 2005, 191 Yuan for the average farmer and 583 Yuan for the top 10 per cent richest farmers (column 1, Table 8-5). Even in terms of percentage changes, the rise in agricultural output values is less for the poorest than for the richest. On the other hand, food expenditure increases for all farmers, but in percentage terms the rates of increase are nearly identical in 2005 and are lower for the poor than for the rich in 2010 (although the difference is very small).

The analysis of the impacts by region shows interesting results that have strong implications for the regional development plan. Although the average farmer in China will gain from trade liberalization, the farmers in western and northern China are negatively affected. Indeed the gains we estimated for China as a whole are mainly due to the positive effects that occur in southern and coastal provinces. The agricultural output value per household will decline by as much as 100-340 Yuan (or 1-4.5 per cent of output) in north-west and north-east China, while it will increase by 100-500 Yuan (1-8 per cent) in southern China (Maps 8-3a and 8-3b). This should not come as a surprise, since the production structures differ significantly across regions (Maps 8-1 and 8-2, Table 8-6). The provinces showing positive effects from trade liberalization are those that produce more exportable than importable commodities (compare Table 8-6 or Map 8-1 with Maps 8-3a and 8-3b).

Table 8-5: Impacts of WTO accession and trade liberalization on per household food expenditure by income category in China, compared with the baseline, in 2005 and 2010.

	2005		2010	
	Changes in value (Yuan)	Percentage change (%)	Changes in value (Yuan)	Percentage change (%)
Agricultural output value				
Below int'l poverty line	77	1.7	221	4.4
Importable sector	-138	-6.3	-177	-7.2
Exportable sector	215	9.6	399	15.5
Average farmers	191	2.8	460	5.8
Importable sector	-198	-7.2	-264	-8.5
Exportable sector	389	9.3	723	15.1
Top 10% richest farmers	583	5.3	1205	9.3
Importable sector	-212	-7.5	-304	-9.3
Exportable sector	795	9.7	1509	15.6
Food consumption				
Below int'l poverty line	25	0.9	76	2.4
Importable sector	-20	-2.3	-21	-2.2
Exportable sector	45	2.4	97	4.4
Average farmers	44	1.1	102	2.3
Importable sector	-16	-2.0	-17	-1.9
Exportable sector	61	1.9	119	3.3
Top 10% richest farmers	62	1.0	134	2.0
Importable sector	-13	-1.5	-12	-1.3
Exportable sector	75	1.4	146	2.6

Map 8-3a: Impacts on agricultural output value for the average farm in 2005: Yuan/household



Map 8-3b: Impacts on agricultural output for the average farm in 2005: percentage of output, %

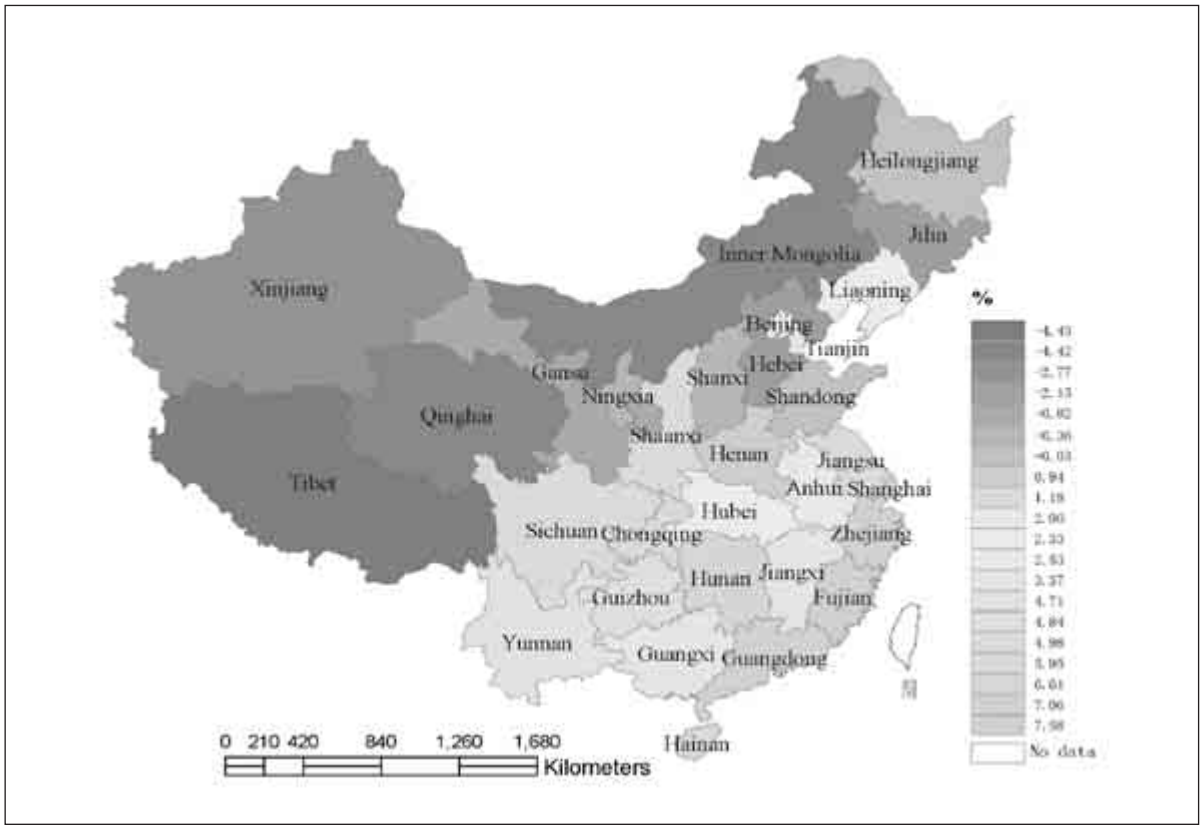


Table 8-6: Agricultural production structure, importable and exportable shares (%) by province, 2001

	Importable	Exportable	Net exportable	Rice	Horticulture	Importable crops
Tibet	88	12	-75	0	1	99
Xinjiang	72	28	-44	2	9	90
Gansu	67	33	-35	0	3	97
Inner Mongolia	66	34	-31	2	3	96
Heilongjiang	65	35	-30	12	3	86
Hebei	63	37	-27	1	4	95
Jilin	60	40	-20	14	4	82
Shanxi	57	43	-13	0	6	94
Henan	56	44	-13	4	5	91
Qinghai	56	44	-12	0	2	98
Ningxia	53	47	-7	7	8	86
Shandong	53	47	-6	0	18	81
Shaanxi	48	52	3	2	7	91
Anhui	41	59	18	29	8	63
Liaoning	40	60	19	14	8	78
Tianjin	39	61	23	0	1	99
Beijing	31	69	37	1	13	87
Hubei	31	69	37	38	7	55
Yunnan	30	70	40	25	9	66
Jiangsu	28	72	45	33	11	56
Guizhou	27	73	45	23	12	65
Chongqing	24	76	51	30	21	49
Sichuan	24	76	51	25	14	61
Guangxi	23	77	54	51	9	40
Jiangxi	10	90	79	77	8	15
Hunan	10	90	79	70	9	21
Hainan	10	90	80	62	14	24
Shanghai	9	91	81	56	17	27
Guangdong	8	92	85	64	21	15
Zhejiang	4	96	91	34	58	8
Fujian	3	97	93	70	14	16
National	40	60	19	18	8	74

Note: Net exportable = exportable – importable.

Likewise, at the national level, while we show that on average farmers, including the poor, will gain from trade liberalization, this result does not hold for every province (Table 8-7). From Table 7-3 we saw that at the national aggregate levels the overall impact is small, mainly because there are offsetting effects among provinces. But as can be seen in Table 8-7, the impacts differ significantly across provinces, even for the farmers in the same income categories.

Because trade impacts tend to be commodity-specific, and because farmers from different income groups in different provinces grow different sets of commodities, farmers experience sharper regional and income class specific impacts (Table 8-7). This also means that trade impacts affect equity. In the case of China, while nearly all farmers in many provinces in the east and south will benefit from trade liberalization, producers primarily in the west and north suffer because the region is the largest producer of maize, wheat, cotton, edible oil crops, sugar and soybeans, and these commodities endure the most harm as a result of liberalization.

Interestingly, not all the poor will gain or lose in terms of their production with trade liberalization. Our analyses show that the poor that are located in the rich areas (again in the south and east) gain from trade liberalization, while the poor living in the poor areas (in the west and north) lose out (Map 8-4). Therefore, trade liberalization may contribute to poverty reduction in some parts of

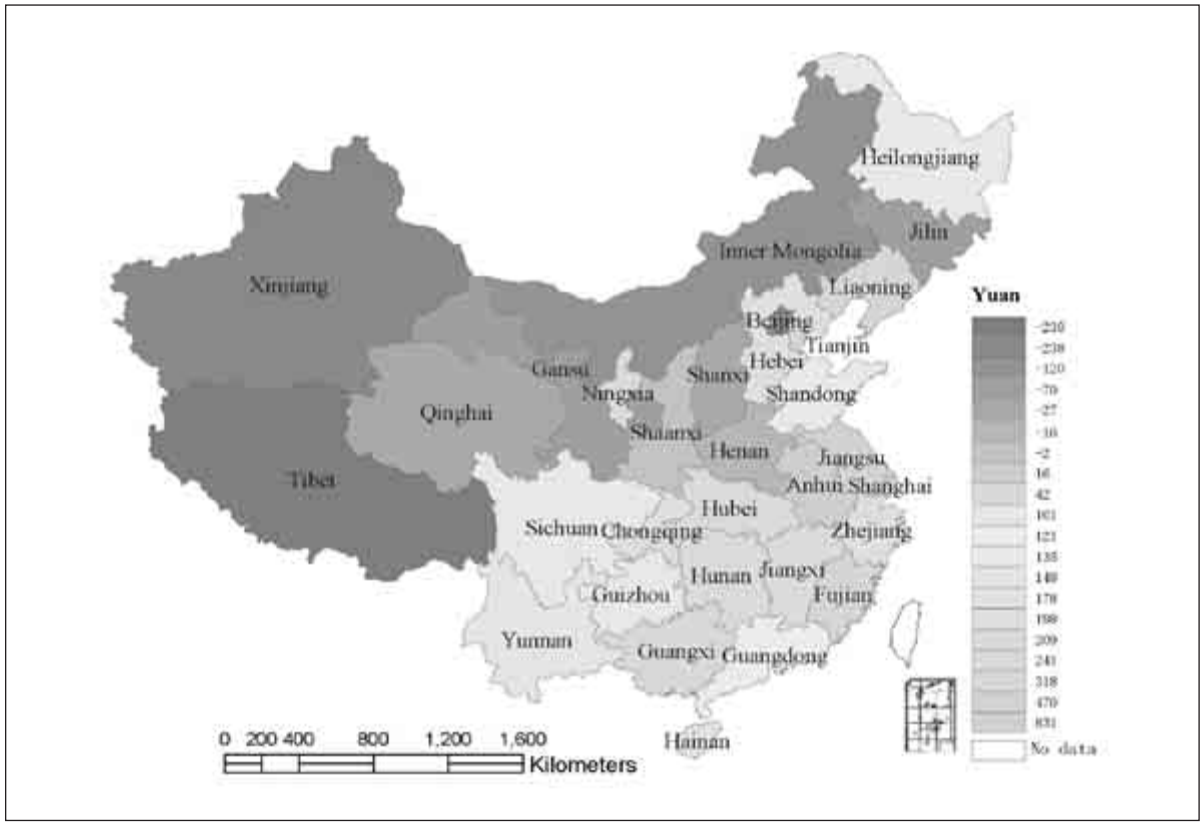
China, but it may also worsen income distribution in other parts of the country. The other important finding is that the poor will gain (or lose) less than the rich in each sector because, despite having farms that are of a similar size, their land produces less than that of the richer producers. It could be that the lower production is due to inferior land resources and climate. It could also be that poorer producers have access to fewer inputs. If so, the clear policy implications are that the Government should provide ways for farmers to access better technology, water control and credit.

The impacts of WTO accession on food consumption by income group in the selected provinces are shown in Table 8-8. Several observations can be made from these results. First, the effect on rural residents as producers is typically greater than the effect on them as consumers. Changes in production (both positive and negative) are greater than changes in expenditures because, while the rural resident as a producer enjoys (suffers) all of the gains (losses) from price increases (decreases), the rural resident as a consumer is only affected by a fraction since a great deal of the output is sold to consumers in the city.

Table 8-7: Impacts of WTO accession and trade liberalization on per household agricultural output values by income in the selected provinces, compared with the baseline, 2005 and 2010

	2005		2010	
	Changes in value (Yuan)	Percentage change (%)	Changes in value (Yuan)	Percentage change (%)
Zhejiang				
Below int'l poverty line	157	6.8	309	11.4
Average farmers	397	7.6	752	12.5
Top 10% richest farmers	951	8.2	1786	13.5
Guangdong				
Below int'l poverty line	163	4.4	323	7.7
Average farmers	684	7.6	1348	12.8
Top 10% richest farmers	2936	11.0	5799	17.9
Jilin				
Below int'l poverty line	-77	-1.3	61	0.9
Average farmers	-128	-1.2	105	0.9
Top 10% richest farmers	370	1.8	1165	5.0
Jiangxi				
Below int'l poverty line	187	4.7	368	8.3
Average farmers	278	4.5	549	8.0
Top 10% richest farmers	476	4.9	913	8.2
Henan				
Below int'l poverty line	-7	-0.2	77	1.7
Average farmers	80	1.2	296	3.8
Top 10% richest farmers	818	5.8	1685	10.5
Sichuan				
Below int'l poverty line	164	3.8	355	7.2
Average farmers	389	5.9	789	10.6
Top 10% richest farmers	683	7.5	1339	12.7
Ningxia				
Below int'l poverty line	42	1.0	166	3.4
Average farmers	-3	0.0	88	0.9
Top 10% richest farmers	-119	-0.7	-238	-1.1
Shaanxi				
Below int'l poverty line	27	0.7	123	2.9
Average farmers	101	2.0	280	4.8
Top 10% richest farmers	297	3.5	664	6.7
Guizhou				
Below int'l poverty line	138	3.4	317	6.9
Average farmers	270	5.0	565	9.2
Top 10% richest farmers	471	6.8	941	12.0

Map 8-4: Impacts of WTO accession on agricultural output values and on the poor, 2005 (Yuan/household).



Second, the difference in consumption impacts among income groups within the same province (Table 8-8) is much smaller compared to the production impacts (Table 8-7). This is explained by the fact that the variation in consumption patterns among income groups is much smaller than the variation in production structures.

Finally, our analysis also shows that the trade effects are more important on commodity types than on regions of the country in terms of expenditure impacts (Table 8-8). In other words, when examining our data by province, we find that there are only slight differences among provinces. Evidently, because markets are fairly well integrated, consumer baskets are more similar throughout China than production baskets. Farm households in the north and west of the country obviously cultivate a group of products that will be more hurt by trade liberalization.

Table 8-8: Impacts of WTO accession and trade liberalization on food expenditure per household by income category in the selected provinces, compared with the baseline, 2005 and 2010

	2005		2010	
	Changes in value (Yuan)	Percentage change (%)	Changes in value (Yuan)	Percentage change (%)
Zhejiang				
Below int'l poverty line	65	1.4	133	2.5
Average farmers	88	1.4	170	2.3
Top 10% richest farmers	105	1.1	200	1.8
Guangdong				
Below int'l poverty line	67	1.2	141	2.3
Average farmers	123	1.5	243	2.7
Top 10% richest farmers	151	1.4	283	2.4
Jilin				
Below int'l poverty line	46	1.5	97	2.8
Average farmers	41	1.3	88	2.6
Top 10% richest farmers	34	0.9	79	2.2
Jiangxi				
Below int'l poverty line	32	1.0	70	1.9
Average farmers	47	0.9	98	1.9
Top 10% richest farmers	50	1.0	99	1.8
Henan				
Below int'l poverty line	-1	0.0	18	0.7
Average farmers	13	0.4	43	1.3
Top 10% richest farmers	70	1.3	149	2.6
Sichuan				
Below int'l poverty line	50	1.4	106	2.7
Average farmers	65	1.6	129	2.9
Top 10% richest farmers	68	1.4	130	2.6
Ningxia				
Below int'l poverty line	7	0.2	49	1.4
Average farmers	24	0.7	91	2.4
Top 10% richest farmers	38	1.0	149	3.7
Shaanxi				
Below int'l poverty line	-5	-0.3	11	0.4
Average farmers	-1	-0.1	17	0.6
Top 10% richest farmers	2	0.1	22	0.7
Guizhou				
Below int'l poverty line	42	1.3	95	2.7
Average farmers	56	1.6	115	3.1
Top 10% richest farmers	64	1.6	126	2.9

9. Impacts of WTO accession on China's environment

9.1 Agriculture and the environment

The reform policies of 1978 and beyond unleashed a torrent of human energy as the HRS was implemented. This, combined with new technology in seeds, fertilizers, pest control and irrigation, resulted in phenomenal output growth. Food security goals were achieved. About one third of China's grain output is now used for animal feed as Chinese consumers add animal products to their diets (Table 7-6). China has had a positive trade balance in agriculture for 20 years (Table 2-2). Consumer attention is now focusing on diet diversity, food safety and quality assurance.

However, an enormous accumulated environmental debt remains as a legacy of this success story. It has many dimensions and includes soil erosion on cultivated lands, degradation of grasslands, salinity on irrigated lands, ineffective river basin management, depletion of groundwater and surface aquifers, and pollution of soils, air and water due to excessive application rates of fertilizers and pesticides and poor management of livestock wastes. These environmental problems represent serious threats to China's food security goals and the economic performance of the agriculture and food sector as the population continues to increase, as China tries to comply with WTO standards and as Chinese consumers consider their food purchase choices.

While trade liberalization is expected to have impacts on most of the environmental dimensions mentioned above, this study will exclusively focus on the impacts of WTO accession on chemical fertilizer and pesticide use. This section begins with the discussions on the issues related to fertilizer and pesticide use in China. Then, the impacts of WTO accession on both fertilizer and pesticide use are presented. The analyses further decompose the impacts into the changes in the intensity of chemical use (e.g. input per hectare) and the changes in crop growing areas. Because chemical inputs and crop production patterns differ largely among provinces, we analyse the impacts at both national and provincial levels.

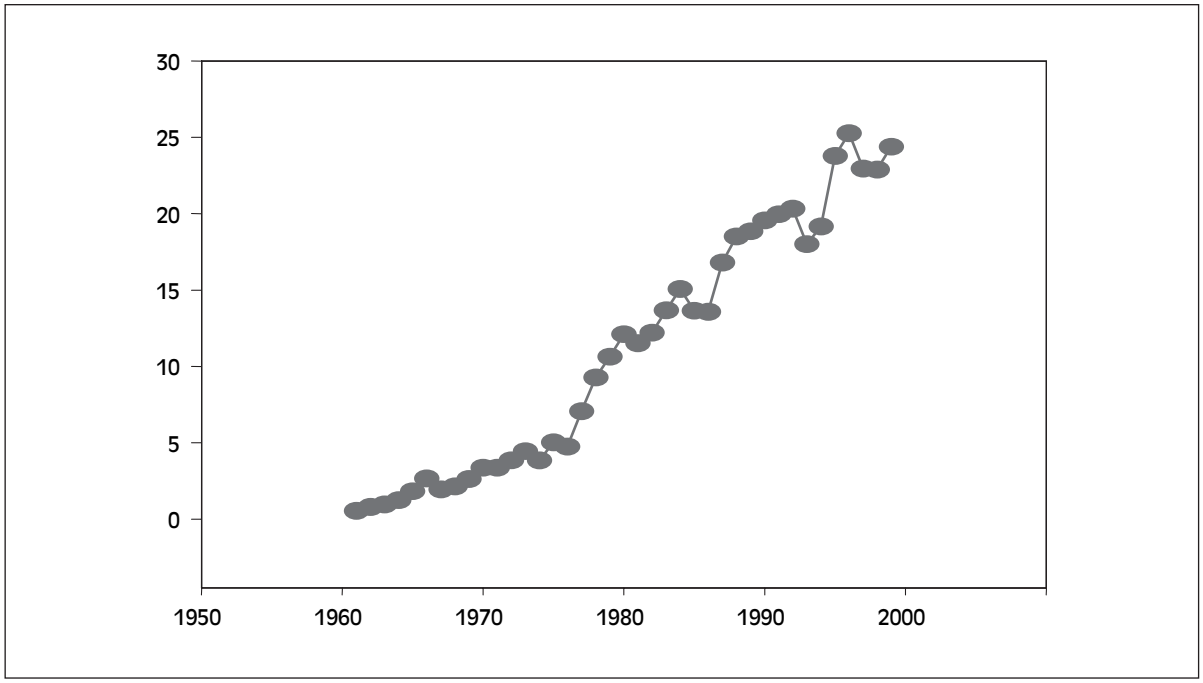
9.2 Chemical inputs

9.2.1 Fertilizer and pesticide use

China has been able to supply enough food for its growing population primarily by increasing the intensity of its farming systems and through the use of modern inputs. Chemical fertilizers and pesticides are key ingredients in this rising intensity. China is now the world leader in fertilizer and pesticide consumption.

In the past 30 years, while world total nitrogen fertilizer application increased seven-fold, China's nitrogen use in crop production increased 45-fold (Figure 9-1, FAO, 2002). On average, nitrogen use per hectare is about three times the world average. In 2001, per hectare fertilizer input (measured in nutrient) in rice production reached 278 kg, ranging from 170-200 kg in the west to 300-400 kg in many provinces in the east and 614 kg in Shandong province (column 1, Table 9-1). Slightly higher quantities of fertilizer are applied for wheat and maize. On average, for example, Chinese

Figure 9-1: Nitrogen fertilizer consumption in China, million tons, 1960-2000



Sources: FAO, 2002.

farmers applied 288 kg/ha and 324 kg/ha of chemical fertilizer in maize and wheat production respectively in 2001. Even more intensive applications of fertilizers by farmers occurred in cotton (392 kg/ha), sugar (668 kg/ha), vegetable (659 kg/ha) and fruit (930 kg/ha) production (the last row, Table 9-1).

The increasing and intensive use of fertilizer has raised many concerns. First, while applying more fertilizer increases crop production, it also raises the cost of production. Farmers now spend 840 Yuan/ha (US$ 102) on inputs in rice production per season (Table 9-2), which represents about 40 per cent of total material inputs or 20 per cent of total production costs. In horticultural production, farmers spent more than 2,000 Yuan/ha on fertilizers in 2001 (last columns).

Second, there is increasing concern regarding the populated regions where fertilizer use is most intensive. For 12 crops (and crop groups) studied, annual total fertilizer use reached 52.4 million tons in 2001 (sum of the last row in Table 9-3), or 148 billion Yuan (about US$ 18 billion, sum of the last row in Table 9-4). Across regions, fertilizer use is generally much greater in southern and coastal areas where population density is higher than in the rest of China (Tables 9-3 and 9-4).

Last but not least, while judicious use of modern technologies is essential for efficient food production throughout the world, inappropriate uses such as excessive application rates or imbalances in input combinations have resulted in serious environmental problems and food safety concerns. The overuse or excessive application of fertilizer has been one of the critical issues on non-point source pollution in China and the extent of overuse has increased significantly over time. For example, the early studies by the Chinese Academy of Agricultural Sciences (CAAS) recorded 10-20 per cent overuse of nitrogen fertilizer in rice production. The overuse rate of fertilizer in rice production rose to 20-30 per cent in the early 1990s (Huang *et al.*, 1994 and 1995) and about 40 per cent in more recent years (Zhang *et al.*, 2004).

Excessive application of pesticides in China's crop production may cause even more problems than fertilizer. Pesticides have been used on a large scale since the 1950s to protect crops from damage

inflicted by insects and diseases. Recently, China surpassed Japan as the world's leading pesticide consumer. Various pesticide compounds have been produced and applied to crops. Many that have been removed from the market in other countries are still widely used in China (Huang *et al.*, 2000). Among them are pesticides that are known to leave highly toxic residues in the environment.

The rising trends of pesticide use in the production of various crops are clearly shown in Figure 9-2. Despite declining pesticide prices over time, per hectare costs of pesticides have tripled for nearly all crops in the past two decades, implying that the growth in the quantity of pesticide used is even faster than that suggested by the trends presented in Figure 9-2. Among the grain crops, rice accounts for the most intensive pesticide use, however, among all crops, pesticide use is most serious in cash crops (e.g. cotton, vegetables and fruit) (Figure 9-2).

While excessive application of pesticide is common in China, the intensity of pesticide use varies among regions. These variations are presented in Table 9-5. This table shows pesticide costs per hectare by type of crop in each province in China. Table 9-6 shows total pesticide costs by crop and by province. A careful examination of pesticide use across provinces shows that pesticide application is highly related to the intensity of land use (i.e. the multi-crop index) and climate situation. More pesticide is used in the southern part of China than in the northern part on a per hectare basis (Table 9-5). Overall, farmers spent 54 billion Yuan (US$ 6.5 billion) on pesticides for the 12 crops in 2001 (sum of the last row in Table 9-6).

Table 9-1: Fertilizer input per hectare by province in China (kg/ha), 2001

Province	Rice	Wheat	Maize	Sweet potato	Potato	Other coarse grains	Soy-beans	Cotton	Oil crops	Sugar crops	Vege-tables	Fruit
Beijing	374	387	287	144	310	161	85	324	222	242	507	930
Tianjin	253	404	296	148	349	161	85	324	222	242	499	930
Hebei	451	433	219	110	290	161	85	324	222	242	586	930
Shanxi	329	284	275	137	321	161	143	250	246	242	460	930
Inner Mongolia	293	448	258	129	230	161	99	299	57	359	374	930
Liaoning	353	453	284	142	310	161	125	312	246	335	248	930
Jilin	272	316	332	166	322	161	133	312	246	367	259	930
Heilongjiang	255	179	224	112	310	161	122	312	246	197	244	930
Shanghai	338	299	313	156	310	161	89	326	369	1371	764	930
Jiangsu	422	328	313	156	310	161	89	397	271	1371	617	930
Zhejiang	317	374	266	133	310	161	89	424	392	1371	426	930
Anhui	267	311	216	108	310	161	42	398	198	1371	500	930
Fujian	312	251	216	108	310	161	107	545	214	1371	1089	930
Jiangxi	218	251	216	108	310	161	107	545	170	713	477	930
Shandong	614	416	332	166	534	161	91	437	306	242	844	930
Henan	341	315	198	99	310	161	39	250	174	242	738	930
Hubei	284	251	352	176	446	161	107	454	236	575	742	930
Hunan	251	251	352	176	310	161	107	602	182	575	693	930
Guangdong	294	251	392	196	310	161	107	545	238	934	986	930
Guangxi	304	251	386	193	310	161	107	545	219	938	841	930
Hainan	200	251	386	193	310	161	107	545	93	474	853	930
Chongqing	155	165	319	159	264	161	50	420	151	917	490	930
Sichuan	206	223	306	153	310	161	107	420	195	917	490	930
Guizhou	246	145	352	176	310	161	107	420	150	410	451	930
Yunnan	271	152	344	172	310	161	38	420	269	410	744	930
Tibet	170	215	260	130	310	161	38	420	148	410	460	930
Shaanxi	170	282	260	130	310	161	67	299	240	711	424	930
Gansu	170	326	494	247	204	161	38	560	189	711	557	930
Qinghai	170	181	260	130	310	161	38	560	181	711	460	930
Ningxia	512	421	390	195	310	161	67	560	181	392	671	930
Xinjiang	512	333	359	180	299	161	38	443	181	392	655	930
China	279	324	288	149	299	161	99	392	212	668	659	930

Table 9-2: Fertilizer input cost per hectare by province in China (Yuan/ha), 2001

Province	Rice	Wheat	Maize	Sweet potato	Potato	Other coarse grains	Soy-beans	Cotton	Oil crops	Sugar crops	Vege-tables	Fruit
Beijing	1184	948	666	222	945	459	173	884	576	651	1314	2516
Tianjin	1305	979	855	285	456	459	173	884	576	651	1075	2516
Hebei	1080	1095	579	193	975	459	173	884	576	651	1677	2516
Shanxi	853	775	702	234	600	459	319	684	769	651	1126	2516
Inner Mongolia	989	1070	897	299	490	459	425	630	152	904	992	2516
Liaoning	989	1070	905	302	945	459	413	1086	769	1030	788	2516
Jilin	773	775	860	287	945	459	385	1086	769	1160	788	2516
Heilongjiang	729	481	593	198	945	459	401	1086	769	710	537	2516
Shanghai	935	634	835	278	945	459	319	1091	827	4509	2368	2516
Jiangsu	1177	947	835	278	945	459	319	1091	804	4509	2219	2516
Zhejiang	859	833	835	278	945	459	319	1020	824	4509	1511	2516
Anhui	708	812	584	195	945	459	84	1078	480	4509	2051	2516
Fujian	903	576	584	195	945	459	184	1555	736	4509	3087	2516
Jiangxi	785	576	584	195	945	459	184	1555	418	2196	1136	2516
Shandong	1332	1167	820	273	2209	459	299	1140	888	651	2783	2516
Henan	980	783	523	174	945	459	100	684	479	651	1826	2516
Hubei	750	576	816	272	1358	459	184	1148	614	1725	3017	2516
Hunan	747	576	785	262	945	459	184	1295	417	1725	2504	2516
Guangdong	1001	576	997	332	945	459	184	1555	608	3416	2454	2516
Guangxi	1000	576	997	332	945	459	184	1555	587	2282	2602	2516
Hainan	761	576	997	332	945	459	184	1555	271	1545	3243	2516
Chongqing	653	491	860	287	629	459	184	781	506	2307	1129	2516
Sichuan	643	560	734	245	945	459	184	781	467	2307	1129	2516
Guizhou	693	460	1031	344	945	459	184	781	516	1497	1393	2516
Yunnan	859	444	1038	346	945	459	146	781	932	1497	1796	2516
Tibet	456	317	524	175	945	459	146	781	259	1497	1638	2516
Shaanxi	456	665	524	175	945	459	226	630	589	1826	1199	2516
Gansu	456	1042	1437	479	741	459	146	1693	587	1826	2619	2516
Qinghai	456	590	524	175	945	459	146	1693	573	1826	1638	2516
Ningxia	1311	941	930	310	945	459	146	1693	573	1408	1978	2516
Xinjiang	1311	1054	1182	394	921	459	146	1398	573	1408	2165	2516
China	840	858	776	256	884	458	297	1084	577	1952	2018	2516

Table 9-3: Fertilizer use by province in China (1,000 tons), 2001

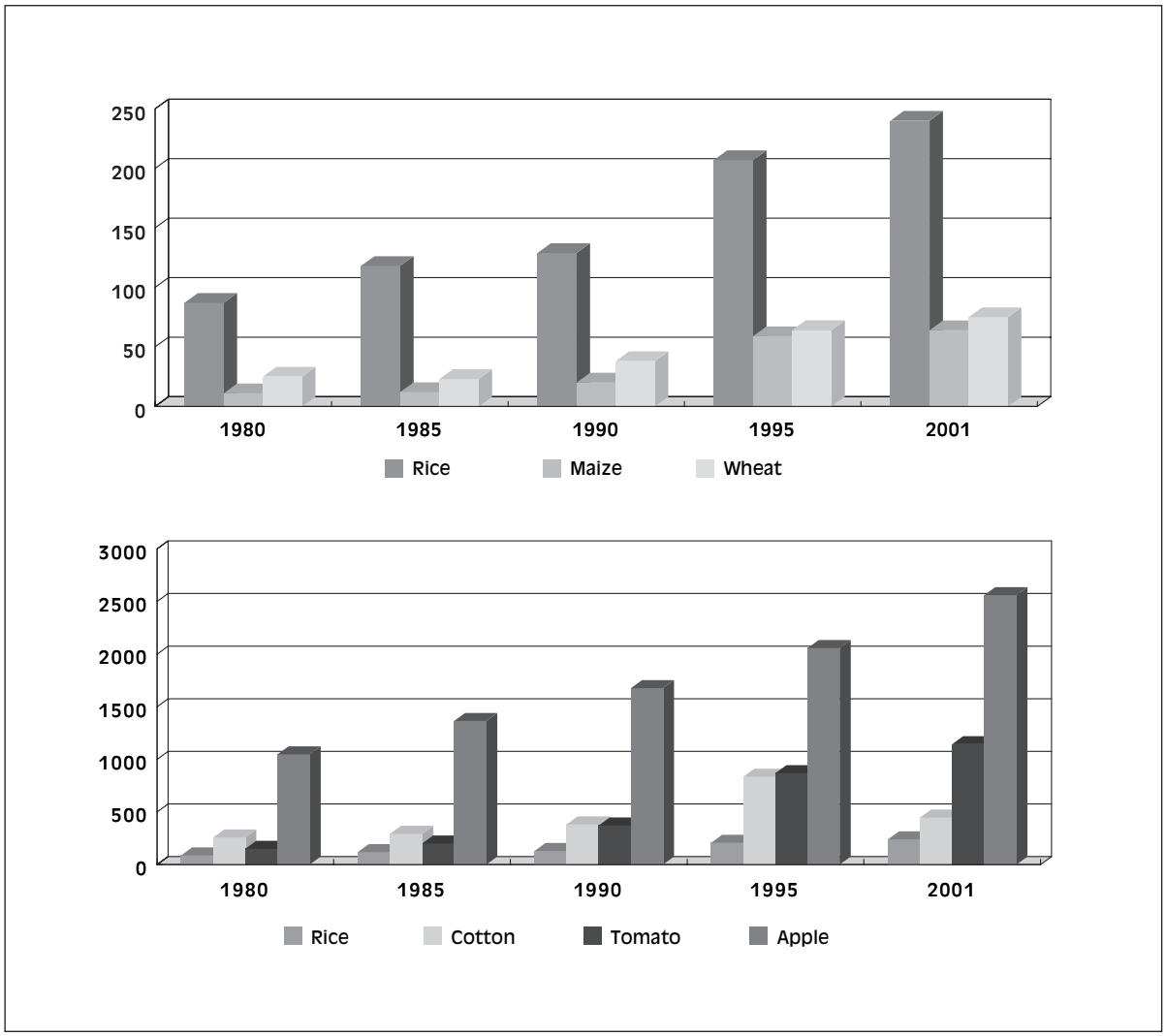
Province	Rice	Wheat	Maize	Sweet potato	Potato	Other coarse grains	Soy-beans	Cotton	Oil crops	Sugar crops	Vege-tables	Fruit
Beijing	3	28	29	1	0	1	2	1	3	0	61	79
Tianjin	3	43	42	0	0	3	4	15	5	0	65	39
Hebei	42	1116	557	25	53	84	32	136	140	2	542	981
Shanxi	2	233	230	7	95	78	31	23	76	1	114	250
Inner Mongolia	25	231	392	1	129	83	75	0	35	21	68	57
Liaoning	182	45	445	9	33	71	42	2	58	6	102	336
Jilin	186	17	867	0	29	18	57	0	58	13	67	150
Heilongjiang	402	76	478	0	130	45	404	0	74	36	104	158
Shanghai	52	10	2	0	0	2	0	0	24	2	114	38
Jiangsu	849	561	134	23	0	33	22	152	251	9	728	166
Zhejiang	425	45	14	14	20	8	11	12	120	24	240	243
Anhui	521	610	127	41	4	25	29	145	281	11	282	88
Fujian	361	8	8	29	27	3	10	0	26	21	613	519
Jiangxi	613	10	4	18	0	2	16	38	132	18	288	230
Shandong	107	1476	832	51	68	13	36	322	308	0	1561	693
Henan	142	1513	436	57	0	28	22	214	251	1	962	319
Hubei	564	185	141	40	106	10	23	157	346	11	806	219
Hunan	928	28	95	52	31	7	22	90	166	17	574	328
Guangdong	696	3	64	78	15	3	9	0	84	153	1108	922

Province	Rice	Wheat	Maize	Sweet potato	Potato	Other coarse grains	Soy-beans	Cotton	Oil crops	Sugar crops	Vege-tables	Fruit
Guangxi	736	4	215	59	0	3	27	0	72	539	783	757
Hainan	71	0	6	24	0	1	1	1	5	29	137	138
Chongqing	119	70	156	75	80	7	4	0	34	2	174	103
Sichuan	432	334	367	134	96	41	20	28	205	28	457	300
Guizhou	184	75	254	40	153	13	15	1	75	7	168	84
Yunnan	298	97	392	30	117	48	5	0	54	110	290	204
Tibet	0	10	1	0	0	22	0	0	2	0	4	1
Shaanxi	24	402	262	13	81	37	15	15	70	1	122	632
Gansu	1	366	231	0	99	58	3	32	62	8	104	262
Qinghai	0	28	1	0	18	8	0	0	30	0	8	5
Ningxia	38	126	58	0	25	15	2	0	18	0	32	40
Xinjiang	38	248	147	0	6	9	3	500	39	33	82	210
China	8042	7996	6987	820	1413	778	941	1884	3105	1105	10762	8553

Table 9-4: Fertilizer cost by province in China (million Yuan), 2001

Province	Rice	Wheat	Maize	Sweet potato	Potato	Other coarse grains	Soy-beans	Cotton	Oil crops	Sugar crops	Vege-tables	Fruit
Beijing	8	69	67	1	0	3	3	3	8	0	158	215
Tianjin	15	104	121	1	0	9	8	40	12	0	139	105
Hebei	102	2824	1472	44	177	238	66	370	364	6	1553	2654
Shanxi	4	636	588	12	177	222	69	62	238	3	278	677
Inner Mongolia	85	552	1362	1	276	237	321	1	93	52	181	155
Liaoning	510	106	1418	20	101	203	138	8	181	19	325	911
Jilin	531	42	2245	0	85	52	166	0	180	42	205	407
Heilongjiang	1148	204	1264	0	398	127	1335	0	233	129	229	429
Shanghai	144	20	4	0	0	5	1	1	53	6	354	102
Jiangsu	2366	1622	359	41	0	93	78	419	745	28	2619	449
Zhejiang	1151	101	43	29	60	24	39	28	253	78	853	657
Anhui	1380	1592	344	74	12	71	57	391	679	37	1157	239
Fujian	1044	17	21	52	82	9	18	0	91	70	1737	1404
Jiangxi	2203	22	12	32	0	5	27	110	325	57	687	623
Shandong	231	4136	2054	83	281	38	118	838	895	0	5148	1876
Henan	408	3759	1151	100	0	79	57	587	691	3	2381	864
Hubei	1490	424	327	62	322	29	40	398	900	33	3279	592
Hunan	2756	63	212	77	93	21	38	193	381	52	2075	888
Guangdong	2370	6	164	132	45	8	16	0	215	558	2758	2495
Guangxi	2424	8	555	102	0	10	46	0	193	1311	2423	2048
Hainan	270	0	17	42	0	2	2	3	15	94	522	373
Chongqing	499	207	421	135	190	21	14	1	114	6	400	280
Sichuan	1345	839	881	214	293	116	35	52	490	71	1053	813
Guizhou	519	240	744	79	468	37	26	2	257	27	519	227
Yunnan	945	285	1182	60	358	137	18	1	186	403	701	553
Tibet	1	15	2	0	0	63	0	0	4	0	14	3
Shaanxi	64	946	526	17	248	105	52	32	172	3	343	1711
Gansu	3	1171	671	0	358	164	12	96	192	21	489	709
Qinghai	0	92	1	0	54	23	0	0	97	0	29	13
Ningxia	97	282	137	0	77	43	4	0	57	0	94	109
Xinjiang	96	785	485	0	19	25	12	1579	125	120	273	567
China	24210	21171	18848	1410	4171	2217	2816	5213	8438	3229	32976	23148

Figure 9-2: Pesticide use in major crops in China, 1980-2001, (Yuan/ha) at 1995 price



Source: NDRC.

Table 9-5: Pesticide cost per hectare by province in China (Yuan/ha), 2001

Province	Rice	Wheat	Maize	Sweet potato	Potato	Other coarse grains	Soy-beans	Cotton	Oil crops	Sugar crops	Vege-tables	Fruit
Beijing	195	83	144	72	61	33	54	470	157	14	510	2271
Tianjin	262	96	74	37	38	33	54	470	157	14	508	2271
Hebei	549	73	80	40	120	33	54	470	157	14	329	2271
Shanxi	144	65	13	6	45	33	10	442	180	14	366	2271
Inner Mongolia	196	53	45	23	61	33	29	211	37	72	1015	2271
Liaoning	198	53	86	43	61	33	75	532	180	33	334	2271
Jilin	173	50	53	26	61	33	116	532	180	121	334	2271
Heilongjiang	160	48	57	29	61	33	113	532	180	83	503	2271
Shanghai	655	216	79	40	61	33	76	567	144	318	1945	2271
Jiangsu	421	160	79	40	61	33	76	567	152	318	1634	2271
Zhejiang	393	63	79	40	61	33	76	1013	98	318	941	2271
Anhui	217	54	50	25	61	33	55	574	95	318	1229	2271
Fujian	267	79	50	25	61	33	35	976	189	318	1479	2271
Jiangxi	208	79	50	25	61	33	35	976	77	321	1106	2271
Shandong	320	83	104	52	138	33	143	417	224	14	863	2271
Henan	195	80	82	41	61	33	62	442	112	14	709	2271

Province	Rice	Wheat	Maize	Sweet potato	Potato	Other coarse grains	Soy-beans	Cotton	Oil crops	Sugar crops	Vege-tables	Fruit
Hubei	190	79	84	42	25	33	35	610	89	348	1500	2271
Hunan	293	79	85	42	61	33	35	1069	84	348	1709	2271
Guangdong	257	79	61	31	61	33	35	976	159	315	971	2271
Guangxi	264	79	61	31	61	33	35	976	90	226	1124	2271
Hainan	95	79	61	31	61	33	35	976	40	74	2202	2271
Chongqing	107	25	18	9	40	33	35	544	9	151	1254	2271
Sichuan	130	84	42	21	61	33	35	544	59	151	1254	2271
Guizhou	135	29	92	46	61	33	35	544	71	209	410	2271
Yunnan	176	68	42	21	61	33	42	544	157	209	1543	2271
Tibet	64	16	11	5	61	33	42	544	11	209	365	2271
Shaanxi	64	45	11	5	61	33	37	211	69	100	549	2271
Gansu	64	70	67	34	13	33	42	112	56	100	1487	2271
Qinghai	64	66	11	5	61	33	42	112	101	100	365	2271
Ningxia	280	75	103	52	61	33	42	112	101	114	497	2271
Xinjiang	280	41	43	21	57	33	42	217	101	114	622	2271
China	240	75	64	30	57	33	77	446	111	198	1045	2271

Table 9-6: Total pesticide cost by province in China (million Yuan), 2001

Province	Rice	Wheat	Maize	Sweet potato	Potato	Other coarse grains	Soy-beans	Cotton	Oil crops	Sugar crops	Vege-tables	Fruit
Beijing	1	6	14	0	0	0	1	1	2	0	61	194
Tianjin	3	10	10	0	0	1	2	21	3	0	66	95
Hebei	52	187	202	9	22	17	21	197	99	0	305	2395
Shanxi	1	53	11	0	13	16	2	40	56	0	90	611
Inner Mongolia	17	27	69	0	35	17	22	0	22	4	185	140
Liaoning	102	5	134	3	7	15	25	4	42	1	138	822
Jilin	119	3	138	0	6	4	50	0	42	4	87	367
Heilongjiang	252	20	122	0	26	9	375	0	54	15	215	387
Shanghai	101	7	0	0	0	0	0	1	9	0	291	92
Jiangsu	846	273	34	6	0	7	19	218	141	2	1928	405
Zhejiang	526	8	4	4	4	2	9	28	30	6	531	593
Anhui	422	105	29	9	1	5	37	208	135	3	693	216
Fujian	309	2	2	7	5	1	3	0	23	5	832	1268
Jiangxi	584	3	1	4	0	0	5	69	60	8	669	562
Shandong	55	295	261	16	18	3	57	307	226	0	1597	1693
Henan	81	385	180	23	0	6	35	379	162	0	925	780
Hubei	378	58	34	10	6	2	8	212	130	7	1630	534
Hunan	1081	9	23	12	6	1	7	160	76	10	1416	802
Guangdong	608	1	10	12	3	1	3	0	56	51	1091	2252
Guangxi	641	1	34	9	0	1	9	0	30	130	1047	1848
Hainan	34	0	1	4	0	0	0	2	2	4	355	336
Chongqing	81	11	9	4	12	2	3	0	2	0	444	253
Sichuan	272	126	50	18	19	8	7	36	62	5	1170	734
Guizhou	101	15	66	10	30	3	5	1	35	4	152	205
Yunnan	194	44	47	4	23	10	5	1	31	56	602	499
Tibet	0	1	0	0	0	5	0	0	0	0	3	2
Shaanxi	9	65	11	1	16	8	8	11	20	0	157	1544
Gansu	0	78	31	0	6	12	4	6	18	1	278	640
Qinghai	0	10	0	0	3	2	0	0	17	0	6	12
Ningxia	21	22	15	0	5	3	1	0	10	0	24	99
Xinjiang	21	30	17	0	1	2	3	245	22	10	78	512
China	6914	1861	1561	167	267	159	726	2146	1622	327	17068	20892

Intensive pesticide use can have several adverse effects and the concerns are rising. In addition to the direct costs of pesticides, the long-term, highly concentrated application of pesticides may contaminate farm produce, pose serious danger to the agroecosystem and adversely affect human health. There is growing concern regarding the increasing use of pesticides that pollute rivers, lakes and the sea as a result of run-off and seepage and become sources of ecological problems (CCICED, Non-Point Pollution Task Force, 2004). China's accession to WTO has raised food safety concerns due to the residual effects of high rates of fertilizer and pesticide applications.

The trend of pesticide use in cotton production, which declined after 1997, is an interesting case that merits further discussion. Insect pests, particularly the cotton bollworm, have been a major problem for cotton production in northern China. Initially, farmers used chlorinated hydrocarbons (e.g. DDT) until these were banned for environmental and health reasons in the early 1980s. In the mid-1980s, farmers started using organo-phosphates but, in the case of cotton, pests developed resistance. In the early 1990s, farmers began to use pyrethroids that were more effective and safer than organo-phosphates. However, as in the case of other pesticides, China's bollworms began to rapidly develop resistance to pyrethroids in the mid-1990s. At this point, farmers resorted to cocktails consisting of organo-phosphates, pyrethroids and whatever else they could obtain (including DDT, although its use is illegal) with less and less impact on the pests (Pray *et al.,* 2002; Huang, Hu, Pray, Qiao and Rozelle, 2003).

Because of the rising pressure from pests and increasing ineffectiveness of pesticides, cotton farmers' use of pesticides rose sharply. In China, farmers used more pesticide per hectare on cotton than on any other field crop, except vegetables and fruit. Cotton production accounted for nearly US$ 500 million worth of pesticides annually in the mid-1990s (Huang, Hu, Pray, Qiao and Rozelle, 2003). China's pest problems led the nation's leaders to release Bt cotton for commercial use in 1997 (Pray *et al.,* 2001).

Bt cotton has spread very rapidly in China, pulled by farmers' demand for technology that has reduced their pesticide costs and exposure to pesticides, and allowed them to do other things with the time they would have spent spraying pesticides. The evidence from 5 years of experience with Bt cotton is that this technology is extremely valuable to over four million smallholders in China who have been able to increase their yield per hectare, reduce pesticide costs, reduce the time they spend spraying dangerous pesticides, and reduce the number of occurrences of sickness due to pesticide poisoning (Pray *et al.,* 2002).

9.2.2 Impacts of WTO accession on chemical input use

The CAPSiM assumes that the price elasticity of chemical inputs is high and that with WTO accession and cheaper chemical fertilizers and pesticides on the market farmers will use more chemical inputs in rice production. However, site investigations suggest that this may not necessarily be the case, at least as far as the study sites (Qing'an county of Heilongjiang province and Shayang county of Hubei province) are concerned. We thus assume two scenarios to project the change in chemical input use under the WTO accession impacts.

9.2.2.1 Scenario I: Change in chemical input use caused by output and input price changes

Fertilizer use

In this scenario, trade liberalization affects the prices of both outputs and inputs. Under a more liberalized environment, it is expected that China will import more fertilizer and pesticide as there were still some distortions on both fertilizer and pesticide world markets at the time China joined the WTO in 2001. Farmers respond to the price changes by changing their crop mix (or crop area allocation) and their input application rates.

Because of the effects of substitution, our study shows that the changes in total crop growing area due to WTO accession are minimal. Although the

Table 9-7: Crop growing area and impacts of WTO accession, 2001-2010

			Crop area under WTO scenario (1,000 ha)		Percentage change of crop area: WTO vs. baseline	
	Crop area in 2001		2005	2010	2005	2010
Total	148928	100	147510	147062	-0.4	-0.2
Rice	28812	19.3	28644	28290	1.0	1.4
Wheat	24664	16.6	24168	23713	-0.2	-0.1
Maize	24282	16.3	23469	23343	-2.7	-2.6
Sweet potato	5498	3.7	5459	5419	0.1	0.1
Potato	4719	3.2	4692	4671	-0.2	-0.3
Other coarse grains	4836	3.2	4863	4834	1.5	1.7
Soybeans	9482	6.4	9539	9441	0.9	0.1
Cotton	4810	3.2	4785	4779	-0.2	0.1
Oil crops	14631	9.8	13700	13444	-5.9	-7.3
Sugar crops	1654	1.1	1618	1569	-1.8	-4.4
Vegetables	16339	11.0	16850	17305	2.1	3.3
Fruit	9200	6.2	9723	10254	2.5	3.9

total crop growing area will decline with WTO accession, the reduction will be just 0.4 per cent in 2005 and even less, 0.2 per cent, in 2010 (row 1, Table 9-7). This scenario of nearly constant total crop area occurs when the prices of both inputs and crop outputs decline. As discussed earlier, aggregate crop output prices are estimated to drop by 2-4 per cent in 2005-2010. The overall negative impacts of lower crop output prices will be offset by the positive impacts of the decline in fertilizer and pesticide prices due to trade liberalization.

Total fertilizer use could change with trade liberalization even if the total crop area remains constant since fertilizer application rates differ among crops. Section 7 of this study has shown that trade liberalization will provoke a reduction in the production of less comparative advantage crops such as maize, wheat, cotton, sugar and edible oil. It is estimated that the crop areas of these commodities will decrease by about 0.2 per cent for wheat and 5.9 per cent for oil crops in 2005 (Table 9-7). On the other hand, the growing areas that produce more comparative advantage crops such as rice, vegetables and fruit will increase by 1 to 4 per cent in the next 10 years (the last column). It is important to note that crops that will experience a rise in crop area are associated with higher fertilizer uses than others (Table 9-1), therefore we could expect that the changes in crop mix due to trade liberalization will result in an increase in fertilizer use.

The results of analyses confirm our expectations. Table 9-8 summarizes the aggregate impacts of WTO accession on fertilizer use and the impacts by crop in 2005 and 2010. Fertilizer demand is projected to increase with trade liberalization, but the impacts are very small. For example, we estimate that total fertilizer demand will rise by just 0.7 per cent in 2005 and reach a moderate rate of 2.4 per cent in 2010 (row 1, Table 9-8) due to China's WTO accession (2001-2005) and further trade liberalization under the Doha Round (2005-2010). In total quantity terms, the overall impacts are estimated to be an increase of 361,000 tons of fertilizer in 2005 and about 1.3 million tons in 2010.

The increases in fertilizer use come from both crop structural changes and higher application rates. Crop-mix changes presented in Table 9-7 will result in an increase in total fertilizer use of about 0.4 per cent. The large increase in fertilizer use for vegetable crops (4.4 per cent in 2005 and 7.7 per cent in 2010) and fruit production (5.2 per cent in 2005 and 9 per cent in 2010) and a moderate rise in rice production (2.2 per cent in 2005 and 3.7 per cent in 2010) will be largely offset by the decline in fertilizer applications in maize, edible oils and sugar crop production (columns 3 and 4, Table 9-8).

Table 9-8: Impacts of WTO accession on fertilizer use by crop, 2001-2010

	Fertilizer use in 2001		Impacts (%): WTO vs. baseline		Impact (%) due to per hectare input change		Impact (%) due to crop area changes	
	Amount (1,000 tons)	Share (%)	2005	2010	2005	2010	2005	2010
Total	52387	100	0.7	2.4	57	65	43	35
Rice	8042	15.4	2.2	3.7	53	60	47	40
Wheat	7996	15.3	-0.2	0.6	22	111	78	-11
Maize	6987	13.3	-4.6	-3.7	42	31	58	69
Sweet potato	820	1.6	0.3	0.8	61	86	39	14
Potato	1413	2.7	0.1	0.8	na	na	na	Na
Other coarse grains	778	1.5	1.7	2.4	11	28	89	72
Soybeans	941	1.8	1.1	0.3	18	83	82	17
Cotton	1884	3.6	-0.8	0.1	81	43	19	57
Edible Oil	3105	5.9	-11.5	-13.5	52	50	48	50
Sugar	1105	2.1	-5.2	-10.3	66	60	34	40
Vegetables	10762	20.5	4.4	7.7	52	56	48	44
Fruit	8553	16.3	5.2	9.0	51	55	49	45

Table 9-9: Impacts of WTO accession on fertilizer use by province, 2001-2010

	Fertilizer use in 2001		Impacts (%): WTO vs. baseline		Impact (%) due to per hectare input change		Impact (%) due to crop area changes	
	Amount (1,000 tons)	Share (%)	2005	2010	2005	2010	2005	2010
China	52387	100	0.7	2.4	57	65	43	35
Beijing	207	0.4	2.5	5.1	57	61	43	39
Tianjin	218	0.4	1.1	3.1	65	66	35	34
Hebei	3710	7.1	0.8	2.7	68	69	32	31
Shanxi	1139	2.2	-0.1	1.4	na	87	na	13
Inner Mongolia	1117	2.1	-1.4	-0.6	38	na	62	na
Liaoning	1333	2.5	0.5	2.4	88	73	12	27
Jilin	1464	2.8	-1.7	-0.4	34	na	66	na
Heilongjiang	1908	3.6	0.4	1.5	72	80	28	20
Shanghai	243	0.5	2.9	5.6	53	58	47	42
Jiangsu	2929	5.6	1.8	3.9	55	61	45	39
Zhejiang	1176	2.2	1.5	3.3	51	60	49	40
Anhui	2164	4.1	-0.5	0.5	48	na	52	na
Fujian	1625	3.1	3.3	6.0	51	56	49	44
Jiangxi	1369	2.6	1.0	2.6	49	62	51	38
Shandong	5467	10.4	0.5	2.3	79	72	21	28
Henan	3944	7.5	0.3	1.9	74	70	26	30
Hubei	2608	5.0	0.2	1.7	55	68	45	32
Hunan	2338	4.5	1.2	2.8	51	62	49	38
Guangdong	3135	6.0	2.7	5.0	50	56	50	44
Guangxi	3194	6.1	1.2	2.3	41	56	59	44
Hainan	413	0.8	2.9	5.1	49	55	51	45
Chongqing	824	1.6	0.5	2.1	70	69	30	31
Sichuan	2442	4.7	0.0	1.4	na	74	na	26
Guizhou	1070	2.0	-0.6	0.7	33	na	67	na
Yunnan	1646	3.1	-0.1	1.1	20	78	80	22
Tibet	41	0.1	0.4	1.2	na	56	na	44
Shaanxi	1673	3.2	1.2	3.3	57	63	43	37
Gansu	1225	2.3	-0.1	1.4	na	87	na	13
Qinghai	98	0.2	-3.1	-2.9	48	37	52	63
Ningxia	354	0.7	0.2	1.7	na	80	na	20
Xinjiang	1315	2.5	-0.2	1.2	42	79	58	21

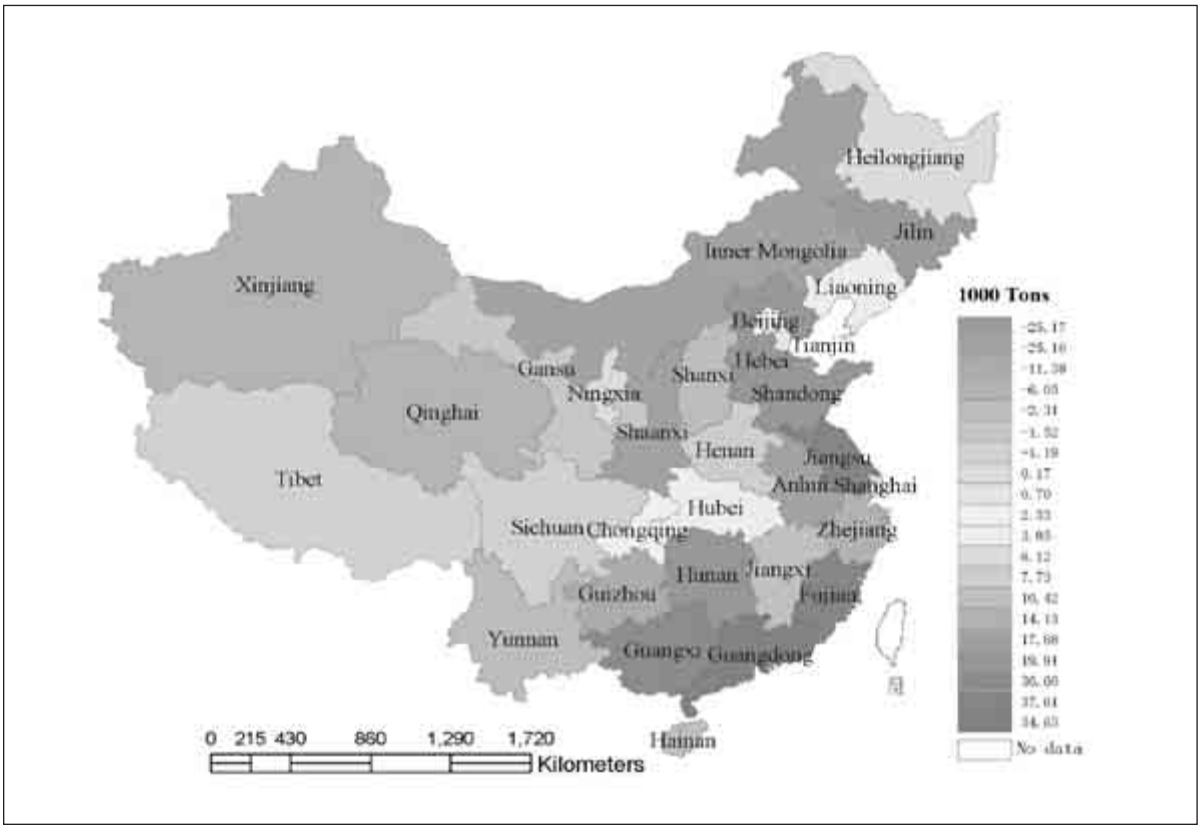
Table 9-8 shows that the rise in demand for fertilizer is mostly due to fertilizer application rates per unit of land and accounted for 57 per cent of changes in 2005 and 65 per cent in 2010. This is mainly explained by the changes in fertilizer prices that will fall by about 0.5 per cent annually over the next 10 years.

Because the impacts of trade liberalization on fertilizer demand differ among crops, we expect the impacts to vary across regions. These results are evidenced in our analyses and are presented in Table 9-9. In Shanghai, Beijing, Guangdong, Hainan, and Fujian, the demand for fertilizer in crop production under the WTO scenario is projected to rise by 2-3 per cent in 2005 and 4-6 per cent in 2001 (columns 3 and 4, Table 9-9). Demand for fertilizer will also increase moderately in Jiangsu and Zhejiang (about 2-4 per cent in 2005-2010). It is worth noting that the above-mentioned provinces are also the regions where fertilizers have been used intensively and fertilizer-induced non-point source pollutions are emerging.

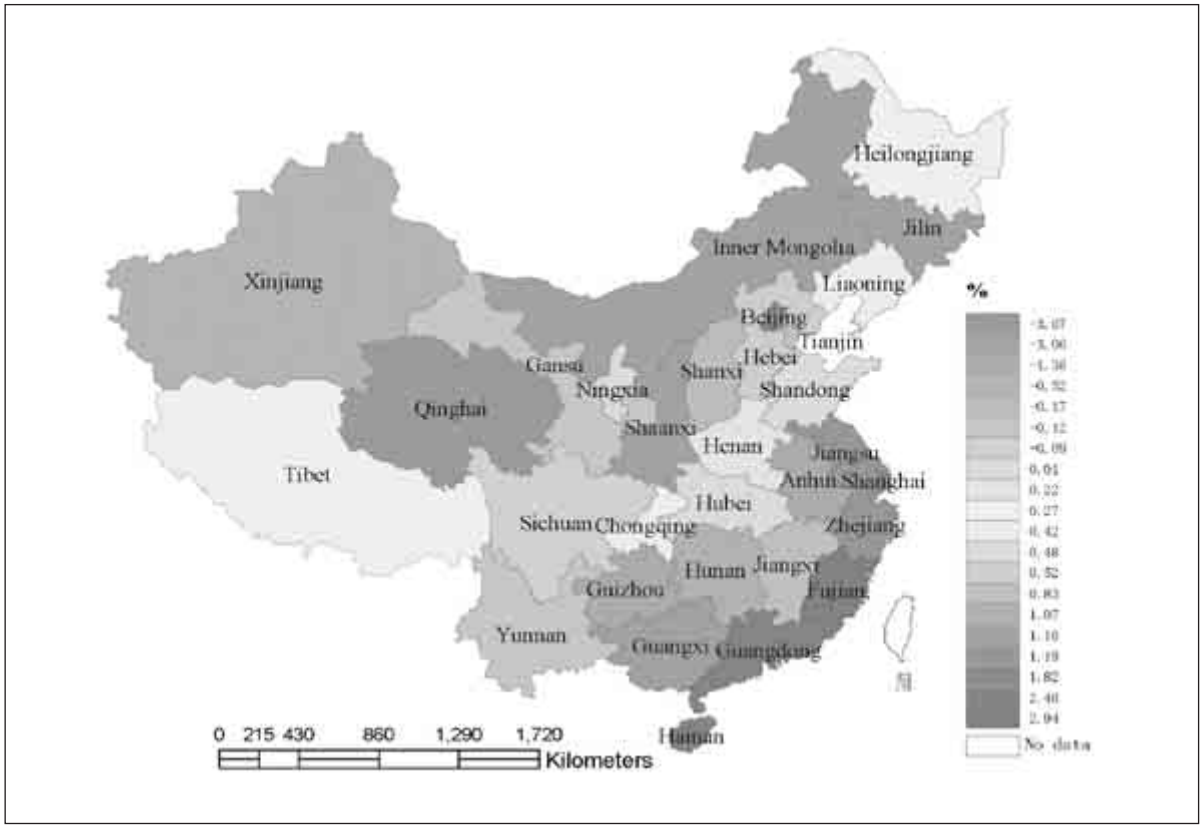
Apart from the provinces discussed above, the impacts of trade liberalization on fertilizer demand are minimal. In most inland provinces fertilizer use will increase by about 1-2 per cent only. However there are also several provinces (e.g. Qinghai in the west and Jinlin in the north) where demand for fertilizer will decrease under trade liberalization; the crops grown in these provinces generally fall within the lower comparative advantage commodities. The negative impacts of fertilizer use due to the drop in output prices will exceed the positive impacts of the decreasing fertilizer prices.

More visual results are presented in Maps 9-1a and 9-1b. All provinces along the coastal areas and some inland provinces in the south or east will experience a rise in demand for fertilizer with trade liberalization, while many provinces in the west and north will decrease their fertilizer use. By 2005, the impacts of fertilizer demand due to trade liberalization will range from decreases of 25 thousand tons in Jilin and 15 thousand tons in Inner Mongolia to practically no change in Gansu,

Map 9-1a: Impacts on fertilizer use by province, 2005 (1,000 tons)



Map 9-1b: Impacts on fertilizer use by province, 2005 (%)



Map 9-2: Impact of WTO accession on per hectare fertilizer use in rice production by province, 2005 (kg/ha)

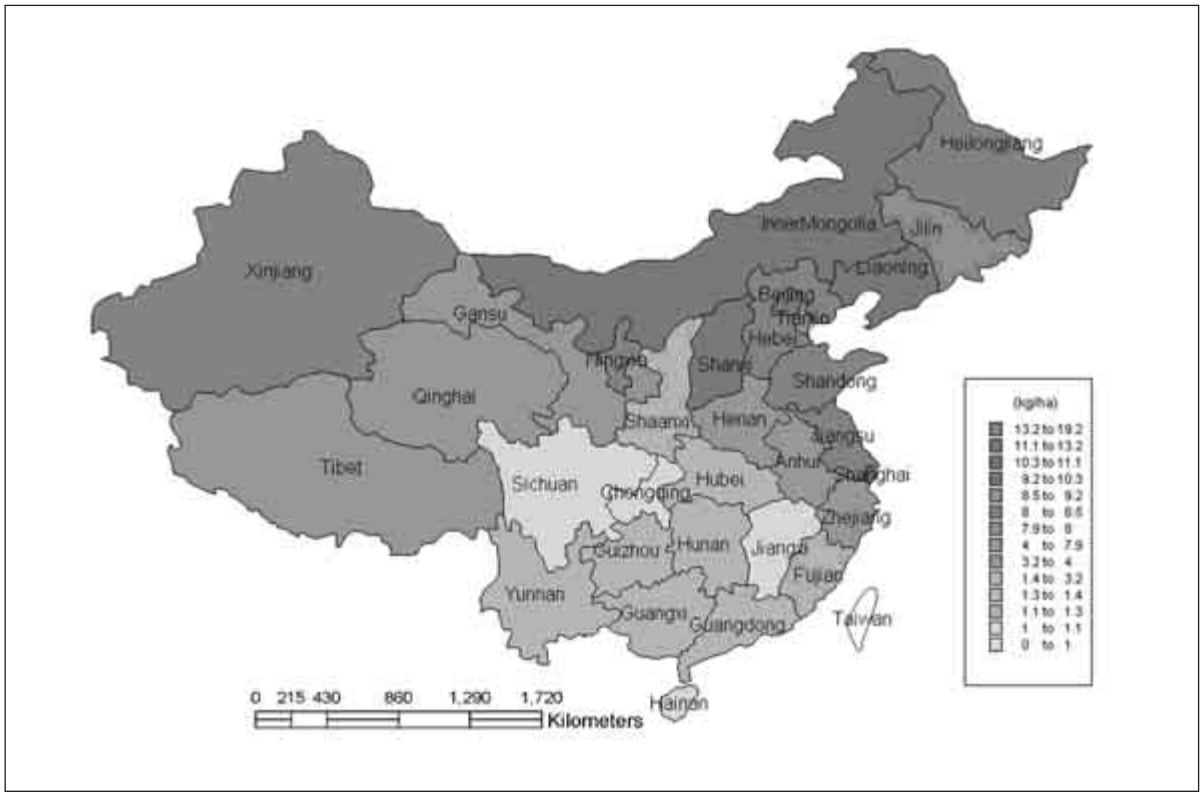


Table 9-10: Impacts of WTO accession on fertilizer use in rice production, by province, 2001-2010

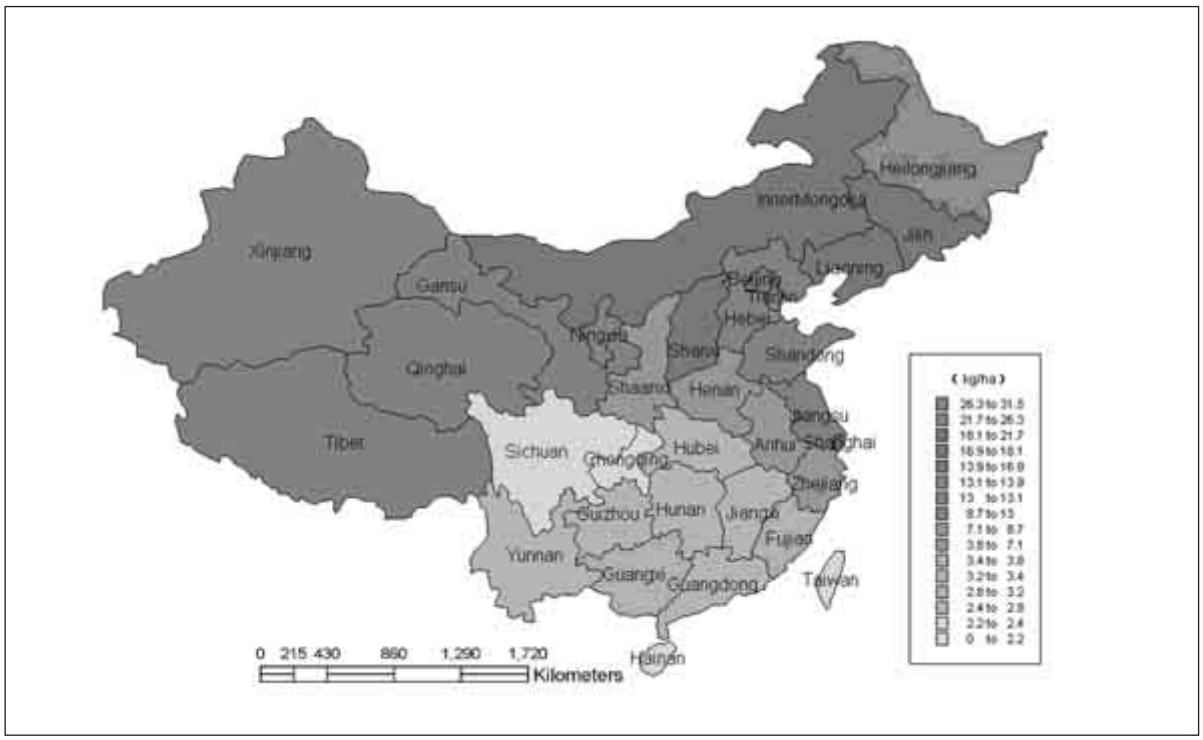
			Impact in 2005		Impact in 2010	
	Share of rice fertilizer use in all crops in 2001 (%)	Share in national rice fertilizer use in 2001 (%)	Per hectare fertilizer use (kg/ha)	Total fertilizer use (1,000 tons)	Per hectare fertilizer use (kg/ha)	Total fertilizer use (1,000 tons)
China	15.4	100.0	3.3	178	6.2	288
Beijing	1.2	0.0	11.7	0	19.2	0
Tianjin	1.3	0.0	7.9	0	13.0	0
Hebei	1.1	0.5	14.1	3	23.2	4
Shanxi	0.1	0.0	10.3	0	16.9	0
Inner Mongolia	2.3	0.3	9.2	2	15.0	2
Liaoning	13.7	2.3	11.1	11	18.1	17
Jilin	12.7	2.3	8.5	11	13.9	17
Heilongjiang	21.1	5.0	8.0	24	13.1	37
Shanghai	21.4	0.6	10.6	3	17.3	5
Jiangsu	29.0	10.6	13.2	51	21.7	78
Zhejiang	36.1	5.3	3.7	9	7.1	15
Anhui	24.1	6.5	3.2	12	6.0	19
Fujian	22.2	4.5	1.4	3	3.5	5
Jiangxi	44.8	7.6	1.0	5	2.4	9
Shandong	1.9	1.3	19.2	6	31.5	10
Henan	3.6	1.8	4.0	3	7.6	5
Hubei	21.6	7.0	1.3	4	3.2	8
Hunan	39.7	11.5	1.1	7	2.8	14
Guangdong	22.2	8.7	1.3	5	3.3	10
Guangxi	23.0	9.1	1.3	6	3.4	11
Hainan	17.1	0.9	0.9	1	2.2	1
Chongqing	14.4	1.5	0.7	1	1.7	2
Sichuan	17.7	5.4	0.9	3	2.3	6
Guizhou	17.2	2.3	1.1	1	2.7	3
Yunnan	18.1	3.7	1.2	2	3.0	4
Tibet	0.5	0.0	5.3	0	8.7	0
Shaanxi	1.4	0.3	2.0	1	3.8	1
Gansu	0.1	0.0	5.3	0	8.7	0
Qinghai	0.0	0.0	5.3	0	8.7	0
Ningxia	10.7	0.5	16.0	2	26.3	3
Xinjiang	2.9	0.5	16.0	2	26.3	3

Ningxia, Sichuan and Tibet, and increases of about 30-40 thousand tons in Hunan, Hebei, Shangdong, and Guangxi, and more than 50 thousand tons in Jiangsu, Fujian and Guangdong (86 million tons). In terms of relative changes, all impacts fall within 3 per cent (both positive and negative, Map 9-1b).

Rice is the most important crop and accounts for the largest volume of fertilizer use in China. We estimate that rice farmers applied more than 8 million metric tons of fertilizer (in nutrient form) in 2001 (Table 9-3), which accounted for 15.4 per cent of total fertilizer use in all crops studied (Table 9-10). The share of rice in total crop fertilizer use is highest in Jiangxi (44.8 per cent), followed by Hunan (39.7 per cent) and Zhejiang (36.1 per cent) (column 1, Table 9-10). In 11 of the 31 provinces, rice accounted for more than 20 per cent of total fertilizer use in crop production in 2001 (Table 9-10). Four provinces (Hunan, Jiangsu, Guangdong and Guangxi) accounted for about 40 per cent of the nation's total fertilizer use in rice production.

For the country as a whole, trade liberalization will increase fertilizer use in rice production by 2.2 per cent in 2005 and 3.7 per cent in 2010 (Table 9-8). More than half the increase results from more intensive use (i.e. kg/ha) of fertilizer due to the rise in the price of rice and the decline in the price of fertilizer. In absolute terms, trade liberalization will result in an increase of 3.3 kg/ha in fertilizer application in 2005 and 6.2 kg/ha in 2010 (1st line, Table 9-10). The impacts from changes in the level of inputs per hectare combined with the impacts due to changes in the rice growing area is a total

Map 9-3: Impact of WTO accession on per hectare fertilizer use in rice production by province, 2010 (kg/ha)



increase of 178 thousand tons of fertilizer application in 2005 and 288 tons in 2010. This represents about half of the net total increase in fertilizer use for all crops in 2005 and 23 per cent in 2010. Therefore the impacts of WTO accession on rice fertilizer applications have significant implications for the overall change in fertilizer use and this is particularly true for the major rice production provinces such as Jiangxi, Hunan, Zhejiang, Jiangsu and all provinces in southern China (e.g. Guangdong, Fujian and Guangxi).

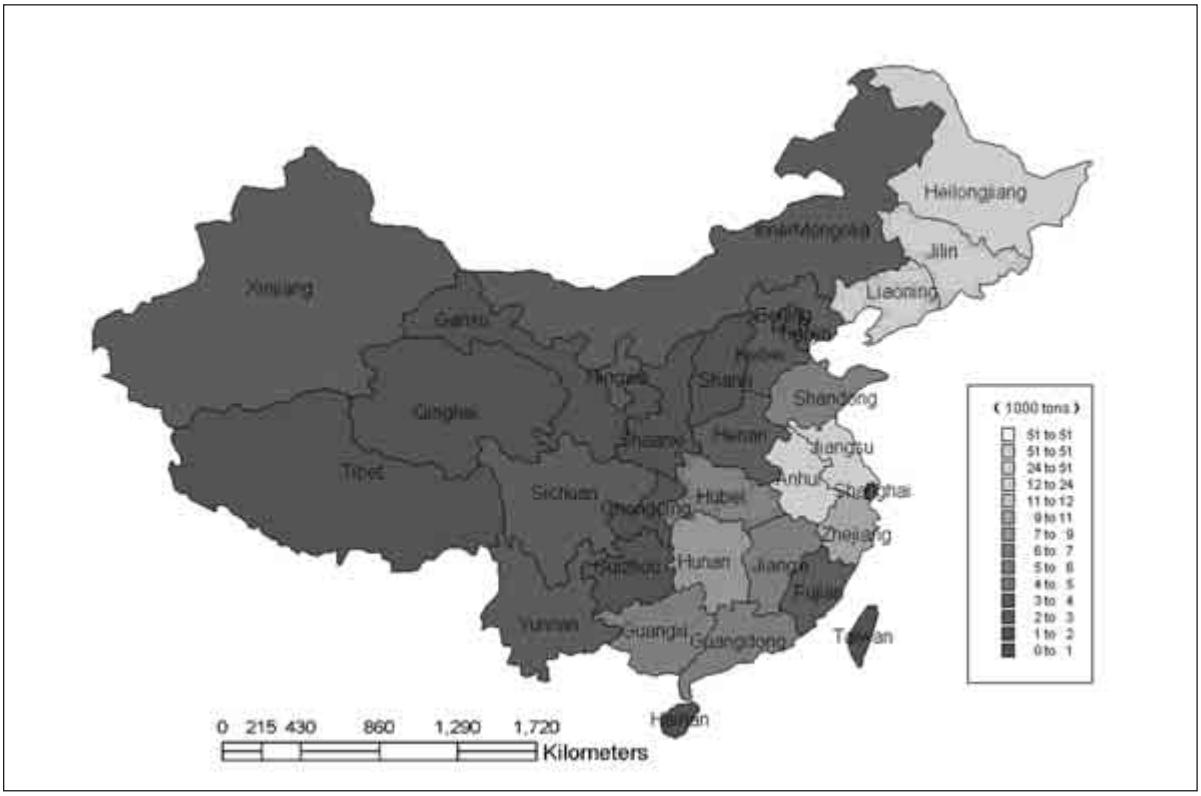
Table 9-10 also shows the significant differences in the WTO impacts on fertilizer uses among provinces. The higher impacts on fertilizer use in the northern part of China compared to the southern provinces reflects the fact that the price of japonica rice will rise and that of indica rice will fall with trade liberalization. For the provinces where indica rice production dominates, the impacts of falling fertilizer prices seem to be largely offset by a small decline in the price of indica rice, therefore the impacts of trade liberalization lead to a slight increase in fertilizer use in all provinces of southern China. This implies that the larger increases in fertilizer applications in south and east China discussed above are not due to the change in fertilizer use in rice production, but to fertilizer use in other crops such as vegetables and fruit.

Pesticide Use

Chinese farmers spent nearly 54 billion Yuan (US$ 6.5 billion) in 2001 on various pesticides to control insects and diseases in 12 crops studied (Table 9-11). Rice production accounts for the highest pesticide use, not because of the application rate per hectare but because of the large growing area. For aggregate commodity groups, fruit and vegetables alone accounted for about two thirds of pesticide consumption.[11]

[11] Pesticide use in vegetables and fruit may be overestimated since it is likely that the crop growing areas are over-reported in China. This also applies to total fertilizer use in vegetables and fruit. Further efforts are needed to investigate the accurate data on horticultural production.

Map 9-4: Impact of WTO accession on total fertilizer use in rice production by province, 2005 (1,000 tons)



Map 9-5: Impact of WTO accession on total fertilizer use in rice production by province, 2010 (1,000 tons)

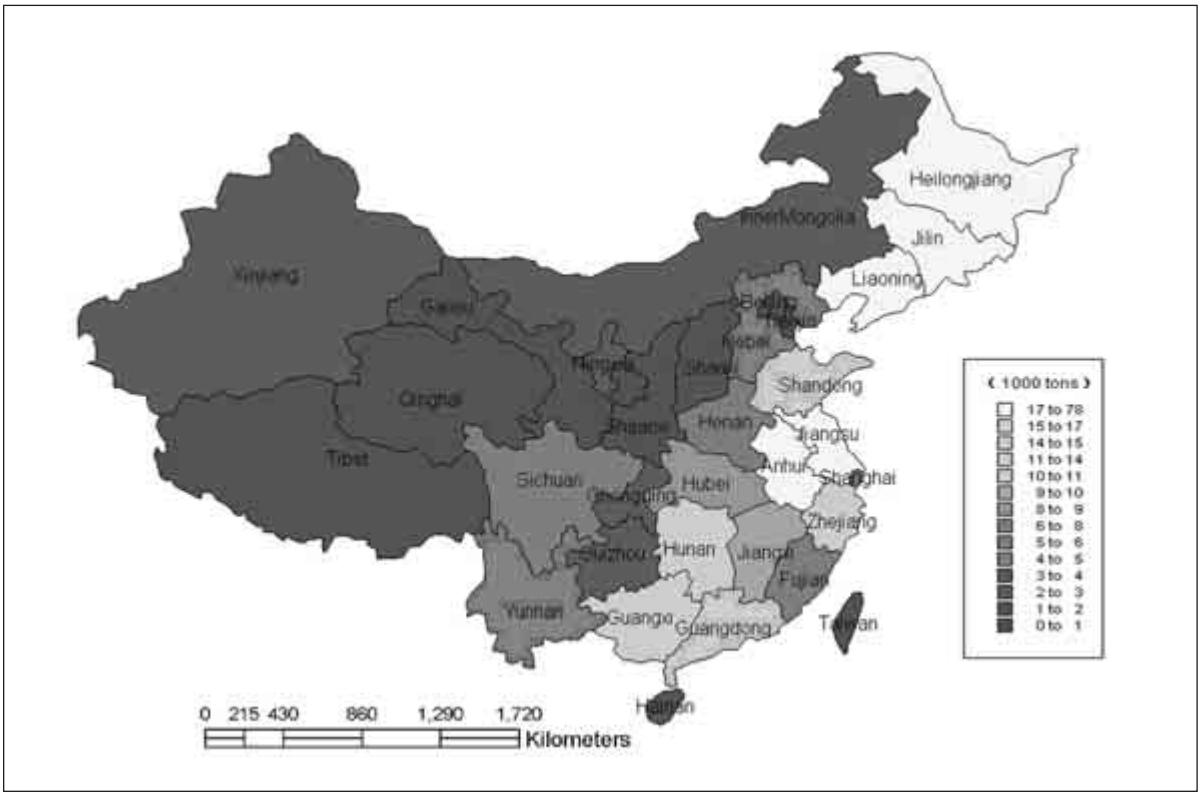


Table 9-11: Impacts of WTO accession on pesticide use by crop, 2001-2010

Crop	Pesticide costs in 2001 (million Yuan)	Share of pesticide use by crop (%)	Impacts on pesticide costs: WTO vs. baseline (%)		Impacts on pesticide use (quantity): WTO vs. baseline (%)		Impacts due to crop area changes (the rest is due to input/ha changes) (%)	
			2005	2010	2005	2010	2005	2010
Total	53709	100	-0.7	-3.0	3.2	5.7	47	42
Rice	6914	12.9	-2.3	-6.2	1.6	2.5	62	54
Wheat	1861	3.5	-4.0	-8.4	-0.1	0.2	na	Na
Maize	1561	2.9	-6.8	-11.1	-2.9	-2.4	90	98
Sweet potato	167	0.3	-3.7	-8.2	0.2	0.5	46	22
Potato	267	0.5	-4.0	-8.5	-0.1	0.1	na	Na
Other coarse grains	159	0.3	-2.4	-6.7	1.6	1.9	92	82
Soybeans	726	1.4	-3.0	-8.4	1.0	0.3	86	16
Cotton	2146	4.0	-4.3	-8.0	-0.3	0.6	48	12
Edible Oil	1622	3.0	-10.7	-16.3	-6.7	-7.7	84	85
Sugar	327	0.6	-6.7	-14.3	-2.8	-5.6	63	71
Vegetables	17068	31.8	-0.1	-2.2	3.9	6.5	52	48
Fruit	20892	38.9	1.3	0.2	5.3	8.8	47	42

The analyses show that the impacts of trade liberalization will have more of an impact on pesticide use than on fertilizer use. Liberalizing the pesticide sector will lead to reductions in pesticide prices of about 1 per cent per year in 2002-2010 as cheaper and better pesticides are imported over time. Declines in pesticide prices and price increases for horticultural crops and rice (the most intensive pesticide user within the grain sector) significantly increase pesticide demand. Our study shows that trade liberalization will cause pesticide use to increase by about 3.2 per cent in 2005 and 5.7 per cent by 2010.

Increases in pesticide use are due partly to a rise in the application rate and partly from crop structure changes (Table 9-11). For example, out of the 3.2 per cent increase in pesticide use in 2005, 47 per cent of the increase is a result of changes in crop area and 53 per cent from changes in the application rate per unit of land. The share of the impact due to crop area changes rises over time as the horticulture growing area expands.

The greatest changes in both absolute and relative terms due to trade liberalization occur in fruit, vegetables and rice crops (for crops showing an increase in pesticide use), and in edible oil crops, sugar crops (sugar cane and sugar beet) and maize (for crops presenting a drop in pesticide use) (Table 9-11). These results are to be expected because of the different impacts of WTO accession on crops with a greater comparative advantage and those with a lower comparative advantage. For crops with a higher comparative advantage the increase in pesticide use as a result of trade liberalization comes from the expansion of the crop areas and the increase in pesticide application rates. Whereas for several crops in which China does not have comparative advantages (e.g. maize, edible oil crops and sugar crops), the increase in pesticide use due to lower pesticide prices is greater than the decline in pesticide use due to the fall of the crop's output prices and therefore the overall applications of pesticide fall in 2001-2010.

Similar to the findings on fertilizer use, the impacts of WTO accession on pesticide use vary among provinces. Nearly all provinces increase pesticide use and the most significant increases are in southern China (Table 9-12 and Map 9-6). In percentage terms, a higher rate of increase is projected in most of southern China and a few provinces in the north (e.g. Beijing, Shaanxi and Gansu) and in north-east China. The increase in pesticide use in southern China is mainly due to the expansion of horticulture, whereas in north-east China, Shaanxi and Gansu they are largely due to the expansion of japonica rice production.

Table 9-12: Impacts of WTO accession on pesticide use by province, 2001-2010

	Pesticide costs in 2001 (million Yuan)	Share in national pesticide use in 2001 (%)	Impacts on pesticide costs: WTO vs. baseline (%)		Impacts on pesticide use (quantity): WTO vs. baseline (%)		Impacts due to crop area changes (the rest is due to input/ha changes) (%)	
			2005	2010	2005	2010	2005	2010
China	53709	100	-0.7	-3.0	3.2	5.7	47	42
Beijing	282	0.5	0.2	-1.5	4.1	7.2	44	40
Tianjin	212	0.4	-0.7	-2.8	3.2	5.8	44	40
Hebei	3506	6.5	-0.4	-2.4	3.5	6.3	41	38
Shanxi	893	1.7	-0.5	-2.5	3.4	6.2	40	37
Inner Mongolia	538	1.0	-1.8	-4.6	2.1	4.1	37	36
Liaoning	1297	2.4	-0.5	-2.5	3.5	6.2	42	38
Jilin	820	1.5	-1.4	-4.0	2.5	4.7	37	36
Heilongjiang	1474	2.7	-1.6	-4.9	2.3	3.8	47	40
Shanghai	502	0.9	-0.1	-2.3	3.8	6.4	52	47
Jiangsu	3880	7.2	-0.9	-3.5	3.0	5.2	51	47
Zhejiang	1745	3.2	-0.6	-2.9	3.4	5.7	50	44
Anhui	1864	3.5	-2.0	-5.1	1.9	3.6	44	40
Fujian	2457	4.6	0.2	-1.7	4.1	7.0	49	44
Jiangxi	1966	3.7	-1.1	-3.6	2.9	5.0	48	43
Shandong	4528	8.4	-1.2	-3.5	2.8	5.1	40	38
Henan	2955	5.5	-1.8	-4.5	2.1	4.1	40	38
Hubei	3008	5.6	-1.1	-3.6	2.8	5.1	47	43
Hunan	3604	6.7	-1.2	-3.8	2.8	4.9	49	43
Guangdong	4088	7.6	0.0	-1.9	4.0	6.8	48	43
Guangxi	3750	7.0	-0.2	-2.4	3.7	6.3	48	43
Hainan	738	1.4	0.4	-1.4	4.3	7.3	50	45
Chongqing	821	1.5	-0.1	-2.2	3.8	6.4	50	45
Sichuan	2507	4.7	-0.7	-3.0	3.3	5.7	48	44
Guizhou	628	1.2	-1.8	-4.5	2.2	4.2	38	37
Yunnan	1517	2.8	-0.8	-3.2	3.1	5.4	47	42
Tibet	11	0.0	-1.4	-4.4	2.6	4.2	54	46
Shaanxi	1850	3.4	0.7	-0.7	4.7	7.9	47	42
Gansu	1076	2.0	-0.1	-2.0	3.8	6.6	44	40
Qinghai	51	0.1	-4.6	-8.3	-0.6	0.4	na	na
Ningxia	200	0.4	-1.1	-3.5	2.8	5.2	40	38
Xinjiang	942	1.8	-1.1	-3.4	2.8	5.3	42	37

For the impacts of WTO accession on pesticide uses in rice production, we estimate a 1.6 per cent rise in pesticide application in 2005 and 2.5 per cent in 2010 (Table 9-12). About 62 per cent of the increase in pesticide use in 2005 will be due to changes in the rice production area; in 2010 this share drops to 54 per cent (Table 9-11). The percentage increase of pesticide use in rice production is less than the overall changes for all crops.

Table 9-13 presents our estimates of the impacts of trade liberalization on pesticide use by province. As can be seen, there are wide variations among regions, simply because of the geographic distribution of japonica and indica rice growing areas in China. Southern China produces indica rice, the prices of which will fall with trade liberalization and therefore the percentage impacts of WTO accession on pesticide use are lower than for the rest of China. For provinces where both indica and japonica rice are produced, the percentage changes in pesticide use are between those of provinces producing solely either japonica or indica rice. The indica-japonica rice production region includes Zhejiang, Anhui, Henan and Shaanxi.

Map 9-6: Impacts on pesticide use by province, 2005 (%)

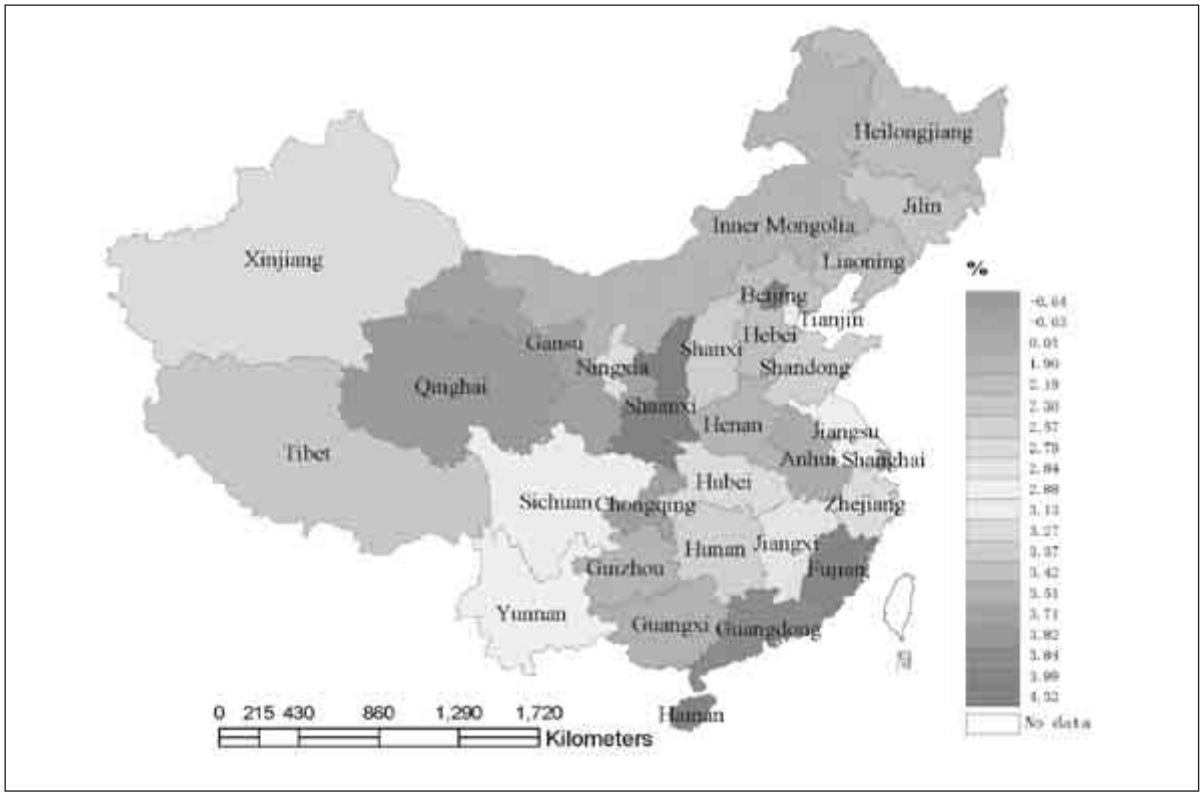
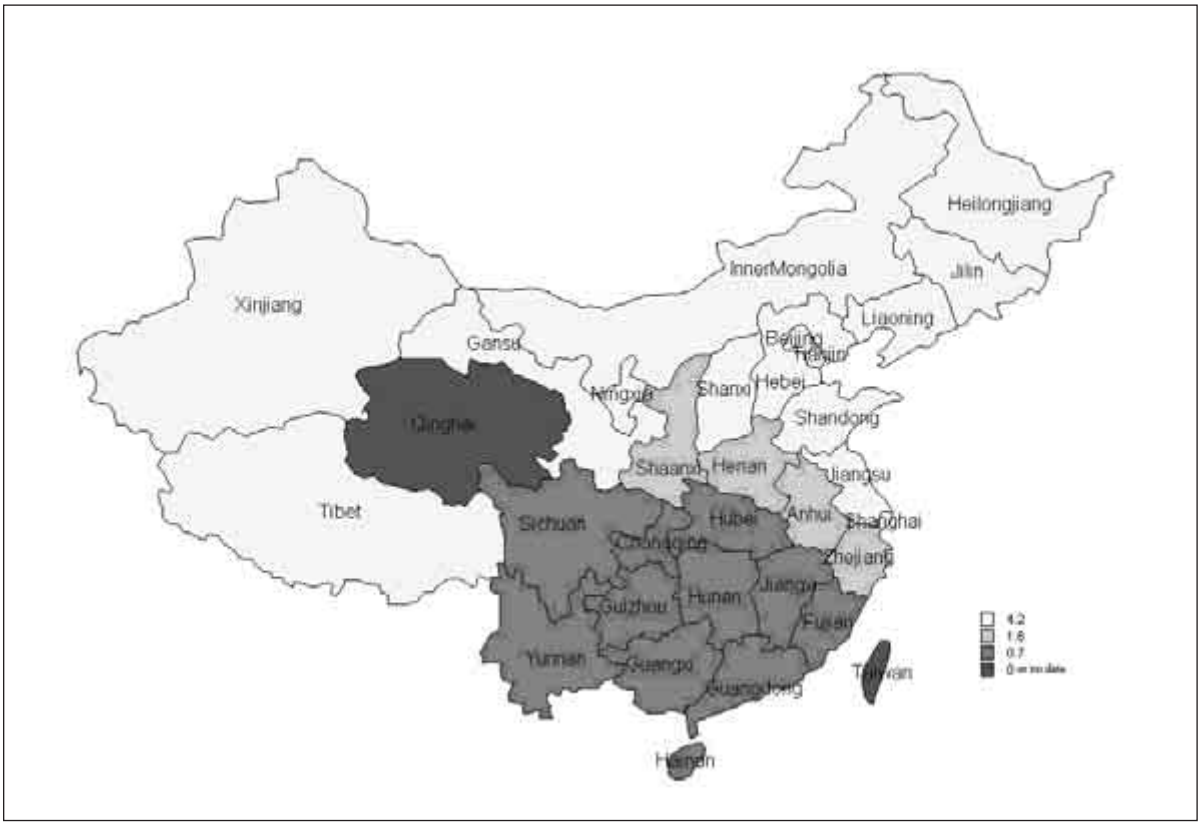


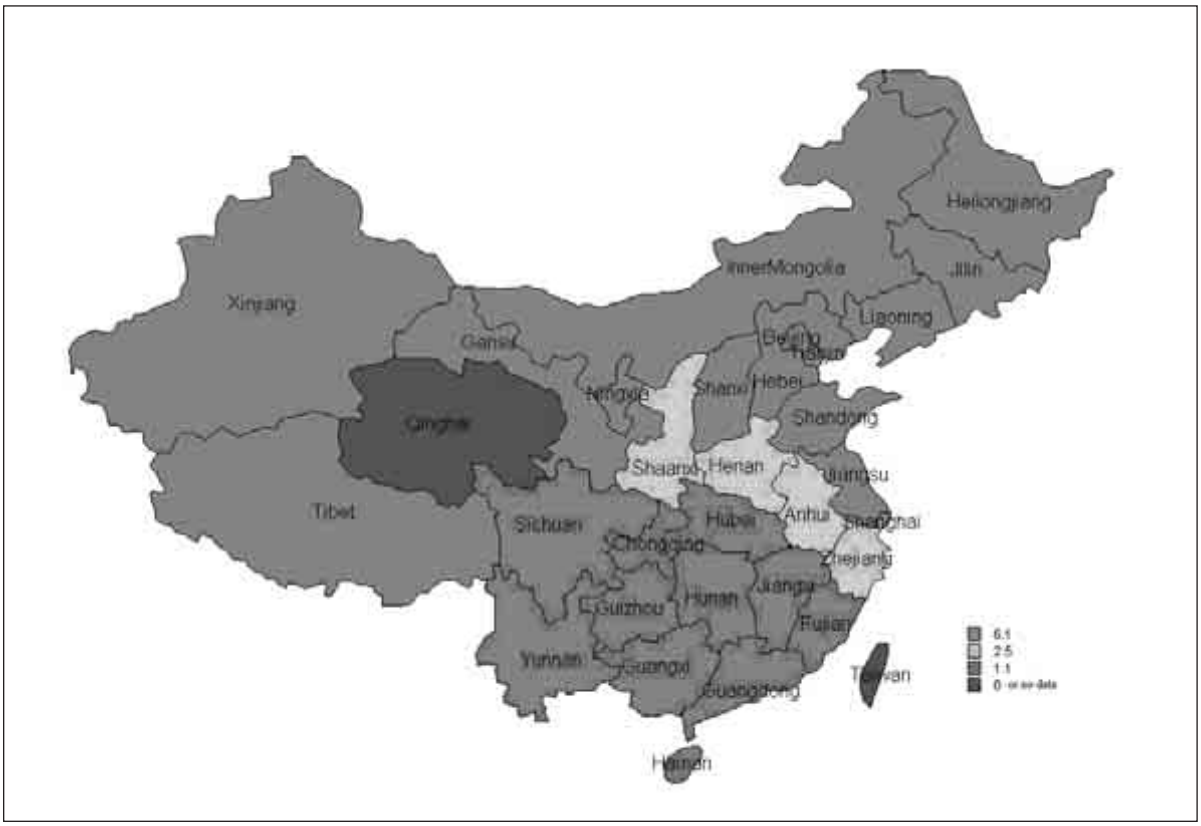
Table 9-13: Impacts of WTO accession on pesticide use in rice production by province, 2001-2010

	Share of rice production's pesticide use out of overall pesticide use in 2001 (%)	Share in pesticide use in overall national rice production in 2001 (%)	Percentage impact on amount of pesticide use (%): WTO vs. baseline	
			2005	2010
China	12.9	100	1.6	2.5
Beijing	0.5	0.0	4.2	6.1
Tianjin	1.4	0.0	4.2	6.1
Hebei	1.5	0.7	4.2	6.1
Shanxi	0.1	0.0	4.2	6.1
Inner Mongolia	3.1	0.2	4.2	6.1
Liaoning	7.9	1.5	4.2	6.1
Jilin	14.5	1.7	4.2	6.1
Heilongjiang	17.1	3.6	4.2	6.1
Shanghai	20.1	1.5	4.2	6.1
Jiangsu	21.8	12.2	4.2	6.1
Zhejiang	30.2	7.6	1.6	2.5
Anhui	22.7	6.1	1.6	2.5
Fujian	12.6	4.5	0.7	1.1
Jiangxi	29.7	8.5	0.7	1.1
Shandong	1.2	0.8	4.2	6.1
Henan	2.7	1.2	1.6	2.5
Hubei	12.6	5.5	0.7	1.1
Hunan	30.0	15.6	0.7	1.1
Guangdong	14.9	8.8	0.7	1.1
Guangxi	17.1	9.3	0.7	1.1
Hainan	4.6	0.5	0.7	1.1
Chongqing	9.9	1.2	0.7	1.1
Sichuan	10.8	3.9	0.7	1.1
Guizhou	16.1	1.5	0.7	1.1
Yunnan	12.8	2.8	0.7	1.1
Tibet	0.6	0.0	4.2	6.1
Shaanxi	0.5	0.1	1.6	2.5
Gansu	0.0	0.0	4.2	6.1
Qinghai	0.0	0.0	/	/
Ningxia	10.4	0.3	4.2	6.1
Xinjiang	2.2	0.3	4.2	6.1

Map 9-7: Impacts of WTO accession on pesticide use in rice production by province, 2005 (%)



Map 9-8: Impacts of WTO accession on pesticide use in rice production by province, 2010 (%)



9.2.2.2 Scenario II: Change in chemical inputs mainly caused by changes in the growing area

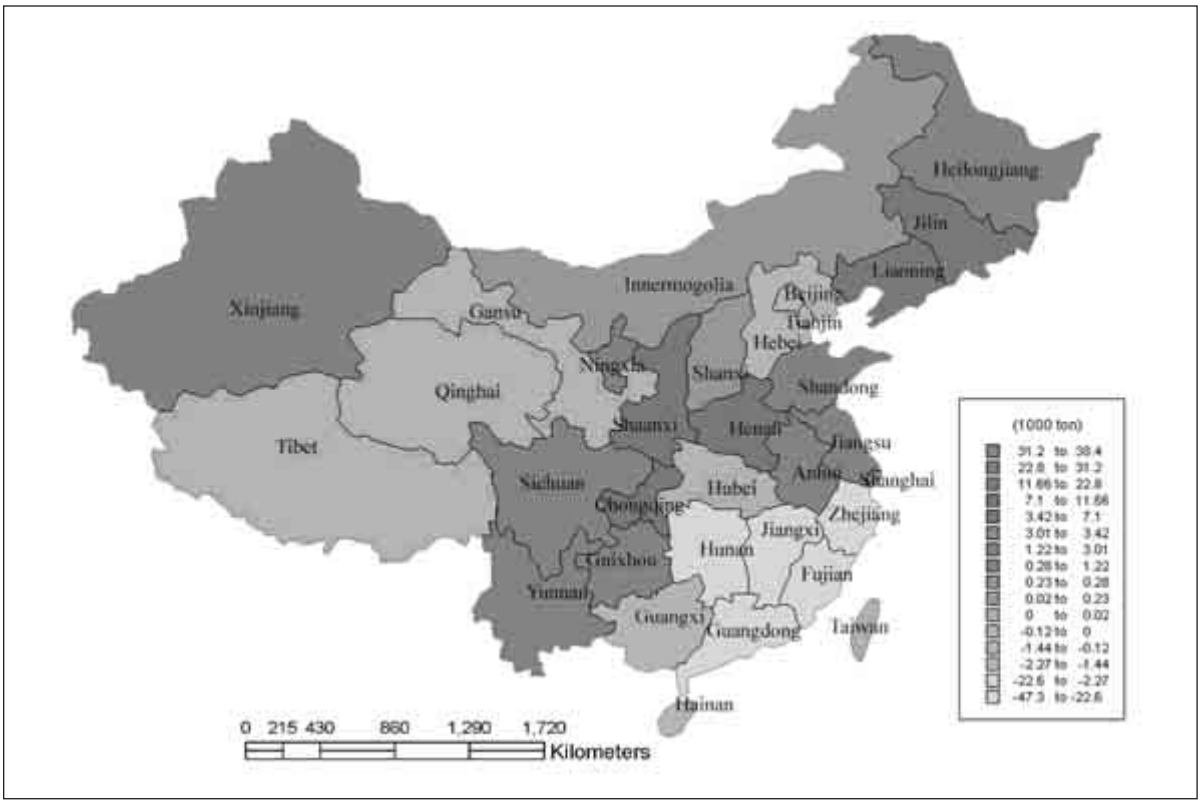
The above results were taken from the CAPSiM calculation based on the assumption that changes in chemical input use are mainly caused by changes in the prices of inputs and outputs. From the field survey in Heilongjiang and Hubei provinces it was found that most of the farmers in the two case study sites would not necessarily modify their chemical inputs per unit as a result of the change in price of inputs. Changes in the rice growing area due to the change in the price of outputs and grain support policy adjustments are the main drivers of change in chemical input use in rice production. We thus take another scenario to estimate the environmental impacts of rice trade liberalization on the assumption that changes in chemical input use in rice production are mainly caused by the changes in the rice growing area; the price-demand elasticity of chemical inputs is neglected.

Table 9-14: Changes in chemical input use caused by WTO accession

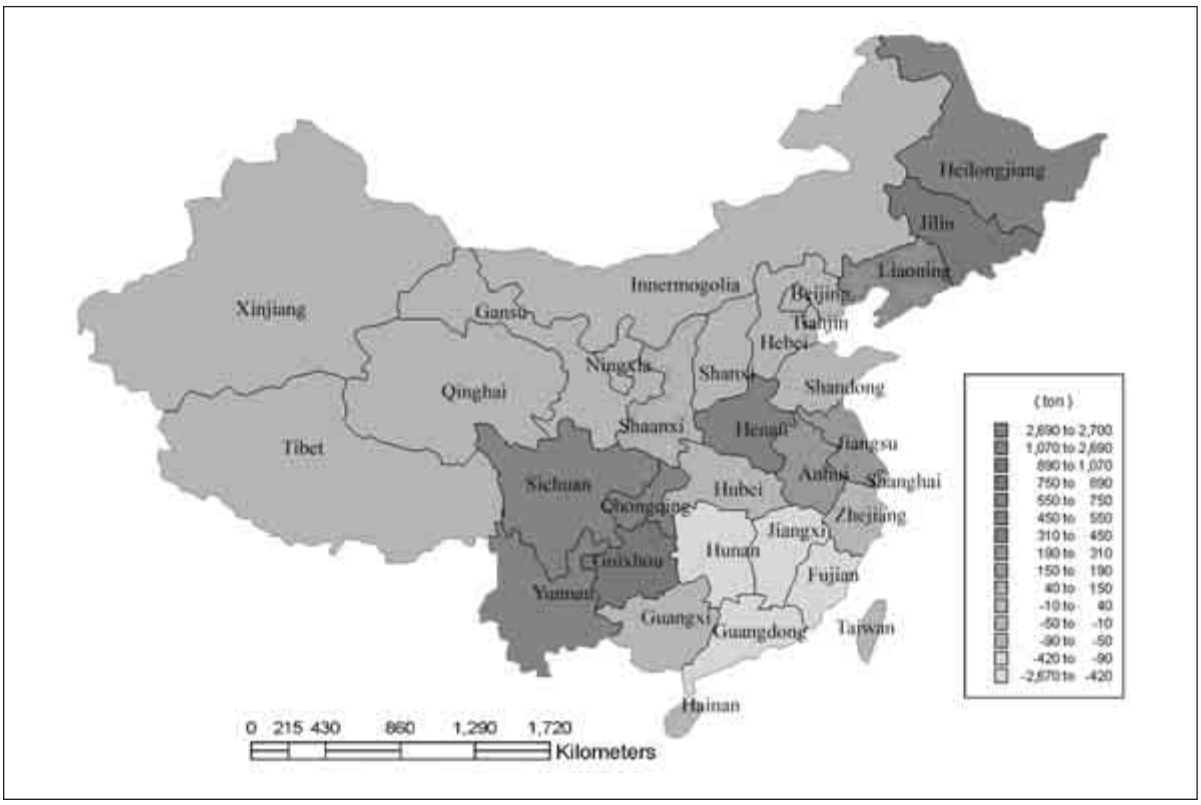
	Input per unit area in rice production(kg/ha)			Chemical inputs change caused by WTO accession in 2005			Chemical inputs change caused by WTO accession in 2010		
	Fertilizers (kiloton)	Films (ton)	Pesticides (ton)	Fertilizers (kiloton)	Films (ton)	Pesticides (ton)	Fertilizers (kiloton)	Films (ton)	Pesticides (ton)
Beijing	367.5	7.5	2.93	-0.06	-1.1	-0.44	-0.08	-1.6	-0.62
Tianjin	312	18	1.66	-0.12	-7.2	-0.66	-0.17	-9.9	-0.91
Hebei	489	6	2.43	-1.44	-17.6	-7.14	-1.98	-24.3	-9.84
Shanxi	337.5	10.5	0.81	0.23	7.0	0.54	0.31	9.7	0.75
Shandong	753	1.5	3.97	0.29	0.6	1.51	0.40	0.8	2.10
Henan	378.75	12.75	1.62	11.66	450.6	59.94	16.07	620.6	82.56
Shaanxi	231	3	1.1	3.42	44.4	16.27	4.71	61.1	22.41
Ningxia	528	3	0.64	1.47	8.4	1.79	2.03	11.5	2.46
Liaoning	367.5	13.5	2.39	15.14	556.1	98.44	20.85	765.9	135.58
Jilin	234	13.5	0.77	13.11	756.1	43.13	18.05	1041.4	59.40
Heilongjiang	295.5	22.5	0.41	35.40	2695.7	49.12	48.76	3713.0	67.66
Inner Mongolia	246	18	0.36	0.02	1.3	0.03	0.02	1.6	0.03
Gansu			0.58	0.00	0.0		0.00	0.0	
Xinjiang	375.8		0.49	1.22	3.3	1.59	1.68	4.5	2.20
Fujian	373.5	7.5	7.69	-18.81	-377.6	-387.19	-25.90	-520.1	-533.30
Guangdong	349.5	3	7.12	-41.35	-354.9	-842.37	-56.95	-488.9	-1160.20
Guangxi	352.5	7.5	3.62	-2.27	-48.2	-23.28	-3.12	-66.4	-32.04
Hainan	232.5		1.66	-1.44	-6.2	-10.31	-1.99	-8.6	-14.19
Shanghai	306		9.85	3.01	9.9	97.02	4.15	13.6	133.57
Jiangsu	398.25	4.5	4.37	31.54	156.3	295.11	43.44	215.3	406.41
Zhejiang	312.75	4.5	9.96	-15.25	-81.1	-458.76	-21.00	-111.7	-631.86
Anhui	275.25	9.75	3.15	33.78	196.6	375.26	46.52	270.6	516.82
Jiangxi	274.5	7.5	2.21	-22.33	-610.1	-179.76	-30.75	-840.2	-247.59
Hubei	263.25	6	2.89	-22.60	-418.0	-227.96	-31.12	-575.7	-313.94
Hunan	292.5	16.5	4.92	-47.31	-2668.9	-795.81	-65.16	-3675.9	-1096.08
Chongqing	201	9	1.71	7.10	318.0	60.41	9.78	437.9	83.21
Sichuan	255	12	1.71	22.76	1070.9	152.60	31.34	1474.9	210.18
Guizhou	339	8.25	0.9	31.20	893.8	89.88	42.97	1230.9	123.79
Yunnan	274.5	9	1.51	38.39	1243.7	210.68	52.87	1712.9	290.16
National total	–	–	–	76.77	3821.4	-1380.37	105.73	5262.9	-1901.31

Note: Since the data on pesticide use per unit area for rice production is not available, we use the data for the national average to approximate.
Source: NDRC (2003); Lin (2000).

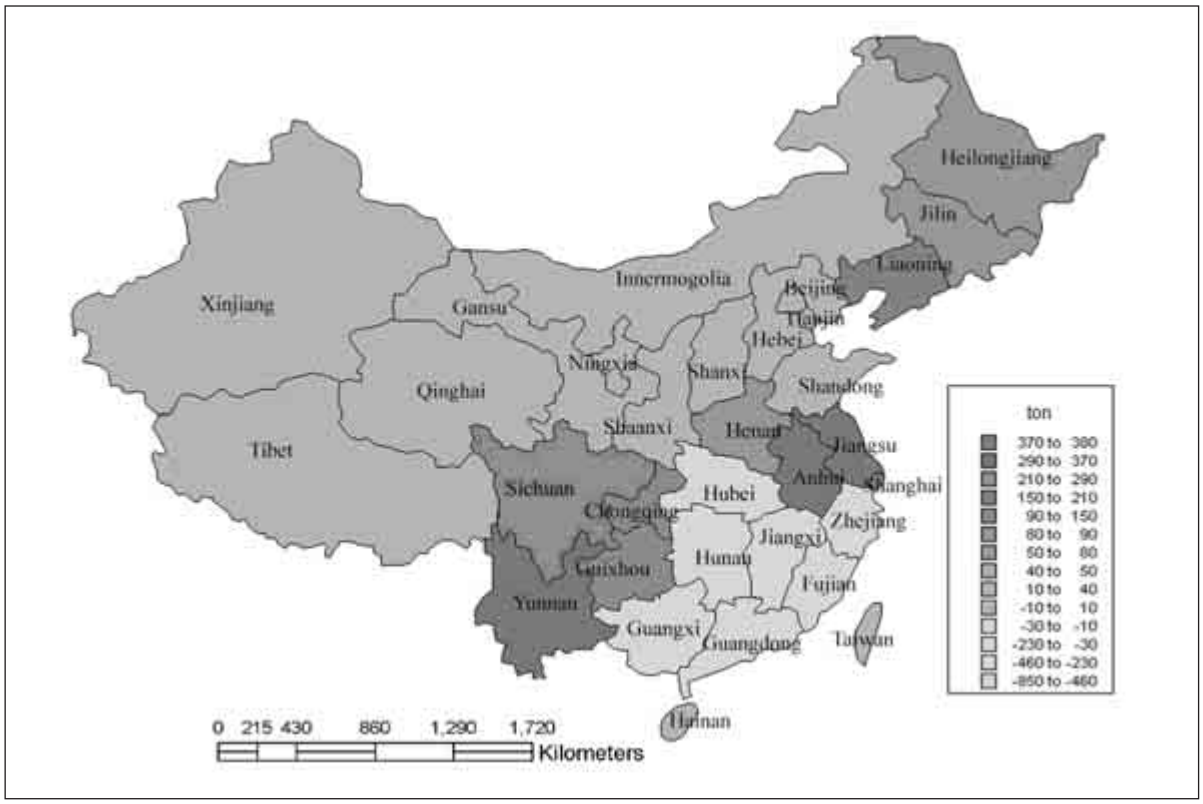
Map 9-9: Change in total fertilizer use in rice production caused by WTO accession by province, 2005 (1,000 tons)



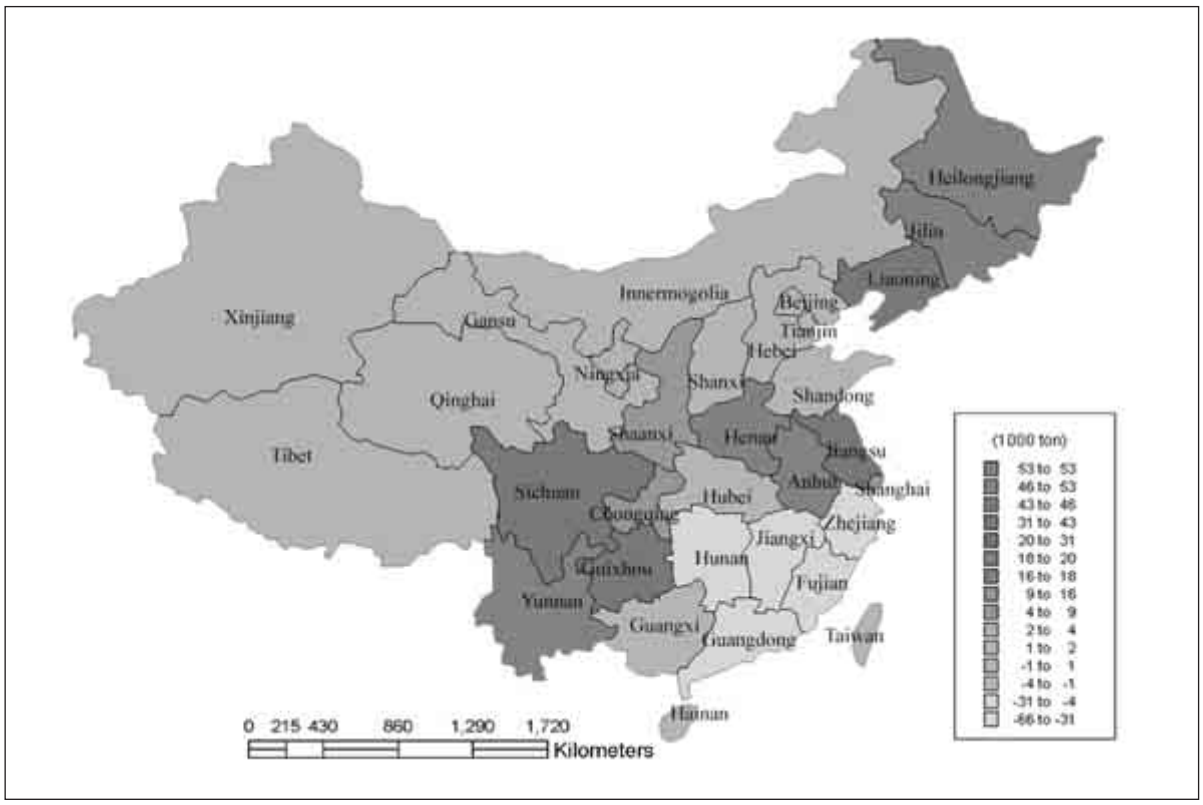
Map 9-10: Change in total film use in rice production caused by WTO accession by province, 2005 (tons)



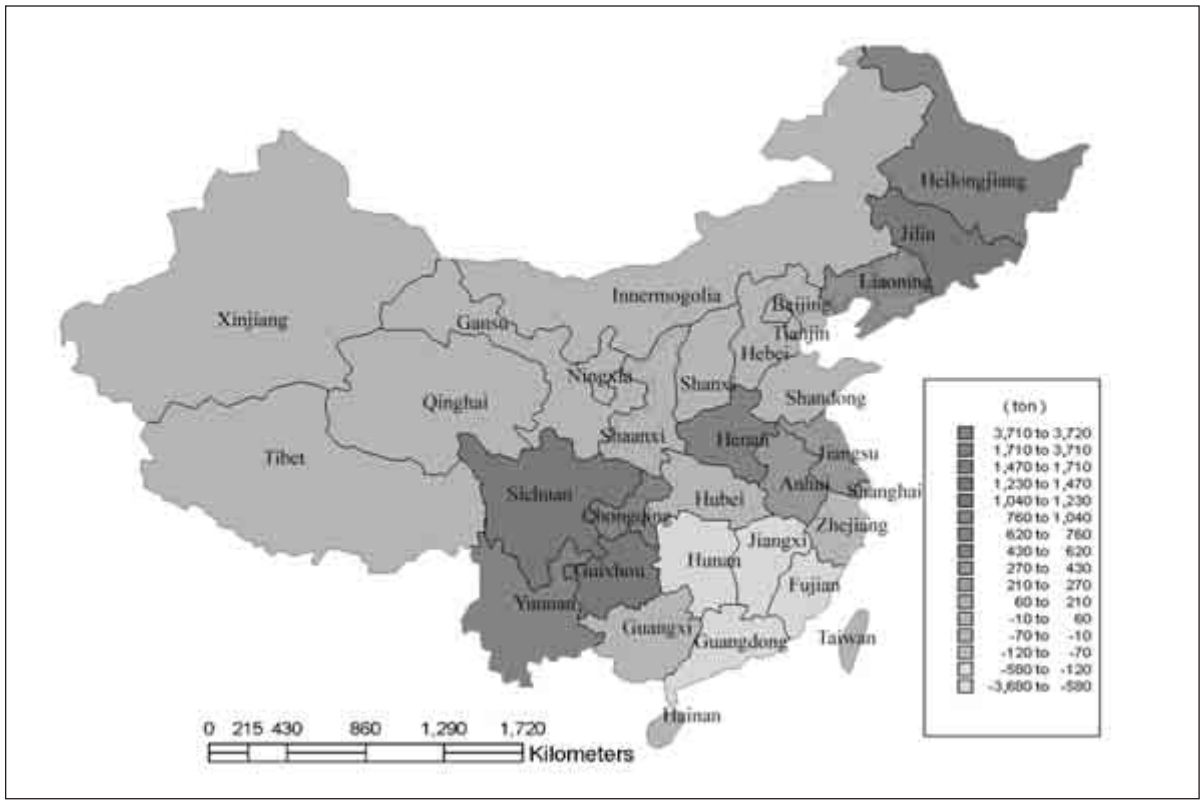
Map 9-11: Change in total pesticide use in rice production caused by WTO accession by province, 2005 (tons)



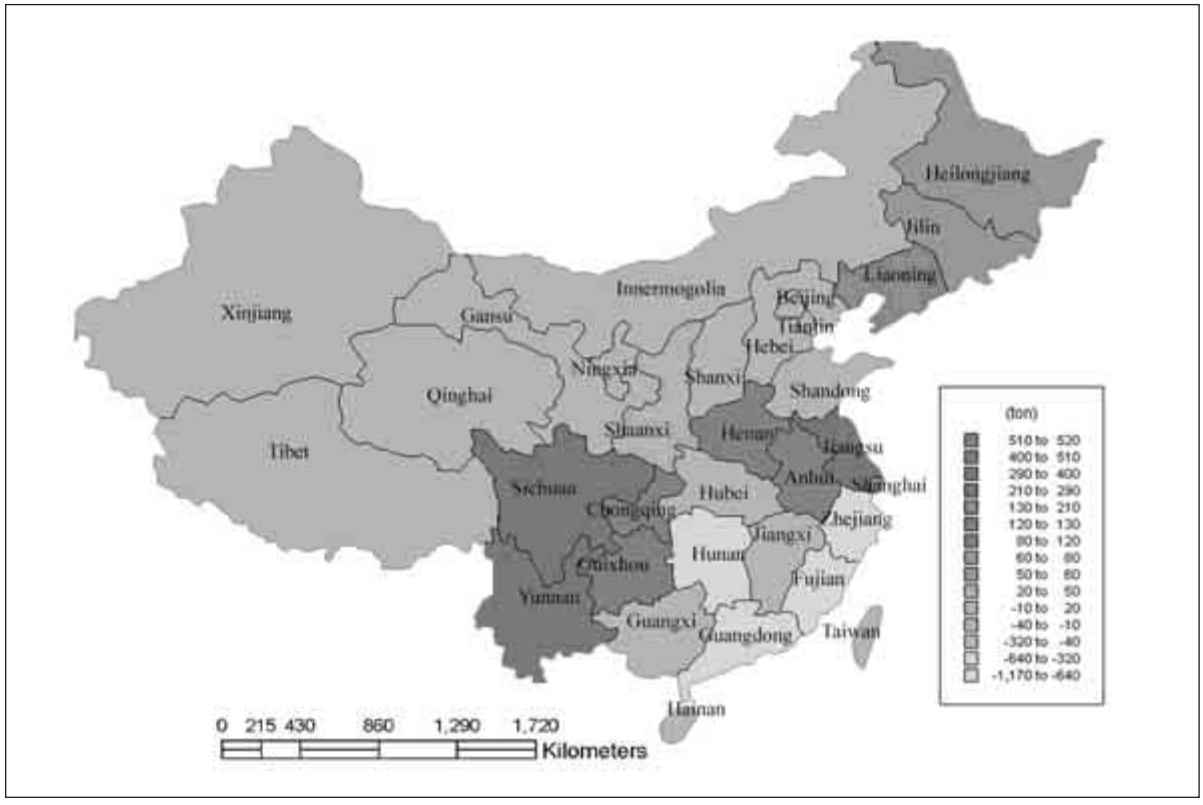
Map 9-12: Change in total fertilizer use in rice production caused by WTO accession by province, 2010 (1,000 tons)



Map 9-13: Change in total film use in rice production caused by WTO accession by province, 2010 (tons)



Map 9-14: Change in total pesticide use in rice production caused by WTO accession by province, 2010 (tons)



From the above results we can see that, except for central and southern China where there is a decrease in fertilizer and film use, most areas will undergo an increase in fertilizer and film use, especially in north-east and south-west China and in the provinces of Henan, Jiangsu and Anhui. Overuse of fertilizers may cause more serious eutrophication of surface waters, deterioration of soil quality and air pollution. Increasing accumulation of films would form an obstruction layer in the soil, which is harmful to soil quality in terms of its capacity for ventilation, permeation and so forth.

The situation in relation to pesticide use is different. The areas with a high level of pesticide use in rice production are mainly in southern China, and pesticide use in these areas may either increase slightly or decrease as a result of trade liberalization. Though WTO accession could boost rice production in north-east China, the rise in pesticide use can be offset at the national level. This could be helpful in alleviating the harmful effects on farmer's health and biodiversity in most provinces in central and south-east China.

9.3 Wetlands

9.3.1 Wetlands in China

Wetlands are one of the most important environmental resources for humans in that they play an important role as water reserves and in climate adjustment, flood control, pollutant degradation, biodiversity protection and so forth.

The Ministry of Water Resources reported in 2000 that the total wetlands area in China is 65.94 million ha (of which about 26 million ha are natural wetlands). This represents 10 per cent of the total wetland area in the world, and ranks first in Asia and fourth in the world.

Wetlands in China are mainly distributed over eight regions, namely in the north-east, middle and lower reaches of the Yangtze River, the Qinghai-Tibet Plateau, north of the Hangzhou Gulf, south of the Hangzhou Gulf, the Yunnan-Guizhou plateau, Inner Mongolia and Xinjiang. Wetlands are mostly marshes in the north-east, salines, meadows and marshes in the north-west and Qinghai-Tibet plateau, estuarine wetlands in the eastern coastal area, lakes and rivers in the middle and lower reaches of the Yangtze River and Qinghai-Tibet Plateau, and constructed mangrove wetlands in the south-eastern coastal area and the islands of the South China Sea.

9.3.2 Impacts of rice trade liberalization on wetlands

9.3.2.1 Adding difficulties to "Returning croplands to wetlands" project in the north-east

Heilongjiang province has a wetland area of 4.34 million ha, which accounts for 16 per cent of the total in China. Wetlands in Heilongjiang are mainly distributed across the Sanjiang Plain, Songnen Plain, Daxing'anling Mountain Range and Xiaoxing'anling Mountain Range.

The "Bei da huang" area lies in Heilongjiang and is the largest farm group in China. To the north of "Bei da huang" is Xiaoxing'anling Mountain Range, to the west is Songnen Plain, and to the east is Sanjiang Plain. "Bei da huang" is one of three Black Soil zones in the world. This area was exploited from 1947 and developed into the largest farm group and the most important commodity grain production base in the country. "Bei da huang" has contributed greatly to solving grain shortage and economic development over the past 50 years. However, excessive exploitation has resulted in dramatic shrinkage of the wetland area in Sanjiang Plain, the largest natural wetland in China. After 1949, the Sanjiang Plain wetland area decreased from 5.34 million ha to 1.48 million ha, and the cultivated area increased from 0.786 million ha to 4.57 million ha (Liu *et al.*, 2004).

Under the pressure of environmentalists, the "Returning croplands to wetlands" policy was initiated by the central Government in recent years, and 14 wetland nature reserves have been newly designated or expanded. The Honghe National wetland nature reserve was expanded by 60 per cent, and the Raolihe, Changlindao, Yanwodao and Qindeli wetland nature reserves were newly

designated. On the edge of the national wetland nature reserves of Honghe, Raolihe and Xingkaihu, 0.2 million ha of cultivated area will be reconverted to wetland in three years.

Since China's accession to WTO, Heilongjiang province is one of the major competitive-advantage rice producers. Revenue from japonica rice will push the expansion of rice growing, which will add difficulties to the implementation of the "Returning cropland to wetland" project to some extent.

9.3.2.2 Help to implement "Returning croplands to lakes" project in the middle and lower reaches of the Yangtze River

Wetlands in the middle and lower reaches of the Yangtze River consist of lakes and rivers, including the Yangtze River and its branches, Poyang Lake, Dongting Lake, Honghu Lake, Tai Lake, Chao Lake and Hongze Lake, and thousands of other small lakes and swamps. Due to over-exploitation, the wetlands area has undergone serious shrinkage over the past 50 years.

After 1949, one third of the lakes in the area were converted to innings, representing an area of 1.3 times 10^4 km^2, i.e. about 1.3 times the total area of the lakes Poyang, Dongting, Tai, Hongze and Chao. Approximately 1,000 lakes of different sizes have disappeared. In Hubei province, the former thousand-lake-province, the number of lakes dropped from 1,066 to 83. Dongting Lake was divided into three parts.

After the flood disaster in 1998, the Chinese Government initiated the "Returning croplands to lakes" project in Hubei, Hunan, Anhui and Jiangxi provinces. After six years of efforts the project has made substantial progress. For example, the Dongting Lake wetland area has increased by 1,390.84 km^2 since the project was implemented (Zhuang *et al.,* 2003).

Under trade liberalization, rice production in most major lake provinces (e.g. Hubei, Hunan and Jiangxi) is at a disadvantage. Farmers will therefore place importance on improving rice quality not quantity. It is projected that the rice area will shrink, which is favourable to the implementation of the "Returning croplands to lakes" project in the middle and lower reaches of the Yangtze River.

9.4 Greenhouse gas emissions

9.4.1 Emission rate of methane from rice paddy

One of the important contributing factors to the global greenhouse effect is the emission of methane and nitrous oxide. The annual concentration growth rates of these gases in the air are 1 per cent and 2.5 per cent respectively. Increasing nitrous oxide concentrations in the air will contribute to further destroying the ozone layer in the stratosphere, and solar ultraviolet radiation will further affect human health. Rice paddy is an important source of these two gases. For methane, the contribution rates of natural wetlands and rice paddy are 12 and 18 per cent respectively. It was always believed that the nitrous oxide emissions were lower from rice paddy than from dry land. However, studies show that the volume of methane emissions from rice paddy is high. Consequently, changes in rice production will impact greenhouse gas emissions.

The climate and soil conditions differ across rice production zones, and there is considerable diversity in terms of paddy varieties and cultivation systems. These factors affect methane emissions that will thus differ depending on the local conditions of the rice growing area. These differences are presented hereafter.

From Table 9-15, we can see that the daily rate of methane discharge of early rice ranges from 0.069g/m^{-2}.d^{-1} g/m^2·d (Yunnan province) to 0.317g/m^2·d (Sichuan province), with an average of 0.201g/m^2·d. Methane discharge from late rice ranges from 0.106g/m^2·d (Yunnan province) to 0.502g/m^2·d (Guangdong province), with an average of 0.340 g/m^2·d. For single season rice (including single season late rice and wheat batch rice) the methane discharge ranges from 0.034g/ m^2·d (Ningxia province) to 0.621g/m^2·d (Beijing), with an average of 0.378g/ m^2·d. For special winter paddy fields in Sichuan province the rate is 0.976g/m^2·d, which is the highest.

Table 9-15: Methane emission rates from rice paddy by province in China, 1994 (g/m²·d)

Rice paddy growing zone	Province and urban districts	Early rice	Late rice	Single season rice (single season late rice, wheat batch rice, winter paddy field (WL))
North rice zone	Beijing			0.621
	Tianjin			0.31
	Hebei			0.234
	Shangxi			0.135
	Shangdong			0.31
	Henna			0.237
	Shanxi			0.158
	Ningxia			0.034
North-east rice zone	Liaoning			0.187
	Jilin			0.103
	Heilongjiang			0.112
	Inner Mongolia			0.198
North-west rice zone	Gansu			0.086
	Xinjiang			0.167
Southern rice zone	Fujian	0.186	0.413	0.347
	Guandong	0.261	0.502	0.514
	Guangxi	0.206	0.408	0.399
	Hainan	0.154	0.413	0.408
Central rice zone	Shanghai			0.236
	Jiangsu	0.176	0.284	0.324
	Zhejiang	0.189	0.292	0.343
	Anhui	0.231	0.279	0.311
	Jiangxi	0.221	0.386	0.438
	Hubei	0.298	0.387	0.539
	Hunan	0.214	0.371	0.493
	Sichuan	0.317	0.389	0.423, 0.976
South-west rice zone	Guizhou	0.097	0.193	0.192
	Yunnan	0.069	0.106	0.139
	Tibet			0.054

Note: d is the period of growth.
Source: Wang, 2001.

Most of the rice zones with high emission rates have higher paddy output and a higher average temperature. The higher sand content in the soil may be the reason of the higher emission rates of Beijing and Sichuan provinces.

9.4.2 Changes in methane emissions from paddy fields resulting from free trade

$$\Delta D = \Delta A \times B \times C$$

in which,

ΔA: change in the rice growing area (1,000 ha)

B: period of growth (d) (for early paddy, 70-90d; for late paddy 80-100d; for single season paddy, 80-100d, 90-110d)

C: the rate of methane emission from paddy ($g.m^{-2}.d^{-1}$) (refers to Table 9-15)

ΔD: change in the quantity of methane emissions from paddy field (10^4 kg)

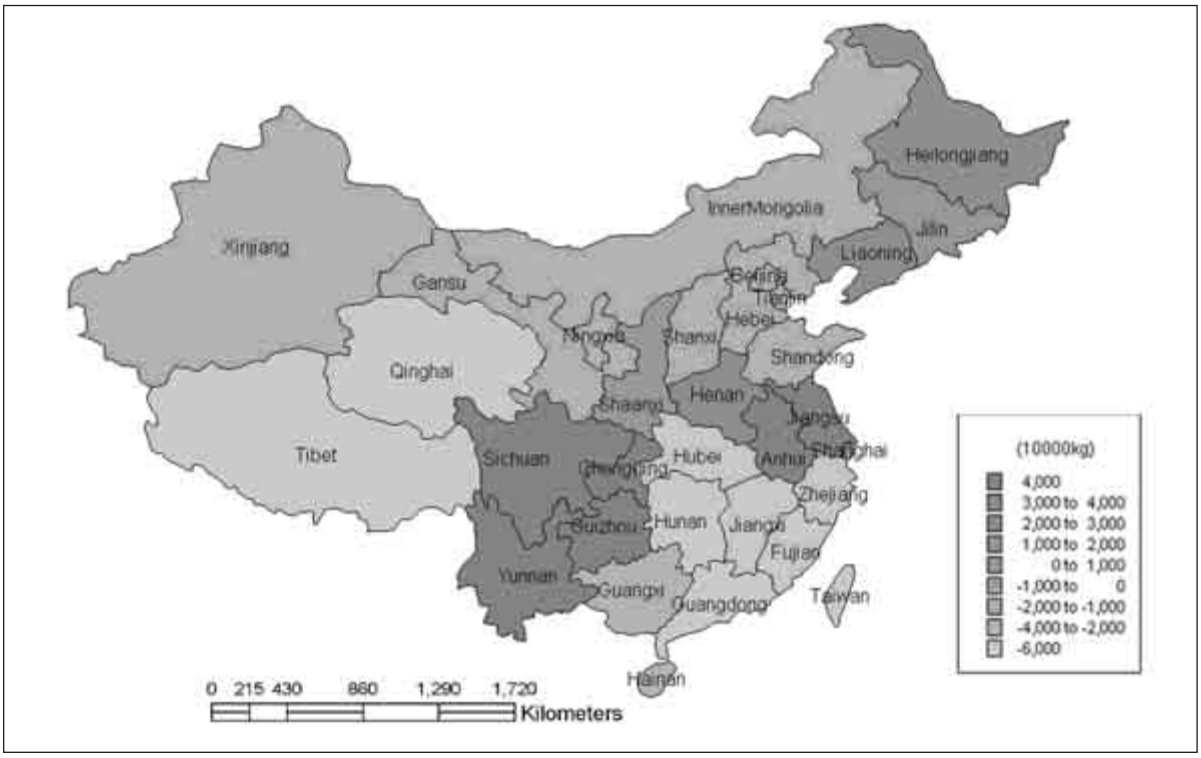
From our estimation (Table 9-16), the changes in the rice paddy growing areas resulting from free trade are favourable to decreasing overall greenhouse gas emissions. Methane emissions would be reduced mostly in southern China (e.g. Hunan, Jiangxi, Fujian and Guangdong provinces), which will offset the increasing emissions in northern China, especially in the north-east. Maps 9-15 and 9-16 summarize changes in methane emissions by province resulting from free trade.

Table 9-16: Forecasted changes of methane emissions from paddy fields as a result of free trade

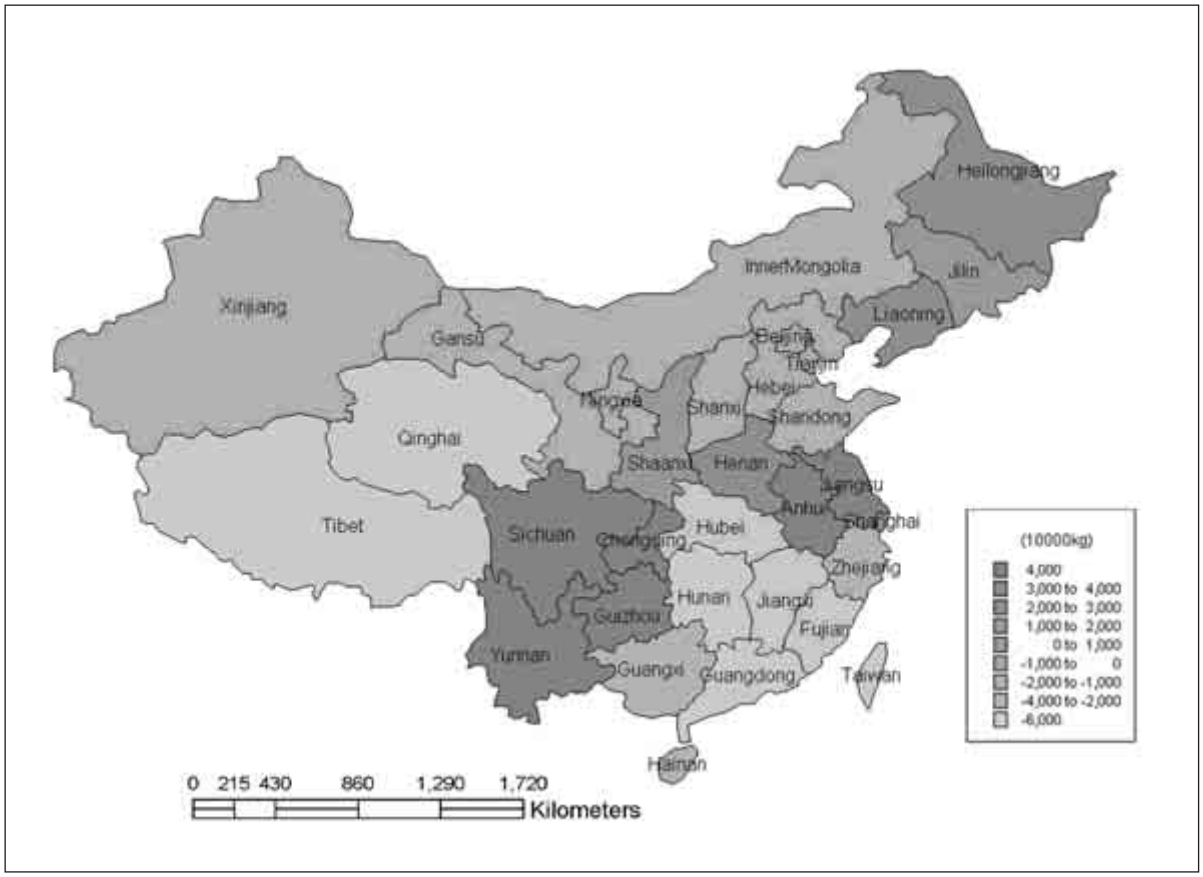
	Average methane emission rates from paddy fields in different regions (g./m^{-2}.d^{-1})	Average rice growing period in different regions (d)	Forecasted changes in the ricegrowing area in 2005 (kha)	Forecasted changes in the am ount of paddy methane emissions in 2005 (10^{4}kg)	Forecasted changes in the rice growing area in 2010 (kha)	Forecasted changes in the amount of paddy methane emissions in 2010 (10^{4}kg)
Beijing	0.621	95	-0.15	-8.9	-0.21	-12.2
Tianjin	0.31	95	-0.40	-11.8	-0.55	-16.2
Hebei	0.234	95	-2.94	-65.3	-4.05	-89.9
Shanxi	0.135	95	0.67	8.6	0.92	11.8
Shandong	0.31	95	0.38	11.3	0.53	15.6
Henan	0.237	95	37.00	833.1	50.96	1147.4
Shaanxi	0.158	95	14.79	221.9	20.37	305.7
Ningxia	0.034	95	2.79	9.0	3.84	12.4
Liaoning	0.187	95	41.19	731.7	56.73	1007.8
Jilin	0.103	95	56.01	548.0	77.14	754.8
Hei Longjiang	0.112	95	119.81	1274.8	165.02	1755.8
Inner Mongolia	0.198	95	0.07	1.3	0.09	1.7
Gansu			0.00	0.0	0.00	0.0
Xinjiang	0.167	95	3.25	51.6	4.48	71.1
Fujian	0.315	90	-50.35	-1429.0	-69.35	-1968.1
Guangdong	0.426	90	-118.31	-4532.5	-162.95	-6242.5
Guangxi	0.338	90	-6.43	-195.3	-8.85	-268.9
Hainan	0.325	90	-6.21	-181.6	-8.55	-250.1
Shanghai	0.236	90	9.85	209.1	13.56	288.1
Jiangsu	0.261	90	67.52	1588.2	93.00	2187.4
Zhejiang	0.275	90	-46.06	-1138.7	-63.44	-1568.3
Anhui	0.274	90	119.13	2934.1	164.07	4041.1
Jiangxi	0.348	90	-81.34	-2550.1	-112.03	-3512.2
Hubei	0.408	90	-78.87	-2896.2	-108.63	-3988.9
Hunan	0.359	90	-161.75	-5231.1	-222.78	-7204.7
Chongqing	0.469	90	35.33	1490.3	48.66	2052.5
Sichuan	0.469	90	89.24	3764.0	122.91	5184.2
Guizhou	0.161	90	99.87	1444.1	137.55	1988.9
Yunnan	0.105	90	139.52	1314.3	192.16	1810.2
Total				-1804.8		-2485.8

Source: Author's estimations.

Map 9-15: Impact of WTO accession on methane emissions in rice production, 2005 (10,000 kg)



Map 9-16: Impact of WTO accession on CH4 emissions in rice production, 2010 (10,000 kg)



9.5 Water resource conflicts

Sufficient water supply is important to rice cultivation. China's gross annual water resources amount to 2,812.4 billion m^3 and rank 4th in the world. However, the conflict over water resources is obvious because of the country's overpopulation. The water resource per capita is only 2,253.5 m^3 (ranking 121st in the world) and China is one of the 13 countries with the most severe water shortage.

Water resources in China are unevenly distributed in space and time, with more in the south and east and less in the north and west, more in summer and autumn and less in winter and spring. This aggravates the disparities in supply and demand in some areas. South of the Yellow River Valley, the land mass accounts for less than half of the country's total. Yet the quantity of runoff in this area amounts to 85 per cent of the country's total. In the northern area the water resource deficiency is serious with a per capita availability of only 233 m^3 in the coastal area of Hebei province, i.e. 137 m^3 less than Israel, the country with the lowest water resources in the world. Per capita water resource availability is only 357 m^3 in the Haihe and the Luanhe River Valley, where Beijing and Tianjin are located, which is close to that in desert countries like Israel and Saudi Arabia.

In a country with as large a population as China, excessive agricultural production in order to guarantee sufficient supply of grain has also put a great deal of pressure on national water resources.

Currently, China has an efficient irrigated area of about 500 million ha, which only accounts for about 50 per cent of the country's cultivated area on which nearly 80 per cent of the country's grain is produced. Rice is the most water-consuming grain of all. Water requirements in rice cultivation in different areas are presented in Table 9-17.

Table 9-17: Water requirement in China's rice cultivation areas (mm)

	Rice type	Transpiration amount	Evaporation capacity	Total
North of Qinling Mountain Range and Huaihe River	Single-harvest rice	340-580	240-340	580-920
North of the Yangtze River, south of Qingling Mountain Range and Huaihe River	Single-harvest semi-late rice	330-400	180-290	510-690
South of the Yangtze River	Double-harvest early rice	160-260	110-210	270-470
	Double-harvest late rice	210-420	140-290	350-710

Source: Editorial Board, 1985.

According to investigations on the irrigation situation of some main rice producing regions, double-harvest rice is the major crop in the district that lies to the south of the Yangtze River. The irrigation quota of southern double-harvest rice is generally between 600-860 mm; it is relatively high in Zhejiang province where it exceeds 1,000 mm. The central China single-harvest rice zone that lies to the north of the Yangtze River/Qiantang River and to the south of Qingling Mountain Range has a relatively lower quota of between 290 to 420 mm. The rice districts that lie to the north of the Qinling Mountain Range and Huaihe River – except for Anhui and Henan provinces where the irrigation quota is relatively lower and close to that in the central area – and the rice growing areas in the north, north-west and north-east all require a relatively higher quota of 1,000-1,500 mm.

Table 9-18: Irrigation quotas for the main rice producing regions (mm)

Area	Experimental place	Rice type	Utilized rainfall in growth period	Irrigation quota	Total
South of the Yangtze River and Qiangtangjiang River	Haikou of Guangdong	Rotate early rice	271.6	346.2	859.5
		Rotate late rice	280.2	513.3	
	Xingan of Guangxi	Rotate early rice	224.1	224.1	629.1
		Rotate late rice	87.1	405.0	
	Changsha of Hunan	Rotate early rice	201.3	313.5	667.2
		Rotate late rice	125.9	353.7	
	Nanchang of Jiangxi	Rotate early rice	348.5	375.0	602
		Rotate late rice	259.8	227.0	
	Fuzhou of Fujian	Rotate early rice	175.5	322.6	322.6
		—	—	—	
	Jinhua of Zhejiang	Rotate early rice	120.1	363.0	1043
		Rotate late rice	166.5	680.0	
To North of the Yangtze River and Qiantangjiang River, south of Qingling mountains and Huaihe River	Danyang of Jiangsu	Single-harvest late rice	269.1	411.6	411.6
	Sui county in Hubei	Single-harvest semi late rice	272.2	287.0	287.0
	Pi county in Sichuan	Single-harvest semi late rice	263.0	375.0	375.0
North of Qinling mountains and Huaihe River	Bangbu of Anhui	Single-harvest semi late rice	157.0	435.0	435.0
	Xinxiang of Henan	Single-harvest semi late rice	399.2	425.0	425.0
	Hebei,Tianjin	Single-harvest semi late rice	320.0	1000-1500	1000-1500
	Huhehot of the Inner Mongol	Single-harvest semi late rice	201.9	1066.5	1066.5
	Chahayang of Heilongjiang	Single-harvest semi late rice	186.1	1440	1440

Source: Editorial Board, 1985.

According to estimations regarding changes in the rice growing area in each province under the influence of trade liberalization, the changes in water requirements for rice cultivation in some main provinces are presented in Table 9-19.

According to Table 9-18, in the area that lies to the south of the Yangtze River and Qiantangjiang River, irrigation water requirements will decrease by a large margin under the influence of trade liberalization because of the reduction in the rice cultivation area, especially in the economically developed coastal areas such as Guangdong province. Hunan province, where indica rice predominates, will largely reduce its water requirements.

In the central area that lies to the north of the Yangtze River and Qiantangjiang River and to the south of Qinling Mountain Range - Huaihe River, single-harvest rice requires less water. Under the influence of trade liberalization, rice-growing areas will increase and decrease simultaneously, and overall water requirements do not change much.

In the area that lies to the north of Qinling Mountain Range and Huaihe River, especially Hebei province in north China, the reduction of the rice growing area combined with a reduction in rice cultivation in Beijing and Tianjin under the influence of trade liberalization will relieve pressure on water resources in north China to a certain extent. The rice cultivation area in the north-east will expand slightly. The water requirements of single-harvest japonica rice in the north-east are quite large, so although water resources in the north-east are more abundant than in the north, pressure on the local water resources will still be considerable if the cultivated area increases as a result of trade liberalization.

Generally, as a result of trade liberalization the comparative advantage of north-east japonica rice will make the conflict in relation to water resources more prominent, but in other areas the problem will generally be relieved, especially in southern China.

Table 9-19: Influence of trade liberalization on water requirements for rice cultivation

Area	Provinces	Irrigation quota for rice cultivation (mm)	Change in the rice growing area resulting from trade liberalization (kha)		Change in the consumption of irrigation water resulting from trade liberalization (1 million m^3)	
			2005	2010	2005	2010
South of the Yangtze River and Qiantangjiang River	Guangdong	859.5	-118.31	-162.95	-1016.87445	-1400.55525
	Guangxi	629.1	-6.43	-8.85	-40.45113	-55.67535
	Hunan	667.2	-161.75	-222.78	-1079.196	-1486.38816
	Jiangxi	602	-81.34	-112.03	-489.6668	-674.4206
	Fujian	322.6	-50.35	-69.35	-162.4291	-223.7231
	Zhejiang	1043	-46.06	-63.44	-480.4058	-661.6792
North of the Yangtze River and Qiantangjiang River, south of Qingling mountains and Huaihe River	Jiangsu	411.6	67.53	93	277.95348	382.788
	Hubei	287.0	-78.88	-108.63	-226.3856	-311.7681
	Sichuan	375.0	89.24	122.91	334.65	460.9125
To the north of Qinling Mountains and Huaihe River	Anhui	435.0	119.13	164.07	518.2155	713.7045
	Henan	425.0	37	50.96	157.25	216.58
	Hebei	1000-1500	-2.94	-4.05	-0.0294	-0.0405
	Inner Mongolia	1066.5	0.07	0.09	0.74655	0.95985
	Heilongjiang	1440	119.81	165.02	1725.264	2376.288
	Total				-481.35875	-663.01741

10. Concluding remarks and policy implications

10.1 Impacts of trade liberalization in general

Since the early 1980s, domestic reforms to boost agricultural growth and farm income have covered nearly every aspect of the economy, starting with land reforms and gradually moving to both input and output markets, from policies specific to the agricultural sector to macro-economic policies. The reforms have had significant impacts on the country's economy. China has been able to not only increase its ability to feed its growing population with limited per capita natural resources, but also to become, recently, one of the world's major food and agricultural product exporters. Per capita availability of food, household food security and nutrition have all been improved significantly. Increased domestic production is almost solely responsible for increased per capita food availability.

China's experience demonstrates the importance of both domestic and external reforms in agricultural development. Technological development, institutional change, price and market liberalization, rural economic development and other conducive policies have all played a considerable role in improving agricultural productivity, farmers' incomes and food security in a nation with limited land and other natural resources. External reforms in general have paralleled domestic reform. Trade liberalization has proceeded smoothly since the late 1980s. Through nearly 20 years of external reform, China's foreign trade regime has gradually changed from a highly centralized, planned and import-substitution regime to a more decentralized, market-oriented and export-promoting regime.

In analysing the impacts of WTO accession on China's agriculture, we conclude that the positive impacts are, in general, greater than the negative ones. Although effects on the rural economy of other subsectors may be equally large, or even larger, this study focuses on the agricultural sector and shows that there will be an impact, and that the net impacts are positive for average farmers in China. Indeed, our findings on the NPRs show that, for some agricultural commodities, WTO accession will lead to a drop in prices and a rise in imports. Edible oils, sugar, maize and cotton may be the most affected commodities. There are also commodities in which China has a considerable comparative advantage, e.g. japonica rice, meat and horticulture products, and WTO accession could bring benefits to those engaged in producing them. The prospect of increased imports of feed grains (e.g. maize and soybeans) at lower prices result in livestock producers becoming even more competitive.

Our study also shows that as some prices rise and others fall as a result of WTO accession, farmers are encouraged to adjust their agricultural production structure towards products with a higher comparative advantage. In response to the overall rise in food prices, consumers decrease their consumption. However, with the increased incomes that accompany farmers' shifts to more profitable agricultural products, most of the farming sector is likely to be better off (although we do not measure the indirect rise in consumption due to the income effects of higher agricultural profits).

We show the poverty and equity effects through several findings. First, according to the analysis,

although on average farmers at the national level will benefit from WTO accession, it does not hold for all provinces. Average farmers in many less developed provinces in western and northern parts of China will not gain from trade liberalization. The main reason is that the farmers in the east and south produce more products in which China has a comparative advantage. The net impacts on agricultural production of average farmers in several western and northern provinces are indeed negative. Second, while at the national level the poor benefit on average, not all the poor in every region will gain from trade liberalization. We find that the poor in many provinces in western and northern regions will lose from agricultural production. Third, in almost all provinces where there are gains, the richer will gain more than the poor, the main reason being that the lands of the richer farmers produce higher yields for the same commodity and, consequently, more output (e.g. more horticultural products, meat and fish).

The impacts of WTO accession on rice, one of the most important crops in China, are mixed. While farmers growing indica rice will be affected negatively by WTO accession, the analyses show that japonica rice production will expand moderately due to trade liberalization. The benefits for rice production from trade liberalization are mainly found in northern China, especially the north-east, including Heilongjiang, Jilin and Liaoning provinces. Losses from trade liberalization in rice production are mainly found in southern China, the country's main indica rice growing area. Because of the clear regional distribution of japonica and indica rice production in China, WTO accession has equity implications on the national rice economy.

Studies on the impacts of WTO accession on chemical input applications produced various conclusions on different assumptions regarding determinants to input use. Considering that chemical input use is determined by a combination of changes in the price of both inputs and outputs, both fertilizer and pesticide applications are projected to rise with trade liberalization, although pesticide use will increase more than fertilizer use. At the provincial level, the percentage increases in fertilizer and pesticide applications in rice production are greater in the northern part where japonica rice is grown than in the southern part of the country where indica rice is grown.

However, assuming the input per unit area were to remain stable, we obtain a different result, which indicates that pesticide applications would decrease and fertilizer and film applications would increase overall. The reason for the decrease of pesticide applications at the national level in this scenario is that the expansion of rice production resulting from trade liberalization is mainly concentrated in areas with an already lower rate of pesticide use, and areas where there is a traditionally high rate of pesticide use are mostly located in southern regions where the rice growing zone is projected to shrink. Thus the increase in pesticide applications in some regions could be offset at the national level.

Based on our estimations, changes in the rice production zones resulting from free trade are in favour of decreasing greenhouse gas emissions overall. Methane emissions would mainly be reduced in southern China (e.g. Hunan, Jiangxi, Fujian and Guangdong provinces), which would offset increasing emissions in the north of China, especially in the north-east.

Increased pressure on water resources will be greater in northern China than in central and southern China. Disparities in the distribution of water resources in China will be magnified by the increased demand for water in rice production in northern areas.

10.2 Impacts of trade liberalization by region

From the maps in the previous chapter we can see that, by and large, the impacts of trade liberalization vary between north and south, east and west.

10.2.1 Southern China

South-east China

The south-east region, including Hainan, Guangdong and Fujian provinces, is the main importer of super indica rice. Trade liberalization will improve

the importing environment, which will threaten rice production in the region. However, the negative impacts on rice production are offset when we take into account the impacts on other agricultural production sectors. The share of exportable agricultural output in the south-east is over 90 per cent, the highest in China. So, provinces in the south-east region will benefit greatly from trade liberalization overall.

Despite the drop in rice output, farmers' incomes and chemical input use in the south-east will increase because the production of exportable commodities other than rice will expand following China's accession to WTO. Our projection shows that the increases in farmers' income and chemical input use in the south-east are the highest in China.

Central and south-west China

Central China is the main indica rice-growing region in China. The provinces in the middle and low reaches of the Yangtze River, like Hunan, Hubei and Jiangxi, are the largest cultivation areas of medium and low quality indica rice. Under trade liberalization, the drop in price of indica rice will hurt rice producers in these provinces. Impacts on other provinces producing japonica and indica rice, such as Shanghai, Jiangsu and Anhui, will not be obvious.

For agricultural production as a whole, the exportable output share is the second highest in China. Shanghai, Hunan and Jiangxi provinces, with a high exportable share of more than 90 per cent, will benefit greatly from trade liberalization, though the impact on rice production is negative in Hunan and Jiangxi. According to our projected results, farmers' incomes will increase by 6.5-7 per cent. The average exportable share of other provinces in central China and provinces in the south-west vary from 70 to 80 per cent, and farmers' incomes will increase by 3-5 per cent.

Southern and central regions with a high population density generally use much more fertilizer and pesticide than the rest of China. Although the drop in rice production will reduce pollution from fertilizers and pesticides, it does not affect the increasing trend of chemical inputs in view of the production expansion of other exportable outputs such as vegetables, fruit and other horticultural commodities.

Rice cultivation requires large volumes of irrigation water. In central China, water resources are relatively abundant, but there still exists a problem of water shortage due to water pollution. A decrease in rice cultivation is thus helpful in reducing conflicts over water resources.

In the middle and lower reaches of the Yangtze River Valley, the decrease in rice production will be favourable to wetland protection efforts and the implementation of the "Return croplands to wetlands" project.

10.2.2 Northern China

North-east

The north-east region, including Liaoning, Jilin and Heilongjiang provinces, is the most important high quality japonica rice production region in China. Theoretically, the benefits for rice production in the north-east will be greatest under trade liberalization, especially in Heilongjiang.

The production share of importable commodities in Heilongjiang and Jilin is 60-65 per cent, compared to 40 per cent in Liaoning. For agricultural production as a whole, Liaoning will benefit more than Heilongjiang and Jilin from trade liberalization. Our results show that trade liberalization will result in a 2.4 per cent increase in agricultural income for farmers with average income levels in Liaoning, and a decrease in income of 0.3 per cent in Heilongjiang and 2 per cent in Jilin in 2005.

Increased use of fertilizers and pesticides as a result of the expansion of rice production mainly occurred in the north-east. However, since the level of fertilizer and pesticide use is very low in the north-east because of climate and geographical advantages, the threat from chemical pollution on the environment and farmers' health will not be serious.

Although, relatively speaking, water resources in the north-east are more abundant than in the north

and west of China, the substantial water requirements of single-harvest Japonica rice in the north-east combined with the expansion of rice production will amplify the pressure on water resources.

In the north-east, the tendency towards expanding rice production will offset to some extent the efforts of the "returning croplands to wetlands" project, which will have a negative impact on the wetland protection scheme.

North and north-west China

North China is the region with the most serious water shortage problem, especially in the Hebei plain and the river basins of Haihe and Luanhe. Serious water shortages will limit rice production in north China. Beijing, Tianjin and Hebei provinces will decrease rice production despite the higher price of japonica rice and increased opportunities after trade liberalization. Other provinces in north China will benefit inconspicuously from rice production.

The production share of importable products in the north is 50-65 per cent, and even 70-90 per cent in north-west provinces (e.g. Xinjiang and Tibet Autonomous Regions). Trade liberalization will hurt producers in the north primarily because the region is the largest producer of maize, wheat, cotton, edible oil, sugar and soybeans (the commodities most hurt by trade liberalization).

Positive impacts on farmers' incomes decrease from east to west and from south to north. Our results show that, except in Beijing and Tianjin, farmers will benefit a great deal from trade liberalization, but there will be no obvious impacts on farmers in other provinces of north China. Farmers' incomes in the north-west, such as Xinjiang, Tibet, Qinghai and Gansu, will decrease by 2-4 per cent.

10.3 Policy recommendations

10.3.1 Policies for farmer income equity

In terms of equity issues, policy makers need to take one of two actions. First, they need to try to encourage farmers in poorer, inland areas to shift their production (where appropriate) to more competitive crops. Second, officials may also need to take other non-trade actions to improve the livelihoods of farmers, especially in areas where farmers do not have an advantage in any farming activity. In such areas rural education, better communications and other services that might facilitate their conversion to the non-farm sector may be the most beneficial policy.

The impact on agriculture, however, is only part of the story. Although this study does not analyse non-farm impacts, trade liberalization is also expected to affect the access of households to non-farm employment and the wages they earn from the off-farm market. In general, China will gain a lot from trade liberalization. In view of rising exports of manufactured goods, the manufacturing sector will hire a lot of rural labour. In a country like China, raising the demand for off-farm labour is probably the most important thing that can happen in the economy. The nation needs to continue promoting policies that facilitate investments allowing rural households to move to these jobs without constraints.

10.3.2 Policies for harmonizing food security and environmental management

Adjusting the import & export structure on the basis of food security

WTO accession means that China will gradually be integrated with the global economy and participate in resource distribution throughout the world. It is necessary to coordinate domestic production and grain imports by adjusting the import and export structure. On the basis of food security, increasing the import of land-intensive products and the export of labour-intensive products would be helpful in making full use of international resources to improve the domestic agricultural environment.

Enhancing capacity for rural environmental management

At present, capacity to manage the rural environment is very weak in China. There are still less than ten people managing the rural environment of

a country with a massive population. Lack of capacity restricts rural environmental management and ecological construction. Enhancing the ability of rural environmental management would be helpful in internalising environmental costs.

Controlling chemical inputs

Because the environmental impacts of chemical applications are negatively associated with rice production, it is important for the Chinese Government to ensure compatibility between the economic and environmental objectives of rural development policies and institutional changes under trade liberalization. There are many alternatives that China may consider in dealing with the issue of the excessive use of chemicals in crop production under a more liberalized economy.

First, a more economically rational application of crop inputs and wider use of IPM and other new technologies could substantially reduce application rates and total usage and thus mitigate negative environmental impacts. A recent study by CCAP shows that farmers could reduce the use of nitrogen fertilizer by 20-30 per cent without yield loss through SSNM. But the extension of SSNM requires substantial investment in training and agricultural extension services. Other recent studies by CCAP show that GM rice reduces pesticide use by more than 90 per cent in rice production, and Bt cotton reduced pesticide use in cotton production by about 65 per cent.

Second, raising the price of chemical inputs and converting financial support from chemical inputs to other production factors, including super seeds and machines, can limit chemical input application rates without harming farmers' enthusiasm.

Third, the Government could ensure an increase in farmers' incomes from rice trade liberalization by improving quality and investing more in scientific research to accelerate green food production and super quality rice development.

Balancing water conflicts

According to the conclusions above, trade liberalization will increase the pressure on water resources in the north more than in the south, which will magnify the distribution inequality in China. In order to balance the water conflicts, the Government should take the following actions.

First, it is suggested to increase the price of irrigation water in northern areas to encourage farmers to adopt water saving irrigation technologies voluntarily.

Second, it is suggested that the Government increase the cost of wetland exploitation to control the total rice growing area in the north.

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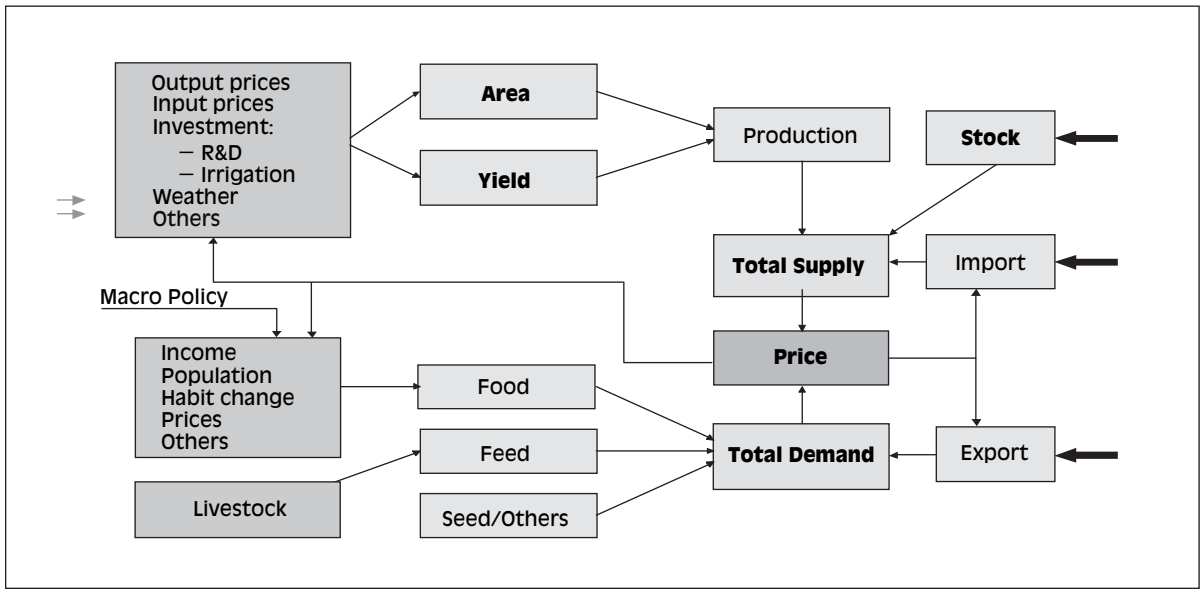
Appendix A: A framework for analysing the impacts of trade liberalization on agriculture and poverty in China

A.1 Overview

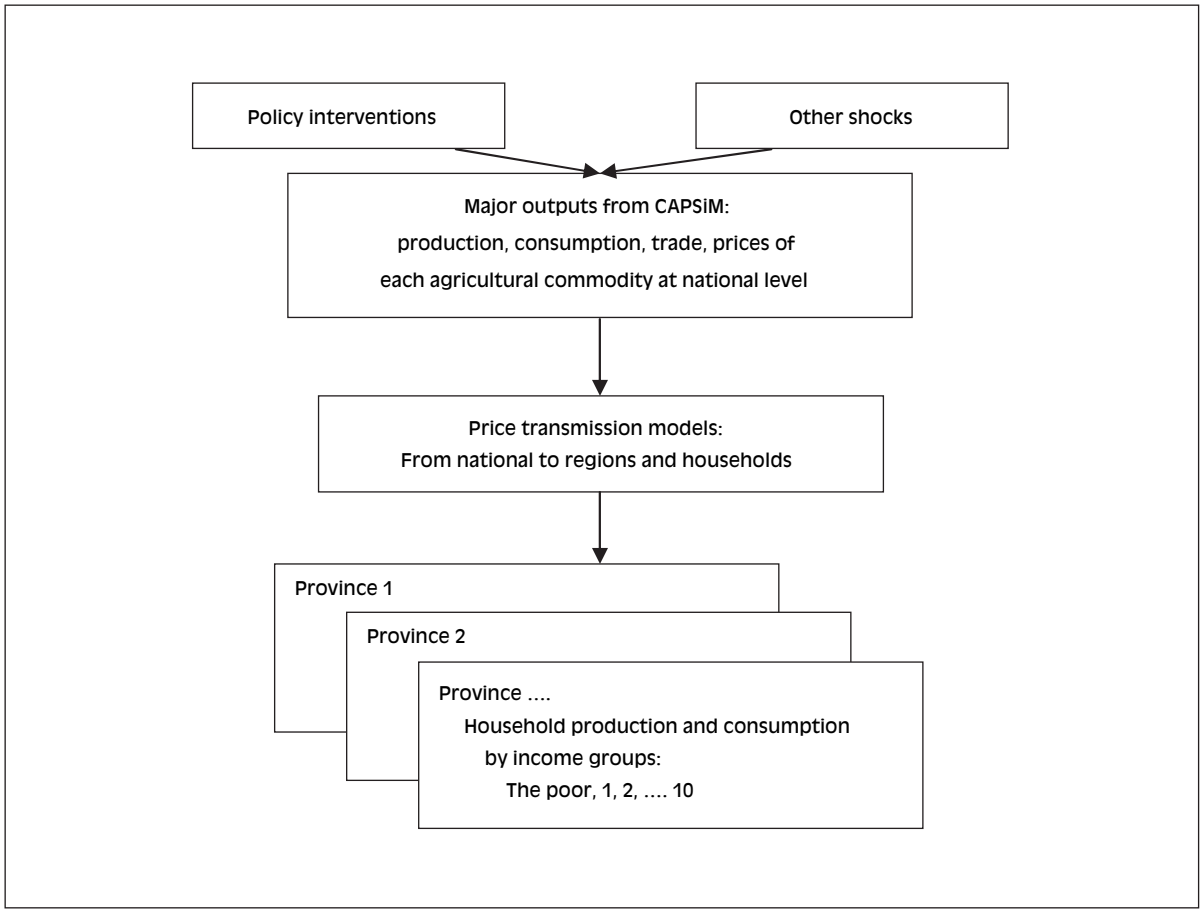
The qualitative analysis of the impacts of trade liberalization on agriculture and poverty is implemented in an integrated analytical framework that links the national markets with individual groups of farmers in each region. This integrated analytical framework includes three major components: a national partial equilibrium model, price transmission, and a household response model for various groups of farmers.

Appendix Figure 1 provides an overview of one individual crop in CAPSiM. For each crop, the total supply is composed of three sub-models, namely import, stock change, and domestic production. Domestic production is modelled separately by area and yield equations that are the function of output and input prices; supply shifters such as investment in research and development and irrigation; climate shocks; erosion; salinity control; and others. The total demand for each commodity includes export demand, demands for food and feed, seed use, industrial demand and others (e.g. post-harvest loss and loss in food marketing and processing). Food demand is determined by a completed demand system with

Appendix Figure 1: Overview of an individual crop in CAPSiM



Appendix Figure 2: Overall analytical framework



the imposition of adding up homogeneity and symmetric conditions on the demand elasticity matrix for both rural and urban zones. The impacts of urbanization and food market development in rural areas are examined explicitly in the model. The feed demand sub-model for each crop automatically links with livestock and fish sub-models. The model structure of the livestock and fish sectors for each commodity has a similar structure to the crop model. The equilibrium for all commodities is solved simultaneously. Details of model specifications are presented in the next section.

To examine the effect of agricultural trade liberalization on poverty, in this study we measure it as the impacts on household agricultural production and food consumption. The national impacts on commodity prices derived from CAPSiM are transmitted to the households in each province through a price transmission model and household supply and demand response model as shown in Appendix Figure 1. The studies of price transmission and household response (for each group of farmers in each region) are far beyond the scope of this project. Although the current CAPSiM has developed modules for this kind of study, the analysis needs to incorporate a number of assumptions on how the impacts at the national level would be transmitted to various households. The analysis on household supply and demand responses to price changes for each group of households by region are undertaken. But our market integration analyses clearly show that the price changes in one market have been largely transmitted to other markets since the mid-1990s (Huang, Rozelle and Chang, 2004). To simplify the analysis, we assume that a price change of 1 per cent at the national level is transmitted as a 0.85 per cent price change in each region.

A.2 China's Agricultural Policy Simulation and Projection Model (CAPSiM)

The model includes production, demand, import and export, storage change and market cleaning sub-models. The specifications of each sub-model are defined below. Note that in the following discussion, any variables with ^ represent the percentage changes, for example $\hat{X} = dX/X$.

A.2.1 Domestic production

A.2.1.1 Crop production

Area:

$\log A_{it} = a^{A}_{i0} + \Sigma_j b^{A}_{ij}(\log p^{S}_{jt})$,

and with the following restrictions

$\Sigma_j b^{A}_{ij} = 0$ for all i

$b^{A}_{ij} W_{it} = b^{A}_{ji} W_{jt}$ for all i, j

Yield:

$\log Y_{it} = a^{Y}_{i0} + \Sigma_j b^{Y}_{ij}(\log p^{S}_{jt}) + c_i \log R_{it} + k_i \log I_t + g_i \log Z^{erosion}_t + h_i \log Z^{salinity}_t$

$\Sigma_j b^{Y}_{ij} = 0$

Production:

$Q_{it} = A_{it} * Y_{it}$

$\hat{Q}^{S}_{it} = \hat{A}_{it} + \hat{Y}_{it} + (Z^{A1}_{i(t-1)} + Z^{A2}_{it} + Z^{A3}_{it} + Z^{Y1}_{it} + Z^{Y2}_{it})$

Where:

A : crop harvested area

Q : total production

Z^{A1} : area changes due to climate shocks

Z^{A2} : area changes due to policy not included in the model

Z^{A3} : area changes due to other external factors

P^{S} : prices of output received by farmers or the input prices paid by farmers

Y : crop yield

W : individual crop area shares in the total crop area

R : stock of crop technology

I : irrigation stock

$Z^{erosion}$: ratio of erosion area to total land area

$Z^{salinity}$: ratio of salinity area to total cultivated area

Z^{Y1} : yield changes due to climate shocks

Z^{Y2} : yield changes due to other factors not included in the model

i : index crop

j : index both crop outputs and inputs

a^{A}, b^{A}, a^{Y}, b^{Y}, c, k, g, and h are the area or yield supply response elasticities. And the following theoretical restrictions are imposed:

$b^{A}_{ij} = b^{A}_{ji} * A_j / A_i$;

$(dA_i/dp_j^{S})/(dA_j/dp_i^{S}) = p_i^{S}/p_j^{S}$; and

$\sum_j b^{A}_{ij} = 0$.

A.2.1.2 Animal product supply responses

$\log q_{it} = a^{q}_{i0} + \Sigma_j b^{q}_{ij}(\log p^{S}_{jt})$

$\hat{q}_{it} = \hat{q}_{it}\,|_{without\_shocks} + Z^{q1}_{it} + Z^{q2}_{it}$

$\Sigma_j b^{q}_{ij} = 0$, for all i (homogeneity).

Where:

q : livestock production

Z^{q1} : change in production due to disease shocks

Z^{q2} : change in production due to other shocks

i : index animal products (i.e. pork, beef, mutton, poultry, eggs, milk, fish, etc.)

j : index animal products (i.e. pork, beef, mutton, poultry, eggs, milk, fish, etc.) and input factors (i.e. maize, other feed, labour, etc.) in animal production.

a^{q} and b^{q} are the animal product supply response elasticities.

Production by Mode

$q_{ikt} = \theta_{ikt}\, q_{it}$

$\theta_{ikt} = \theta_{ik(t-1)} + \gamma_{ik}$

$\Sigma_k \theta_{ikt} = 1$

Where:

q : livestock production

θ : share of each production mode

γ_{ik} : annual change in θ ;

i : index animal products: pork, beef, mutton, poultry, eggs, milk and fish

K : index production mode, including: backyard, specialized household and intensive commercial production.

A.2.2 Domestic demand

A.2.2.1 Food demand

$$\log d^R_{it} = a^{RD}_{i0} + \Sigma_j b^R_{ij}(\log p^D_{jt}) + e^R_i \log Y^R_t + m_i \log Z^{MKT}_t$$

$$\log d^U_{it} = a^{UD}_{i0} + \Sigma_j b^U_{ij}(\log p^D_{jt}) + e^U_i \log Y^U_t$$

$$d_{it} = \theta^R_t d^R_{it} + \theta^U_t d^U_{it}$$

$$D^{Food}_{it} = d_{it} * Pop_t$$

Where:

d^R, d^U : per capita food demand in rural and urban areas, respectively

d : per capita food demand at the national level

D^{food} : national total food demand

p^D : consumer price

Y^R, Y^U : per capita income in rural and urban areas, respectively

Z^{MKT} : food market development index

b^R, b^R : price elasticity matrix of food demand in rural and urban areas, respectively.

e^R, e^U : income elasticities of food demand in rural and urban areas, respectively

m : market development elasticity of food demand in rural areas

θ^R, θ^U : rural and urban shares in the total population

Pop : total population

i and j : index food, including: rice, wheat, maize, sweet potato, potato, other coarse grains, soybeans, sugar, oil, fruit, vegetables, pork, beef, mutton, poultry, eggs, milk, fish and other foods.

For both rural and urban demand models the following parameter restrictions hold:

Homogeneity: $\Sigma_j b_{ij} + e_i = 0$, for all i;

Symmetric: $b_{ij} = W_j * (b_{ji}/W_i + e_{ji})$, if i>j;

Engel aggregation or Cournot condition:

$$\sum_i b^R_{ij} * W_i + W_j = 1.$$

A.2.2.2 Total feed demand

$$D^{feed}_{jt} = \Sigma_k (1 + \delta_{jkt}) \beta_{jk} \theta_{jkt} q_{jt}$$

$$\theta_{jkt} = \theta_{jk(t-1)} + \gamma_{jk}$$

$$D^{feed}_t = \Sigma_j D^{feed}_{jt}$$

$$D^{feed}_{it} = \Sigma_i f_{it} D^{feed}_t$$

$$f_{it} = (1 + r_f)^t f_{i(t-1)}$$

Where:

q : livestock production

D^{feed} : total feed demand

β : feed/meat ratio

δ : efficient gain in feeding livestock

f : grain is share of total feed grain

r_f : annual growth rate of f

i : index individual grain and other feed, including: rice, wheat, maize, sweet potato, other coarse grains and soybeans

j : index meat products, including: pork, beef, mutton, poultry, eggs, milk and fish

k : index production mode, including: backyard, specialized household, and commercial intensive (company) production.

A.2.2.3 Other demand

$$D^{seed}_{it} = (1 + \beta^S_t) d^{seed}_{i(t-1)} A_{it}$$

$$D^{ind}_{it} = (1 + \beta^I_{it}) D^{ind}_{i(t-1)}$$

$$D^{waste}_{it} = (1 + \beta^W_{it}) d^{waste}_{i(t-1)} Q_{it}$$

Where A and Q are the same as those defined in (1.1) (crop area and total production), others are:

D^{seed} : total seed use
D^{ind} : industrial use
D^{waste} : post-harvest loss
d^{seed} : seed use (kg) per hectare
d^{waste} : waste (loss) as share of production
β^{S} : annual growth rate of seed use per hectare
β^{I} : annual growth rate of industrial use
β^{W} : annual growth rate of post-harvest loss
i : index individual commodities, including: rice, wheat, maize, sweet potato, potato, other coarse grains, soybeans, cotton, oil crops, sugar crops, vegetables and other crops.

A.2.2.4 Total crop product demand

$$D_{it} = D^{food}{}_{it} + D^{feed}{}_{it} + D^{seed}{}_{it} + D^{ind}{}_{it} + D^{waste}{}_{it}$$

Where:

D : total demand
i : index individual grains, including: rice, wheat, maize, sweet potato, potato, other coarse grains, soybeans, cotton, rapeseed, sugar crops and other crops.

The others are defined in the previous equations.

A.2.3 Stock

$$B_{it} / D_{it} = B_{i(t-1)} / D_{i(t-1)} + lp^{D}{}_{it}$$

Where:

B : stock
l : marginal change in grain stock due to grain price change.

A.2.4 Trade

After estimating the changes in production of and demand for agricultural products using the models given above, we can obtain the percentage changes in import and export with a decomposition equation derived from a constant elasticity of substitution (CES) mechanism, in response to the percentage changes in their domestic and foreign prices.

Consider the two components case, where the elasticity of substitution is defined as the percentage changes in the ratio of the two cost-minimizing component demands, given a 1 per cent change inversely to their price ratio:

$$\sigma \equiv (\hat{q_1} / \hat{q_2}) / (\hat{p_2} / \hat{p_1}).$$

For larger values of σ, the rate of change in the quantity ratio exceeds the rate of change in the price ratio, and the cost share of the component that becomes more expensive actually falls. Expressing the above equation in terms of percentage change we obtain:

$$(\hat{q}_1 - \hat{q}_2) = \sigma(\hat{p}_2 - \hat{p}_1).$$

The CES functional form gives the following relationship between the changes in quantities demanded of components and the composite good:

$$\hat{q} = \theta_1 \hat{q}_1 + (1 - \theta_1)\hat{q}_2,$$

where θ_1 is the cost share of component 1 and $(1-\theta_1)$ is the cost share of component 2. Solving for $\hat{q}_2$ gives:

$$\hat{q}_2 = (\hat{q} - \theta_1 \hat{q}_1)/(1 - \theta_1),$$

which may be substituted into $(\hat{q}_1 - \hat{q}_2) = \sigma(\hat{p}_2 - \hat{p}_1).$ to yield:

$$\hat{q}_1 = (1 - \theta_1)\sigma(\hat{p}_2 - \hat{p}_1) + \hat{q}.$$

Note that this conditional demand equation is homogeneous with a degree zero in price, and the compensated cross-price elasticity of demand is equal to $(1-\theta_1)\sigma$. The CES functional form also gives the following relationship between the changes in prices of components and the composite good:

$\hat{p} = \theta_1 \hat{p}_1 + (1-\theta_1)\hat{p}_2$.
First we solve $\hat{p}_2$ as a function of $\hat{p}_1$ and $\hat{p}$, then substitute this to

$\hat{q}_1 = (1-\theta_1)\sigma(\hat{p}_2 - \hat{p}_1) + \hat{q}.$ to obtain:

$$\hat{q}_1 = \sigma(\hat{p} - \hat{p}_1) + \hat{q}.$$

Note that *the form of the above equation is unchanged when the number of components* increases *beyond two*. This equation decomposes the change in the derived demand, $\hat{q}_1$, into two parts. The first is the substitution effect. It is the product of the CES and the percentage changes in the ratio of the composite price to the price of component 1. The second is the expansion effect. Owing to constant return to scale, this is simply an equi-proportionate relationship between the composite and the component.

In the trade model, FOB and CIF prices are first exchanged into domestic currency. Next they are transformed into domestic market prices at the national level by deducting producer subsidy expenditures. Then, the percentage changes in the quantities imported and exported are given in the form of equation $\hat{q}_1 = \sigma(\hat{p} - \hat{p}_1) + \hat{q}.$ In this equation, the percentage changes in composite quantity and price are the percentage change in the total quantity demanded and weighed averages percentage changes in the producer price, consumer price, import price and export price using their cost share in the last year as weights, respectively. The elasticity of substitution σ = 2.2 (FAO).[12]

$$\hat{X}_{it}^{import} = \sigma(\hat{p}_{it} - \hat{p}_{it}^{import}) + \hat{q}_{it}$$

$$\hat{X}_{it}^{export} = -\sigma(\hat{p}_{it} - \hat{p}_{it}^{exp\,ort}) - \hat{q}_{it}$$

$$X^{net\ import}{}_{it} = X^{import}{}_{it} - X^{export}{}_{it}$$

$$p^{import}{}_{it} = p^{ib}{}_{it}(1 + PSE^{import}{}_{it})$$

$$p^{export}{}_{it} = p^{xb}{}_{it}(1 + PSE^{export}{}_{it})$$

$$p^{ib}{}_{it} = XR_t p^{cif}{}_{it}$$

$$p^{xb}{}_{it} = XR_t p^{fob}{}_{it}$$

Where:

X^{import}	: Import
X^{export}	: Export
$X^{net\ import}$	: Net import
XR	: Exchange rate
p^{rural}	: Rural consumer price
p^{cif}	: CIF price
p^{fob}	: FOB price
PSE	: Producer subsidy expenditure
I	: index individual grain, including rice, wheat, maize, sweet potato, potato, other coarse grains, soybeans, sugar, pork, beef, mutton, poultry, eggs and fish.

A.2.5 Market clearing

$$X^{net\ import}{}_{it} + S_{it} = D_{it} + B_{it} - B_{i(t-1)}$$

Where:

S	: total domestic production, $S = Q^S$ for crop, S = q for animal products
D	: total domestic demand
$B_t - B_{t-1}$	: stock changes
i	: index individual commodities, i.e. rice, wheat, maize, sweet potato, potato, other coarse grains, soybeans, cotton, oil crops, sugar crops, vegetables, fruit, pork, beef, mutton, poultry, eggs, fish, etc.).

A.3 Linkage with households

Household characteristics and price transmission are two critical data and parameters needed to link the results from the national model to individual households. In this study, we divide China into 11 groups of different income levels in each of three regions (eastern China, central China and western China). Household information includes per capita production and consumption of major agricultural commodities.

[12] The CIF and FOB prices are subject to changes in the prices of traded commodities in the world market that are estimated based on projections of world market prices by the World Bank.

Empirical estimates of the price transmission from the national to local and farm levels are required to transmit the changes to the national agricultural prices in each region and each group of households. Our market integration analyses showed that China's agricultural markets were highly integrated, particularly after the mid-1990s (see Chapter 3). To simplify the analyses, we assume that the price changes at the national level are largely (75 per cent) transmitted to the local levels. Of course, we should be cautious when discussing the results for the period prior to 1995.

Appendix B: Case studies – field surveys in Heilongjiang and Hubei provinces

B.1 The selection of case study sites

China has a vast territory and rice cultivation is widely spread. The rice growing area is divided into north and south. Based on the different natural conditions and rice varieties, the impacts on the two rice-growing areas under trade liberalization may be different. We selected two typical provinces, Heilongjiang and Hubei, as our case sites. Both of these provinces are important rice production regions in China. Heilongjiang is the largest rice production province in the north, and the main province producing polished japonica rice for export. Hubei, which lies in the middle reaches of Yangtze River Valley, is a traditional indica rice production region.

B.2 Background of the case sites

B.2.1 Rice production in Heilongjiang province

Heilongjiang lies in cold rice growing regions at high latitude; it is also one of the highest latitudinal rice growing regions in the world. The special climatic conditions (i.e. wide temperature differences, simultaneity of rain and heat) make this area suitable for single-season rice cultivation.
The soil here is fertile and seldom suffers from pests, thus providing the conditions for growing high-quality rice. This province is one of the main ecological regions in China for growing green and high-quality rice.

Early in 1895, rice cultivation started in Wuchang and Ning'an counties in the south of Heilongjiang province. In 1948, new rice-related farm technology was developed and generalized, thereby considerably increasing yields. Thereafter, rice production in the whole province moved into a fast development phase, gradually spreading to other areas in the province. Paddy fields can be found from eastern counties such as Hulin in the Wusuli River basin to western counties such as Tailai in the Nunjiang River basin, and from southern counties such as Wuchang in the Lalin and Suifen River basin to northern counties such as Heihe in the Heilongjiang River basin, as well as in central areas of the Songhuajiang and Mudanjiang River basins. By 2002 the rice growing area was 15 times larger than in 1949, and yields per unit area increased five-fold over the same period. Heilongjiang province developed gradually to become one of the biggest rice producing provinces in north China. In 2002, the province's rice growing area accounted for 40 per cent of the overall north rice-growing region.

B.2.2 Rice market in Heilongjiang province

Although Heilongjiang's rice history is short, its special ecological environment makes it a major high quality japonica rice production province. Since the mid-1980s, it not only realized rice self-sufficiency but also started to sell rice to other southern provinces and cities. In recent years, rice produced in the north-east, especially in Heilongjiang, has been evaluated highly, both domestically and abroad. The share of Heilongjiang rice in the international market is also gradually expanding.

Presently, annual rice production in Heilongjiang province is about 10 million tons of paddy, equivalent to 7 million tons of polished rice. Out of the total polished rice production, farmers themselves consume less than 2 million tons. The remaining 5 million tons (71.4 per cent of total production) is sold on the market, including only about 1 million tons on markets within the province where rice accounts for less than one quarter of the staple food consumption of the residents, and 4 million tons on markets outside the province.

Heilongjiang and Liaoning provinces are the primary polished japonica rice export provinces. Rice produced in these provinces is mainly exported to countries in East and South Asia such as Japan, South Korea, etc. The United States and Australia are the main competitors, although in terms of production costs, China's comparative advantage is more obvious.

B.2.3 Rice production in Hubei province

Hubei, with its subtropical monsoon climate, distinct four seasons and heavy rainfall, is the agricultural transition zone between temperate and subtropical regions. It bears the virtues of both the north and south concurrently. Crops, especially rice, can grow throughout the year. The rice cultivation system includes both single harvest rice and double-harvest rice, and variety types include indica, japonica and glutinous rice.

There is a long history of rice cultivation in Hubei province. Since the Shang and Zhou Dynasty rice production has been abundant, and now paddy fields can be seen everywhere throughout the province. In the 1970s, the rice growing area reached 46.466 million mu (1 ha = 15 mu). In 1980s and 1990s, the growing area remained at about 39 million mu and accounted for 50 per cent of the grain production area in the province. Total production was about 150 million tons, accounting for 70 per cent of the province's total grain output. This made Hubei the fifth largest rice production province in China. Each year the province produces 9 million tons of grain, of which 5 million tons are sold on markets outside the province. The province thus makes an important contribution to national grain security. Since 1997, because of structural adjustments and the problem of overstocking, both the rice growing area and gross production have decreased, but the province still plays an important role in national rice production.

B.2.4 Rice market in Hubei province

Rice production is always sufficiently abundant to ensure autarky. During the planned economy period indica rice was sold in the south and polished japonica rice was sold in the north. More than 9 million tons of grain were provided annually, a large proportion of which was sold outside the province, making Hubei one of the largest rice providers of all provinces. Since the 1990s, however, with improvements in national grain production capacity and living standards, the problem of the poor quality of Hubei rice has become increasingly obvious. With strong market competition, the lack of a high-quality variety has decreased the province's share in international and domestic markets.

One and a half million tons of rice is transported outside Hubei province annually, of which a small amount is exported abroad. The domestic market of Hubei rice is mainly the south-east coastal zone (Guangdong, Guangxi, Fujian, etc.) where sales account for over 80 per cent of the total volume of sales outside the province. In recent years, because of its limited output of high quality indica rice, Hubei's market has gradually been occupied by rice imported from circumjacent provinces and Thailand. Hubei rice has begun to be sold in Yunan and Guizhou provinces, and is still being exported to Africa and North Korea, but rice exported to these regions and countries is of medium to low quality. A small amount of high quality indica rice is exported to Middle East countries.

Polished japonica rice is mainly sold to markets such as Shanghai. In recent years, under the impact of the domestic high-quality north-eastern rice, Hubei's northern japonica rice market is also gradually being lost and the late japonica rice growing area has been sharply reduced. The glutinous rice is sold to breweries in Sichuan and Zhejiang.

B.3 Path analysis of the impacts of China's WTO accession on the rice sector

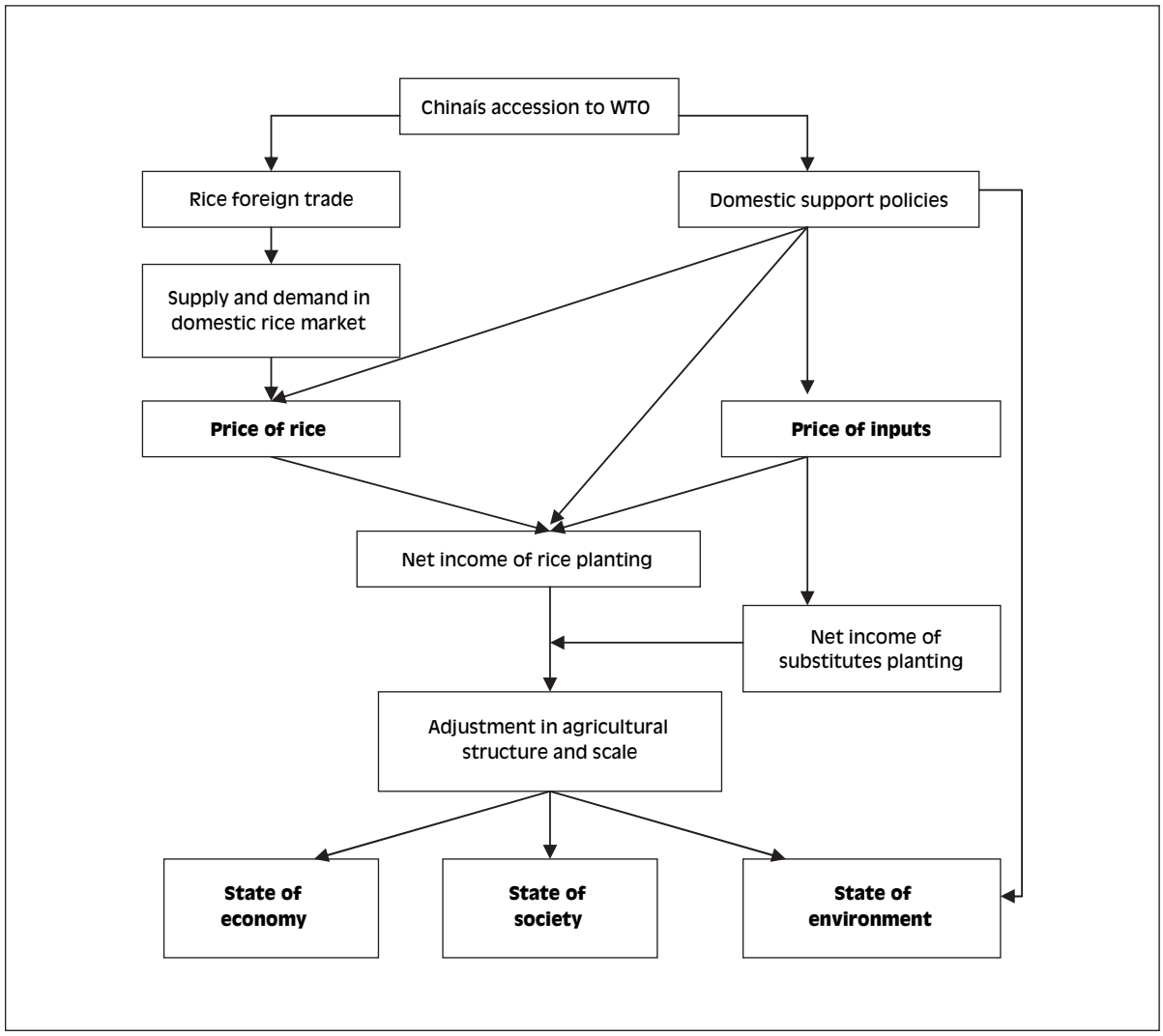
We interviewed local experts and bureaucrats at the national, provincial and county levels, and carried out sample investigations in 40-50 households in Qing'an county of Heilongjiang province and in Shayang county of Hubei province. The investigation allowed us to better understand how trade liberalization would impact rice-related social, economic and environmental conditions and estimate the magnitude of that impact.

On the basis of the investigation, we have identified two paths of trade liberalization impacts on the rice sector.

One path is that changes in rice imports and exports resulting from trade liberalization may influence the domestic rice market, which may further affect the rice sector. The other path is that the adjustment of domestic support policies under the WTO rules may influence the rice sector directly and indirectly. These adjustments mainly concern subsidy-related or tax-related policies and interventions on input and output prices in rice production.

These trade liberalization impacts on the rice sector may bring about corresponding changes in the state of the economy, society and the environment. The approach of the analysis is presented hereafter.

Appendix Figure 3: Path analysis of the impacts of China's WTO accession



Appendix Table 1: Rice imports and exports of Heilongjiang and Hubei provinces

		Year:	1999	2000	2001	2002	2003
Heilong-jiang	Rice imports (t)		0	0	0	0	0
	Rice exports (t)		202896	268806.7	93945	241370	0
	Rate of net rice export increase (%)			32.5	-65.1	157	-100
Hubei	Rice imports (t)		5398	3092.8	3077	1994	
	Rice exports (t)		159686	180760	171053	80410	
	Rate of net rice export increase (%)			15.2	-5.5	-53.3	

B.3.1 Impacts on rice imports and exports

According to calculations, the DRCC (Zhong, 2003) of japonica rice in Heilongjiang province is 0.78, and that of japonica and indica rice in Hubei province is 1.15 and 1.16 respectively. Theoretically, Heilongjiang japonica rice has a greater export advantage and rice exports may increase after China's WTO accession, which would incite farmers to expand rice production. Conversely, rice produced in Hubei province has a lower competitive advantage, which may act as a disincentive to rice production for farmers in Hubei. The actual state of rice imports and exports is presented in the table hereafter.

According to the rate of net rice export increases in recent years, we can see that rice foreign trade did not change to the extent that it conformed to the comparative advantage, i.e. the impacts of trade liberalization on rice imports and exports is not notable. The reasons may be as follows.

Firstly, in a country with such a large population as China, rice constitutes an important agricultural product in terms of food security. This means that foreign trade of rice could not undergo complete liberalization immediately after China's WTO accession. Heilongjiang and Hubei provinces are the country's main rice supply provinces. On the basis of grain shortage in recent years, especially in 2003, foreign trade of rice is determined more by domestic policies than by the international market in order to guarantee food safety.

Secondly, although Heilongjiang and Hubei provinces are the main rice export provinces in China, the total amount of rice exports represents less than 3 per cent of domestic production. Therefore, even if trade liberalization can have obvious impacts on rice imports and exports, it is difficult to reflect these influences in the domestic rice market.

B.3.2 Impacts on domestic support policies

The adjustments to China's agricultural support policies under WTO rules mainly include the enhancement of Green Box policies and structural adjustment of Amber Box policies. Although some changes may be demanded directly by China's own agricultural market reforms rather than as a result of WTO accession, we consider that WTO accession can accelerate China's own reforms as long as the policy adjustments are in accordance with the requirements of WTO rules.

These policy adjustments in the two provinces mainly include:

1. Reducing agricultural tax

The rural taxation reform has been implemented in Heilongjiang and Hubei provinces since 2002 and its main aim is to alleviate the overly heavy burden on farmers through reductions in agricultural taxes. In 2004, agricultural tax was cancelled in Heilongjiang province and the tax rate was reduced by 3 per cent in Hubei province.

The rural taxation reform began before China's accession to WTO. It can be considered as a form of direct subsidy to farmers in compliance with Green Box rules and is helpful in accelerating trade liberalization.

2. Complete opening of the grain market and implementation of a minimum acquisition price

According to the No.1 Document of Central Government, China will completely open its grain market from 2004. The Government encourages market subjects of all kinds of ownership to engage in grain business, which is helpful in promoting fair competition and de-monopolizing State involvement in grain acquisition.

The minimum acquisition price policy is implemented on important products in substitution to the protective price. If the market price is higher than the minimum acquisition price, grain will be purchased at the market price by licensed enterprises. When the market price is lower than the minimum acquisition price, appointed enterprises will purchase unlimited quantities of grain from farmers at the minimum acquisition price in order to stabilize the grain market.

3. Reducing the distribution subsidy and implementing a direct grain-production subsidy

The direct subsidy system was implemented in Heilongjiang and Hubei provinces in 2004 based on the No.1 Document of Central Government that encourages the development of grain production in the main growing regions and the increase of grain farmers' incomes by such means as cancelling subsidies on the storage costs of former state grain enterprises and transferring not less than one third of the grain risk fund as a direct subsidy to farmers for grain production.

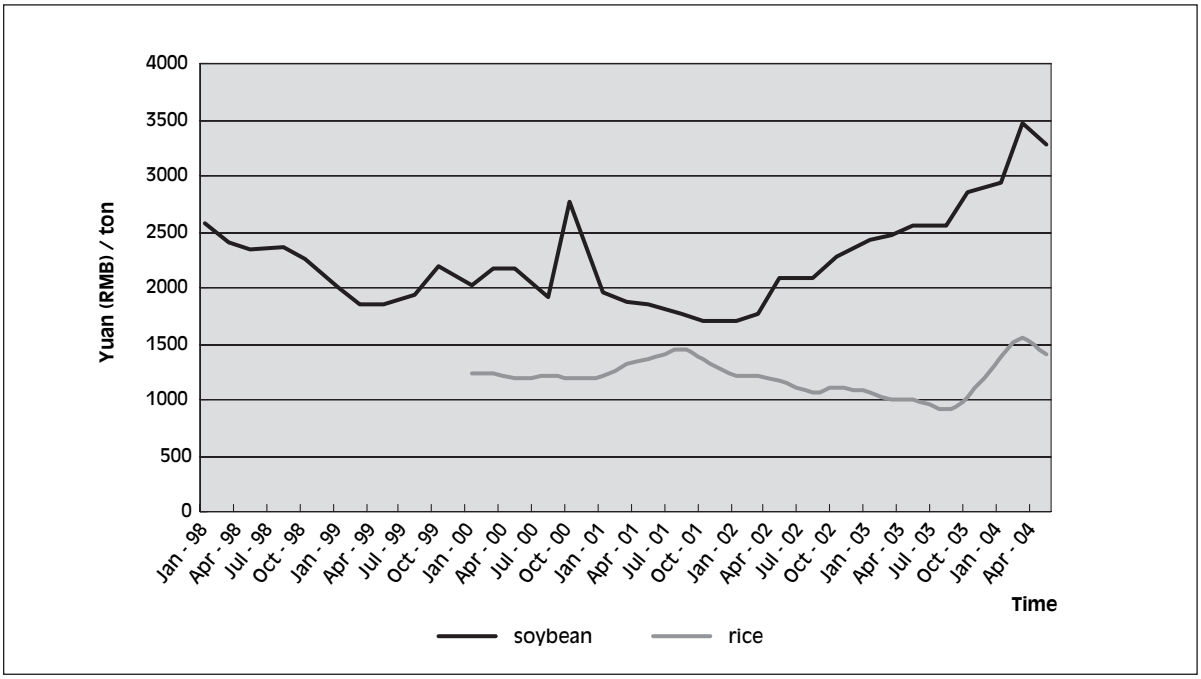
After the implementation of the direct subsidy system, farmers can obtain a subsidy of 13.64 Yuan per mu in Heilongjiang province and 10 Yuan in Hubei province, or 30 Yuan in major production areas of Hubei province.

B.4 Impact on the rice economy and rice production

B.4.1 The influences on the market price of rice

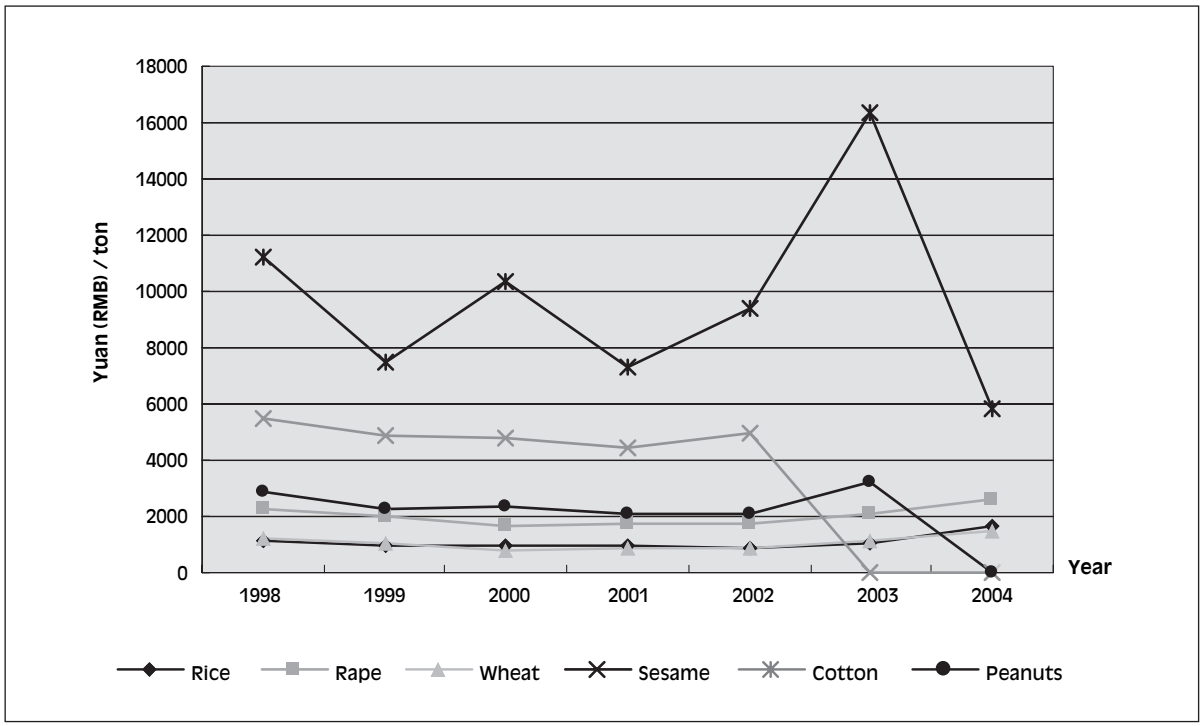
After China's accession to WTO, the price on the rice market of Heilongjiang province started to decrease; it only began to increase at the end of 2003 and beginning of 2004. The price of its substitute crop – soybeans – has been increasing. The price of rice in the Hubei market has been relatively stable; after a small decrease in the first

Appendix Figure 4: Price changes of soybeans and rice in Heilongjiang province (1998-2004)



Source: The Grain and Oil Information Center of Heilongjiang Province.

Appendix Figure 5: Price changes of main crops in Hubei province (1998-2004)



Source: Hubei Provincial Bureau of Statistics.

year after WTO accession, it began to increase during 2003 to 2004. In the area of our investigation in Hubei province, the rice variety grown is middle-season indica rice, which is rotated with rapeseed or wheat. The price change trend of these two crops was in accordance with that of rice. In Shayang county of Hubei Province, the main substitute crops for rice include sesame, cotton and peanuts. The price of cotton was the highest, and rose rapidly from 2001 to 2003. In late 2003, the price of cotton was twice as high as it was before WTO accession, but it then fell suddenly to an even lower price than before WTO accession.

B.4.2 The influences on agricultural production

B.4.2.1 Results of the site investigation

The investigations based on farmer households in Qing'an county, Heilongjiang province indicate that, after China's accession to WTO, rice and corn production costs did not change to any obvious extent and soybean production costs increased slightly. The net revenue from rice cultivation fell sharply and rose to a peak in 2003, while that of soybean and corn cultivation continued to rise steadily, except for a small fluctuation in 2002.

The costs mainly include agricultural tax and the costs of inputs such as fertilizers and pesticides. Heilongjiang province implemented the rural taxation reform for the first time in 2002. Because of the conversion of fees to taxes, agricultural tax increased in 2002. Since then, it has been falling in accordance with the lowering of the tax rate. In 2004 the agricultural tax was cancelled in Heilongjiang province and the direct subsidy system was implemented. The cost of chemical inputs for the above-mentioned crops was stable, except for a small increase in soybean production after China's accession to WTO.

As already mentioned, the price of soybeans increased after China's accession to WTO and only began to decrease slightly from April 2004. The price of rice continued to decline from the mid-1990s until 2003 when there was a shortage in domestic grain supply because of the dramatic drop

Appendix Table 2: Household survey of crop production in Qing'an county, Heilongjiang province

	1999	2000	2001	2002	2003	2004
Number of villages surveyed				16		
Number of households surveyed				50		
Background of the households						
Average population per household	4	4	4	3	4	4
Workforce per household	3	2	2	3	3	2
Crop area per capita (mu/capita)	8.14	8.18	8.22	8.16	8.20	
Population with middle school educational diploma per household	2	2	2	3	3	3
Prices of the main crops						
Rice (kg/kg)	1.26	2.29	1.34	1.15	1.00	1.48*
Soybean (kg/kg)	1.97	2.21	1.83	1.98	2.57	3.29*
Cost of agricultural inputs for the main crop						
Rice:						
Fertilizer cost (Yuan/mu)	48.15	48.24	50.32	50.19	51.51	
Pesticide cost (Yuan/mu)	10.17	10.03	11.23	11.70	10.34	
Soybean:						
Fertilizer cost (Yuan/mu)	25.03	24.57	23.86	25.37	28.26	
Pesticide cost (Yuan/mu)	6.64	7.68	7.38	7.42	7.84	
Agricultural tax (Yuan/mu)	15.01	15.08	16.80	29.82	24.65	0
Net revenue (Yuan/mu)						
Net revenue from rice (Yuan/mu)	169.83	61.26	167.55	58.35	182.21	
Net revenue from soybean (Yuan/mu)	65.48	71.73	52.64	104.69	150.35	
Planting structure						
Increase rate of the crop growing area (%)		0.73	0.88	-0.12	0.23	0.2*
Increase rate of the rice growing area (%)		-0.56	-1.79	-0.36	-17.6	37.5*
Increase rate of the soybean growing area (%)		33.2	0.20	-8.47	19.2	4.72*
Increase rate of the corn growing area (%)		-32.1	17.1	6.02	-10.0	6.35*
Proportion of rice area to total crop area (%)	24.35	24.77	23.32	23.72	19.53	24.10*
Proportion of soybean area to total crop area (%)	32.47	44.24	42.49	39.71	47.31	44.44*
Proportion of corn area to total crop area (%)	39.94	27.78	31.20	33.77	31.23	28.96*
Proportion of other crops area to total crop area (%)	3.24	3.21	3.09	2.80	1.93	2.50*

** Author predicted values*

in rice production in 2002. In 2004, rice cultivation expanded by 37.5 per cent under the grain production support policies.

According to the results of investigations carried out in Shayang county, Hubei province, the net revenue from rice and its rotating crops did not change to any obvious extent, but that of its substitute crop, cotton, rose sharply. In 2003, the cotton growing area expanded by 24 per cent while the growing areas of other main crops, including rice, shrank. From late 2003, the price of cotton fell dramatically, but the price of other crops rose, which resulted in some of the lands previously used to grow cotton being used to grow other crops, especially rice, under the grain support policies in 2004.

B.4.2.2 Primary conclusions

Through the analysis of the investigation results from the two counties, we draw two primary conclusions.

Firstly, fluctuations in rice cultivation in the two case study counties mainly depend on grain support policies and the state of domestic grain storage, rather than comparative advantage. In other words, the influences of trade liberalization on rice production depend more on the adjustments in domestic support policies than the direct change in imports and exports resulting from trade liberalization since, as mentioned before, the latter will not exert obvious impacts on domestic rice production for two reasons. On the one hand, changes in rice foreign trade cannot reflect the

Appendix Table 3: Survey of crop production in Shayang county, Hubei province

	1999	2000	2001	2002	2003	2004
Number of villages surveyed				26		
Number of households surveyed				50		
Background of the households						
Average population per household	4	4	3	4	4	4
Workforce per household	2	2	2	3	3	2
Corp area per capita (mu/capita)	2.5	2.3	2.5	2.4	2.3	2.4
Average population per household	2	2	2	3	3	3
Prices of the main crops						
Middle-season indica rice	42.26	47.43	47.85	45.1	53.6	80.5
Rapeseeds	101.57	80.93	85.73	85	105.23	131
Wheat	53.15	37.81	44.59	42.5	58.07	75
Gingili	244.95	238.17	223.64	246.3		
Cotton	371.83	517.54	367.21	469.4	817.22	289.5
Peanuts	111.92	115.27	103.95	106.4	159.78	
Cost of agricultural inputs of the main crop						
Rotate middle-season indica rice with rapeseeds:						
Fertilizer cost (Yuan/mu)	90.21	88.91	94.35	95.67	97.17	
Pesticide cost (Yuan/mu)	15.37	18.85	20.12	19.42	22.02	
Rotate middle-season indica rice with wheat?						
Fertilizer cost (Yuan/mu)	85.1	84.83	90.89	98.62	89.99	
Pesticide cost (Yuan/mu)	13.11	18.49	20.43	20.43	22.1	
Gingili						
Fertilizer cost (Yuan/mu)	24.00	22.37				
Pesticide cost (Yuan/mu)	4.10	4.13				
Cotton						
Fertilizer cost (Yuan/mu)	92.72	82.44	102.89	82.98	103.90	
Pesticide cost (Yuan/mu)	42.70	45.04	53.74	45.76	54.93	
Peanuts						
Fertilizer cost (Yuan/mu)	28.27	19.48	38.75	35.88	34.82	
Pesticide cost (Yuan/mu)	3.36	3.56	3.0	3.23	2.50	
Agricultural tax (Yuan/mu)	19.24	20.79	51.02	36.91	39.47	
Net revenue (Yuan/mu)						
Middle-season indica rice	-13.19	50.16	133.10	139.84	138.41	
Rapeseeds	-146.44	-114.08	-75.04	-62.91	-13.79	
Wheat	-145.22	-73.74	-75.95	-87.09	-74.53	
Gingili	99.43	89.00				
Cotton	-192.60	42.77	-2.21	192.33	594.72	
Peanuts	49.87	63.19	201.5	293.91	206.61	
The planting structure						
Increase rate of the entire crop growing area (%)	- 4.58	5.91	3.26	3.93	-3.81	2.0
Increase rate of middle-season indica rice growing area (%)		1.3	2.4	1.57	- 4.22	17.11
Increase rate of gingili growing area (%)	11.90	13.13	-9.66	6.89	-10.71	2.4
Increase rate of cotton growing area (%)	- 27.78	2.37	8.99	-17.41	24.00	-18.00
Increase rate of peanut growing area (%)	18.43	34.44	8.60	-1.95	- 2.39	- 4.02
Proportion of rotating middle-season indica rice with rapeseed (%)	33.16	26.40	36.23	39.50	39.26	39.82
The proportion of rotating middle-season indica rice with wheat (%)	31.75	35.11	24.43	24.16	20.73	24.23
Proportion of gingili area to total crop area (%)	7.64	8.20	7.18	7.14	7.09	6.92
Proportion of cotton area to total crop area (%)	17.66	18.15	19.15	14.76	20.31	17.88
Proportion of peanut area to total crop area (%)	8.64	10.03	11.61	7.14	11.41	10.89
Proportion of other crops area to total crop area (%)	1.15	2.11	1.6	3.1	7.09	4.3

effect of trade liberalization because of the importance of rice to national food security. On the other hand, the scale of China's rice foreign trade is very small in relation to domestic output, and this determines the minimal impact of changes in rice foreign trade on the domestic grain market. Adjustments of agricultural support policies, such as the implementation of the grain production

Appendix Table 4: Survey of farmers' income in Qing'an and Shayang counties

		2000	2001	2002	2003	2004
Households in Qing'an county, Heilongjiang province	Rural per capita net income (Yuan)		2501	2625	2814	
	Increase rate of per capita net income (%)		3.6	5.0	7.2	
	Contribution factors:					
	Variation of rice price (%)	81.75	-41.48	-14.18	-15.00	48.00
	Variation of the other crops' price (%)	12.18	-17.19	8.20	29.80	28.02
	Variation of fertilizer cost (%)	-2.43	2.90	1.47	3.89	
	Variation of pesticide cost (%)	2.86	4.87	3.36	-4.83	
	Variation of farmers' burden (%)	0.47	11.41	-22.4	-17.34	
Households in Shayang county, Hubei province	Rural per capita net income (Yuan)	2989	2999	2960	3644	
	Increase rate of per capita net income (%)		0.33	-1.30	23.1	
	Contribution factors:					
	Variation of rice price (%)	12.23	0.89	-5.75	18.85	50.19
	Variation of the other crops' price (%)	12.03	-16.63	15.09	50.10	-42.06
	Variation of fertilizer cost (%)	-8.16	28.88	-3.90	6.50	
	Variation of pesticide cost (%)	18.4	28.23	-7.79	14.35	
	Variation of farmers' burden (%)	8.06	57.31	-32.9	-43.7	

subsidy and the reduction of agricultural tax, will modify the net revenue from rice cultivation and exert obvious impacts on rice production.

Secondly, in the same policy and market circumstances, the different impacts among provinces are mainly due to the comparative advantage of rice production. Theoretically, the comparative advantage of rice cultivation is greater in Heilongjiang than in Hubei, so rice production will benefit more from trade liberalization in Heilongjiang than in Hubei. By comparing the rate of increase of the rice growing area in Qing'an county with that in Shayang county, we can see that the site investigation results also support the above conclusion. In 2003, the rice area shrank in Qing'an county, however the rate of decrease was lower than before China's accession to WTO. Conversely, although the rice growing area expanded in Shayang county, the rate of increase was lower than before China's accession to WTO. In 2004, with a similar background of support policies and demand in the domestic market, the rice growing area in both counties increased substantially, but at different rates. The increase rate in Qing'an county is 37.5 per cent, which is 17.11 per cent higher than in Shayang county.

B.5 Impact on farmers' incomes

Changes in farmers' incomes in Qing'an depend more on the revenue from dry land crops rather than rice because the paddy area is relatively small compared to dry land in Heilongjiang province. Besides, the rural taxation reform and implementation of the direct subsidy are also helpful in increasing farmers' incomes. Conversely, in Shayang the revenue from rice mainly determines changes in income. Even if the changes in other factors are all helpful in increasing income, the low price of rice can reduce the total net income (see household income in 2002, Appendix Table 4).

B.6 Impact on the ecology and the environment

B.6.1 The influences on chemical inputs

The use of chemical inputs per unit area is stable according to the household survey. The impacts of input and output price fluctuations on the use of chemical inputs per unit area are slight, so the total change in chemical input use is mostly caused by changes in the crop area.

Appendix Table 5: Change in fertilizer use in surveyed households

		Fertilizer use per unit area (kg/mu)	Change in fertilizer use (kg)			
			2000	2001	2002	2003
Households surveyed in Qing'an county, Heilongjiang province	Rice	17.80	-39.5	-126.3	-25.0	-1219.0
	Soybeans	9.10	1597.2	12.8	-542.7	1126.4
	Corn	15.15	-3162.3	1143.1	471.5	-83.4
	Total		-1604.6	1029.6	-96.2	-176.0
Households surveyed in Shayang county, Hubei province	Rotating middle-season indica rice with rapeseed	36.90	-959.4	2151.6	973.0	-366.1
	Rotating middle-season indica rice with rapeseed	37.15	1009.6	-1944.4	138.0	-857.2
	Gingili	22.5	117.5	-93.6	29.6	-40.9
	Cotton	34.05	71.3	276.7	-584.0	664.9
	Peanuts	14.15	210.5	70.7	-17.4	-21.0
	Total		449.5	411.0	539.2	-620.3

Appendix Table 6: Change in pesticide use in surveyed households

		Pesticide use per unit area (kg/mu)	Change in pesticide use (kg)			
			2000	2001	2002	2003
Households surveyed in Qing'an county, Heilongjiang province	Rice	0.21	-0.47	-1.49	-0.29	-14.38
	Soybeans	0.14	24.57	0.20	-8.35	25.98
	Corn	0.09	-18.78	6.79	2.80	-0.49
	Total		-5.32	5.50	-5.84	11.11
Households surveyed in Shayang county, Hubei province	Rotating middle-season indica rice with rapeseed	3.3	-85.80	192.42	87.02	-32.74
	Rotating middle-season indica rice with rapeseed	1.59	43.21	-83.22	5.91	-36.69
	Gingili	1.13	5.90	-4.70	1.49	-2.05
	Cotton	9.17	19.20	74.52	-157.28	179.06
	Peanuts	0.72	10.71	3.60	-0.89	-1.07
	Total		-6.78	182.62	-63.75	106.51

B.6.2 Optimisation of the rice industry structure is helpful in improving the environment

The problem of low quality rice has restricted the development of Hubei's rice economy. Since the early 1990s, Hubei Province has begun to focus on the development of high quality rice. With the opening of the rice market, increasingly intensive competition required better quality rice, which accelerated the optimisation of rice and grain production.

In 1999, the Hubei Provincial Government put into action the "high-quality rice" project. After three years, 30 per cent of rice production in Hubei province reached the high quality level according to national standards. Since the MOA implemented the clean food plan in 2002, the whole province has accelerated the development of clean rice and green rice production. Ecological farmland has been established in 15 counties where the construction of "paddy/duck" and "paddy/fish" systems has become popular. According to data provided by the Green Food Office of the Hubei Provincial Government, 17 enterprises applied for the "Green Food Label". The number increased to 20 in 2002 and 55 in 2003, one third of which in 2003 were enterprises applying for green rice.

Owing to suitable natural resources and special climatic conditions, the soil in Heilongjiang province is fertile and seldom suffers from pests, and thus the conditions are favourable for the cultivation of high quality rice. Heilongjiang province is one of the main "green rice" production regions in China.

Qing'an county is a national green food production base. Since 1993, there have been 22 green food product varieties, among which are five varieties of green rice, including the QiheYuan Brand, Jinqiu Brand, Qingxin Brand and Lvzhou Brand. The area used for green food production has covered 0.9 million mu, including 0.5 million mu for rice, 0.23 million mu for soybeans, 0.1 million mu for corn and 0.07 million mu for other crops. The Green Food Bases that have reached the national standard cover an area of 0.3066 million mu, including 0.15 million mu for rice paddy, 0.06 million mu for soybeans, 0.06 million mu for corn, 0.03 million mu for broomcorn and 6.6 thousand mu for vegetables.

Acceleration of the optimisation of rice production and the development of green production under trade liberalization are helpful in improving the quality of the environment.

B.6.3 Influences of local financial deficiency on the ecological construction

The State-initiated environmental protection projects require local Governments to provide a certain amount of funds. However, this cannot always be realized because of local financial deficiencies. Local bureaucracies always act as the organizers in project implementation. After China's accession to the WTO, adjustments to agricultural policies, such as the reform of rural taxation, will further worsen the financial problem, which will add difficulties to the implementation of these projects.

According to the statistical data on Shayang County, in 2001 the total fiscal income of 13 towns was 132.77 million Yuan, and the total fiscal budget was 90.26 million Yuan. Agricultural expenditure was 4.01 million Yuan, representing just 4.4 per cent of the total expenditure. After the reform of rural taxation, the total fiscal income was 86.12 million Yuan in 2002, i.e. only 65 per cent of that in 2001. The fiscal expenditure was 47.27 million Yuan, out of which agricultural expenditure was 7.07 million Yuan, which represents an increase of 76.3 per cent compared to the previous year. The proportion of agricultural expenditure in relation to the total financial expenditure rose to 15 per cent, while the fiscal budget used for other purposes was sharply reduced. In our investigation, there are difficulties even in determining the wages of management, which will undoubtedly curtail the ability to organize the implementation of ecological construction.

Appendix C: The research team

Name	Expertise and position in the project	Institution
Tu Ruihe	Project Manager	Dept of International Cooperation, SEPA
Hu Tao	Project Coordinator and Team Leader of Chinese team	PRCEE, SEPA
Huang Jikun	Agricultural Policy and Economics; Team Leader of CCAP team	Center for Chinese Agricultural Policy, CAS
Mao Xianqiang	Environmental Economics and Environmental Science; Team Leader of BNU team	Beijing Normal University School of Environment,
Guo Dongmei	Environmental Economics and Policy Analysis Assistant to Project Coordinator	PRCEE, SEPA
Xu Zhigang	Agricultural Policy and Economics; Team Member	Center for Chinese Agricultural Policy, CAS
Scott Rozelle	Agricultural Policy and Economics; Team Member	Dept. of Agri. and Resource Economics, University of California, Davis
Li Ninghui	Economics; Team Member	Institute of Agricultural Economics, Chinese Academy of Agri. Sciences
Zhang Lingyun	Environmental Economics and Environmental Sciences; Team Member	School of Environment, Beijing Normal University
Tu Yingyan	Environmental Economics and Environmental Sciences; Team Member	School of Environment, Beijing Normal University
Xiao Yang	Geographical Information System (GIS) and Environmental Sciences; Team Member	School of Environment, Beijing Normal University
Zhang Sheng	Environmental Economics and Environmental Sciences; Team Member	Department of Environmental Protection Enforcement & Inspection, SEPA
Dong Wenguang	Agricultural Environment Protection; Team Member	Beijing Station of Agricultural Environmental Monitoring
Li Xianqiang	Environmental Management; Team Member	Beijing Institute of Petrochemical Technology