China's food economy in the early 21st Century

Development of China's food economy and its impact on global trade and on the EU

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Development of Chinese food economy and Chinese agricultural policies. Simulations of future developments in China and in global trade with a model for the Chinese food economy and a model for global trade analysis. Simulation of developments in a 'business as usual' scenario. Assesment of impacts of WTO accession and phasing out of multi fiber agreement. Simulation of possible impacts of the WTO-Doha round. Simulation of impacts of Chinese 'green box' policies on Chinese food economy. Simulation of impacts of application of GM products in Chinese agriculture for the Chinese economy and global trade. Analysis of trade between China and the Netherlands and foreign direct investment in China.

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Preface

The sheer size of China's economy, its rapid growth and its increasing integration into the global economy will make China a crucial player on the world markets for agricultural products. Small adjustments in China's agricultural supply and demand will have significant implications on world agricultural trade and on its trading partners, including the EU countries. This makes China's long-term agricultural development an issue of both national and international significance.

This report aims to provide a better understanding of China's growing economy and the implications for China's food demand, supply and trade as well as for the global food economy, and to explore agribusiness trade and FDI (Foreign Direct Investments) opportunities between China and EU countries, the Netherlands in particular. Issues covered are the development of the Chinese food economy and of Chinese agricultural policies, impacts of China's accession to the WTO and the phasing out of the Multi Fiber Agreement, the impacts of policy proposals of major participants in the WTO-Doha round, impacts of Chinese green policies, economic perspectives of biotechnology in China, and trade and investment opportunities

This report is the result of a cooperation of the Center for Chinese Agricultural Policy (CCAP) of the Chinese Academy of Sciences (CAS) and the Agricultural Economics Research Institute (LEI) of Wageningen University and Research Center (WUR). The study is carried out by a project group that consisted of Dr. Jikun Huang (CCAP), Dr. Ninghui Li (Institute of Agricultural Economics (IAE) of the Chinese Academy of Agricultural Sciences (CAAS), Dr. Frank van Tongeren, Dr. Hans van Meijl, Dr. Xiaoyong Zhang and Jaap Post (all LEI). Paul Veenendaal (LEI) participated in an earlier stage in the project group. The team has also benefited from inputs by Scott Rozelle (UC Davis, USA). The project was financed by the Dutch Ministry of Agriculture, Nature management and Food safety (MLNV), by IAE (CAAS) with contributions from the Chinese Government.

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Summary

Introduction

Contrary to some expectations, China has hitherto succeeded in feeding its population with its limited resources. More than twenty percent of world population is living in China while its share in arable land is less than ten percent. The performance of China's agriculture is impressive in the light of a growing population and high-income growth rates. Both developments result in an enormous growth in food demand. However, will China also be able to feed its population in the future? There are some good reasons to pose this question. China's population will grow from almost 1.3 billion people to about 1.5 billion people in 2030. Increasing income per capita and continued urbanization imply a considerable increase in the demand for food per head, in particular as a consequence of the rising consumption of meat. In addition, China faces a number of supply-side issues, as agriculture has to compete with other sectors for scarce natural resources.

The question mentioned above is not only of importance for China's population and its political leaders but also for the rest of the world. Since the start of the economic reform in 1978 China is gradually opening its windows to the world. The accession of China to the WTO in November 2002 is an important milestone in this development. Being a member of the WTO, China will benefit from further liberalization of world markets by getting more export opportunities and offering better access to the Chinese market. A next step in further liberalization is foreseen as result of the Doha-round of trade negotiations. In a liberalized world, shortages in food supply in China can have disrupting effects on world markets and consequently on the food economy of other countries.

This study aims to provide some answers on the question if China can feed its population in the period 2001-2020 and to which extent it will participate in world trade. Particular attention is paid to effects on the trade of the European Union.

In the first part of the study a picture is sketched of the developments of Chinese agriculture and of the policy changes since 1978. Next, the results of a so-called baseline are presented. This baseline describes the development of the Chinese food economy and its impact on world markets until 2020 under the assumption that no policy changes will take place. In the baseline attention is paid to the effects of the accession of China to the WTO and the phasing out of the Multi Fiber Agreement. The second part analyses the impact of assumed policy changes. This involves both external as well as internal policy changes. The external changes are studied by means of scenarios for the Doha-round of trade negotiations in the framework of the WTO. The internal changes are studied by assumptions for the Chinese agricultural policies with regard to 'green box' policies. In particular attention will be paid to the national and international impact of the development of biotechnology in China.

Two models are used for the analysis: the Global Trade Analysis Project (GTAP) and the Chinese Agricultural Projection Simulation Model (CAPSiM). The first model is a general equilibrium model that is adapted for this study. The second is a partial equilibrium model for the Chinese agricultural sector making use of an adjusted set of data.

China's food economy and its agricultural policies in the past 25 years

Food demand in China increased during the last decades by strong economic growth and further increase in population. Nevertheless China succeeded in improving food security. The annual growth rate of agricultural production was about four times higher than annual population growth in the past 25 years. Per capita food availability rose from 2300 kcal per day in 1980 to more than 3000 kcal per day in the late 1990s. In particular the intake of protein and fat rose considerably. The share of animal products rose from 4% in the sixties to 19% in the late nineties. After decollectivisation access to food was primarily defined through access to land, nowadays real income is a decisive factor. The degree of market integration still growing. China even became a net exporter of food products, in particular of labor-intensive products as horticultural products and animal products (including aquatic products). The export of agricultural and food products increased threefold in the period 1985-2000. Soybean became an important import product.

Policy changes delivered an important contribution to this development. The introduction of the household responsibility system (HRS), which granted every rural household a piece of agricultural land, delivered an important contribution in the improvement of the efficiency of agriculture in the early 1980s. A next contribution followed by the liberalization of input markets as for respectively machinery, fertilizers and pesticides. The liberalization of the seed market is still in progress. Agricultural product markets are to a large extent liberalized. The biggest government intervention occurred in the grain market. Agriculture was implicitly taxed by grain policies, and the transfer of surplus has contributed to the development of the industry and of the urban area. Nowadays the procurement quota for grains, by which agriculture has to deliver part of the harvest many years against low prices, is abolished. The policies to stimulate the development of rural enterprises have promoted rural employment and increased rural income. The share of farmers involved in off-farm employment increased from 15% in 1980 to more than 40% in 2000. The reforms in policy for agricultural technology delivered also an important contribution to agricultural development and in particular to the increase of yields.

The exchange rate policies improved the international terms of trade for the agricultural sector. In addition, in the pre-accession period of the WTO, China relaxed access to import and export markets. After the accession to the WTO the AMS (aggregate measurement of support) will decrease to less than 8.5% of agricultural output value. A trade quota system exists only for grains, edible oils, cotton sugar and wool.

Model instruments to gain better understanding of China's future food economy.

Two model instruments are used in this study: the Global trade Analysis Project (GTAP) and the Chinese Agricultural Policy Simulation Model (CAPSiM). The standard GTAP model is a multi-region, computable static general equilibrium model, with perfect competition and constant returns to scale. Each single region is modeled along relatively standard lines of multi-sector AGE models. Important assumptions are perfect competition on factor markets and output markets. This kind of models does not necessarily attempt to capture all detail but are flexible to allow elaborations in face of specific policy questions. The standard GTAP model is adapted in this study to be able to analyze the questions that are central in this study.

The China Agricultural Policy Simulation Model (CAPSiM) is a partial equilibrium model for the agricultural sector. CAPSiM is a comprehensive model for China's food demand, supply and trade analysis. The model explicitly accounts for urbanization and market development, technology, agricultural investment, environmental trends and competition for labor and land use, as well as the price responses of both demand and supply. The model can be used both for policy simulation and projection over time for key agricultural variables in response to exogenous shocks. The major components of CAPSiM include the modules for production, consumption specified separately for rural and urban consumers, stocks changes, trade and market clearing for 20 commodity (groups) that account for 90% of China's agriculture.

Models and data problems
The reliability of the outcomes of the models not only depends on the characteristics of the models and the linkage between the models but also to a large extent on the data used in the models. It is demonstrated that China's livestock supply and demand statistics are not consistent with even the most basic criteria: supply does not equal demand and the implied derived demand for feed does not equal the supply of feed. To overcome this problem a number of data sources are used to create new supply and demand series. Demand is corrected upward to make up for three omissions in the data and supply is corrected downward. The changes, which are all carefully documented, narrow the gap for all livestock products. Since livestock makes up 30 percent of agricultural GDP (AGDP), and since the growth rate of livestock was overstated by 37 percent, the reported growth rate of AGDP between 1987 and 1999 would have to be lowered by 1 percentage point to 3 percent annually. GDP growth would have to be lowered by 0.11 percent. The adjusted supply and demand series meet the criteria mentioned above. A decomposition analysis shows that the single largest source of the discrepancy was the adjustment to account for the out-of-home consumption that the survey of the National Statistical Bureau of China (CNSB) failed to include. Making corrections to China's livestock statistics, however, may not be the end of the story. Li and Liu (2002) show that fishery statistics are subject to similar statistical problems. Zheng (2001) says that township and village enterprise output and employment statistics were overstated. All of these would support the recent findings by Rawski (2001) that China's overall growth data are overestimated.

China's agricultural development and impact of Green policies
Over the last four decades, per capita availability of food, household food security, and nutrition all have improved significantly. Increased domestic production is almost solely responsible for increased per capita food availability and significantly contributes to poverty alleviation and farmers' income.

China's experience demonstrates the importance of technological development, institutional change, price and market liberalization, rural economic development and other conducive policies in improving agricultural productivity, farmer income, and food security in a nation with limited land and other natural resources. Among various factors, technology has been one of major driving forces of productivity growth and the engine of China's agricultural economy development. New technologies contributed over half of the increase in rice yields between 1975 and 1990. More than 50 percent of the growth of grain production and nearly 40 percent of the growth of the output of cash crops between 1978 and 1992 can be associated with research expenditures.

However, the expenditures for agricultural research are relatively low. The agricultural research intensity is much lower than that of the developed countries.

A baseline projection with CAPSiM for the period 2001-2020 shows that the self-sufficiency rate for grain will remain as high as 90 percent. Only for feed grains, such as maize, the self-sufficiency level will fall below 75 percent in the long run. In the non-grain crop sector the imports of soybean, edible oils, sugar and cotton will increase. In the livestock sector the annual growth rates of pork and poultry will exceed demand. Pork, poultry and fish will be important export products.

The development of production, demand and self-sufficiency rates depend on many factors. As mentioned above, one of these factors is investment in agricultural research. Two scenarios show this. One with an increase of investment in agricultural research of 2 percent and another with an increase of 7 percent per year throughout the projection period. Under the high research investment scenario the self-sufficiency rate for grain will rise from 90 percent in 2002 to 95 percent. In the low growth scenario the self-sufficiency rate for grains will drop to 84 percent and for maize even to 65 percent. The impacts on the other crops are also substantial.

The expansion of production in the past is partly gains arising from the mobilization of inputs. However, for the future China's agriculture can rely less on inputs for a further increase in production. Furthermore, decollectivization and fiscal reform have already been tapped for most of their gains. However, improved technology has been the largest factor, by far, behind agricultural production growth, and as such is a major source of increased food availability in China. Based on the results of this study and the experience in the rest of the world, if China wants its agriculture to continuously supply sufficient food for the growing population with rising income and under trade liberalization, China has to increase its agricultural research investment. The current agricultural research investment intensity (0.44%) can be characterized as low.

Future development of China's food economy and implications to Global Trade

In this study a GTAP model simulation is made of the developments in the periods 2001-2005, 2005-2010 and 2010-2020 to analyze China's capacity to feed itself in the future and its relation with the world market. The most important assumption for this simulation, the so-called baseline, is that during this period policy changes in the past will be fully implemented but that no new policy changes will take place. In this baseline we distinguish the effects of the accession of China to the WTO, the phasing out of the Multi Fiber Agreement (MFA) and the enlargement of the EU with 10 new member states.

The projection for 2000-2005 shows an important growth of the output of labor-intensive products as fish, meat and horticultural products. The growth figures of the land intensive products as grains are much lower. Also the processed food industry is a strong growth sector. Outside the agricultural sector the labor-intensive manufacturing sectors are fast growing, in particular the textiles and garments industries. Backward linkages also allow the cotton output to grow steeply in the wake of the impressive growth rates of textiles. The accession of the WTO has only a limited effect on this development, most important is the negative effect on the production of some land intensive products and a positive effect on the production of the food industry. The phasing out of the Multi Fiber Agreement boosts the production of the textile industry and that of cotton.

Imports of all groups of products will increase with more than twenty percent in the period 2001-2005, except for the products of the labor-intensive industry. For most products there exist a close relation with the accession of China to the WTO and to a lesser extent with the phasing out of the MFA.

We expect China's exports to decrease in land intensive products as wheat, coarse grains and cotton. On the other hand we expect ring exports of horticultural products, fish, products of the food industry. Besides the labor-intensive industries, and in particular textiles, will show a big increase in exports. These changes have only partly to do with the accession of China to the WTO and the phasing out of the MFA. Both factors play significant role in the decrease in the exports of coarse grains and of cotton and in the increase of the exports of horticultural products, meat, food and textile.

On the longer term China's self sufficiency ratios will decrease for most of the agricultural products and in particular for coarse grains and oil seeds. Due to rising consumption and lack of own resources the self-sufficiency ratio for energy products will show a further decrease. Especially the imports of oil are expected to rise further. On the other hand the self-sufficiency rate of textile and that for products of the labor-intensive industry will show important increases.

The impacts of these changes on the world market are limited. For most product groups the share of China's export in the world market will be below ten percent. However, there are some exceptions. The most impressive one is textile; the share of China in the export market will increase from less than twenty percent in 2001 to more than forty percent in 2020. For fish and labor-intensive industrial products the share of China will increase to more than ten percent but will remain below twenty percent. The share of food industry products will rise also above ten percent but will decrease below this level afterwards.

What can China expect from the WTO Doha development round?

What can China expect from the new Doha development round? To address this question, this study provides insights in the economic effects of the new WTO Doha round for China on the basis of the policy proposals of the major participants in the negotiations: the USA, the EU and the CAIRNS group. The analysis for China with the help of simulations of the GTAP model is put against the background of worldwide effects and provides insights into the nature and magnitude of the impacts of the WTO Doha Round for international trade and the resulting welfare improvements. The study focuses on agricultural liberalization, but also includes liberalization in industrial tariffs and liberalization in services trade. It uses the baseline developed in chapter 5 as the benchmarks against which the effects of a new WTO round are assessed.

The results of the analysis show that China belongs to the countries that gain most from the new round of trade negotiations. China is estimated to capture about 8% of the global income gains in 2010 while its share in world GDP is around 3%. For all proposals is estimated that China's export trade will grow relatively more than that of World export trade.

The effects on China's agricultural incomes are, however not estimated to be very large. The USA and the CAIRNS proposal have comparatively greater effects on agricultural income than that of the EU, because they more aggressively open the protected markets of Japan and Korea. The effects on Chinese agricultural production are limited. For sugar we estimate decrease in production for all three proposals. As a consequence the imports of sugar will increase. The self-sufficiency ratio's for strategic agricultural products will hardly change, in other words the level of food security will be barely affected.

More important are the negotiations for the manufacturing sector. More than seventy percent of the gains for China are attributed to liberalisation in this sector. As far as the textile industry and the food industry are concerned this will increase the demand for agricultural products like cotton and raw materials for the food processing industry. Expanding labor-intensive industries, fostered also by new export opportunities, may be part of a rural development strategy that includes labor absorption into industries outside primary agriculture.

Prospects of biotechnology in rice and cotton: trade and welfare implications

China has the fourth largest GM crop area, after the USA, Argentina and Canada. The Chinese government views agricultural biotechnology as a tool to help China improve the nation's food security, increase agricultural productivity and farmers' incomes, foster sustainable development and improve its competitive position in international agricultural markets. On the other hand, there is growing concern among policy makers regarding the impact of the ongoing global debate about biotechnology on China's agricultural trade, biosafety and the potential opposition derived from public concerns about the environmental and the food safety of GM products. Because of these three new regulations on the biosafety management, trade and labeling of GM farm products came into effect on 20 March 2002 and require importers of GM agricultural products to apply to China's Ministry of Agriculture for official safety verification approval.

China has recently developed insect-resistant Bt cotton and is putting a lot of efforts in the development of transgenic rice resistant to insects. In 2001, approximately four million small farmers in China adopted Bt cotton. The largest part of the potential productivity gains from Bt cotton will be realized already by 2005. In contrast, GM rice is not yet available to farmers on a commercial basis, and our estimates indicate that large productivity gains are yet to be realized between 2005 and 2010.

Chinese factor markets for labor and land will witness different effects, depending on the type of biotechnology being adopted. The scarce land resources can be utilized more effectively with land-saving technologies. The adoption of somewhat laborsaving GM crops does not necessarily lead to falling wages. This is especially the case in Bt cotton. Here, the expansion of the cotton sector itself, together with rising labor demand from the unskilled labor intensive textiles sector more than compensate for the savings in labor inputs obtained by adopting the GM crop.

The economic gains from GMO adoption are substantial. In the most optimistic scenario, where China commercializes both Bt cotton and GM rice, the welfare gains calculated with the GTAP model amount to an additional annual income of about 5 billion US$ in 2010. This amounts to about 3.5 USD per person. If actual adoption rates are lower, we still observe an income gain of 3 billion USD in 2010. Given the importance of rice for agricultural production, employment and food budget shares, the gains from GM rice adoption are orders of magnitude larger than the Bt cotton gains.

Although the productivity gains for China translate to rising exports or reducing imports, the patterns of global trade in both the textiles and garments and the rice sectors are not affected very much. The impact is negligible on major rice importers, but major rice exporters (i.e., Thailand, Vietnam and Burma) may experience a drop in net export revenues. Rice exports from China represent only a small share in international rice trade. There is an immediate impact on the export revenues of major cotton exporters, most notably India and Pakistan. The cost savings and yield increases from Bt cotton translate into lower production cost for the Chinese textiles and garments industry, but these cost reductions are not of such orders of magnitude that other garments producers (e.g., India, Bangladesh, but also Mauritius) are affected very much. The phasing out of the multifiber agreement by 2005 is of greater importance for global textiles and garments trade than Bt cotton commercialization in China.

Our results indicate that trade restrictions do not significantly lower the gains from biotechnology research in China. A trade ban on GM rice (food crop) has only a minor effect since the portion of rice exported is very small. The effects of unilateral labeling of soybean imports are larger. If China wants to label GM products, this raises the domestic price of soybeans, and benefits Chinese soybean farmers. However, domestic labeling also raises the price of domestic GM rice, and this affects rice consumers.

Trade and FDI relations between China and The Netherlands

The development into a socialist market economy and the gradual opening of the Chinese market for foreign companies after 1978, have had an important positive impulse on China's strong economic growth in the past 25 years. Both international trade and foreign direct investments (FDI) contributed to this development. China attracted substantial foreign direct investments (FDI) in the last decades; in 2002 it became the most important recipient of FDI in the world. Although its FDI inflow only accounts for around 3% of its GDP, it delivers an important contribution in the growth of productivity. More than 60% of FDI is in the manufacturing sector. FDI has been pouring into the coastal regions although recent policy is shifting to the western part of China to exploit its rich resources and stimulate domestic demand there.

Dutch FDI in China began in the 1980s, but it took off in 1992 after the opening up policy was formally adopted national wide. The Dutch FDI stock accounts for less than 1% of China's total FDI. Also Dutch FDI is strongly skewed toward manufacturing which absorbed two third of the total. The direct investments of the Netherlands in Chinese agriculture account for 4,5% of Dutch FDI in China. In terms of regional preference, Jiangsu is their first choice, followed by Shanghai.

The Netherlands is one of the largest trading countries in the world. The Dutch share in China's import is limited. China, on the other hand, has a huge trade surplus with the Netherlands. Dutch exports to China are concentrated in industrial machinery, while importing office machines and automatic data processing equipment from China. As far as agricultural trade is concerned edible offal and flower bulbs are the major Dutch export categories to China. China's exports of agricultural products to the Netherlands are very limited.

It is expected that China's strong economic growth will continue and that China will remain one of the most hottest investment destinations. Some observers expect (e.g. the Economist Intelligence Unit) forecasts that China's annual FDI inflow will be over 60 billion US$ during 2003-2007. FDI and export opportunities for the Dutch agribusiness exist in horticulture, intensive livestock sector and to a much lesser extent in dairy sector.

1 Introduction

1.1 Background and objectives

In 2001, China had a population of almost 1.3 billion. The annual increase in population is about 12 million, and China's population is expected to reach 1.5 billion by 2030. Twenty years of economic reform have brought about rapid income growth. As a result, the demand for food - and particularly for meat - has continued to grow. In turn, the increase in demand for meat has accelerated the demand for feed grain (Huang, Rozelle & Rosegrant, 1999). Previous projections show that the food requirements in 2030 will be nearly double those of the early 1990s (Zhang, 2003). Moreover, the growing demand for energy in China calls for increased biofuel production, and meeting these needs will compete with food production for natural resources.

On the supply side, the increase in the agricultural supply and the food supply in China during the 1970s and 1980s is one of the most remarkable success stories in science, technology, and policy-making. Several factors have contributed to the sharp increase in production. Technological changes - which have increased the availability of water, inorganic fertilizers, and other farm chemicals - have meant that agricultural production growth has exceeded population growth (Huang, Rosegrant & Rozelle, 1996). Institutional change stimulated production, particularly in the early reform period (Lin, 1992). The impacts of price and marketing reforms and trade-related policies on agricultural production were generally positive (except for macro-economic policy), but the impacts vary among crops and over time (Huang & Rozelle, 2002).

Future gains, however, may not have as many sources and may rely mostly on further technological breakthroughs. High input levels and diminishing marginal returns mean that increasing inputs will not provide large increases in output. Water shortages and increasing competition from industry and commercial cash crops do not provide much hope for large gains in yield from investment in water control. Institutional change in many cases provides only one-time changes and has been shown to be largely exhausted in China (Huang & Rozelle, 1996). Many have predicted that in future almost all gains will have to come from second- and third-generation Green Revolution technologies (Pingali et al. 1997; Huang et al., 2002).

Trade liberalization further challenges China's agricultural economy. China's recent accession to the World Trade Organization (WTO) has led to a large-scale debate about its effects on both the domestic and the global economy. China's accession affects all areas of its economy, but is widely expected to have a particularly dramatic effect on agriculture. Some argue that the impacts of accession on China's agriculture will be substantial (Carter & Estrin, 2001; Li et al., 1999). There are two reasons for this: The reforms in China over the past 25 years have largely ignored trade policies for key farm products, and therefore much remains to be done; and China has committed itself to major changes in farm trade policies by 2005 - commitments that are far greater, and much faster, than any other developing country committed itself to in the Uruguay Round Agreement on Agriculture (Anderson et al., 2002).

However, others believe that the overall effects on agriculture will be modest, with the exception of a few commodities (Anderson & Peng, 1998; Huang et al., 2000). The diversified views on the implication of China's accession for the country's domestic agricultural economy can partly be attributed to a lack of understanding of the current policy distortions and the likely policy changes that may follow accession (Martin, 2002; Huang & Rozelle, 2002).[1]

The sheer size of China's economy, its rapid growth, and its increasing integration into the global economy will make China a crucial player in the future development of the world markets for inputs and outputs of agricultural products. Small adjustments in China's agricultural supply and demand will have significant implications for world agricultural trade and for China's trading partners, including the EU. This makes China's long-term agricultural supply, demand, and international trade an issue of both national and international significance.

Against this background, the overall goal of this report is to provide a better understanding of China's growing economy and the implications for China's food demand, supply, and trade, as well as for the global food economy, and to explore agribusiness trade and FDI (foreign direct investments) opportunities between China and the EU, and particularly the Netherlands. Specifically, this report seeks to achieve the following objectives:

1) To identify and document China's major domestic policies, development strategies, and long-term economic plans; and to develop several logical, consistent, and plausible scenarios in both international and domestic contexts. In generating these scenarios, food and agriculture are regarded as an integral part of the economy.
2) To determine the structure of demand for agricultural products and sources of demand growth, with a special emphasis on livestock products, within the domestic market. New estimates of demand parameters based on recent micro level information of both urban and rural households will be incorporated into the analysis.
3) To determine the capability of the Chinese agricultural sector to meet domestic market needs and to identify the factors that significantly contribute to the domestic supply of agricultural products, as well as the factors that may prevent China from being able to increase production as domestic demand increases in the future.
4) To project China's demand for, supply of, and trade in major food products in the early 21st century under various development scenarios, and to make projection outcomes for the years 2005, 2010 and 2020.
5) To examine China's potential export products and its demand for imports, and to investigate the impact of these export potentials and demand projections on world markets and trade flows and, through these international effects, examine the consequences for the EU. Furthermore, to assess both the up- and downstream opportunities for China and the EU in international trade and FDI.

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[1] A review of previous studies on the projections of China's food economy is summarized in the project working paper, 'A Comparison Study of Projection Models in China's Food Economy' by Zhang (2001) and in Zhang (2003).

1.2 Methodology

The use of models is instrumental in gaining a better understanding of the capacity of China to feed its growing population with its limited natural resources, and of the impacts of China's growing economy on world markets and the EU. The models used in this study comprehensively and simultaneously account for the major driving forces and policies determining China's domestic food demand and supply, and influencing the linkages of China's economy with the rest of the world, and particularly with the EU. These linkages are examined and simulated through the models established, which reflect trade relations, the impacts of China's agricultural and trade policies on the rest of the world, and the impacts of agricultural and trade policies of the EU and other major trading partners on China's food economy. In this regard, two models are used: China's Agricultural Policy Simulation Model (CAPSiM) and an adapted version of the Global Trade Analysis Project (GTAP) model. CAPSiM was developed by the Chinese Center for Agricultural Policy (CCAP) of the Chinese Academy of Sciences (CAS). The GTAP model was developed by an international group of economists and adapted for this study by the Dutch Agricultural Economics Research Institute (LEI) of Wageningen University and Research Center (WUR).

Thus, to achieve the overall objective of this report, methodologies are used and developed for each of the specific project objectives, namely:

- Objective 1 (policy identification and scenario development) is achieved through performing a thorough review of the existing literature with respect both to China's long-term policy and development plans, and to the international trade environment. The key issues and relationships in these fields are identified and scenarios are developed. A distinction is made between policy scenarios for world trade based on the discussions in the WTO Doha Round, and scenarios for Chinese agricultural policy. In these scenarios, the agricultural and food sector are regarded as an integral part of the economy.
- Objective 2 (domestic demand analysis) is achieved through estimating demand (focusing on food products and distinguishing between rural and urban households) using the demand module of the CAPSiM model. The identification of structural changes in food consumption patterns is a major contribution of this sub-study. Once the demands for meat (pork, beef, mutton, chicken, eggs, milk), fish, and other animal products are known, the implied feed demand (and hence the overall demand for grain) is calculated by applying a set of feed conversion ratios. These ratios may change over time as a result of technological changes and substitution possibilities.
- Objective 3 (domestic supply analysis) requires an examination of the effects of technology, public investment, agricultural price and marketing policies, infrastructure development, comparative advantage of agriculture, environmental stress, and other supply-related factors influencing agricultural and food supply.
- Objective 4 (domestic projections). In addition to price response of both demand and supply, a series of important structural factors and policy variables are explicitly accounted for in CAPSiM. These variables include urbanization and market developments on the demand side, technology, agricultural investment, environmental trends, and major agricultural production constraints, such as the availability of water and land for agricultural use and barriers to international technological

transfer on the supply side, and major pricing and marketing trade policies on the international trade side.

- Objective 5 (international trade analysis) is achieved by using an adapted version of the world trade model (GTAP) to assess the impacts China's trade potential will have on world market prices and on the trading opportunities of both China and the EU. The GTAP model is also used to identify the impacts of the WTO Doha Round: Scenarios concerning trade with the EU and the impacts of the external trade environment on China's economy are assessed.

1.3 Contents of this publication

This publication is composed of eight chapters. In the following chapter (Chapter 2), the development of China's agriculture and food supply since the reform of 1978 is described, as are the internal and external policies of the Chinese government as far as they are relevant to the agricultural sector and to food supply. Particular attention is paid to the implementation of policies and their impact on agricultural development. Dr. Jikun Huang and Dr. Scott Rozelle wrote this chapter.

Chapter 3 deals with the methodologies used for the study. Particular attention is paid to the GTAP model and its adaptation for this project, and to CAPSiM. In addition, available time series are analyzed and improved in order to make the data used in the project more consistent. The authors of this chapter are Dr. Frank van Tongeren, Dr. Hans van Meijl, Dr. Jikun Huang, and Dr. Li Ninghui.

Chapter 4 addresses the future development in China of the demand and supply of food with the help of a 'business as usual' baseline scenario. Additional scenarios are presented for alternative developments of rural and urban household income. This chapter also focuses on the impact on the food supply of 'green box' policies, namely those policies that are allowed within the framework of the WTO. Of particular interest are the impacts of research investment policy, irrigation investment policy, and policies aimed at reducing the increase of erosion and salinization. The scenarios are simulated with CAPSiM. Dr. Jikun Huang, Dr. Li Ninghui, and Dr. Scott Rozelle wrote the chapter.

In Chapter 5 the results of the construction of the baseline with the GTAP model are presented. In this model, the relations with the world market are also taken into account. This global baseline is a projection of the developments in the periods 2001-2005, 2005-2010, and 2010-2020 if no new policy changes occur. The baseline takes into account China's accession to the WTO, the phasing out of the Multi Fiber Agreement, and the accession of ten new Member States to the EU. The impacts of these recent policy decisions are given separately. In addition, the changing relations with other parts of the world - and particularly with the EU - are sketched. Dr. Hans van Meijl and Dr. Frank van Tongeren wrote this chapter.

Chapter 6 deals with the possible effects of the further liberalization of trade within the framework of the Doha Round. The focus is on the effects both on world markets and on China, and particularly as far as agricultural products and food are concerned. The scenarios are based on the WTO proposals made by the USA, the EU, and the CAIRNS group. The effects are the results of simulations with the GTAP model. The authors of this chapter are Dr. Frank van Tongeren and Dr. Hans van Meijl.

An important domestic Chinese policy is the development of biotechnology, and this is the subject of Chapter 7. The effects of the application of GM cotton and GM rice on economic welfare in China and on world trade are estimated with the help of the GTAP model. This chapter also deals with the possible impacts on China of the introduction of the labeling of GM products. Dr. Frank van Tongeren, Dr. Jikun Huang, Dr. Hans van Meijl, and Dr. Li Ninghui wrote the chapter.

Chapter 8 deals with trade and foreign direct investments (FDI), and describes the Chinese trade in food and agricultural products as well as FDI in the Chinese agricultural sector as a part of global trade and FDI. There is a special focus on the relations between China and the Netherlands. Some opportunities for trade with China and for FDI in China are identified. The authors of this chapter are Dr. Xiaoyong Zhang and Mr. Jaap Post.

Lastly Mr. Jaap Post wrote Chapter 1, the summary and the conclusions. Besides he did a large part of the editing in cooperation with Mrs. Tania Ravensbergen.

2. Agricultural Development and Policies in China

2.1 Introduction

Agricultural development and food security are among the central issues of concern of policy makers in many developing countries, including China. However, the progress made in developing countries differs across regions and among countries. China is one of the most interesting cases to explore when studying agricultural development. For the past 25 years, the annual rate of growth of agriculture at the national level has been about four times higher than that of population growth. In contrast to many earlier analysts who expected China to become more dependent on agricultural imports as a result of the rapid industrialization and liberalization of its economy, net food import growth has not occurred. In fact, even after more than 20 years of reforms and rapid growth, China continues to be a net exporter of food and agricultural products (NSBC, 1981-2002).

At the micro level, China has also made remarkable progress during the last 20 years in improving household agricultural production and food security and in reducing the incidence of malnutrition. According to China's measure of poverty, the incidence of rural poverty fell from over 30 percent in the late 1970s to around 10 percent in 1990, and to only 3 percent in 2001 (NSBC, 2002).

Successful past efforts, however, do not guarantee future agricultural production growth and food security. While most recent studies have concluded that the increases in China's food and grain imports will not starve the rest of the world, China still faces an enormous challenge to supply its growing population with high-quality, reasonably priced food and to steadily increase rural income in the future (World Bank, 1997). Agricultural productivity growth and the availability of resources (i.e. water and land) for agricultural production will determine the extent of China's ability to feed itself in the future, because rapid industrialization and urbanization will lead to competition for resources between agricultural and non-agricultural sectors.

Recent events have brought the agricultural development issue even more to the forefront of the agenda of many policy makers. China's recent accession to the World Trade Organization (WTO) promises many changes. It will undoubtedly make China's agricultural economy even more dynamic. Moreover, before there was time to analyze the impacts of the nation's accession, the Doha Ministerial Conference launched a new round of multilateral trade negotiations. Trade negotiators have been given a mandate in the next round of WTO negotiations to further liberalize the world economy, including agriculture.

Several key questions arise for policy makers when they address the challenge of how to increase farm income and food security. What is the current status of agricultural development? What policies have contributed to or hindered agricultural production growth and farm income in the past? Can the successful policies of the past be continued in the future? What are the major constraints and challenges faced by China's agricultural sector? How will trade liberalization affect China's agricultural production, domestic market and national household food security? How can China formulate effective policies to achieve the sustainable growth of agricultural supply and productivity, farm income and food security in the decades ahead?

The aim of this chapter is to answer some of the above questions, that is, to evaluate the performance of the agricultural sector, review the role of policies in agricultural development and identify the key issues related to agricultural production that need further interventions. In section 2 an overview of the national's economy, including agricultural and rural sectors, is provided. Section 3 presents an evaluation of the previous achievements and sources of growth in agricultural production and food security in China. Section 4 contains a review of China's development strategies and policies and the reforms it has pursued in order to increase agricultural productivity and farm income. The impacts of reforms on agricultural production incentive, trade, market integration and rural labor employment are evaluated in section 5, which concludes this chapter.

2.2 An Overview of National Economy and Agricultural Growth

2.2.1 Economic Performance

Since the late 1970s, remarkable progress has been made in the performance of the agricultural sector, even though its growth rate does not match that of the overall economy; growth in all sectors are highly correlated with the periods in which China's leaders implemented the various reform measures that have gradually liberalized the institutional and market structure of the economy (Table 2.1). Although there is a cyclical pattern in China's growth rates (Figure 2.1), the Chinese economy outperformed almost all other countries in Asia. Indeed, China has been one of the fastest growing countries in the world since 1980 (World Bank, 2002). The rapid growth has been accompanied by sharp structural changes in the economy. Whereas agriculture accounted for more than 30 percent of gross domestic product (GDP) prior to the economic reforms of 1979, by 2000 the share of agriculture had fallen to 16% (Table 2.2).

Economic Growth Before the Early 1990s

In the early reform period, annual GDP growth rates increased dramatically from 4.9 percent in 1970-78 to 8.8 percent in 1979-84 (Table 2.1). During this period, as economic growth and family planning effectively lowered the nation's population growth rates, the annual growth rate of GDP per capita more than doubled between the pre-reform period (1970-78: 3.1 percent) and 1979-84 (7.1 percent). During the early reform period, also the growth in the agricultural economy was remarkable (7.1 percent annually, Table 2.1), which provided the foundation for the successful transformation of China's reform economy (Perkins, 1992).

Table 2.1 The annual growth rates (%) of the Chinese economy, 1970-2000

	Pre-reform	Reform period		
	1970-78	1979-84	1985-95	1996-2000
Gross domestic products	4.9	8.8	9.7	8.2
Agriculture	2.7	7.1	4.0	3.4
Industry	6.8	8.2	12.8	9.6
Service	n/a	11.6	9.7	8.2
Foreign Trade	20.5	14.3	15.2	9.8
Import	21.7	12.7	13.4	9.5
Export	19.4	15.9	17.2	10.0
Rural enterprises output	n/a	12.3	24.1	14.0
Population	1.80	1.40	1.37	0.90
Per capita GDP	3.1	7.1	8.3	7.1

Note: the figure for GDP in 1970-78 is the growth rate of national income in real terms. Growth rates were computed using the regression method.
Source: CNSB, Statistical Yearbook of China, various editions.

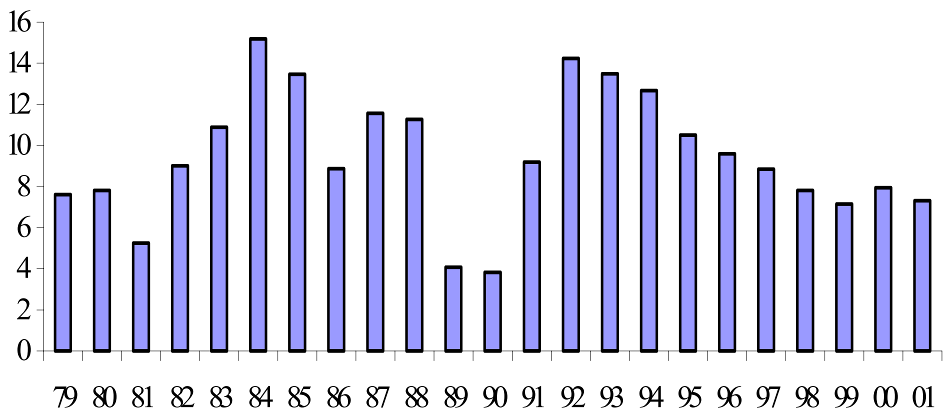

Figure 2.1 Annual growth rate (%) of GDP, 1979-2001
Source: NSBC, 2002.

After reaching its peak growth in 1984 (15 percent), the pattern of rapid economic growth continued into the later reform period in the late 1980s (Figure 2.1). In fact, growth may have been too fast. In response to an overheated economy and unprecedented inflation rates, China's leaders were forced in the late 1980s to adopt a set of stringent, macro-economic contraction policies (Naughton, 1995). As a consequence, after two years of high inflation, in 1989-1990 the economic growth slowed sharply. The annual GDP rate in 1989-1990 reached only about 4 percent, the lowest rate in the entire reform period. After the brief slowdown, the government responded promptly by implementing a series of policy measures to stimulate the economy through the use of fiscal and financial expansions, the devaluation of the exchange rate, the expansion of special economic zones and the imposition of higher agricultural prices. The economy soon rebounded: the annual GDP growth rate increased to 14 percent in 1992 and then remained steady at 10-13 percent in 1993-96 (Figure 2.1). While the economy was growing at top speed during the mid 1990s, inflation rates increased again (Figure 2.2).

Table 2.2 Changes in the structure (%) of the Chinese economy, 1970-2000

	1970	1980	1985	1990	1995	2000
Share in GDP						
- Agriculture	40	30	28	27	20	16
- Industry	46	49	43	42	49	51
- Services	13	21	29	31	31	33
Share in employment						
- Agriculture	81	69	62	60	52	50
- Industry	10	18	21	21	23	22.5
- Services	9	13	17	19	25	27.5
Share in export						
- Primary products	n/a	50	51	26	14	10
- Foods	n/a	17	14	11	7	5
Share in import						
- Primary products	n/a	35	13	19	18	21
- Foods	n/a	15	4	6	5	2
Share of rural population	83	81	76	74	71	64

Source: CNSB, China's Statistical Yearbook, various editions; and China Rural Statistical Yearbook, various editions.

Recent Economic Growth

Although the economy was growing rapidly in the mid 1990s, inflation was high and in order to avoid a repetition of the economic slowdown that occurred in the late 1980s, China's leaders implemented a range of measures aimed at achieving a soft landing (Zhu and Brandt, 2001). As before, financial and credit policies were tightened, and administrative controls over new investments were implemented. To keep the economy from flagging too much, China's leaders increased urban wages and invested heavily in agriculture in an attempt to counterbalance the contraction measures. The growth decelerated gradually, but unlike in the late 1980s, it slowed only marginally. During the late 1990s, annual economic growth remained high, namely at about 8 percent (Table 2.1 and Figure 2.1).

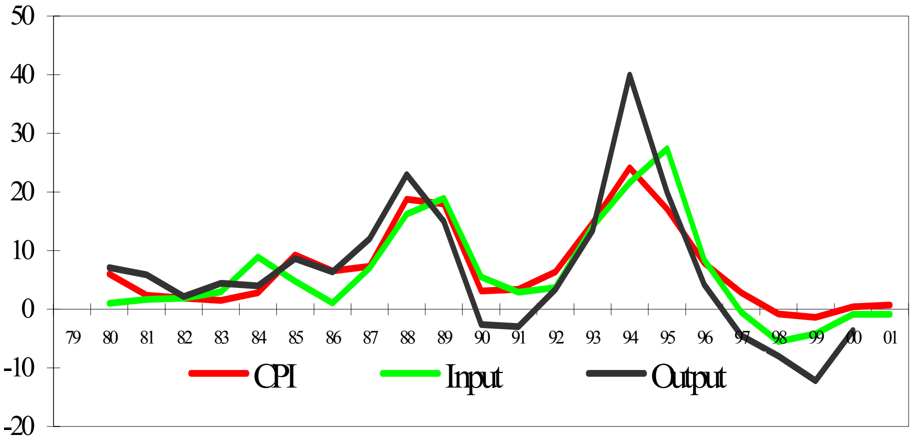

Figure 2.2 Annual changes (%) in agricultural output, input and consumer price indices, 1979-2001
Source: NSBC, 2002.

Foreign Trade
Throughout the reform era, foreign trade has been expanding even more rapidly than GDP. Annual growth rates of foreign trade reached nearly 15 percent in both the 1980s and the early 1990s (Table 2.1). Although the Asian economic crisis adversely affected China's foreign trade growth rate, it still grew at nearly 10 percent a year between 1996 and 2000. During 2000 and 2001, the average annual growth rate of foreign trade reached 19 percent. Although the growth rate of agricultural exports declined, so did those of all other Asian countries. Most observers believe the slower growth rates occurred because of the depressed world commodity markets and the general slowdown of the world economy (ADB, 2002).

With the rapid growth of China's external sector, foreign trade has been playing an increasing role in the national economy since the beginning of the reforms in the late 1970s. China's trade to GDP ratio increased from less than 13 percent in 1980 to 45 percent in 2001 (NSBC, 2002). During the same period, the total value of China's primary goods trade (mainly agricultural products) increased from USD 16.1 billion to USD 72.1 billion, an annual growth rate of 7.4 percent (NSBC, 2002). Now that China has joined the WTO, the growth of foreign trade is likely to remain high and even accelerate in the coming years.

Inflation and Agricultural Prices
Over the past two and a half decades, China's consumer prices have increased by about 400 percent. Prices underwent two periods of notably high inflation, namely 1988-89 (an average of 18 percent) and 1993-95 (19 percent) (Figure 2.2). During the rest of the years of the reform period between 1979 and 2001, the average inflation rate was only 3.6 percent (NSBC, 2002). During both periods of high inflation, efforts to control the increasing prices proved to be effective. The price inflation in 1988-89 was quickly reduced to 2.1 percent in 1990 and to 2.9 percent in 1991. Likewise the high inflation rates in 1993-95 were rapidly reduced to 8.3 percent in 1996 and to 2.8 percent in 1997. Indeed, during re-

cent years China has experienced a negative rate of inflation (in 1998-99) and one that was almost zero (0.4% in 2000 and 0.7% in 2001).

The changes of agricultural input and output prices followed the same pattern experienced in the rest of the economy (CPI, Figure 2.2). Despite these similarities, the terms of trade have varied from period to period. To promote agricultural production, agricultural procurement prices had been increased continuously until the late 1980s. During this period, the real prices of agricultural output increased more than those of agricultural inputs. Rising terms of trade provided a favorable policy environment and high incentives to farmers (Swinnen and Rozelle, 2003). In contrast, agricultural output prices have declined more than input prices in all years since the late 1980s (with the exception of 1994), even though the real prices of agricultural inputs underwent a slight decline.

Agricultural and Non-agricultural Employment

The structural changes in the economy have had a substantial impact on employment. While the share of employment accounted for by the industrial sector has remained at about 40-50 percent for the last three decades, employment in the service sector increased rapidly from 13 percent in 1970 to 21 percent when the economic reforms were started (Table 2.2). By 2000, the share of employment accounted for by the service sector had reached 33 percent. During this period, employment in the agricultural sector (including part-time agricultural labor) fell from 81% in 1970 to 69% in 1980 (Table 2.2). Employment in agriculture has continued to fall throughout the reform era, reaching about 50 percent in 2000. In the late 1990s, more than 40 percent of the rural labor force was employed in the non-agricultural sector (de Brauw et al., 2002). A large and increasing part of the rural labor force is self-employed (the rate increased from 8% in 1990 to 13% in 2000; de Brauw et al., 2002). In addition it has to be mentioned that a recent survey suggests that more than 100 million rural workers found employment in the urban sector in the late 1990s (de Brauw et al., 2002). Expanding non-agricultural employment has contributed substantially to the growth of farm income (Rozelle, 1996). Non-agricultural income exceeded agricultural income in 2000 for the first time, accounting for just over 50 percent of the total income of farmers. In 2001, the share increased to 51 percent (NSBC, 2002).

2.2.2 Challenges and Development Objectives

While China is often recognized as of one the most rapidly growing economies in the world, its economy is facing a number of challenges. The nation's high-growth economy is currently suffering from an increasing inventory, excess capacity and weak aggregate demand. The economy's success in creating new jobs in the nation's urban and rural enterprises has slowed (CNBS, 2002). Rural income growth has also slowed since the mid 1990s, as both agricultural prices and the growth of employment in the off-farm sector declined.

Table 2.3 Per capita income changes for the rural and the poorest 20% of the population, 1980-2001

Year	Real per capita income index		Average/ poorest 20% income ratio	Income disparity	
	Average rural	Poorest 20%		Gini coefficient	Urban/rural income ratio
1980	100	100	1.97	0.24	3.4
1985	175	157	2.20	0.23	2.2
1990	183	154	2.34	0.31	2.3
1995	239	179	2.62	0.34	2.8
2000	317	219	2.85	0.35	2.8
2001	330	224	2.89	0.32	2.9

Source: CNSB, various editions and rural household income and expenditure surveys conducted by CNSB.

The rapid economic growth has been accompanied by increasing income disparity (World Bank, 1997). The income gap among regions, between urban and rural, and among households in the same location has been continually increasing since the mid 1980s (Table 2.3). The rural to urban income ratio exceeds 3.4, the level it was at in 1980. Although the rural reforms increased rural incomes at a faster pace than urban ones during the 1980s, since the one-off impact of the institutional reforms was exhausted in the mid 1980s, urban income growth has been consistently higher than that of the rural sector. Recent falls in agricultural prices and the slowdown in the growth of off-farm employment have further constrained rural income growth.

Income disparities have also increased in rural areas (World Bank, 1997). On average, per capita rural income increased by 330 percent between 1980 and 2001 (Table 2.3). While the income levels of the poorer farmers (the bottom 20 percent of the population) increased by 224 percent, this growth was more than 30 percent less than the national average. Rising Gini coefficients, which increased from 0.24 in 1980 to 0.35 in 2000 and 0.32 in 2001, illustrate the increasing income disparity among rural residents in 2001 (Table 2.3).

In response to the sluggish growth of rural incomes and widening disparities, the government has taken a number of policy actions. The major policies implemented include providing investments to assist in the restructuring of the economy, privatizing rural enterprises, reforming financial institutions, easing monetary policy, increasing fiscal spending on R&D and infrastructure investment, and increasing aid to poor areas, including implementing the western development plan. The efforts have not been minimal. For example, fiscal spending on infrastructure increased by CNY 100 billion in 1998, CNY 110 billion in 1999 and CNY 150 billion in 2000 (ADB, 2002). Investments were targeted at stimulating demand and at increasing the efficiency of the nation's business environment. The government spending plan will be continued for the next fine years.

Despite the significant reduction of rural poverty during the past two and a half decades (Table 2.4), China's fight against poverty is far from over. Recently China issued a new 10-year Poverty Reduction Strategy for 2000-2010, focused on assisting the 30 million rural people with an income under the official poverty line (an annual income of CNY 625 per capita). It is worth noting that the official poverty line was established in the mid 1980s and is substantially lower than the international norm. The World Bank estimates that in the late 1990s, over 18 percent of China's population lived below the international norm (i.e. about USD 1 per day; World Bank, World Development Indicators, 2002).

Table 2.4 Rural poverty in China, 1978-2001

Year	Absolute poverty (millions)	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	89	11.0
1985	96	11.9
1986	97	11.9
1987	91	11.2
1988	86	10.4
1989	102	11.6
1990	85	9.4
1991	94	11.0
1992	80	8.8
1993	75	8.3
1994	70	7.7
1995	65	7.1
1996	58	6.3
1997	50	5.4
1998	42	4.6
1999	34	3.9
2000	32	3.4
2001	29	3.2

Sources: the data for 1978-1988 are from World Bank (China: Strategies for Reducing Poverty in the 1990s, 1992); the 1989-2001 data are from Rural Social and Economic Survey Service of CNSB (2002).

In the midst of the rural income slowdown, the accession of China to the WTO has raised new concerns about China's food security. While most studies show that China's WTO accession may contribute to GDP growth, policy makers worry about the negative effect on the service and agricultural sectors. The main concern is whether or not China's small farmers can compete in international markets.

In this environment, food security has been and will continue to be a central goal of China's agricultural policy. Both the Tenth Five-year Plan for 2001-2005 and the National Long-term Economic Plan for the coming 15 years call for the continued expansion of agricultural production and increases in farm income growth. The nation's commitment to eliminate absolute poverty is also reaffirmed. Our review of recent policy changes shows that China has already positively responded to the challenges that confront it as a result of its accession to the WTO (Huang and Rozelle, 2002). If done well, China's policies can play an important role in improving its food security and in helping the nation to achieve its other development goals.

2.3 Role and Performance of Agriculture

2.3.1 The Changing Role of Agriculture in the Economy

The average annual growth rate of agriculture has been about 5 percent throughout the reform period (Table 2.1). 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.

Successive transformations of China's reform economy are based on economic growth in the agricultural sector (Nyberg and Rozelle, 1999). During this process, the share of agriculture in the national economy has declined significantly. Agriculture has made important but declining contributions to national economic development in terms of gross value added, employment, capital accumulation, urban welfare, foreign exchange earnings and poverty alleviation. Before 1980, agriculture contributed more than 30 percent of the nation's GDP and half of its export earnings. By the mid 1990s, the share of agriculture in the economy and the share of agricultural exports in total exports fell below 20 percent (Table 2.2). In 2000 agriculture's share of GDP was only 16 percent.

The shifts in the economy can also be seen in employment (NSBC, 2001): agriculture employed 81 percent of the labor force in 1970, but only 50 percent in 2000. Such a sharp shift in the structure of employment shows that China is shifting 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 ha as early as the 1950s. Population growth and limited land resources will shift China's comparative advantage from land-intensive economic activities (e.g. agriculture) to labor-intensive manufacturing and industrial activities (Anderson 1990).

2.3.2 Agricultural Production Performance

Growth Patterns

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 rates of production growth that have outpaced the increase in population.

After 1978, decollectivization, price increases and the relaxation of trade restrictions on most agricultural products accompanied the take-off of China's agricultural economy. Between 1978 and 1984, grain production increased by 4.7 percent per year and the output of fruit increased by 7.2 percent (Table 2.5). The highest annual growth rates were in the oilseed, livestock and aquatic product sectors; these sectors expanded in real value terms by 14.9, 9.1 and 7.9 percent, respectively.

Table 2.5 Annual growth rates (%) of the agricultural economy by commodity, 1970-2000

Commodity	Pre-reform	Reform period		
	1970-78	1978-84	1985-95	1996-2000
Grain total				
Production	2.8	4.7	1.7	0.03
Sown area	0.0	-1.1	-0.1	-0.14
Yield	2.8	5.8	1.8	0.17
Rice				
Production	2.5	4.5	0.6	0.3
Sown area	0.7	-0.6	-0.6	-0.5
Yield	1.8	5.1	1.2	0.8
Wheat				
Production	7.0	8.3	1.9	-0.4
Sown area	1.7	-0.0	0.1	-1.4
Yield	5.2	8.3	1.8	1.0
Maize				
Production	7.4	3.7	4.7	-0.1
Sown area	3.1	-1.6	1.7	0.8
Yield	4.2	5.4	2.9	-0.9
Cotton				
Production	-0.4	19.3	-0.3	-1.9
Sown area	-0.2	6.7	-0.3	-6.1
Yield	-0.2	11.6	-0.0	4.3
Soybean				
Production	-2.3	5.2	2.8	2.6
Sown area	-2.2	1.1	0.8	2.5
Yield	-0.1	4.1	2.0	0.1
Edible oil crops	2.1	14.9	4.4	5.6
Rapeseed				
Production	4.3	17.3	5.4	2.6
Sown area	6.4	7.2	4.3	1.4
Yield	-2.0	10.1	1.1	1.2
Vegetable area	2.4	5.4	6.8	9.5
Fruits				
Orchards area	8.1	4.5	10.4	1.5
Outputs	6.6	7.2	12.7	8.6
Total cash crop area	2.4	5.1	2.1	3.5
Meats (pork/beef/poultry)	4.4	9.1	8.8	6.5
Fishery	5.0	7.9	13.7	10.2

Note: growth rates were computed using the regression method. Growth rates of individual and groups of commodities are based on production data; sector growth rates refer to value added in real terms.
Sources: CNSB, 1980-2001 and MAO, 1980-2001.

However, as by the mid 1980s the one-off efficiency gains from the shift to the household responsibility system (HRS) essentially had been reaped, the growth rate of the food and agricultural sectors decelerated (Table 2.5). The declining trend was most pronounced for grain crops. While dropping below the rate of growth generated in both the pre-reform and the early reform periods, the production of rice, other grains and cash crops has continued to expand since 1985 (Table 2.5). In the meantime, rapid economic growth, urbanization and food market development have boosted the demand for meats, fruits and other non-staple foods, changes that have stimulated sharp shifts in the structure of agriculture (Huang and Bouis, 1996; Huang and Rozelle, 1998). For example, the share of livestock output value more than doubled (from 14 to 30 percent) between 1970 and 2000 (Table 2.6). Aquatic products increased even more rapidly. One of the most significant signs of structural changes in the agricultural sector is that the share of cropping in total agricultural output fell from 82 to 56 percent.

Table 2.6 Changes in the structure (%) of China's agricultural economy, 1970-2000

	1970	1980	1985	1990	1995	2000
Share in agricultural output						
Crop	82	76	69	65	58	56
Livestock	14	18	22	26	30	30
Fishery	2	2	3	5	8	11
Forestry	2	4	5	4	3	4

Source: CNSB, Chinas' Statistical Yearbook, various editions and China Rural Statistical Yearbook, various editions.

In the cropping sector, the importance of the three major crops, rice, wheat and maize, have waxed and waned. The share of the major cereal grains in sown area increased from 50 percent in 1970 to a peak level of 57 percent in 1990, and then gradually declined to less that 50 percent in 2001 (Table 2.7). Most of the fall has been due to the decreasing wheat-sown area. The area share of rice declined marginally. In contrast, the sown area of maize grew by about 50 percent between 1970 and 2000 (Table 2.7). The increase in maize area - China's main feed grain - is correlated in no small way with the rapid expansion of the nation's livestock production during the same period.

In addition to maize area expansion, other cash crops such as vegetables, edible oil crops, sugar crops and tobacco have expanded. In the 1970s, vegetables accounted for only about 2 percent of total crop area; by 2001, the share had risen to 10 percent (Table 2.7). The area share of edible oil also grew by 200-300 percent.

Table 2.7 Share of crop-sown areas, 1970-2001

	1970	1980	1985	1990	1995	2000	2001
Rice	22.1	23.1	21.9	22.3	20.5	19.2	18.5
Wheat	17.4	19.7	20.0	20.7	19.3	17.1	15.8
Maize	10.8	13.7	12.1	14.4	15.2	14.8	15.6
Soybean	5.5	4.9	5.3	5.1	5.4	6.0	6.1
Sweet potato	5.9	5.1	4.2	4.2	4.1	3.7	3.3
Cotton	3.4	3.4	3.5	3.8	3.6	2.6	3.1
Rapeseed	1.0	1.9	3.1	3.7	4.6	4.8	4.6
Peanut	1.2	1.6	2.3	2.0	2.5	3.1	3.2
Sugar crops	0.4	0.6	1.0	1.2	1.3	1.0	1.1
Tobacco	0.2	0.3	0.9	0.9	0.9	0.8	0.8
Vegetable	2.0	2.2	3.2	4.3	6.3	9.7	10.5
Others	30.1	23.5	22.5	17.4	16.3	17.2	17.4
Total	100	100	100	100	100	100	100

Source: CNSB, China's Statistical Yearbook, various editions; China Rural Statistical Yearbook, various editions.

Sources of Growth

Past studies have demonstrated that there are a number of factors that have simultaneously contributed to agricultural production growth during the reform period. The earliest empirical efforts focused on measuring the contribution of the implementation of the HRS (McMillan et al. 1989; Fan, 1991; Lin, 1992). These studies concluded that most of the increase in productivity in the early reform years was a result of institutional innovations, particularly the HRS, which gave individual farmers control and income rights in agriculture.

More recent studies show that since the HRS was completed in 1984, technological change has been the primary engine of agricultural growth (Huang and Rozelle, 1996; Fan, 1997; Fan and Pardey, 1997; Huang et al., 1996). Improvements in technology contributed by far the largest share of crop production growth even during the early reform period. The results of these studies show that further reforms outside the decollectivization process also have high potential for affecting agricultural growth. Price policy has been shown to have a sharp influence on the growth (and deceleration) of both grain and cash crops during the post-reform period. Favorable output to input price ratios contributed to the rapid growth in the early 1980s. However, this new market force is a double-edged sword. A deteriorating price ratio caused by slowly increasing output prices in the face of sharply increasing input prices was an important factor behind the slowdown in agricultural production in the late 1980s and the 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 (Wang, 2000). The proportion of cultivated area under irrigation increased from 18 per cent in 1952 to approximately 50 percent in the early 1990s. (NSBC, 2001). However, increasing demand for domestic and industrial water uses poses a serious threat to irrigated agriculture, and increasing water scarcity is now seen as a major threat to the future food security and well-being of people especially in the northern region. Wang and colleagues (1993) show that the water management reform has helped increase the efficiency of water use in northern China, although the scope for such reform in the long run is somewhat limited.

Trends in environmental degradation - including erosion, salinization and the loss of cultivated land - suggest that considerable stress is being put on the agricultural land base. Erosion and salinization have increased since the 1970s, and the area of land under cultivation has decreased. A number of recent studies (Huang and Rozelle, 1995; Huang et al., 1996) have shown that these factors affect the output of rice, other grains and other agricultural products.

2.3.3 Agricultural Trade Performance

Although agricultural production was growing rapidly, agricultural trade was growing even more rapidly. Agricultural trade (both imports and exports) nearly tripled between 1980 and 1995 (Table 2.8). During this period, exports increased 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 percent in 1980, it fell to only 10 percent in 2000 (Table 2.2). In the same period, the share of food exports in total exports fell from 17 to 5 percent. During the same period, the share of food imports fell from 15 to 2 percent.

Product-specific trade trends reveal equally sharp shifts and suggest that exports and imports are increasingly moving in a direction that shows that China is trading goods in a manner that is consistent with its comparative advantages (Table 2.8). In general, the net exports of land-intensive bulk commodities - such as grains, oilseeds and sugar crops - have decreased (or imports have increased). At the same time, exports of higher-valued, more labor-intensive products - such as horticultural and animal (including aquaculture) products - have increased. Grain exports, nearly one third of food exports in the mid 1980s, were less than 10 percent of what they were during most years of the 1990s. By the late 1990s, horticultural, animal and aquatic products accounted for 70-80 percent of food exports (Huang and Chen, 1999; Table 2.8).

Table 2.8 Structure of China's food and feed trade (USD millions), 1980 to 1999

	SITC	1980	1985	1990	1995	1999
Exports:						
Live animals	00	384	304	430	473	374
Meat	01	361	448	791	1349	1054
Dairy products	02	71	57	55	61	71
Fish	03	380	283	1370	2875	2969
Grains	04	423	1065	614	281	1273
Fruit and vegetable	05	746	825	1759	3399	3150
Sugar	06	221	79	317	321	214
Coffee and tea	07	328	435	534	523	561
Animal feeds	08	58	241	623	351	239
Other foods	09	49	66	107	290	541
Oilseeds	22	n/a	n/a	n/a	522	373
Vegetable oils	4	n/a	n/a	n/a	454	132
Total food		3021	3803	6600	10,899	10,951
Imports:						
Live animals	00	5	18	14	18	22
Meat	01	1	6	54	97	503
Dairy products	02	5	31	81	60	160
Fish	03	13	44	102	609	890
Grains	04	2458	982	2353	3631	574
Fruit and vegetable	05	48	52	83	185	384
Sugar	06	316	274	390	935	183
Coffee and tea	07	56	40	30	74	72
Animal feeds	08	14	83	182	423	620
Other foods	09	2	23	46	92	182
Oilseeds	22	n/a	n/a	n/a	110	1531
Vegetable oils	4	n/a	n/a	n/a	2596	1352
Total food		2918	1553	3335	8828	6474
Net exports:						
Live animals	00	379	286	416	455	352
Meat	01	360	442	737	1252	551
Dairy products	02	66	26	-26	1	-89
Fish	03	367	239	1268	2266	2079
Grains	04	-2035	83	-1939	-3350	663
Fruit and vegetable	05	698	773	1676	3214	2766
Sugar	06	-95	-195	-73	-614	31
Coffee and tea	07	272	395	504	449	489
Animal feeds	08	44	158	441	-72	-381
Other foods	09	47	43	61	198	359
Oilseeds	22	n/a	n/a	n/a	412	-1158
Vegetable oils	4	n/a	n/a	n/a	-2142	-1220
Total food		103	2250	3265	2071	4477

Source: Mathews (2002), based on UN COMTRADE statistics.

2.3.4 Food Security

Food security at the macro national level implies that adequate supplies of food are available through domestic production and/or through imports to meet the consumption needs of the country's population. China's per capita food consumption has increased substantially over last three decades. Per capita food availability increased from 1717 kcal in the early 1960s to 2328 kcal per day in 1979-81 (Table 2.9). By the late 1990s, per capita food availability reached more than 3000 kcal per day, a level near to that achieved in most developed countries. During the same period (between the 1960s and late 1990s), other indicators of nutrition also improved. For example, protein intake and fat consumption measures on a per capita per day basis increased significantly. Protein intake increased from 45 to 84 grams, and fat consumption increased from 17 to 82 grams. Table 2.9 also shows that most of the improvement in the quality of China's diet has been achieved since 1980. In the early 1960s, nearly 96 percent of calories came from grains and other non-livestock products. By the 1990s, the reliance on non-meat food products had been reduced to about 81 percent. During the same period, the share of calories contributed by animal products increased from 4 to 19 percent . Similar trends during the last four decades can be established for the changing sources of protein and fats.

Table 2.9 Per capita supply and sources of calories, protein and fat per day in China, 1961-2000

	1961-1963	1969-1971	1979-1981	1989-1991	1998-2000
Supply					
Calories	1716.7	1993.3	2328.0	2683.3	3033.0
Protein (grams)	44.8	47.5	54.5	65.0	84.3
Fat (grams)	16.8	23.5	32.5	53.0	81.9
Sources (%)					
Calories					
-Vegetable products	95.9	94.1	92.6	88.4	81.3
-Animal products	4.1	5.9	7.4	11.6	18.7
Protein					
-Vegetable products	90.5	87.9	86.4	77.7	65.6
-Animal products	9.5	12.1	13.6	22.3	34.4
Fat					
-Vegetable products	66.1	56.8	53.4	49.0	41.4
-Animal products	33.9	43.2	46.6	51.0	58.6

Sources: FAO database.

At the micro level, household or individual food security depends on a number of factors. These are mostly related to various forms of entitlements to income- and food-producing assets, as well as to the links between domestic and external markets, and the transmission effects of the latter on small, low-income and resource-poor producers and consumers.

Access to food in China has changed over time. In the early years of the reform, decollectivization policies gave all farm households in China a piece of land. During this time, however, markets did not function well (de Brauw et al., 2003). As a result, most farmers produced primarily for their own subsistence. Access to food was primarily through the land that was allocated to them by the state.

2.4 The Reform Experience

The focus of this section is on China's major reforms, as this will provide a better understanding of the policy initiatives that have helped create China's agricultural economy and the environment in which the nation is trying to achieve a degree of food security. The reform strategy will be examined by looking at its various components, their implementation and the objectives of and rationality for each reform component. How the reforms have affected agricultural performance and food security will also be examined.

2.4.1 Institutional Reform

China's rural economic reform, first initiated in 1979, was founded on the HRS. The HRS reforms dismantled the communes and contracted agricultural land to households, mostly on the basis of family size and number of people in the household's labor force.

The HRS reforms were completed in 1984. At their conclusion, the average farm size in terms of cultivated land was about 0.6 ha. Because of regional variations in land endowments, however, the size of farms varies among regions, ranging from over 1 ha in the northeast and nearly 1 ha in northern China, to about 0.5 ha in the southwest and 0.2-0.3 ha in southern China. Because the multiple cropping index (the number of crops planted each year on the same plot of land) increases from 1 (= 1 per year) in the northeast to 2-3 in southern China, variations of sown area among China's regions are less than those of farm size.

China's land rights are both complicated and changing (Brandt et al., 2002). The first term of the land contract was 15 years. During this time, although the ownership of the land remained with the collective, income and control rights were given to the farmers. The effects of such a land policy on the equitable distribution of land to farmers and its effect on food security and poverty alleviation have been both obvious and well documented. The land policy has also contributed greatly to efficiency. Specifically, the income and control rights contributed significantly to the agricultural production and productivity growth in the early 1980s (Lin, 1992; Huang and Rozelle, 1996). Huang, Rosegrant and Rozelle (1996) demonstrate that agricultural output and yields grew as a direct result of decollectivization.

Although local leaders were supposed to have given farmers land for 15 years in the early 1980s and for 30 years as from the late 1990s, the collective ownership of land has resulted in the frequent reallocation of village land. Many people are concerned that such moves by local leaders could result in insecure tenure and negative effects on investment (Brandt et al., 2002). Many authors have shown, however, that in fact there has been little effect on either short- or long-term land productivity. Officials are still concerned that collective ownership and weak alienation and transfer rights could have other effects, such as impacts on migration and rural credit (Johnson, 1995). As a result, China recently passed a new land law, the Rural Land Contract Law (which came into effect on 1 March 2003), which is intended to greatly increase tenure security.

Above all, the government is now searching for a mechanism that will allow those who stay in farming to gain access to additional cultivated land and to increase their income and competitiveness. Even without much legal protection, over the past decade, researchers are finding increasingly more land in China is rented in and out (Brandt et al., 2002). In order to accelerate this process, the new Rural Land Contract Law further clarifies the rights for transfer and exchange of contracted land. The new legislation also allows family members to inherit the land during the contracted period. The aim of this new set of policies is to encourage farmers to use their land more efficiently and to increase their farm size.

2.4.2 Input Price and Marketing Policies

The reforms in fertilizer, seed and other input markets follow China's gradual reform strategy (Huang, Rozelle and Hu, 1997). In the first stage, reformers only implemented measures that provided incentives to sets of individuals and for less important commodities, and did not alter the institutional structure that had been set up to provide abundant and inexpensive food to the urban economy. Decollectivization and administrative output price hikes improved incentives to farmers. China's leaders, who remained responsible for meeting the same ambitious food sector goals, made few adjustments to the rest of the rural economy in the early 1980s, leaving machinery, fertilizer and the seed systems virtually unchanged and heavily planned. Since the mid 1980s, the market liberalization has been gradually implemented, starting with machinery, and pesticides. The meaningful liberalization of strategically important inputs, such as fertilizer, occurred only in the early 1990s. The reform of the seed industry did not begin until the late 1990s.

Fertilizers

Throughout most of the 1980s, the Agricultural Inputs Corporations (AICs) - state-owned enterprises with local trade and retail sales monopolies - rationed subsidized fertilizers and controlled the flow of fertilizers into and out of each jurisdiction in almost the same way they had in the 1970s (Stone, 1988). In the early years of the reforms, however, poorly developed markets often meant that government sales agencies were the only viable marketing channel for agricultural inputs, and it is doubtful whether the input markets would have emerged quickly or effectively even had the sector been liberalized. The state-owned trading arm of the AIC handled rationed and subsidized fertilizers before fertilizer markets were liberalized. China's leaders kept the nominal price of subsidized fertilizers constant throughout the 1970s and 1980s, and the state-run system dominated fertilizer markets even when trade was allowed. For example, urea retail prices were about CNY 450-500 per ton between 1970 and 1985 (Huang and Rozelle, 2003). In real terms, however, urea prices declined by 50 percent between 1970 and 1990.

Like the rest of the economy, however, reform gradually spread to input markets (Ye and Rozelle, 1994). Fiscal deterioration and commercialization of the state-owned fertilizer industry started in the late 1980s and induced policy makers to liberalize fertilizer markets. Although farmers lost access to the inexpensive fertilizer from the state, when officials reduced the quantity of subsidized fertilizer, removed price controls and formally allowed private individuals to sell fertilizer, they created new opportunities for markets to develop.

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 the use of the system's trucks and warehouses and a share of trading profits in return 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 pattern similar to that of the grain marketing reform, a two-tiered price system was implemented. Fertilizer became available at in-quota and above-quota prices. Above-quota prices of fertilizer were about twice as much as in-quota ones. For example, urea prices during the transition period of the late 1980s and early 1990s became available at a low price from the AIC if individuals had access to fertilizer coupons; above quota fertilizer was also increasingly available from private traders or from agents from the commercialized branches of local AICs. The amount of fertilizer a farmer could purchase at in-quota prices depended on the amount of grain he sold to the government grain procurement agency.

Although there were few traders in the late 1980s, gradually the liberalization of the fertilizer market seemed to work well. Private traders multiplied quickly. Fertilizer became more available to farmers, even those in poorer areas, than ever before (Stone, 1993). 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 to learn about operating outside the plan and to develop procurement and sales networks (Xiao and Fulton, 1997; Ye and Rozelle, 1994). Soon, AIC-based companies were competing with not only private individuals, but also each other.

In the early 1990s, two key decisions gave perhaps the strongest impetus to the emergence of competitive fertilizer markets, which initially had been less developed than grain markets: private trading was authorized and China's 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, and with surprisingly little disruption, fertilizer markets supplanted planned distribution networks (Xiao and Fulton, 1997). Increasing competition improved the efficiency of markets, made traders more responsive to consumer demands and reduced transactions costs. Fertilizer markets, like those for grain, soon 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 occurred only in the mid 1990s when the country experienced an imbalance between the supply and the demand for food and fertilizer. Fertilizer prices doubled between 1993 and 1996. In part, this was a result of China's phasing out of the in-quota fertilizer program. In part, subsidies to production units in China were eliminated and factory managers had to increase prices for the fertilizer that was being sold on the market. During this time, local, regional and national policy makers asked the quasi-commercialized traders and retailers to reduce their prices. China's leaders appealed to the commercialized AIC employees to refrain from increasing 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 the 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 was once again officially encouraging fertilizer market integration. After liberalization, fertilizer prices stabilized and then declined. At first this was due to increasing availability through domestic production and imports. Later, imports leveled off and most of the increase 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 dropped from CNY 2209/tonne in 1996 (measured in 2001 constant prices) to CNY 1361/tonne in 2001 (Huang and Rozelle, 2003).

Seeds

Efforts to build a national seed system began in the 1950s, shortly after the Communist regime took control. Following several reorganizations, China's seed production and distribution system is now the largest in the world (Hu, 1995). The state seed supply organization (part of which has recently been commercialized) currently consists of approximately 2,200 county seed companies, 500 prefecture seed companies, 30 provincial seed companies, the National China Seed Corporation and hundreds of seed companies owned by the public plant-breeding and other agricultural research institutes and universities. The size of seed companies has increased over time and varies across regions. On average, provincial seed companies now employ 30 staff and county seed companies employ about 20; both figures represent an increase since the mid 1980s (Huang et al., 1997).

Over the past several decades, Ministry of Agricultural officials have developed a number of rules and regulatory institutions to administer the seed industry (World Bank, 1996). In contrast to the common practices in many other countries, until the late 1990s policy makers limited the ownership of seed companies that produced and distributed hybrid rice and maize seeds to state-owned enterprises. According to the policy, the regulations were needed to ensure high seed quality. As part of a reform package created partly in response to the financial stress that affected many public agricultural research units, China has allowed research institutes and universities to distribute the hybrid varieties they produce. In recent years, private firms have been allowed to do the same. According to the policy, seed companies attached to the breeding stations are only supposed to sell the material they have bred in their own breeding programs.

Meaningful reform of the seed industry and related legislation began later than in almost any other sub sector, namely only after the mid 1990s. Recently, however, the laws governing the seed industry have been changed such that this industry in general is now being commercialized by encouraging the entry of new domestic firms. The law has also allowed foreign investment to trickle into the seed industry. In 1997, China passed its Plant Variety Protection Act and signed the UPOV (*Union Internationale pour la Protection des Obtentions Vegetales*; International Union for the Protection of New Plant Varieties) agreement. A few large Chinese firms have been allowed to raise money by selling some of their shares on the stock market. The latest new seed law (2000) defines the role of the private sector: any investor who meets the minimum requirement for capital investment and facilities can sell seed. Companies are now allowed to sell all crop seeds that were bred by public institutes. Such legislation has begun to erode the local monopolies held by county seed companies for so long. Companies that meet certain criteria can get permits to sell seed in all of the counties of a province or in all provinces in the country instead of having to apply to each county and province separately.

While significant reform has taken place, numerous constraints continue to limit the development of China's seed industry. Thousands of small, local seed companies dominate the industry. Many are publicly owned. Although markets often are competitive in a region, in some cases local markets are isolated by a number of measures adopted by local government. In many cases, only small local firms are able to participate. While many of the firms produce, sell and distribute a number of high quality seeds, the products and services they provide vary across regions. Not allowing farmers access to a larger selection of new varieties inhibits efficiency, and limiting the market size of larger firms inevitably harms R&D. As a consequence, the system is likely to result in the slow spread of new major varieties across large regions. The current seed system also appears to affect the rights and ability of breeders to profit from the development and sale of their varieties. Seed regulations require the breeder to hand over parent lines and all breeding information at the start of the registration process. With the information in the public domain and the foundation seed in the hands of seed companies, breeding institutes earn almost no revenue from their varieties over the long run, a factor that has reduced breeders' incentive to search for new breakthroughs.

The lack of separation between policy functions and commercial activities is one of the main problems facing seed industry managers, who under complete liberalization might take a number of positive steps to make their firms more efficient and service-oriented (Rozelle et al., 2000). Although prices have increased recently, in international terms they are still low and many international observers believe this is a major constraint on the expansion of China's seed industry (Pray et al., 1998). The prices of hybrid rice and maize seed in China are among the lowest in the world. China's seed companies charge rates similar only to seed agencies in sub-Saharan Africa, and only 30-50 percent of the price charged in other parts of Asia, Latin America and other developing countries (Huang et al., 1997). Judging by the prevailing level of seed prices, the government appears to have achieved its goal of keeping crop seed affordable for farmers (particularly poor farmers) and has only just begun the process of making seed companies more profitable. However, it is by no means clear that the current low level of seed prices is desirable. Low seed prices obviously benefit farmers, but they also have several disadvantages. In an era in which research institutes and seed companies are being asked to help support themselves through commercial sales of their products, low seed prices undermine their ability to generate increased revenues. Denied opportunities to earn profits, research institutes and seed companies have less incentive to generate new products and/or improve their services.

The lack of competition in many counties and continuing subsidies for local seed companies may be at the root of the reform problems faced by the seed sector. Weak plant-breeder rights have kept the research institutes from becoming serious competitors. Without fully commercialized county seed companies and without reducing administrative intervention in local seed markets, firms do not have much of an incentive to increase services to farmers and will not search hard for innovations and cost-saving techniques. Even if entry restrictions were relaxed, however, high current levels of support and priority access to new products and local distribution networks for state companies may make it impossible for new entrants to survive and expand. Serious reform must address both sides of this issue: they must both encourage competition and ensure that new firms can compete on equal terms.

2.4.3 Commodity Price and Marketing Policies

Grains Marketing Policies

Price and market reforms are key components of China's transition strategy to shift from a socialist to a market-oriented economy. The price and market reforms initiated in the late 1970s aimed at increasing farm level procurement prices and gradually liberalizing the market. These reforms included gradual increases in the agricultural procurement prices towards market prices, reductions in procurement quota levels, the introduction of above quota bonuses for cotton, tobacco and other cash crops, negotiated procurement of surplus production of rice, wheat, maize, soybean, edible oils, livestock and most other commodities at price levels higher than those for quota procurement, and flexibility in the marketing of the surplus production of all categories of agricultural products by private traders.

Although most of the many liberalization efforts have been partial, in most cases they have had a significant impact on productivity and crop selection decisions at the household and the national level (Huang, Rosegrant and Rozelle, 1996). The shift from the collective system to the HRS also increased the price responsiveness of farm households (Huang and Rozelle, 1996). While few works document the effect of market reform, Lin (1992) shows that there was a small, positive impact in the early 1980s.

As the right to private trading was extended to include surplus output of all categories of agricultural products after contractual obligations to the state were fulfilled, the foundations of the state marketing system began to be undermined (Rozelle et al., 2000). After a record growth in grain 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 rice, wheat, maize and cotton, the intention was to gradually eliminate the planned procurement of agricultural products; government commercial departments could only continue to buy and sell at the market. For grain, incentives were introduced by reducing the volume of the quota and increasing the procurement prices. The share of compulsory quota procurement in grain production reached 29% in 1984, but decreased to 18% in 1985, 13% in 1990 and 11% in 1995-1997. While the share of negotiated procurement at market price increased from only 3% in 1984 to 6% in 1985 and 12% in 1990.

Because of the sharp drop in the growth rate of grain output and the increase in food prices in the late 1980s, the pace of marketing reform stalled. The mandatory procurement of rice, wheat, maize, soybean, oil crops and cotton continued. To provide incentives for farmers to increase productivity and to encourage sales to the government, quota procurement prices were increased over time. The increase in the nominal agricultural procurement price, however, was less than the inflation rate, which led to a decline in the real grain price (Huang and Rozelle, 2003).

As grain production and prices stabilized in the early 1990s, however, another attempt was made to abolish the grain ration system. Urban officials discontinued sales at ration prices to consumers in early 1993. For a year and a half, the liberalization move succeeded. Then, while it appeared that both the state grain distribution and procurement systems had been successfully liberalized, food prices increased sharply – as did other prices in the economy. Some people blamed the nation's inflation on the increases in food prices. As a result, the state's compulsory quota system was reimposed in most parts of

China in 1995, but at a lower procurement level. The share of grain compulsory quota procurement in total production remained at only 11% in 1995-97.

Since the mid 1990s, several new policies have been implemented. Immediately after the price increases in the mid 1990s, China announced that it would introduce the provincial governor's 'Rice Bag' responsibility system.[1] The policy was designed to strengthen food security and grain markets by making provincial governors and governments responsible for balancing the supply and demand of cereals in their provinces and for stabilizing local food markets and prices. Policies under the system included reimposing grain rationing to poor consumers, investing in production bases inside the province and attempting to keep grain from being shipped outside the province. Had it been implemented, this policy may have reduced short-term agricultural price fluctuations; however, it would not have been without costs. It is widely believed that the policy may have had an adverse impact on the efficiency of resource allocation, diversification of agricultural production and farm income. Moreover, a great number of efforts to restrict the flow of grain were not successful. Market flows continued as the share of total government procurement (both quota and negotiated procurement) in domestic production dropped from 26% in 1994 to 22% in 1996, driven by the profits that traders could earn by shipping grain from low- to high-priced areas (Huang et al., 2003).

With three record levels of grain production in China in the late 1990s, and almost zero or negative inflation since 1997, increasing grain stocks and declining food prices showed that the economy had bounced back. However, in some sense the government's policies were a victim of their own success. With prices falling sharply, China's leaders were worried about a repeat of the mid 1990s. Thus, instead of proceeding with market reform, they opted to try to exercise greater control over grain prices by means of price protection policy.

In fact, in the late 1990s China's leaders attempted to curb market forces more than in earlier retrenchments, but this time they applied a completely different measure. Market intervention policy shifted from taxing grain producers by setting a lower government quota procurement price (lower than market price), to preventing the price of grain falling by setting a grain protection price (higher than market price). To reduce the financial burden of protection price policy, in 1998 the central government initiated a controversial policy change prohibiting individuals and private companies from procuring grain from farmers.[2] In contrast to past policies, grain quota procurement prices were set at a level higher than market prices, which meant a transfer in favor of those farmers able to sell at that price (Huang, 1998; Lu 1999). China's leaders thought that they could monopolize the grain markets through the commercial arms of grain bureaus, and that the grain bureaus would be able to sell the procured grain at an even higher price in the market and meet the nation's goal of increasing farm income. If the state could have exercised monopoly power in grain markets, it is possible that they could have implemented the price support while enabling the state grain companies (i.e. the commercial arms of the grain bureaus) to earn a profit, while reducing the government's financial burden of maintaining the state-run grain procurement and marketing system. The loser under this policy would have been the consumer, who would have had to pay a higher price for grain.

[1] In China, 'rice' sometimes means staple food: 'Rice Bag' includes rice, wheat, maize and soybean.

[2] Farmers were supposed to deal solely with the commercial arm of grain bureaus and the grain reserve system - although traders were allowed to operate in wholesale and retail markets.

Such win-win policies did not work, however, primarily because the government could not suppress the market activities of traders and of the employees of the commercialized grain system. While above market prices were offered to farmers in some years, cash-strapped grain bureaus could not procure all the grain that farmers wanted to sell. Grain production increased, but since grain bureaus were trying to sell grain to urban and commercial users at above market prices, they had few takers. Unable to stop the activities of millions of private grain traders, urban users continued to buy from their original channels at market-set prices. Not surprisingly, stocks started to accumulate, the real price in the market fell even further, and the commercialized grain bureaus that had been forced to buy grain at high prices now had huge stocks of grain that were worth less than they had paid for them and their debts became greater than ever.

Perhaps most surprisingly, commodity markets have steadily strengthened in rural China through these recurring cycles of reform and retrench. The proportion of retail commodity sales sold at market prices has kept increasing. According to Lardy (2001), the share of agricultural goods sold through the market was just 6 percent in 1978. By 1995 it had increased to 79 percent and by 1999 to 83 percent. Transaction costs have fallen while the degree of integration has increased (Park et al., 2002). As seen, markets are also robust. Despite attempts to intervene, the government has increasingly been unable to halt grain flows in their attempts to implement local price controls.

However, the cost of good markets is that China's time-tested methods of executing grain policies no longer work. In 2000, China's leaders found that the retrenchment policies started in 1998 had achieved few, if any, of the originally intended objectives. The incomes of farmers from agriculture were falling as market prices declined, the financial position of the grain bureaus continued to deteriorate and the government's fiscal burden increased to historical highs as stock accumulated. In 1998, the government's grain marketing subsidies in the form of payments to farmers reached nearly CNY 100 billion. Although the program was scaled back, in 1999 and 2000 subsidies remained at a level of CNY 60-80 billion annually. Yielding once again to market forces, another round of liberalization was launched in 2000. China's leaders decided to eliminate the grain procurement quotas in grain deficit regions (e.g. the coastal provinces of Zhejiang, Jiangsu and Shandong). By 2001, the liberalization efforts spread to inland, surplus regions.

In addition to the development of China's grain markets, the gradual, albeit stop and go marketing reforms have also slowly reduced the tax burdens of grain farmers. Huang and Rozelle (2003) show that grain farmers, in general, have been taxed heavily by grain procurement policy. Importantly, however, with marketing reform, the degree of taxation has been declining significantly over time. Indeed, although historically China's tax on farmers through the procurement system has been high, since 2000 with the elimination of procurement quota and the initiation of the payment of subsidies to farmers and traders, we may be witnessing the beginning of a regime shift from taxation to subsidization.

Livestock and Feed Marketing

Livestock is one of the few major agricultural commodities to have been mostly liberalized since the mid 1980s. Currently, the market prices of livestock are based entirely on domestic demand and supply, as well as on a limited amount of trade. Pork is the major meat product, accounting for about two-thirds of total meat supply in China. Household producers dominate the livestock industry. Most households with hogs raise them in traditional ways in their backyard. Nearly two-thirds raise fewer than three hogs per year (RERC, 1997). In 2000, household backyard production accounted for nearly 80 percent of all hogs raised in China; the remainder was produced by farm households that specialize in livestock production (15 percent) and intensive, large-scale commercial producers (around 5 percent; CCAP, 2002). Households raise backyard hogs with a variety of feed mixes that include maize, sweet potato, other low quality food and feed grains, meal and waste products from home-produced crops (e.g. potato vines).

With the rise of specialized households and the evolution of backyard hog raising in many areas, the way farmers feed livestock has changed over time. Most prominently, the role of maize as a feed has increased over time. It accounted for more than 75 percent of feed in the late 1990s and reached 78 percent in 2000 (CCAP, 2002). Currently, the marketing and pricing policies concerning maize as a feed are the same as those concerning maize as a food, namely it is being increasingly liberalized, which has been fully discussed.

While policies historically have affected maize - China's most important feed grain- there has been only minimal policy interference in the other feed crops. Sweet potato and soybean meal are the second and the third most important sources of feed in China's feed sector. Grain policy has virtually ignored the sweet potato and the soybean. About the only type of direct policy influence has been a result of the effect of the marketing and pricing policies for soybean meal. Since soybean in China is categorized as grain, during the 1980s and 1990s when dealing with soybean meal in international trade issues, it was treated as a grain crop and subject to tight control by the government. However, in the late 1990s, restrictions on soybean meal imports were relaxed earlier than those on grain were. As a result, there have been times when livestock producers have imported large quantities of soybean meal, perhaps at levels beyond what they would have done had all markets been liberalized. More recently, large volumes of soybeans have been imported to supply the large, modern soybean oil plants in the coastal regions.

The role of the sweet potato in the Chinese economy has also been changing rapidly on both the supply and the demand side. Sweet potato is the fourth major staple crop and the second largest feed grain in China. While production has remained fairly stable at 20-23 million metric tons (mmt) annually since the 1970s, the sweet potato area has declined significantly. Hence, the yield growth of sweet potato has generally been lower than maize, except in the past few years.

On the demand side, the utilization of sweet potato also has changed rapidly. As a food staple, like maize, it has also declined. In the mid 1980s, the proportion of sweet potato used as feed and for food processing surpassed the proportion used for direct consumption. Between the 1980s and the end of the 1990s, the proportion used for food fell from about 50 percent of total production to less than 15 percent. In contrast, the use of sweet potato for feed and industrial purposes grew significantly (Huang et al., 2001). By the late 1990s, feed use accounted for more than 40 percent and processing demand accounted for one-third of total sweet potato production. In 2000, sweet potato accounted for about 7 percent of all feed used in China (CCAP, 2002).

2.4.4 Fiscal and Financial Investment Policy

To gain a better understanding of government policy bias among sectors, we need to look at both the state's agricultural product procurement policy (implicit tax) and its investment and tax policies. Table 2.10 shows that government fiscal expenditures on agriculture have been consistently higher than the fiscal revenues from agricultural taxes and other fees collected from agriculture. However, the fiscal revenue from agriculture based on explicit tax and fees is only small portion of the capital contribution of agriculture to industry and to the urban sector. It is also interesting to note that since the early 1980s rural enterprise development has provided the government with significant fiscal income and has led to a net capital outflow from rural to urban areas.

Table 2.10 Capital flows (CNY billions in 2000 prices) from agriculture to industry and from rural to urban through fiscal, financial and grain procurement systems, 1980-2000

	Fiscal system		Financial system		Grain	Cash flow from	
	Agric. to industry	Rural to urban	Agric. to industry	Rural to urban	marketing (implicit tax)	Agric. to industry	Rural to urban
1980	-33.6	-25.8	15.9	7.2	39.3	21.6	20.7
1985	-14.9	13.2	29.5	9.2	11.3	25.9	33.7
1990	-29.6	14.5	62.5	28.8	33.3	66.2	76.6
1995	-18.4	115.8	131.7	89.1	33.5	146.8	238.4
2000	-46.5	153.2	206.9	247.8	-0.1	160.3	400.9
Total: 1980-2000	-533.2	1069.7	613.4	1734.7	613.9	1289.3	2297.0

Note: values are in real terms in 2000 prices (general retail price index used as price deflator).
Source: authors' estimates.

When taken together, a significant capital outflow from agriculture to industry occurred in the last 20 years through financial systems, particularly rural credit cooperatives. A much higher value of capital outflow from rural to urban than agriculture to industry clearly shows that capital accumulated from agriculture not only supports industrialization in the urban sector but also provides notable financial resources for the successful development of rural industry. After accounting for the implicit agricultural taxes that are levied on farmers through the government's procurement system, China extracted a total value of about CNY 1,289 billion (at 2000 prices) of capital from the agricultural sector for use in the nation's industrialization between 1980 and 2000. About CNY 2,297 billion flowed from the rural sector for the urban economy during the same period (Table 2.10). The shifting of capital from agriculture to industry and that from the rural sector to the urban sector has accelerated since the 1980s. In this respect it is interesting to mention that although government expenditures in most areas of agriculture have increased gradually during the reform period, the ratio of agricultural investment to agricultural gross domestic product (AGDP) has monotonically declined since the late 1970s. In 1978, the government sector invested 7.6% of AGDP (NSBC, 2001). By 1995, the proportion had fallen to 3.6% (Huang and Ma, 1998; Nyberg and Rozelle, 1999).

2.4.5 Rural Credit

Although the movement of capital from agriculture to industry is to be expected, mobilizing and efficiently using available financial resources in rural areas is important for achieving high rates of economic growth, especially in the rural areas of developing countries where such funds typically are in short supply (Nyberg and Rozelle, 1999). Evidence is strong that greater financial intermediation accompanies higher incomes. As economies grow, financial institutions often play an important role in directing resources to their most productive use. However, governments in developing countries often use state control of the banking system to pursue policy goals that are not always consistent with efficient intermediation. The fear is that few funds are available for farmers and the activities they want to pursue.

Table 2.11 Percentage of households engaged in various activities financed with loans, and average size of these loans per activity

Year	Fertilizer	Livestock	Small business	Costs of Illness	Construction	Other
Percent of households engaged in activity						
1988	30	25	32	38	56	25
1995	22	18	34	37	56	24
Average loan amount of households receiving loan (CNY, in 1988 prices)						
1988	125	238	1205	494	1667	499
1995	90	143	3767	849	2161	550

Note: 32 observations for Zhejiang, Sichuan, Hubei, Shaanxi, and Shandong, and 24 for Yunnan.
Source: Nyberg and Rozelle, 1999.

Concern over China's rural financial institutions stems from several factors. Despite a number of important financial sector reforms, financial markets have been liberalized more slowly than most sectors (Nyberg and Rozelle, 1999). Regulated interest rates imply credit rationing, making private entrepreneurs and farmers, especially the poor, likely to have difficulty gaining credit access. If rural enterprises have had difficulty gaining access to bank credit, farmers have had even more. Even without interest rate deregulation, small farmers are often rationed out of formal credit markets. Field researchers observe that in many poor villages, local credit cooperatives have stopped lending to farmers, although in the last couple of years the government has made an effort to expand lending. Between 1988 and 1995, farmers reduced credit financing for such key activities as fertilizer and livestock purchases (Table 2.11).

Park, Brandt and Giles (2002) have shown that without access to formal credit in agriculture, informal credit has taken its place. In China, most informal credit in the agricultural sector is in form of loans from relatives and friends. Most loans do not bear any interest, but there is often an implicit obligation to provide an interest-free loan to the relatives/friends if there is a need in the future. Interestingly, although credit constrains the plans of many households to invest in businesses and large consumption goods (such as housing), there is little evidence that farmers - even those in poor areas - are constrained in their day-to-day agricultural production activities (Park and Wang, 2001).

2.4.6 Labor Market Development Policies

China's experience in the development of rural enterprise illustrates the importance of expanding non-agricultural sectors in rural areas to generate employment for rural labor, and increasing agricultural labor productivity and farm income (Table 2.12). Rural industrialization plays a vital role in reducing the agricultural labor surplus. The share of rural enterprises (REs) in GDP increased significantly from 2-4 percent in the 1970s to 30 percent in 1999; already by the mid 1990s, REs dominated the export sector (Table 2.12). REs now employ 35 percent of the rural labor force and are the major source of creating rural employment. With the rapid growth of REs in China, the diversification of farm income has been remarkable. The non-farm-income proportion of total farm income increased sharply from 17 percent in 1980 to 47 percent in 1999 (Table 2.12).

Table 2.12 Farm and rural enterprise (RE) development in China, 1980-99

	Share of RE in rural labor (%)	Share of RE in total GDP (%)	Share of RE in total export (%)	Farmland size (ha/farm)	Non-farm income share (%)
1980	9	4	0	0.56	17
1985	19	9	15	0.51	25
1990	23	14	43	0.43	26
1995	34	25	48	0.41	37
1999	35	30	48	0.40	47

Source: SSB, Statistical Yearbook of China, and China's TVE's Yearbook, various editions.

Prior to the rural reforms, underemployment had been a persistent problem in rural China. This became more apparent as efficiency gains in agriculture during the reforms reduced the labor input needed for crop production. During the same period, the rural labor force grew annually by 2-2.5 percent, with more than 10 million new entrants each year during the 1980s. The increase in rural labor resources combined with land scarcity limited the absorptive capacity of agricultural employment and could have caused an enormous labor surplus, slowed down farm income growth and limited the extent of poverty reduction had the non-agricultural sector not developed.

At the same time, a number of factors are still hindering the adjustment process of labor. There are natural barriers, such as moving costs, which exist in all economies, regardless of the nature of its structure. China's labor markets still contain a number of structural imperfections, such as employment priority for local workers, housing shortages and the urban household registration system (Lin, 1991b; Lyons, 1992; Rozelle, 1994; Lohmar, 1999). One of the costs of these kinds of barriers is that they may slow down the mobility of factors among alternative economic activities, reducing the efficiency of the sector's producers and preventing the poor from sharing the benefits of general economic growth.

2.4.7 Exchange Rate Policy

Macroeconomic policies can have a significant influence on the overall incentives of producers in the agricultural sector (Nyberg and Rozelle, 1999). One of the main mechanisms by which that influence is created is through the nation's exchange rate policy (Huang and Rozelle, 2002). Exchange rates can have great implications for trade. Other external trade policies, for example the management of flows across the border, can also affect trade. China's policies governing the nation's external economy have played a highly influential role in shaping the growth and structure of agricultural production and trade for many decades. During the reform years, new policies have sought to counteract some of the earlier distortions and have themselves contributed to lower levels of protection.

Before economic reform, China adopted a state-monopolized, unified system of foreign exchange management to support the nation's import-substitution industrialization strategy (Lardy, 1995). Under this system, the government strictly controlled the earnings and allocation of all foreign exchange. In 1979 with the implementation of economic reform, China introduced the foreign exchange retention system, aimed at providing incentives to various enterprises and local governments to increase foreign exchange earnings through the expansion of exports. Under the system, enterprises and local governments were able to retain a certain proportion of the foreign exchange they earned through their exports.

In 1988, additional reforms were introduced in an attempt to strengthen the earlier incentives. In particular, China's leaders began allowing local governments and enterprises to control and use all the foreign exchange they earned as long as they did so in accordance with state regulations. While the implications were wide-ranging, the policy shifts provided strong incentives to local leaders in north-eastern China to encourage exports. This applied to many agricultural commodities, such as maize. For example, when maize exports led to increased foreign exchange earnings, officials were able to relax the severe constraints on the importation of technology, capital and other commodities. In the late 1980s - soon after the incentives had been put into place - annual maize exports reached an average of about 4 mmt. In the early 1990s - after the incentives had been strengthened - exports nearly doubled (7.7 mmt).

Even during this time, however, the foreign exchange market was highly regulated. Exchange rate management was controlled by a two-tiered foreign exchange rate system. One rate - the official one - was set by policy. The other rate was set by a swap center, where units with extra foreign currency could exchange it with units that needed additional allotments. The foreign exchange rate from the swap center was based mainly on supply and demand forces. The swap rate was about 20 percent higher than the official rate in the mid 1980s, and as much as 75 percent higher in the late 1980s (Table 2.13, column 4). When China's leaders devalued the official rate by more than 40 percent in the early 1990s, the gap between the swap and officials rates fell to only about 25 percent.

Table 2.13 Official and swap market exchange rates and the real effective exchange rate indices, 1979-2001

Year	Official exchange rate (CNY/USD) (1)	Black market or swap center (CNY/USD) (2)	Real effective exchange rate (1994=100) (3)	Ratio (4)=(2)/(2)
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: From IMF database.

In its efforts to further liberalize the foreign exchange rate system, China's leaders unified the official exchange rate and the swap market exchange rate and adopted a single-currency, managed exchange rate system. The rate was supposed to be managed at the rate that was consistent with supply and demand in 1994. As a result, the rate was effectively devalued from the official exchange rate of CNY 5.76 per USD 1 in 1993 to the managed floating market exchange rate of CNY 8.61 per USD 1 in 1994. This shift was a one-off devaluation of more than 50 percent (Table 2.13). In December 1996, after the currency stabilized at that rate, the Yuan became convertible on China's current account. Since 1996, black-market or unofficial secondary markets for foreign exchange have moved closely with the official exchange rates and stayed remarkably constant.

The impacts of the devaluation of the Yuan on the country's trade are substantial. Foreign reserves increased from USD 28.6 billion in 1990 to USD 73.6 billion in 1995 and reached USD 166.5 billion in 2000 (MOFTEC, 2002). Such large increases in reserves have actually caused a gradual appreciation of the Yuan since the mid 1990s. Since 1996, China has been the world's second largest foreign reserve holder (just behind Japan).

China's exchange rate policy changes have significantly affected the production and trade incentives for producers and traders of imported and exported agricultural commodities. While a nominal exchange rate devaluation is only effective in increasing the price of tradable relative to non-tradable goods, if inflation does not erode the increase in the exchange rate, a real depreciation of the domestic currency increases the local currency prices of tradable relative to non-tradable and contributes to the price competitiveness of domestic exports (Table 2.13). Since agricultural products are generally tradable, agricultural incentives may be expected to increase with real depreciation of the domestic currency.

Table 2.13 shows that China's exchange rate policy during the reform period has clearly been successful in effecting substantial depreciation (i.e. increase) in the real exchange rate. Whereas nominal exchange rates remained constant, and even appreciated, over three decades prior to the reform period (the reforms started in 1979), real exchange rates rapidly depreciated during the entire reform period, with the exception of a couple of years after 1985. From 1979 to 1993, the real exchange rate depreciated by 422 percent (397/94). Evidently, nominal exchange rate depreciation was not eroded by inflation despite significant expansion in the money supply.

The success of the exchange rate adjustments stemmed mainly from the productivity effects of economic reforms and technological innovations in agriculture, foreign trade and industry, which contributed to the relatively low inflation. China was second only to Indonesia in pursuing aggressive adjustments in the real exchange rate in Asia before the mid 1990s or prior to the Asian economic crisis. The favorable trends in the real exchange rate also sharply increased export competitiveness, and thus contributed significantly to the export growth record on the whole and also contributed to the spectacular economic growth performance of the country in the 1980s and the early 1990s.

However, since the adoption of the managed floating exchange rate system in 1994, the value of the Yuan has appreciated slightly (Table 2.13). The official exchange rate declined from CNY 8.61 per USD 1 in 1994 to about 8.28 in 1998-2001. It is widely believed that the domestic currency has gradually become overvalued since 1994, and as such has provided a disincentive to the tradable agricultural sector.

2.4.8 Trade Policy

The changes in the exchange rate system were implemented at the same time that China began to liberalize its international trading system. Lower tariffs and increasing imports and exports of agricultural products began to affect domestic terms of trade in the 1980s. 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 many major agricultural commodities were not included in the move to decentralize trade, the moves did spur the export of many agricultural goods. In addition, policy shifts in the 1980s and 1990s changed the trading behavior of state traders. China's leaders allowed the state traders to increase imports in the 1980s and 1990s.

Moves to relax rights of access to import and export markets were matched by actions to reduce the taxes assessed at the border. After the reduction 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. The simple average agricultural import tariff fell from 42.2 percent in 1992 to 23.6 percent in 1998, and then to 21 percent in 2001 (MOFTEC, 2002).

Changes in trade and domestic marketing policies have resulted in dramatically shifting trade patterns. Agricultural exports and imports have both soared (see previous sections). Huang and Chen (1999) also note that the net exports of land-intensive bulk commodities - such as grains (except for maize), oilseeds and sugar crops – have decreased, while exports of higher-valued, more labor-intensive products – such as horticultural and animal (including aquaculture) products – have increased. In the 1990s, the proportion of grain exports (around 20 percent of total agricultural exports) was less than half of what it was in the early 1980s. By the late 1990s horticultural products and animal and aquatic products accounted for about 80 percent of agricultural exports. These trends are even more evident when the trade data are grouped on the basis of factor intensity.

Overall, trade distortions in the agricultural sector have declined in the past 20 years (Huang and Rozelle, 2002). Much of the reduced protection in agriculture has come from decentralizing authority for imports and exports and relaxing licensing procedures for some crops (e.g. moving oil and oilseed imports away from state trading firms) and foreign exchange rate changes. Other trade policies have reduced the scope of NTBs, relaxed the real tariff rates at the border and changed quotas (Huang and Chen, 1999). Despite this real and, in some areas, rapid set of reforms, the control of a set of commodities that China's leaders consider to be of national strategic importance (e.g. rice, wheat and maize) remain with policy makers to a much larger extent (Nyberg and Rozelle, 1999).

For example, in the case of grain prior to China's accession to WTO, although the import tariff rate was low, China's leaders did not allow the importation of grain except by those agencies and enterprises that held licenses and import quotas. When traders imported grain that was specified as being within the quota, the tariff rate was only about 3 percent. The tariff rate for grain imported above the quota, however, was as high as 114 percent. No above-quota grain entered China, however, because grain imports have to be arranged by state traders. During the entire reform period, China National Cereals, Oils and Foodstuffs Import & Export Corporation (COFCO) has been the nation's single-desk state trading company for grain. It also manages the imports of edible oils. COFCO is one of the largest state trade enterprises (STEs) not only in Asia but also in the world. The value of food and non-food goods imported by China's STEs probably exceeds the value of such goods imported by all other STEs in all current WTO member countries. Over the past decade, COFCO has imported as much as 16 percent of the world's traded wheat, and has exported as much as much as 20 percent of the world's traded maize (Nyberg and Rozelle, 1999). Even after China joined the WTO, COFCO continued to act as a key agent in the international grain trade for national and provincial grain trading companies and still has preferential access to import quotas.

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

Despite the above efforts to commercialize the grain trade, there has been minimal trade liberalization of grains, and particularly of maize (Huang and Rozelle, 2003). Economic logic and casual observation gives reason to believe that China's current system of grain trading causes substantial inefficiencies and creates distortions in the domestic economy. It is possible that such a system could even create uncertainty in world markets. Provincial grain companies serving China's domestic markets complain incessantly about the inconvenience and financial burdens associated with their dealings with COFCO (Nyberg and Rozelle, 1999). Although price stabilization has often been stated to be a goal of trade policy, COFCO has failed in its bid to insulate China from fluctuations on international markets (Lu, 1999). As national and regional monopolies, neither COFCO nor JGIEC faces competition in their dealings on global markets. They also often have considerable rents to protect. Lack of information also characterizes China's maize trade transactions, frustrating both domestic and international traders.

China has also subsidized certain agricultural commodities from time to time. For example, China used export subsidies in the years prior to its WTO accession to increase the exports of two commodities, namely maize and cotton. By providing exporters with payments to encourage the export of maize, China's leaders have increased the protection of domestic producers by increasing the price of domestic commodities. Interviews carried out in the field in 2001 revealed that maize exporters, especially those in north-eastern China, received subsidies that averaged 34 percent of the export price. One trader said that for each ton of maize his company exported in 2001, it received CNY 378 (USD 45.7) per ton after it produced an export bill bearing the export sales price.

2.4.9 Technology Development

After the 1960s, China's research institutions grew rapidly, from almost nothing in the 1950s to a system that now produces a steady flow of new varieties and technologies. China's farmers used semi-dwarf varieties several years before the release of green revolution technology elsewhere. China was the first country to develop and extend hybrid rice. Chinese-bred conventional rice varieties, wheat and sweet potatoes were comparable to the best in the world in the pre-reform era (Stone, 1988).

Agricultural research and plant breeding in China is almost completely organized by the government. Reflecting the urban bias of food policy, most crop-breeding programs have emphasized fine grains (rice and wheat). For national food security considerations, high yields were the major target of China's research program until recent years, when quality improvement was introduced into the nation's development plan.

A nationwide reform of research was launched in the mid 1980s. This reform was intended to increase research productivity by shifting funding from institutional support to competitive grants, supporting research useful for economic development and encouraging applied research institutes to support themselves by selling the technology they produce.

Today, the record on the reform of the agricultural technology system is mixed and its impact on new technological developments and crop productivity is unclear. Empirical evidence demonstrates the declining effectiveness of China's agricultural research capabilities (Jin et al., 2002). Our previous work found that while competitive grant programs probably increased the effectiveness of China's agricultural research system, the reliance on commercialization revenue to subsidize research and compensate for reduced budgetary commitments weakened the system.[1] It is possible that imperfections in the seed industry partly contributed to the ineffectiveness of research reform measures in crop-breeding.

2.4.10 China's WTO Accession

In its most basic terms, the commitments in the agricultural sector can be classified into three major categories, namely market access, domestic support and export subsidies. The commitments linked to WTO accession will lower the tariffs on all agricultural products, increase access to China's markets by the foreign producers of some commodities through tariff rate quotas (TRQs) and remove quantitative restrictions on others. In return, China will gain better access to foreign markets for its agricultural products, and receive a number of other indirect benefits. Domestic support and export subsidies are the other two critical issues that arose during the course of negotiations. Together with a number of other market-access commitments, these 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 actually do not appear to be substantial. Overall agricultural import tariffs (in terms of its simple average) declined from about 21 percent in 2001 to 17 percent in 2004. A continuance of earlier trends, the simple average agricultural import tariff fell from 42.2 percent in 1992 to 23.6 percent 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 20 years one has to conclude that the commitments are merely an extension of China's past changes. WTO in this way can be seen as just another step on China's road to opening up its economy.

The details of the commitments in the agricultural sector are elaborated in Chapter 4 (section 4.3.2). These commitments play an important role in the formulation of the policy assumptions for the baseline projection.

2.5 Impacts of Reforms

Both domestic and external economic and institutional reforms are expected to have wide impacts on China's agricultural and rural economies. This section is focused mainly on the

[1] Findings based on a series of intensive interviews and on survey data gathered from a wide range of Agriculture Ministry personnel, research administrators, research staff and others involved in China's agricultural research system.

impacts on agricultural production incentives, trade, market integration and rural labor employment.

2.5.1 Changes in Agricultural Protection

The first step in analyzing the impact of reform on agricultural production, prices and consumption in China is to understand how protection has changed over time. An aggregate measure of protection (i.e. an index that measures the combined distortion from all policies) can be generated by comparing China's domestic prices with international ones. The measure that we use is called the nominal rate of protection (NPR). The analysis in the case of China, however, is a little more complicated because during its 20 years of reform, it has had several prices, namely a quota price, a negotiated price and a market price. Hence, three different measures can be calculated. Table 2.14 shows the protection of cereals and soybeans using the quota, negotiated procurement and wholesale market prices since the early 1980s. Table 2.15 uses only market prices (or the state administered price in the case of cotton) to show the protection of cotton and livestock products during more recent years.

Table 2.14 Nominal protection rates (NPR) for grain, China, 1978-early 2000

	Quota procurement				Negotiated procurement				Wholesale market			
	Rice	Wheat	Maize	Soy-bean	Rice	Wheat	Maize	Soy-bean	Rice	Wheat	Maize	Soy-bean
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	-13	1	2	-7	-6	7	10	17	-7	22	26	26
2000-01	2	5	6	10	0	2	5	9	-2	18	26	19

Note: border prices are 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 to convert border prices.

This analysis makes it clear that for most of the early reform period, the requirement that farmers submit a mandatory delivery quota of grain and soybean at below market prices has represented a lump-sum tax on farmers and lump sum subsidy for the urban consumers who were able purchase grain from state rationing outlets at below market value (Table 2.14). Before the mid 1990s the average price farmers received for compulsorily delivered grains and soybean was far below the border price. Although all of China's major crops were affected by the state grain quota procurement policy, wheat – the nation's main imported farm commodity – in most periods received favorable treatment relative to rice. For example, in the early 1990s, its rate of taxation, or negative protection (-14), was less than that of rice (-37; row 4). The same bias appears in the other price categories (columns 5-12). The bias is even greater than shown by the within price category comparisons, since a higher proportion of rice production is procured at the low quota procurement price than is the case of wheat, maize and soybean (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 (wheat and maize) rose above them. An examination of China's NPRs based on negotiated procurement and market prices between 1995-99 and 2000-01 (except for the case of rice), shows that China's domestic prices have begun to rise above the border price.

Table 2.15 Nominal protection rates (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 prices at urban wholesale markets. The cotton wholesale price is estimated as the state procurement price times 1.25. Official exchange rates are used to convert border prices.

Interestingly, the case of livestock is markedly different (Table 2.15): the NPRs are negative for all the major commodities, namely pork, beef and chicken. In all periods, meat producers received less than they would have had they sold their output on domestic and world markets at international prices.

When examining the NPRs for almost all commodities over time, as discussed in an earlier section, we can see the impact of China's agricultural trade policy. In the late 1970s and the early 1980s, the domestic wholesale price of China's four major commodities far exceeded the world price (measured at China's border; Table 2.14). For example, China's rice market price was 10 percent above the world market price (row 1). The nation's wheat and maize prices exceeded the world price by around 90 percent. However, in the subsequent 20 years, the protection rate for rice became negative and that for wheat and maize fell to around 30 percent (row 6).

The driving force behind this fall in protection was the gradual but sustained effort to implement trade liberalization policies during the last 20 years (Martin, 2002; Lardy, 1995). Published agricultural tariff rates fell from more than 40% in the early 1990s to 21% in 2001. Assessed tariff rates have fallen even more. During this period, the intervention by state traders and the use of NTBs also gradually fell. In the case of some commodities, there has been a sharp increase in the number of trading firms, both exporters and importers. China has tried to gain access to markets for some commodities outside China. 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 reduced protection appears to have come from decentralizing authority and relaxing licensing procedures for some crops (e.g. taking oil and oilseed imports away from state trading firms), reducing the scope of NTBs, relaxing real tariff rates at the border and changing quotas (Huang and Chen, 1999; Huang and Rozelle, 2002).

2.5.2 Changes in Agricultural Trade

One immediate effect of reduced protection has been the shift in trade patterns that China has experienced. For example, except for rice in the late 1980s and pork in recent years, exports of exportable commodities (including, rice, vegetables, pork, poultry and fish) have increased substantially since the late 1980s (Tables 2.16 and 2.17). In contrast, imports of most importable commodities (including, coarse grains, soybean, edible oils, cotton and sugar - except for late 1990s - and milk) have increased in the same period.

Although Tables 2.16 and 2.17 illustrate the general trends for each of the commodity groups, in some of the groups there is heterogeneity among commodities in terms of their trade patterns. It also shows that shocks in the economy have affected imports from time to time. For example, in addition to the increasing levels 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 (e.g. Thai Jasmine) that are not available in China. The quantity of imported rice, however, has been small, averaging less than 0.3 mmt annually in the 1980s and the 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 grain export restrictions in 1995 and 1996. Despite these aberrations, however, rice exports show a general rising trend over time, except for in the late 1980s. Exports reached a historical high (3.74 mmt) in 1998.

Vegetable, fish and most livestock commodities have become the major exportable products from China's agricultural economy. Trade reform has resulted in the large expansion of vegetable (Table 2.16) and fish (Table 2.17) exports. Most of these commodities are exported to East Asia, Southeast Asia and other international markets. Since the early 1980s, exports of these commodities have nearly doubled every five years. Pork exports – traditionally one of China's largest exportable livestock commodities – expanded steadily from the early 1980s until the mid 1990s. In recent years, however, growing international concern about meat quality and other sanitary/phytosanitary concerns reduced China's pork exports in the late 1990s. Poultry exports, in contrast, grew steadily through the late 1990s. The increasing trends made poultry China's top livestock export product. The annual export of poultry recently reached 0.3-0.4 mmt. Interestingly, because of taste preferences both in and outside China and favorable price ratios, the nation not only exports poultry meat (e.g. chicken breasts), but also imports significant amounts of specialty parts (e.g. chicken feet). Of the three main livestock commodities, beef has been the least traded commodity in recent years. In part, the small volume of beef trade is related to the China's livestock structure, where beef accounts for less than 5% of the livestock economy in value terms.

While China has been developing export markets for horticulture, fish and livestock products during the last 20 years, it has been gradually increasing imports of a number of crops (Table 2.16). China was a net importer of soybean for most of the last 20 years (importing, on average, 0.5-1.3 mmt), and soybean has been the top ranked imported commodity in China since the mid 1990s. Most of the increase in imports can be traced to external policies that liberalized soybean trade in the late 1990s (Huang et al., 2003). In 2001, China imported nearly 15 mmt of soybean to meet its increasing domestic demand. Trade liberalization has also affected imports of edible oil. When examining the affect of trade liberalization on imports and the rest of the economy, the trade patterns of soybean and edible oil are particularly important to understand.

Table 2.16 Imports and exports (x 1000 ton) of major crops, 1985-2000

Commodity	Period*	Import	Export	Net export
Rice	1985	210	1034	824
	1990	467	450	-17
	1995	973	613	-360
	2000	226	2503	2277
Wheat	1985	7336	64	-7273
	1990	13434	109	-13325
	1995	9047	672	-8374
	2000	672	116	-556
Maize	1985	245	4315	4071
	1990	146	4897	4751
	1995	1876	3123	1247
	2000	35	6871	6836
Sweet potato	1985	2	309	307
	1990	68	478	410
	1995	3	214	210
	2000	8	24	16
Other grains	1985	96	514	418
	1990	356	619	263
	1995	1460	323	-1137
	2000	2111	253	-1858
Soybean	1985	97	1113	1016
	1990	1	1107	1106
	1995	485	467	-18
	2000	10346	210	-10136
Cotton	1985	326	346	20
	1990	738	214	-524
	1995	630	45	-585
	2000	59	207	148
Edible oils	1985	160	152	-8
	1990	506	97	-408
	1995	483	271	-212
	2000	1405	15	-1391
Sugar	1985	1538	282	-1256
	1990	1139	788	-351
	1995	1917	697	-1220
	2000	445	253	-192
Vegetable	1985	0	761	761
	1990	1	1432	1431
	1995	23	2510	2487
	2000	97	3423	3326

* All figures are a three-year average centered on the years indicated (e.g. the figure for 2000 is the average for 1999-2001). 'Other grains' include millet, sorghum, barley and other minor coarse grains.

Table 2.17 Imports and exports (x 1000 ton) of major animal products, 1985-2000

Commodity	Period	Import	Export	Net export
Pork	1985	0	286	286
	1990	1	443	443
	1995	9	592	584
	2000	127	201	75
Beef	1985	29	46	18
	1990	52	225	173
	1995	70	125	55
	2000	35	34	-1
Mutton	1985	9	4	-5
	1990	14	3	-11
	1995	20	2	-19
	2000	25	2	-22
Poultry	1985	3	25	22
	1990	68	53	-14
	1995	240	298	58
	2000	798	398	-400
Egg	1985	0	59	59
	1990	3	43	40
	1995	2	28	27
	2000	1	45	44
Milk	1985	195	16	-178
	1990	238	32	-206
	1995	286	95	-192
	2000	437	164	-273
Fish	1985	53	164	111
	1990	101	284	183
	1995	144	607	462
	2000	510	1067	557

Although from a net protection standpoint, maize and cotton appear to be importable commodities, their trade patterns behave differently (Table 2.16). Even though the world market price of maize is lower than that in China, the nation has been a net exporter of maize in most years since the mid 1980s. Unsurprisingly, this can happen only because China has maintained monopoly control over maize imports and exports (Lardy, 1995). The patterns also can be explained by the fact that since the late 1990s China's leaders have used export subsidies to increase exports (Huang and Rozelle, 2002). Export subsidies have increased, reaching in 2001 one-third of the maize export price. Because of these interventions, maize is one of the few major crops that have not experienced falling NPRs since 1995.

Although for the last 20 years China has been one of the world's largest wheat importers, the nation has tended to protect wheat farmers. Wheat imports averaged about 10 mmt a year until the late 1990s (Table 2.16). Wheat imports, however, have exhibited a sharp cyclical pattern, increasing for three or four years before declining for three or four years. Rozelle and Huang (1998) believe that this pattern closely follows the way China's leaders intervened in the wheat trade and slowed down the growth of domestic demand.

In sum, although policy distortions of external trade for some commodities are still high, and in some cases have even increased (or not fallen over time), overall trade liberalization has gradually continued during the last 20 years. In aggregate terms (as shown in Table 2.8), both imports and exports have been increasing for the last 20 years. Total trade in the food sector more than tripled between 1985 and 2000 (Table 2.8). Because the share of agricultural commodities that China trades with the rest of the world is so small (especially when one compares the volume of food trade of China with the volume of food that moves through its domestic market), we should not be surprised that trade does not have a large impact on domestic prices.

2.5.3 Changes in Market Integration and Price Transmission

While important in determining the level of the protection and trade at the national level, the impacts of reforms on farmers in different regions depend not only on the average impacts but also on the size of the area across which it will be felt. This second factor, in turn, is a function of the size and nature of China's market. For example, if large areas of the country are isolated from coastal markets where imports land, then the effects of trade may be circumscribed to restricted parts of the country and should not be expected to have highly adverse impacts on the poor, who are largely located in inland areas far from major urban centers. While being isolated from negative shocks is a plus, there is also a cost: those living in poor, isolated areas also do not benefit from the price rises and opportunities to export. However, if markets exist that link distant regions with the coast, and price changes in one part of the economy quickly ripple through the economy, even though imports are infused into (and exports flow out of) areas concentrated around a few large coastal cities, they can have ramifications for poor households thousands of kilometers away.

To assess how integrated and developed markets are in rural China, we will first describe the data. We will then test for integration and conduct direct tests of how well prices in different markets move together and whether prices are integrated between the market town and China's villages.

Data

The data come from a unique price data set collected by China's State Market Administration Bureau. Nearly 50 sample sites from 15 of China's provinces report prices of agricultural commodities every 10 days. The prices are the average price of transactions that day in the local rural periodic market. We will examine rice, maize and soybean prices from late 1995 to 2000 (except for maize, which was available only through 1998). The assessment of market integration before 1996 is based our previous studies of the same commodities (Park et al., 2002). The three crops are produced and consumed in nearly every province in China.

Rice price data are available for 31 markets. Because of quality differences among rice varieties in different regions of China, we will look at price integration between markets in four regions, namely southern China (South), the Yangtze Valley (YV), the North China Plain (and northwest China; NCP) and northeast China (NE). For the provinces included in the sample, rice prices are available for over 90 percent of the time periods. Prices for maize and soybean data are available for 13 and 20 markets, respectively.[1] Product homogeneity makes it possible to include a broader geographic range of buyers and sellers in a single analysis, and we are able to assess the integration of markets spread out over thousands of kilometers. We will compare these results with those from 1988-1995 that were produced with the same sources of data (Park et al., 2002).

Price Trends

To show how prices change over time and differ across regions, we will use maize as an example. Figure 2.3 shows the trends of maize prices in the selected local markets in major producing provinces (Liaoning and Shandong) and consuming provinces (Guangdong and Sichuan). The data presented Figure 2.3 are maize prices that are reported every 10 days by enumerators who visit rural wholesale markets. Although maize prices fluctuate across seasons, they follow a general downward trend between 1995 and 2000. Moreover, the annual price variation has declined and the price gaps between producing and consuming regions have declined over time. Huang and Rozelle (2002) found that not only maize prices but all other grain prices - including those of rice, wheat and soybean – have moved together across far-reaching localities in China. Similar changing trends were also found for pork (Figure 2.4), though the data presented in Figure 2.4 are at a more aggregated level (annual and by province).

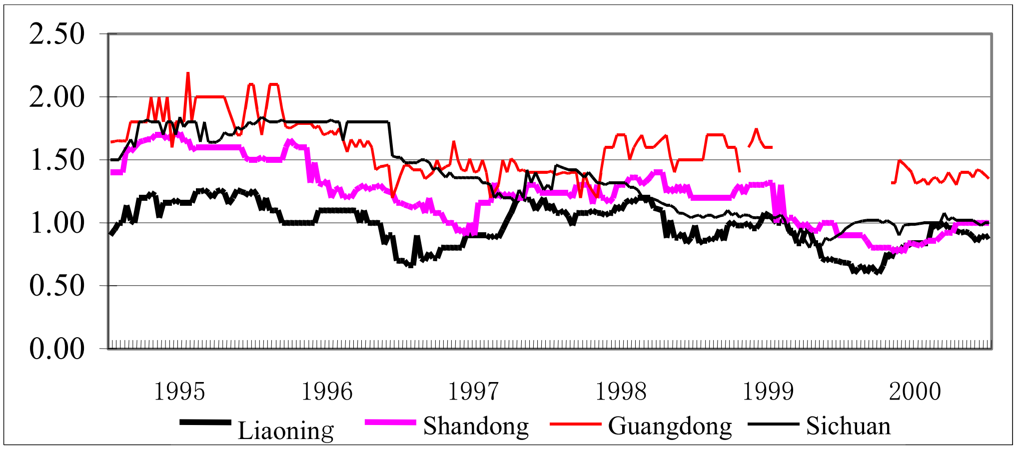

Figure 2.3 Maize retail price trend (CNY/kg), 1995-2000

Integration tests

We use cointegration statistics to test market integration. Cointegration statistics measure the proportion of movement in one price that is transmitted to another price during the period of observation. The coefficient on the 'causing' price is bounded between 0 and 1,

[1] Since we use data over time, we need to convert prices to a real basis. Nominal prices from our data set are deflated using monthly consumer price indices calculated and reported by the China National Statistical Bureau. Deflation facilitates transaction cost comparisons across time and allows us to disregard transaction cost increases in periods associated with inflation.

where 0 indicates that there is no impact on the 'affected' price variable (and markets are not integrated), and 1 indicates that markets completely adjust in the analysis period. A coefficient inside the 0-1 intervals indicates that prices adjust only partially during the period of observation (or that markets are integrated but frictions slow down price transmission). Two markets are cointegrated if the coefficient is 1 at a 5 percent level of significance.

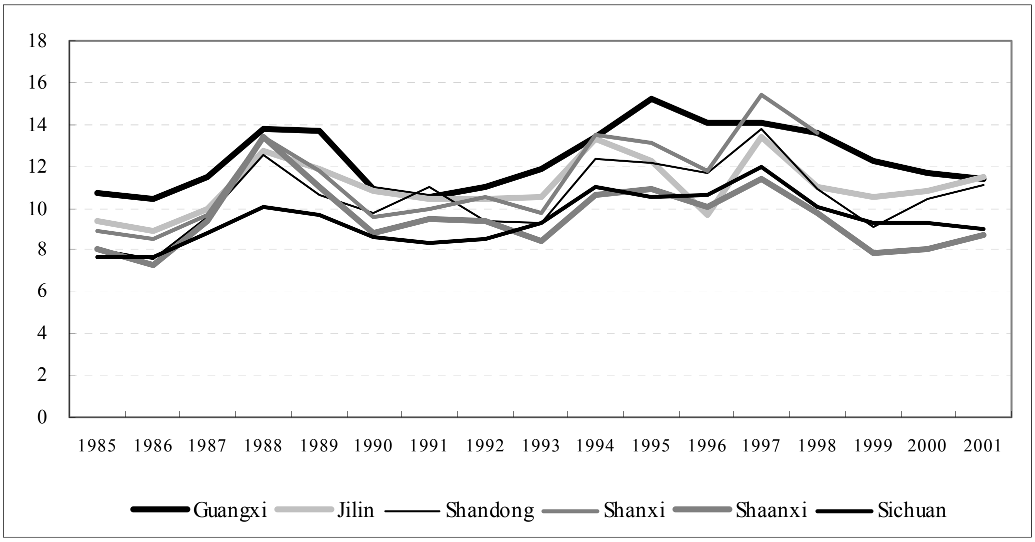

Figure 2.4 Real retail prices (in 2001 prices) of pork in the rural markets by provinces, 1985-2001

Using the results from the early 1990s as the baseline, our current analysis shows that during the late 1990s China's markets continued along their previous path of maturation, and that markets in China are now remarkably integrated. Examining the co-movement of prices between pairs of markets in the late 1990s, we see a large increase in the number of integrated markets. In the case of maize, for example, in 89 percent of the cases prices in one market moved at the same time as in another (Table 2.18). This is up from only 28 percent of the time in the early 1990s. The number of pairs of markets for soybeans, japonica and indica rice show similar increases (rows 2-4). The integration of these markets is notable because in many cases the pairs of market are over 1000 kilometers apart. For example, prices in almost all years were integrated between markets in Shaanxi and Guangdong provinces, and between those in Sichuan province and southern Jiangsu.

Table 2.18 Percentage of market pairs that test positive for being integrated based on the Dickey-Fuller test in rural China, 1988-2000

Commodity	1989-1995	1996-2000
	(percentage of market pairs)	
Maize	28	89
Soybeans	28	68
Japonica rice (Yellow River Valley)	25	60
Indica rice (Yangtse Valley and southern China)	25	47

Note: results for two periods from same data set. For results from 1989 to 1995 for maize and rice, see Rozelle et al. (2000). Rice results are for the whole country in 1989-1995. Results from soybeans are for 1989 to 1995, and all results from 1996 to 2000 are by the authors.

Despite the significant progress in terms of integrations, our results also show that there are pairs of markets during different years that are not integrated. For example, in one-third of the cases, japonica rice prices moved in one market but not in another. The case of indica rice trade is even more notable. In more than half of the times (and places), prices do not move together in China's indica rice producing and consuming regions. While one explanation for such a result is that there is some kind of institution (policy or infrastructure/communication) breakdown that is creating China's fragmentation, as shown by Park and colleagues (2002), it is also the case that since every province in China has rice production and consumption, if during a certain year in a certain area, supply in that region is just equal to demand, moderate price movements in another area may not necessarily induce a flow into or out of the region that is in equilibrium.

Even with the non-trivial number of cases in the late 1990s in which market prices in pairs of markets do not move together, based on each of the market performance analyses, one must conclude that the impacts of trade on China's agriculture was experienced across wide regions of the nation from coastal to inland areas in the late 1990s. However, this is only half of the story. While the above analysis demonstrates a remarkable degree of integration between markets on the coast and those inland, such an analysis is not sufficient to indicate that many of China's villages will be affected by the shocks that hit the coast and are transmitted inland.

To establish such, we will examine the extent to which villages are integrated into regional markets. Our test of integration will essentially test whether farmers in China's villages are price takers or the villages are isolated, meaning that prices are determined *by* local supply and demand. In the briefest terms, if variables that affect local supply significantly affect prices, we will assume villages are isolated and markets are not integrated to the village level; in contrast, if the local supply shock does not affect the price, villagers are price takers and markets will be thought to be integrated.

The data for this study were collected by the China National Rural Survey (CNRS). The survey was of a randomly selected, nearly nationally representative sample of 60 villages in 6 provinces of rural China. A total of 1,199 households were surveyed. The CNRS project team gathered detailed information on both the production and the marketing behavior of all of the farmers in the sample, as well as on the characteristics of each village and the accessibility of the nearest regional market. From these data, we construct an average village price for each month in CNY per kilogram. A community questionnaire reveals how far the village's center is from the nearest paved road and the distance to the county market. Finally, for each crop the farmer cultivated, we know whether it suffered a shock, recording both the incidence and the percentage by which the yield fell. We do not include any variable that controls for the presence of a community buffer stock system, primarily because such an institution is almost never observed in modern China. In addition, sales between farmers in a village are rare (less than 5 percent of sales, according to our data).

Our regression analysis clearly shows that markets in China are integrated down to the village level (Table 2.19). The signs and level of significance of the coefficients on variables demonstrate that the further a village is from a market, the lower the price the farmer receives, which is the expected result. More importantly for our purposes, the t-ratios of the coefficients of the village supply shock variables are all lower in absolute value terms than 1.35, signifying that the output of the local village's crops do not affect the local price. One implication of this result is that it is factors outside the village that affect the price that farmers receive, making them price takers. In other words, farmers - even in China's remote villages - are linked to the markets of its main commodities.

Table 2.19 Soybean, corn and wheat village price regression, 2002

Explanatory variable	(1) Soybean price	(2) Corn price	(3) Wheat price
Distance to the nearest county market	-0.029	-0.00064	-0.0095
	(2.37)**	(-1.63)*	(3.24)**
Village-level shock to production	-0.04	0.12	0.081
	(-0.17)	(-1.34)	(-1.02)
Other variables not shown	timing of sales / net purchase or seller /		

Given the average impacts at national level and market integration presented above, when one examines the benefits or costs for certain groups of farmers due to trade, one only needs to examine their production mixes and match them to the extent the prices of the products rose or fell over the period and whether farmers have been moving into or out the production of those products, which will be presented in Chapter 4. Given the results of market integration analyses presented above, we can conclude that the changes in national prices due to trade in the late 1990s were largely transmitted into different regions except for most remote areas in China.

2.5.4 Rural Labor and Off-farm Employment

Since economic and political reforms began in China 20 years ago, the country has experienced rapid economic growth (Naughton, 1995). The expansion of the rural economy has driven a large part of this growth (Putterman, 1992; Perkins, 1994). In turn, rural labor markets have changed dramatically over the past 20 years and have significantly contributed to the success of the rural economy and household food security (World Bank, 2001). Without well-functioning labor markets, the economy cannot be transformed from one based on agriculture to one based on industry. Hence, it would seem that more important than assessing how well they have contributed to per capita rural incomes and food security, is the question whether or not rural labor markets have emerged in a way that will allow them to more effectively facilitate China's transformation.

In this section, we estimate the nation's aggregate off-farm participation rates. We will also decompose the growth in off-farm employment, examining what segments of the rural labor force, particularly the poor, are growing and where each segment is growing.

The main data for this study are those from the survey presented in the previous section. The survey gathered detailed information on household demographic characteristics, wealth, agricultural production, non-farm activities and investment. Several parts of the household survey were designed to learn about migration from the household and other labor market participation across time. For roughly half of the households surveyed (610 out of 1,199), a 20-year employment history form was completed for each household member and each child of the household head, some of whom were no longer considered household members. In total, the survey divided off-farm jobs into four types: migrant wage earners (henceforth, migrants), self-employed migrants, wage earners and local self-employed. We also asked about the extent of the participation of each member, in each year, in the household's on-farm activities. As a supplement to this household data set, we also collected 215 villages' community level data set that traced labor allocation and movement in 1988 and 1995.

The Evolution of Rural Labor Markets in China

The data show the off-farm labor force expanded steadily between 1981 and 1995. From around 15 percent in 1981, our survey estimates that in 1995, 32 percent of the rural labor force had some employment off-farm (Figure 2.5, Panel A). By assuming that neighboring provinces similar to those surveyed have identical rates of off-farm labor participation, we estimate that off-farm rural employment increased from fewer than 40 million farmers in 1981 to more than 150 million in 1995, a growth of more than 100 million. Although based on a relatively small sample, these numbers demonstrate the consistency of our data with much larger national studies by the National Statistical Bureau of China (NSBC, 1996) and our own 1995 national village survey. Our estimate in 1995 is almost the same as both the SSB's estimate of the non-farm labor force (31 percent) and our own estimates of rural off-farm employment calculated from estimates of village leaders of the participation in the off-farm sector of their villagers (34 percent; Rozelle et al., 1999).[1]

[1] Our data are also consistent with the estimates of SSB in the late 1980s and with Parrish's study (Parrish, Zhe and Li, 1995) in the early 1990s. For example, our data set estimates that 20 percent of the rural labor force worked off-farm in 1988. This figure nearly agrees with the SSB estimates for that year, namely 21 percent. Our 1993 labor force participation rate - 29 percent - is only three percentage points higher than the

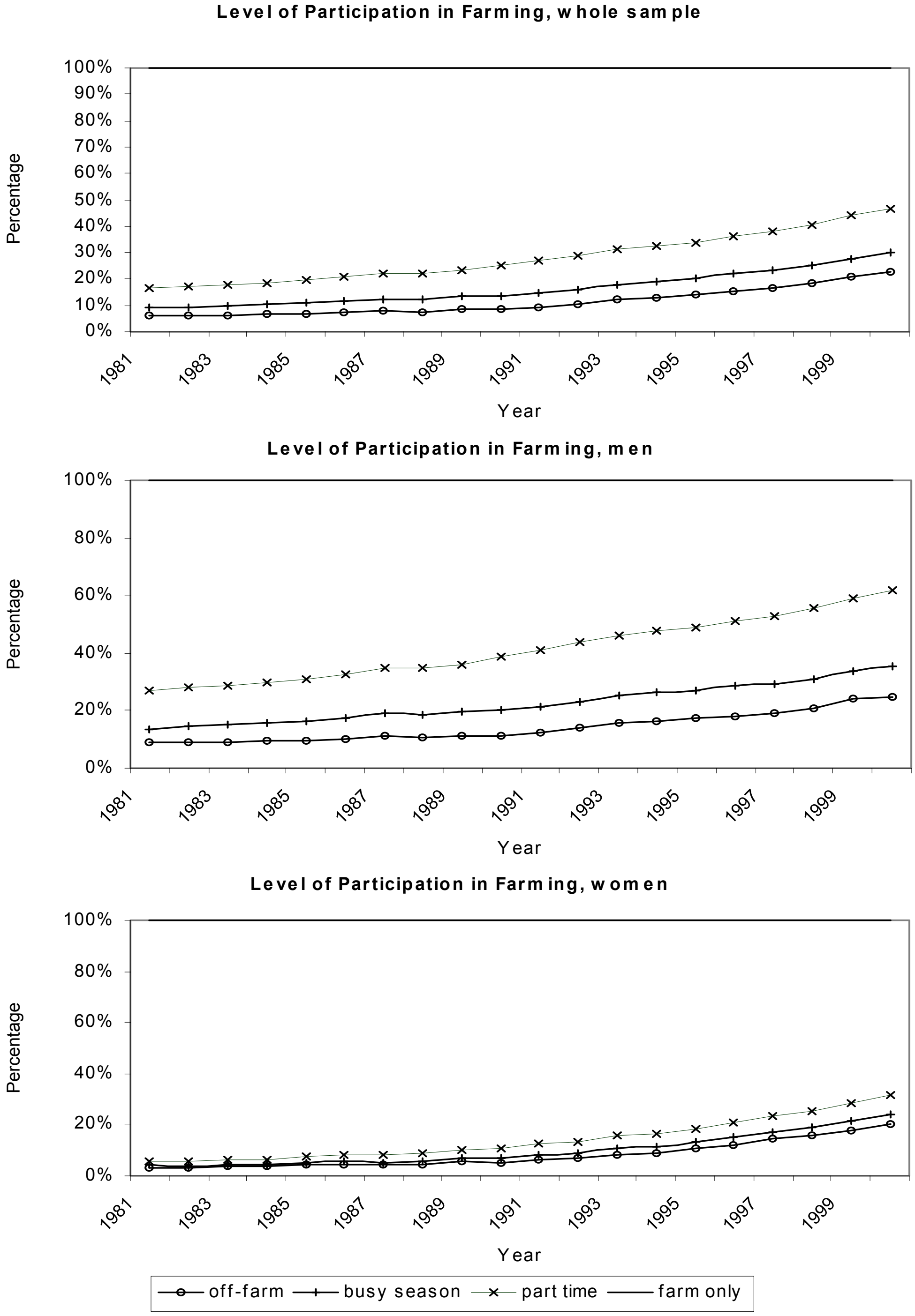

Figure 2.5 Level of participation by individuals, 1981-2000

Despite the Asian financial crisis, China's own structural reforms and a general slowing of economic growth in the late 1990s, our data show that rural off-farm employment

best guess made by Parrish, Zhe and Li's national study, a difference that can partly be explained by Parrish's slightly broader definition of off-farm labor.

growth continued to expand between 1995 and 2000 (Figure 2.5, Panel A). By 2000, 41 percent of rural individuals participated in off-farm work, 9 percent more than in the late 1990s. If so, our data imply that more than 200 million rural individuals worked off-farm in 2000 - an increase of more than 50 million workers in just 5 years. If employment generation and the ability to create jobs during a period of relatively slow growth were indicative of a healthy labor market, then China's labor markets would have to be given a high mark for maintaining rural incomes.

An examination of disaggregated trends provides an initial basis for demonstrating that China's labor markets may be doing more than just providing off-farm income for rural workers. Trends by job type clearly show that the focus of workers over the past 20 years has shifted from rural to urban destinations (Figure 2.6, Panel A). In 1981, most rural individuals (nearly 85 percent) not only spent all of their time in farming, but those who worked off the farm were almost three times as likely to live at home and work in or close to the village (7 percent were local self-employed, and 4.2 percent were wage earners) than to work outside the village (less than 1 percent were self-employed migrants, and less than 4 percent were migrants). By 2000, almost as many off-farm workers were living away from home (more than 85 percent in cities or suburban villages of major metropolitan areas) as were living in the village. Migrants comprised both the largest and the fastest growing component of the rural labor force.

The rise in labor markets has already begun to have a positive impact on increasing the farm participation rates of women (Figure 2.5 and 2.6). Although women participated at rates far below those of men throughout the entire 20-year sample period, since the early 1990s participation rates have risen (Figure 2.5, Panels B and C). In the 1980s, consistent with the findings based on our national community survey study (reported in Rozelle et al., 1999), the participation rates of men (more than 25 percent in 1981) far exceeded those of women (less than 5 percent). Moreover, despite these low initial levels of involvement in the off-farm sector, the growth of the participation rates of women remained below those of men in the 1980s. In the 1990s, however, the rate of growth of the participation of women rose faster than that of men.

The increasing participation rates of women have been driven by the entry of women into all job categories, although the most striking absolute gains have occurred in migration (Figure 2.6). Throughout the 1980s, less than 1 percent of women left their home to work for a wage or become engaged in self-employment. Since 1990, however, the rate of growth has been higher than that for any other category of job type for either men or women. By 2000, nearly 6 percent of the female labor force was working as a wage earning migrant and nearly 3 percent was working as a self-employed migrant. One interpretation of this increase in the participation of women is that as labor markets have become more competitive, the scope for managers to exercise their discriminatory preferences has declined, thus opening up new employment opportunities for those who previously had not been able to participate. Multivariate analyses performed by Rozelle and colleagues (Rozelle et al., 2001) are consistent with these results.

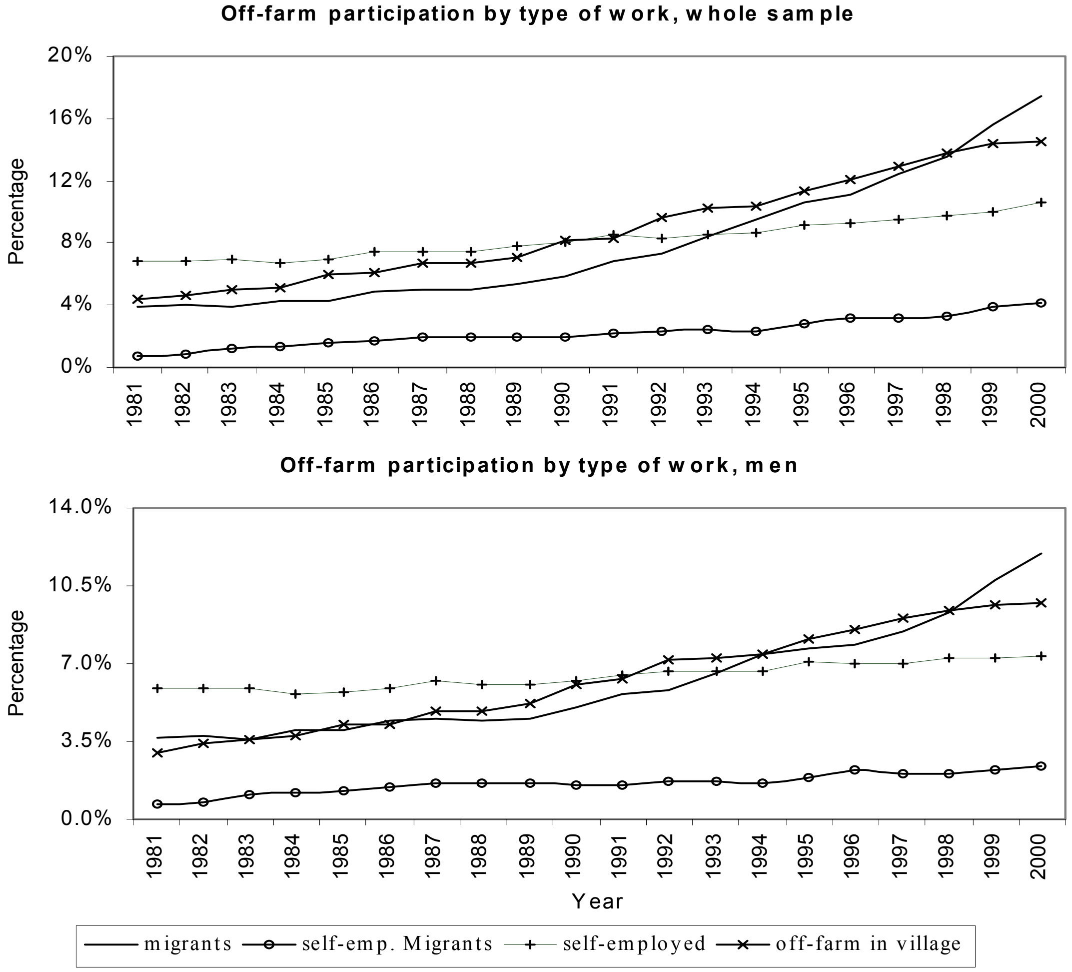

Figure 2.6 Total labor force in different types of off-farm work (%)

A community-level data set we collected in 1996 reveals an even more significant development, namely a shift to higher education Table 2.20. In 1988, 61 percent of migrants nationwide had at least a middle school education. By 1995, the national average climbed to 64 percent. The percentage of high-school-educated migrants nationwide increased from 7 to 8 percent between 1988 and 1995. Although rural men generally have a higher level of education than rural women do, the education of male and female migrants is roughly equivalent. Male migrants are slightly more likely than female migrants to have either a high school or an elementary education, which suggests that the range of opportunities for male migrants is wider.

In the 2000 household data set, the propensity of the more educated to enter the migrant and local off-farm wage sector is confirmed. Multivariate analysis shows that in the 1980s, for each additional year of education, the probability of becoming a migrant increases by 10 percent, and the probability of working in a local wage-earning job increases by 6 percent. By the 1990s, the probability of becoming a migrant increases by 18 percent for each year of additional education, and the probability of finding and off-farm job in-

Table 2.20 Education Level of Male and Female Rural Migrants, 1988 and 1995 [a]

	No More Than Elementary School Education				Lower Middle School Education				Upper Middle School Education			
	Male		Female		Male		Female		Male		Female	
	1988	1995	1988	1995	1988	1995	1988	1995	1988	1995	1988	1995
	(percent)											
Zhejiang	58	42	49	54	38	47	45	39	4	10	6	7
Sichuan	38	37	25	33	57	57	71	62	6	6	4	5
Hubei	70	41	57	42	26	50	43	50	4	9	0	8
Shaanxi	32	40	18	31	55	49	78	62	12	11	4	8
Shandong	31	22	50	29	66	60	50	66	3	17	0	5
Yunnan	40	47	~	45	58	47	~	51	3	6	~	4
National Average [b]	47	39	45	42	46	51	50	51	7	10	5	7

Source: Author's Study

[a] A migrant is defined as one who leaves the village for wage earning employment for at least 1 month and maintains ties with the village by returning a festivals, agricultural peak seasons, etc., at least once a year.

[b] National estimates are generated by summing provincial estimates weighted by estimated proportion of migrants. The estimated proportion of migrants is calculated using the total labor force represented by each province and the estimated percent of migrants from table1. Zhejiang represents Guangdong, Fujian, Jiangsu, Shanghai, and itself. Sichuan represents itself. Hubei represents Henan, Hunan, Jiangxi, Anhui, and itself. Shaanxi represents Ningxia,Gansu, Inner Mongolia, Shanxi, and itself. Yunnan represents Guangxi, Guizhou, and itself. Zhejiang, Sichuan, Hubei, Shaanxi, Shandong, and Yunan are weighted .14, .145, .34, .275, .06, and .04 respectively for male migrants in 1995; .16, .16, .25, .35, .06, and .02 respectively for male migrants in 1988; .30, .12, .30, .20, .04, and .04 respectively for female migrants in 1995; and .62, .11, .18, .08, .01, and 0 respectively for fem migrants in 1988

creases by 17 percent. The participation in formal training and apprenticeship programs also has a large and significant effect in increasing the participation in all forms of labor market activity. To the extent that we would expect well-functioning labor markets to provide more employment opportunities to those with higher levels of human capital, labor markets appear to have played some role during the whole reform period.

Drawing on our earlier community-level data set, the destinations of migrants, both men and women, also changed between 1988 and 1995 and differ from region to region (Rozelle et al., 1999). In coastal areas such as Zhejiang, more migrants stay in their home county than is the case in non-coastal areas. Migrants from inland provinces move outside their own provinces more frequently than others. Surprisingly, most migration destinations were short and medium distance, except in Sichuan and Hubei in 1995.

The number of long-distance migrants, especially women, has increased sharply (Table 2.21). Nationwide, the proportion of migrant men moving to remote destinations increased from 28 to 42 percent between 1988 and 1995, while the proportion of women increased from 7 to 41 percent. Some areas had exceptionally high levels of out-migration. The proportion of men migrating to destinations outside the province increased from 61 to 74 percent in Sichuan and from 14 to 46 percent in Hubei. If these figures are relatively accurate estimates of provincial migration, then nearly 15 percent of male laborers from Sichuan work outside the province. The proportion of women in the long-distance labor market increased sharply in all surveyed provinces except Shandong. In Zhejiang, for example, few women left for work in Shanghai or Fujian in 1988. By 1995, 17 percent had left Zhejiang in search of wage work. Over half of the female migrants from Hubei and Sichuan left their home province.

While China's success at generating off-farm work opportunities for its rural workers is well known, what is less well known is that many of the new jobs are in rural areas and go to workers from other villages. In 1988, only about 1 percent of the rural labor force found employment in another rural village (Table 2.22, row 9, column 4). By 1995, 5 percent of rural workers were employed in a rural village, which was not their home village (column 1).

The increase in the size of the rural labor force, the rapid increase in the proportion of rural workers who leave their home village for work and the increasing share of those workers heading to other rural villages have contributed to the expansion of the rural-to-rural labor movement, which now represents the fastest growing off-farm employment sector in rural China, with an annual growth rate of 27 percent compared to 13 percent growth in local employment and 9 percent growth in rural-to-urban movement (Table 2.22, rows 3, 6 and 9, column 7). Growth in rural-to-rural migration was especially high at 38 percent annually (row 11). We estimate that there were 12.9 million rural-to-rural migrants in 1995, up from 2 million in 1988.[1] An additional 9.8 million rural workers in 1995 commuted to other villages, up from 3 million in 1988. The 22.7 million workers who found non-agricultural employment through rural-to-rural labor movement (12.9 plus 9.8) make China's development unprecedented. We are unaware of a development experience in any

[1] These estimates come from the percentage of rural labour going into villages (estimated by the survey) multiplied by China's total rural labour force as published by the National Statistical Bureau of China (NSBC). The NSBC reports 403 million rural workers in 1988 and 446 million in 1995.

Table 2.21 Destination of Male and Female Migrants in China, 1988 and 1995

	Within the County				Within the Province (but outside the county)				Out of the Province			
	Male		Female		Male		Female		Male		Female	
	1988	1995	1988	1995	1988	1995	1988	1995	1988	1995	1988	1995
						(percent)						
Zhejiang	29	47	74	49	34	24	25	33	38	29	1	17
Sichuan	21	9	28	8	18	17	21	14	61	74	51	78
Hubei	31	24	98	24	55	30	1	8	14	46	1	67
Shaanxi	15	14	33	16	67	50	65	55	18	36	3	29
Shandong	2	13	0	7	66	57	50	76	32	30	50	13
Yunnan	25	30	0	44	75	56	0	41	0	7	0	15
National Average[b]	22	22	69	28	51	35	24	30	28	42	7	41

Source: Author's Study

[a] A migrant is defined as one who leaves the village for wage earning employment for at least 1 month and maintains ties with the village by returning at festivals, agricultural peak seasons, etc., at least once a year.

[b] National estimates are generated by summing provincial estimates weighted by estimated proportion of migrants. The estimated proportion of migrants is calculated using the total labor force represented by each province and the estimated percent of migrants from table1. Zhejiang represents Guangdong, Fujian, Jiangsu, Shanghai, and itself. Sichuan represents itself. Hubei represents Henan, Hunan, Jiangxi, Anhui, and itself. Shaanxi represents Ningxia, Gansu, Inner Mongolia, Shanxi, and itself. Yunnan represents Guangxi, Guizhou, and itself. Zhejiang, Sichuan, Hubei, Shaanxi, Shandong, and Yunan are weighted .14, .145, .34, .275, .06, and .04 respectively for male migrants in 1995; .16, .16, .25, .35, .06, and .02 respectively for male migrants in 1988; .30, .12, .30, .20, .04, and .04 respectively for female migrants in 1995; and .62, .11, .18, .08, .01, and 0 respectively for female migrants in 1988

other country where the rural sector has offered industrial jobs to such a large group of mobile workers.[1]

Summary of Rural Labor Market Findings

In summary, we have provided evidence of how labor markets are clearly acting in a way consistent with an economy that is in transition from agriculture to non-agriculture and a population that is shifting from rural to urban. Our descriptive analysis illustrates that labor markets have allowed migration to become the dominant form of off-farm activity, have expanded the fastest in economies or areas that are relatively well-off, and have increasingly drafted workers from sub sectors of the population (e.g. women), who earlier had been excluded from participation. Rural workers also showed signs of specialization, especially when examined by education. In 2000, better-educated workers worked much less on the farm than did older workers. Finally, our data show that workers are moving further from home and developing ties in other rural areas.

When we talk about the impact of a rise in manufacturing in rural areas on farm income and food security due to liberalization, we can see that this has an impact on some, but not necessarily all, rural residents. First-order impacts are felt by those in the richest villages and in the villages nearest to the core, since these areas, based on their historical ability to manufacture and export these goods, should be able to expand production. However, rural migrants, or those in the lower-middle-income, more remote regions, might also benefit, since they are ones who are providing a lot of the labor in the richer, more centrally located villages. However, we would not expect first-order or immediate benefits for those in middle-income or the most remote villages.

2.6 Concluding Remarks

We can now answer the following key questions. During China's reform era, how has the economy in general and agriculture in particular performed? What agricultural sector and macro-economic policies and reforms has China introduced? What have been the impacts of reforms on production incentives, market integration and rural employment? What are the major constraints and challenges faced by China's agricultural sector?

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

[1] See Lohmar and Rozelle (2000) for more details on the rural-to-rural labour force.

Table 2.22 Composition of China's rural labor force, 1988 and 1995 (% of total rural labor force)

		1995 Village labor force			1988 Village labor force			Growth rates, 1988-1995		
		All workers (1)	Male workers (2)	Female workers (3)	All workers (4)	Male workers (5)	Female workers (6)	All workers (7)	Male workers (8)	Female workers (9)
Full-time agricultural labor	(1)	67	52	77	81	73	89	-1	0	-1
Non-agricultural labor [a]	(2)	33	48	23	19	27	11	12	11	14
Village residents locally employed[b]	(3)	15	22	12	9	13	6	13	11	13
Self-employed	(4)	11	16	8	6	8	4	14	14	17
Village enterprises	(5)	4	6	4	3	5	2	6	5	7
Rural-urban movement	(6)	13	20	6	9	13	3	9	9	11
Commuters	(7)	6	9	4	5	7	3	6	5	7
Migrants	(8)	7	12	3	3	6	0.5	14	13	21
Rural-rural movement	(9)	5	6	5	1	1	2	27	29	24
Commuters	(10)	2	3	2	1	0.7	1	18	26	10
Migrants	(11)	3	3	3	0.5	0.7	0.3	38	30	53

Source: authors' survey.
[a] Many of these workers also contribute labor to agriculture in addition to their off-farm employment
[b] These workers are village residents with off-farm employment in the village
[c] These workers have off-farm employment outside the village but close enough to commute (daily) from their home village
[d] These workers have off-farm employment outside the village and must leave for at least one month at a time for their job

China's experience demonstrates the importance of technological development, institutional change, price and market liberalization, rural economic development and macroeconomic policies in improving agricultural productivity, farm income and food security in a nation with limited land and other natural resources. Technology has been the engine of China's agricultural economy growth. Institutional arrangement and government food policies have also played important roles in China's food production and in its efforts to make food available to the whole of its society. Rural enterprise development and off-farm employment also play a substantial role in the country's economy and farm income. Broad participation in strong rural economic growth has brought about a tremendous reduction in absolute poverty in China.

External reforms in general have paralleled domestic reform. During nearly 20 years of reform, China's foreign trade regime has gradually changed from a highly centralized, planned and import substitution regime, into a more decentralized, market-oriented and export-promoting regime. Reform and trade liberalization in China's external sector has proceeded gradually. In the initial stage, reformers only implemented measures that provided incentives to sets of corporations and institutions. Because the experiences gained from the reform grew and the objectives of trade could be achieved through alternative settings of institutions and policies, trade liberalization has been implemented smoothly since the late 1980s. However, in the late 1990s, China also used various means to protect some of its crops, such as maize and cotton.

The impact on agriculture, however, is only part of the story. Reforms have also affected the access of households to non-farm employment and the wage they earn for being in the off-farm market. In general, China has gained a lot from market liberalization. Increasing exports of manufacturing goods have been produced in factories that hire a lot of rural labor. These factories have also had spill over effects that have helped to make domestic factories more productive and have increased the demand for labor. In a country like China, increasing the demand for off-farm labor is probably the most important factor in improving the economy.

On the other hand, China's future agricultural sector is matter of increasing concern. Rapid industrialization and urbanization will lead to competition for agricultural resource uses. The impacts of trade liberalization on China's domestic agricultural sector, which engages hundreds of millions of small farmers, is the other growing concern of the policy makers. Rapid economic growth has continued unevenly across regions and among income groups, and the income gap among regions and between the rural and urban has not been narrowed.

Limited options for increasing food and agricultural supplies has made the challenge of meeting China's food security target even more formidable. Fiscal constraints may preclude China's leaders from implementing some of the planned policies. The constraints on China's leaders resulting from resource scarcity and politico-economic realities increase the need to understand the scope for food supply expansion from one of the most important sources - investments in agricultural technology - and to understand the scope of income growth from non-farming activities (rural enterprise). The nation needs to keep promoting policies that facilitate investment and that allow rural households to move to these new jobs without constraints.

3 Methodologies and data

3.1 Introduction

The main instruments used for this study are two economic models. We use a model of global trade, which is based on the Global Trade Analysis Project (GTAP), and we use a detailed model of Chinese agriculture, which is called Chinese Agricultural Policy Simulation Model (CAPSiM). This chapter presents an overview of both models. The two models have a different scope of analysis and are based on different assumptions. While the GTAP model is a general equilibrium model with a global coverage, CAPSIM is a partial equilibrium model of Chinese agriculture. The approach taken in this study is attempting to exploit the relative strengths of each approach. For a general discussion of partial versus general equilibrium modeling in agriculture see Van Tongeren et al., 2001.

The global model is especially strong in analyzing issues pertaining to international trade, trade policies and interlinkages between economies. Since its scope is global, the model compromises with regard to its detail in representing national economies. The strength of the Chinese model, on the other hand, lies in its detailed representation of Chinese agriculture, including the development of crop yields and livestock productivity, but also estimates of consumer demand in the face of skewed rural-urban income developments. These aspects are very crucial for estimating the likely impact of China's role on world markets. The CAPSIM model can comprehensively and simultaneously account for the major driving forces and policies determining China's domestic food demand and supply, while the GTAP approach can help us to examine the influence of the linkages of China's economy with the rest of the world.

It is beyond the scope of this report to give a detailed description of the two models, their equations and their underlying databases. This documentation is available elsewhere. Key references are Hertel (1997), for the GTAP model and Huang and Chen (1999) and Huang and Li (2003) for the CAPSIM model. Here we confine ourselves to a general overview that should assist the reader in interpreting the results discussed in later chapters.

3.2 The Global Trade Analysis Project (GTAP): an overview

3.2.1 Introduction

GTAP was initiated with the goal of supporting high-level quantitative analysis of international trade, resource, and environmental issues in an economy wide context. The GTAP project is supported by the leading international agencies in trade and development policy, as well as a number of national agencies with active research programs on these issues. The GTAP project develops and maintains a database, a multi-region multi-sector general equilibrium model. It also provides training courses and organizes an annual conference on global economic analysis.

This project has grown rapidly since its inception in 1993. There is no doubt that the GTAP database and its associated modeling efforts represent a major achievement for advancing quantitative analysis of international trade, resource and environmental issues. The success of this approach is reflected in a high degree of academic recognition as well as the increasing usage for policy analysis by international and national agencies.

3.2.2 Model characteristics

There are basically two strands of quantitative modeling in policy analysis. One approach is to build issue-specific models, depending on the question at hand. These models will usually be capable of capturing many relevant aspects of one specific policy question, but are of less use in a different policy context. The other approach sets out to construct more general and flexible models, which do not necessarily attempt to capture all detail but are flexible enough to allow elaborations in face of specific policy questions. The Global Trade Analysis Project (GTAP) provides such a modeling framework.

The standard GTAP model[1] is a comparative static multi-regional general equilibrium model. In its standard version constant returns to scale and perfect competition are assumed in all markets for outputs and inputs. A detailed discussion of the basic algebraic model structure of the GTAP model can be found in Hertel and Tsigas (1997).[2]

In the GTAP model each country or region is depicted within the same structural model. The consumer side is represented by the regional household to which the income of factors, tariff revenues and taxes are assigned. The regional household allocates its income to three expenditure categories: private household expenditures, government expenditures and savings. For the consumption of the private household, the non-homothetic Constant Difference of Elasticities (CDE) function is applied.

In the model, a representative producer for each sector of a country or region makes production decisions to maximize a profit function by choosing inputs of labor, capital, and intermediates to produce a single sectoral output. In the case of crop production, farmers also make decisions on land allocation. Intermediate inputs are produced domestically or imported, while primary factors cannot move across countries. Markets are typically assumed to be competitive. When making production decision, farmers and firms treat prices for output and input as given. Primary production factors land and capital are fully employed within each economy, and hence returns to land and capital are endogenously determined at the equilibrium, i.e., the aggregate supply of each factor equals its demand.
The production structure is depicted with a production tree with four nests (Figure 3.1). The Leontief and the Constant Elasticity of Substitution (CES) functional forms are used to model the substitution relations between the inputs of the production process. In the output nest, the mix of factors and intermediate inputs are assembled together, forming the sec-

[1] We deliberately refer to the 'standard GTAP model' as the model version that is supported by the GTAP consortium. GTAP users have developed numerous variations on the standard model. In this study we also make some modifications to the standard model. These are discussed more extensively in subsequent chapters.

[2] Or in the internet http:// www.agecon.purdue.edu/gtap/model/Chap2.pdf

toral output. The functional form can be Leontief (fixed proportions) or CES. The substitution relations within the value added nest are depicted by the CES function. While labor and capital are considered mobile across sectors the Constant Elasticity of Transformation (CET) function is used to represent the sluggish adjustment of the factor land. That is, land can only imperfectly move between alternative crop uses. The CES function is applied in the composite intermediate nest depicting the substitution between domestic and imported products. The last nest illustrates the relation between imports of the same good from different regions. The Armington approach treats products from different regions as imperfect substitutes.

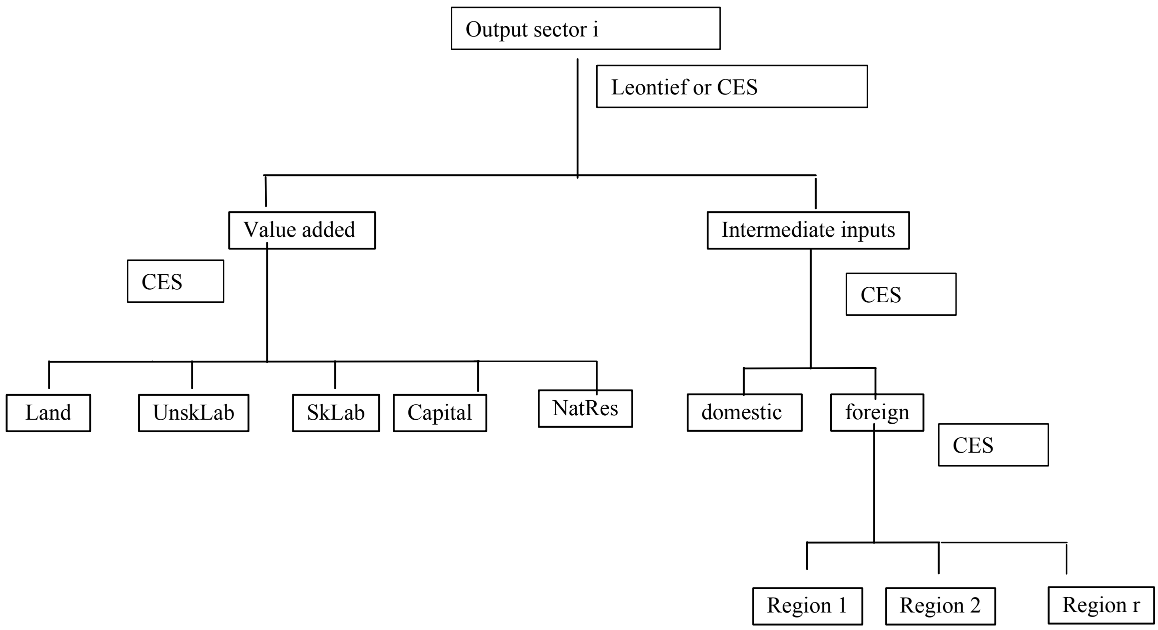

Figure 3.1 Production tree
Source: Hertel and Tsigas (1997).

The GTAP model includes two global institutions. All transport between regions is carried out by the international transport sector. The trading costs reflect the transaction costs involved in international trade, as well as the physical activity of transportation itself. Using transport inputs from all regions the international transport sector minimizes its costs under the Cobb-Douglas technology. The second global institution is the global bank, which takes the savings from all regions and purchases investment goods in all regions depending on the expected rates of return. The global bank guarantees that global savings are equal to global investments. With the standard closure, the model determines the trade balance in each region endogenously, and hence foreign capital inflows may supplement domestic savings. The model does not have an exchange rate variable. However, by choosing as a numeraire an index of global factor prices, each region's change of factor prices relative to the numeraire directly reflects a change in the purchasing power of the region's factor incomes on the world market. This is can be directly interpreted as a change in the real exchange rate.

The welfare changes are measured by the equivalent variation, which can be computed from each region's household expenditure function.

Taxes and other policy measures are included in the theory of the model at several levels. All policy instruments are represented as *ad valorem* tax equivalents. These create wedges between the undistorted prices and the policy-inclusive prices. Production taxes are placed on intermediate or primary inputs, or on output. Trade policy instruments include applied most-favored nation tariffs, antidumping duties, countervailing duties, price undertakings, export quotas, and other trade restrictions. Additional internal taxes can be placed on domestic or imported intermediate inputs, and may be applied at differential rates that discriminate against imports. Where relevant, taxes are also placed on exports, and on primary factor income. Finally, where relevant (as indicated by social accounting data) taxes are placed on final consumption, and can be applied differentially to consumption of domestic and imported goods.

The GTAP model is implemented in GEMPACK - a software package designed for solving large applied general equilibrium models. A description of Gempack can be found in Harrison and Pearson (2002).[1]

Various GTAP users have developed adaptations of the standard model. Such elaboration's, include increasing returns to scale and imperfect competition, dynamic equilibrium formulations and incorporation of non-continuous policy instruments such as Tariff rate quota that resulted from GATT Uruguay round, or production quota as applied in the European milk and sugar sectors. For a model version that uses both increasing returns and production quota, see Francois et al. (2002) and Francois et al. (2003).

3.2.3 Data

The GTAP database contains detailed bilateral trade, transport and protection data characterizing economic linkages among regions, linked together with individual country input-output databases which account for intersectoral linkages. All monetary values of the data are in $US millions and the base year for version 5 is 1997. This version of the database divides the world into 65 regions. China being one of the regions for which individual country data are available. An additional interesting feature of version 5 is the distinction of the 15 individual EU member states. The database distinguishes 57 sectors in each of the regions. That is, for each of the 65 regions there are input-output tables with 57 sectors that depict the backward and forward linkages amongst activities. The database provides quite a great detail on agriculture, with 14 primary agricultural sectors and seven agricultural processing sectors (such as dairy, meat products and further processing sectors)

The bilateral trade data are derived from United Nations Trade Statistics, and support- and protection data from various sources (e.g. UNCTAD TRAINS database for industrial tariff information, the AMDAD database for agricultural protection, OECD's PSE data base for domestic agricultural support). Version 5 is fully documented in Dimaranan and McDougall (2002).

In this study we make extensive use of the GTAP database version 5. However, as we shall explain later, we make some updating adjustments to the Chinese data in the light

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[1] More information can be obtained at www.monash.edu.au/policy/gempack.htm.

of more recent policy information that has become available in the context of WTO accession and in order to incorporate some of the detailed information on agriculture that is embodied in the CAPSIM database (see below).

3.2.4 Relevant GTAP applications on China

There are many GTAP applications, performed by researchers from all over the world that focus on China. As the work on China is evolving very rapidly, it is not very useful to summarize it here. The best way to keep abreast of the developments is to consult the list of applications maintained by the Center for Global Trade Analysis at www.gtap.org.
Some of the issues studied with the help of the GTAP database and GTAP model are:

- China's accession to the WTO: impact on China and/or the rest of the world;
- Impact of APEC trade liberalization on China;
- Food security in China in the future;
- China and world food markets;
- Productivity Growth, 'Catching-up', knowledge spillovers;
- Textiles: impact of URAA, WTO and MFA.

A more elaborate list of China related GTAP applications is given below. Some papers that focus on trade liberalization use the standard static GTAP model. But there are several extensions from the standard model that are relevant for this project. First of all, the comparative static model is sometimes used to generate projections of policy impacts at some future point in time. Such projections are not to be confused with econometric forecasts, but are achieved by constructing an artificial future dataset that is consistent with the model's assumptions -a so called baseline-, and subsequently conducting a policy experiment on the basis of this projected dataset. The artificial future dataset is constructed by making assumptions on the growth of exogenous variables and parameters and subsequently letting the model solve for an equilibrium that is consistent with these assumptions. Typical projections with AGE models rely on exogenous forecasts of GDP, factor endowments and factor productivity. Examples of such an extension are for example, Arndt et al. (1996), Hertel et al. (1999). The projection methodology is also applied in this study, and more fully explained in chapter 4.

Other researchers have incorporated dynamic features. The most frequently used approach is to specify a recursive sequence of temporary equilibria. That is, in each time period the model is solved for an equilibrium, given the exogenous conditions prevailing for that particular period. In between periods, stock variables are updated, either exogenously (e.g. population) or as a result of the equilibrium outcomes of the preceding period (e.g. investment demand leading to a changed capital stock in the next period). Examples of this approach are for example, Walmsley and Hertel (2000), Wang (2003), Lejour (2000).

Recursive dynamics do not guarantee time-consistent behavior. In contrast, in intertemporal equilibrium models agents display optimal behavior over time as well as within periods. Intertemporal models are usually tantamount to using rational expectations assumptions. Such forward-looking behavior leads to equilibrium time paths that move towards a long-run steady state (if it exists). A main reason to incorporate such intertemporal features into general equilibrium models is the desire to model savings rates endogenously, and hence to allow the model to generate alternative (endogenous) growth rates. In such models, a policy change can have a lasting effect on the economy's growth rate through changes in the accumulation of capital stocks. A feature, which is impossible with a fixed savings rate assumption. An example of an application to China is McKibbin and Woo (2003).

Other interesting extensions relevant to China are Adams et. al. (1998) who linked the GTAP model to a CGE model of the Chinese economy and van Meijl and van Tongeren (1998) who model endogenous trade-embodied technology spillovers.

3.3 China's Agricultural Policy Simulation Model (CAPSiM)

3.3.1 Introduction

China's Agricultural Policy Simulation Model (CAPSiM) is a partial equilibrium (PE) model of the agricultural sector. Its structure is typical for a family of PE models that has a well-established history. See Van Tongeren et al. (2001) for a detailed discussion. CAPSiM is a formal framework that has been regularly used by the Center for Chinese Agricultural Policy (CCAP) for agricultural commodity projection and policy simulation, including agricultural sector wide and commodity specific policies, and macroeconomic and trade policies. The model development was initiated in 1989 and has been continually updated with available new estimates on demand and supply elasticities conducted at CCAP and new and reliable data from both CCAP's various primary surveys and other secondary data sources.

CAPSiM is the first and most comprehensive model for China's food demand, supply and trade analysis. Most of the elasticities and parameters used in CAPSiM are estimated econometrically with imposition of theoretical constraints. In the projection or policy simulation, prices can be determined endogenously or exogenously. The model explicitly accounts for urbanization and market development (demand side), technology, agricultural investment, environmental trends and competition for labor and land use (supply side), as well as the price responses of both demand and supply. The model can be used for both short- and long-run policy simulation and projection for key agricultural variables in response to the changes in exogenous shocks to the economy. It is also designed for analyzing the likely impact of specific policies on key variables such as sown area, yield, production, prices, consumption, commodity demand and its components (food, feed and other use), stock formation, and export and import for agricultural commodities.

The model covers a wide range of agricultural products (11 crops[1] plus 7 livestock products[2]) and can be used for long-term projections as long as 25 years. The database starts from 1980 and is mainly fed with primary data, or with secondary data supplemented with field surveys. The included commodities account for about 90% of China's agriculture

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[1] Rice, wheat, maize, sweet potato, potato, other coarse grains, soybean, cotton, oil crops, sugar crops, vegetables.

[2] Pork, beef, mutton, poultry, egg, milk, fish.

The major components of CAPSiM include the models for production (supply), consumption (demand) specified separately for rural and urban consumers, stocks change, trade, and marketing clearing for 18 food and agricultural commodities or commodity groups. Agricultural supply is assumed to respond to the product's own-price, prices of other commodities and inputs, quasi-fixed inputs, and other exogenous shocks. Output is also a function of the stock of agricultural research, the stock of irrigation infrastructure, and three environmental factors: erosion, salinization, and the deterioration of the local environment.

3.3.2 General Framework of CAPSiM

3.3.2.1 Overview of CAPSiM

CAPSiM is driven either by endogenous or by exogenous determinants of supply and demand. Supply equations, which are decomposed by area and yield for crops and output for meat and other products, allow producer own- and cross-price market responses, as well as the effects of shifts in technology stock on agriculture, irrigation stock, ratio of erosion area to total land area, ratio of salinity area to cultivate area, yield change due to exogenous shock of climate, and yield change due to other exogenous shock.

Demand equations, which are decomposed by urban and rural, allow consumer own- and cross-price market responses, as well as the effects of shifts in income, population level, market development and other shocks.

The general framework of CAPSiM is presented in Figures 3.2 and 3.3

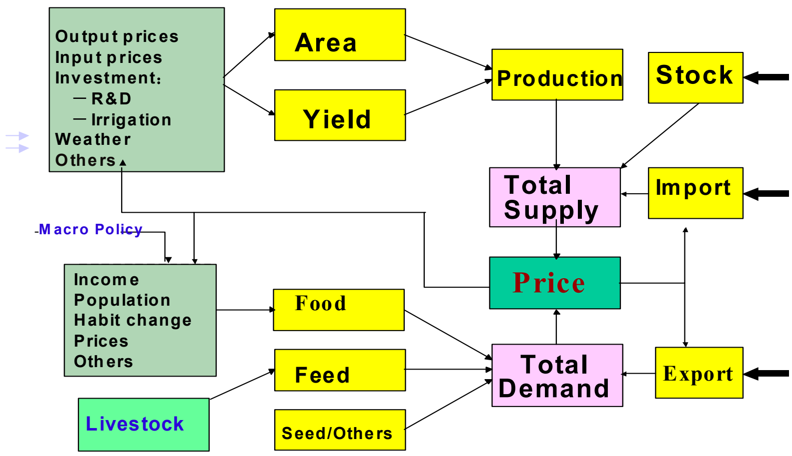

Figure 3.2 CAPSiM Framework

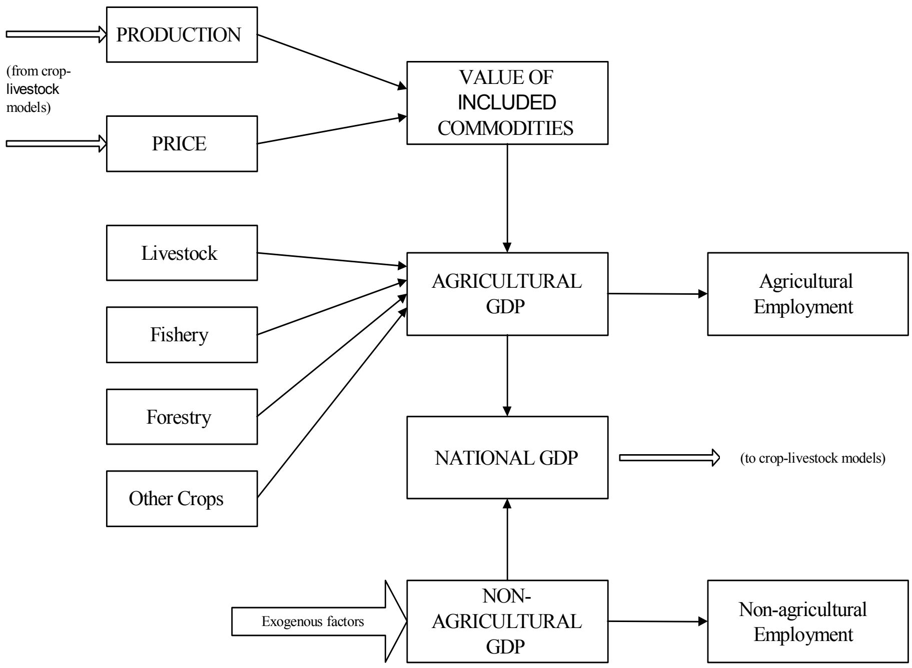

Figure 3.3 Schematic diagram of the macroeconomic linkages

3.3.2.2 Linkage with World Market

Figure 3.4 shows the interactive response between China's and world agricultural markets.

Panel A of Figure 3.4 shows that in the absence of trade, China produces and consumes at point A at P_1, while Rest of the World produces and consumes at point A' at P_3 in panel C. Panel B represents trade market in the world. With the opening of trade, the price of agriculture products in the world market will be somewhere between P_1 and P_3 since China is a large country. Otherwise, if China is such a small country that its supply will have less effect on the total world supply, the equilibrium price of agriculture products in the world market will be almost the same as that in the rest of the world market, that is, P_2 will be almost the same as P_3, supposing that the food markets in the rest of the world are totally opened.

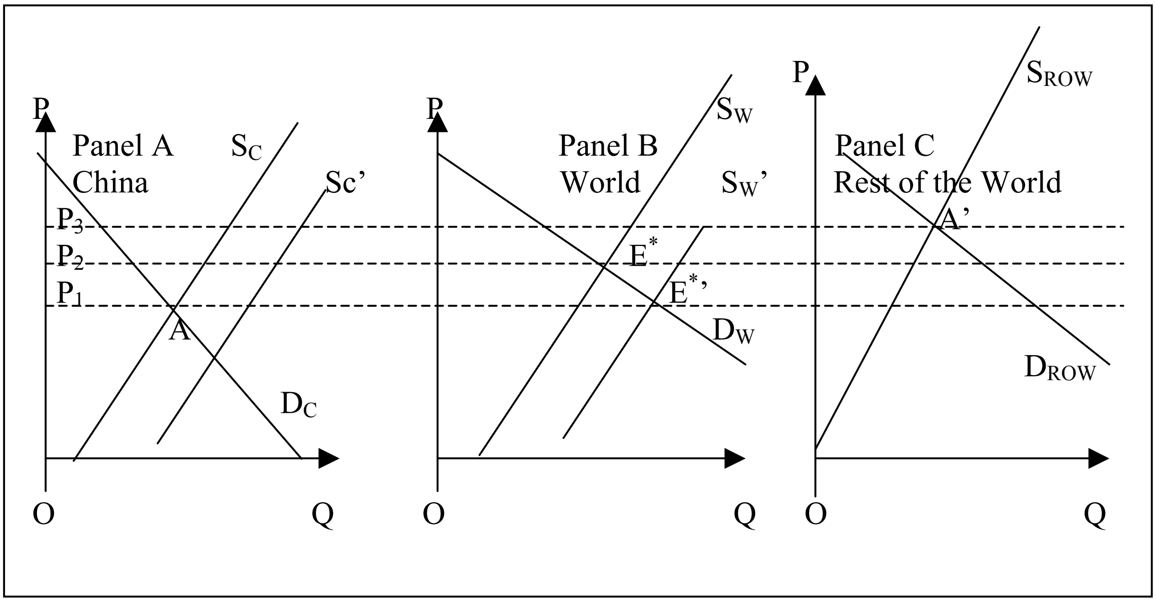

Figure 3.4 The Partial Equilibrium Price of Agriculture Products with Trade

Assume that the production of agriculture products in China increases and that in the rest of the world, production is still at the same level as before. Then, the supply curve in panel A will shift from S_C to S_C', and in turn, the supply curve in panel B will shift from S_W to S_W' because China will export more and the equilibrium price in the world market goes down from the price at E^* to the price at E^*'. If China is a small country, the supply curve in panel B will be unchanged.

The decrease in world market price will induce less export from China, more import into China, increase in Chinese consumption and decrease in Chinese food production, so that, in panel A, the supply curve will shift inward and demand curve shift outward. These shifts will induce changes in world market again. These two markets will interact continually until a new equilibrium point is reached.

A similar analysis can be done whenever there is some change in the demand in China, as well as some changes in the supply and/or demand in the rest of the world.
Therefore, given the fact that China is not a price-taker in the world market, the price of agriculture products in the world market will be subject to change endogenously in order to reach the equilibrium point of the market whenever there is some change in the supply of or demand for agriculture products in the world market.

3.3.3 Specifications of CAPSiM

3.3.3.1 Domestic Production

Crop Production

Crop production is obtained by multiplying harvested area and yield. Crop harvested area is a Cobb-Douglas function of the crop's own price and other crops' prices, and responds to the exogenous shocks from climate, policy and the other sources. Yield is a Cobb-Douglas function of the crop's own price, agriculture technology stock and irrigation stock, and responds to the exogenous shocks from climate and other sources. Most of parameters used in these modules are econometrically estimated.

Area:

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

***Yield*:**

$\log Y_{it} = a^{Y}_{i0} + \Sigma_j b^{Y}_{ij}(\log p^{S}_{jt}) + c_i \log R_t + k_i \log I_t + g_i \log(\text{Erosion}_t) + h_i \log(\text{Salinity}_t)$

Production:

$Q^{S}_{it} = A_{it} * Y_{it}$

Let: $\hat{X} = dX/X$ (percentage change in X) in the subsequent equations.

Variation Relationship:

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

Where:

A: Crop harvested area.
Z^{A1}: percentage change in area due to exogenous shock of climate.
Z^{A2}: percentage change in area due to exogenous shock of policy.
Z^{A3}: percentage change in area due to other exogenous shock.
p^{S}: prices of output and input for producer.
Y: crop yield per hectare.
R: agriculture technology stock.
I: irrigation stock.
Erosion: ratio of erosion area to total land area.
Salinity: ratio of salinity area to cultivate area.
Z^{Y1}: percentage change in yield due to exogenous shock of climate.
Z^{Y2}: percentage change in yield due to other exogenous shock.
i: index crop, including: rice, wheat, maize, sweet potato, potato, other coarse grains, soybean, cotton, oil crop, sugar crop, vegetable, and other crops.
j: index crop output and input, including: rice, wheat, maize, sweet-potato, potato, other coarse grains, soybean, cotton, oil crop, sugar crop, vegetable, and other crops, fertilizer, labor, and land.

Constraints*[1]*:
When $i \neq j$, $b^A_{ij} = b^A_{ji} * A_j / A_i$ because $(dA_i/dp_j^S)/(dA_j/dp_i^S) = p_i^S/p_j^S$. It means that the area's marginal rate of substitution between any two crops must be equal to their price ratio.
$\sum_j b^A_{ij} = 0$ because of homogenous of degree zero. It means that an equal percentage change in all prices leads to no change in the crop area response.
When $i \neq j$, $b^Y_{ij} = 0$, it means that crop yield responds to the change in its own price only.

Livestock Production
Livestock production is a Cobb-Douglas function of prices of output and input for producer and responds to the exogenous shocks from disease and the other sources.

Production:
$\log q_{it} = a^q_{i0} + \Sigma_j b^q_{ij}(\log p^S_{jt})$

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

Where:
q: total livestock production.
Z^{q1}: livestock production change due to exogenous shock of disease.
Z^{Y2}: livestock production change due to other exogenous shocks.
p^S: prices of output and input for producer.
i: index meat production, including: pork, beef, mutton, poultry, egg, milk, fish.
j: index meat and input, including: pork, beef, mutton, poultry, egg, milk, fish, maize and labor.

Constraints:
When $i \neq j$, $b^q_{ij} = 0$, it means that livestock production responds to the change in its own price only

Supply by mode of production:
In China, livestock is produced in three production modes: backyard, specialized household, and commercial intensive production. In order to analyze the technological coefficients of input and output in livestock production, the total livestock production is decomposed into three parts according to these three modes. The share of output in each production mode is subject to be changed from year to year.
$q_{ikt} = \theta_{ikt} * q_{it}$
$\theta_{ikt} = \theta_{ik(t-1)} + \gamma_{ik}$
$\Sigma_k \theta_{ikt} = 1$

[1] In this crop production model, if CAPSiM runs in endogenous mode and if A_{it} is fixed exogenously, at least one of the three shocks, $Z^{A1}_{i(t-1)}$, Z^{A2}_{it} and Z^{A3}_{it}, must be endogenized. Similarly, if Y_{it} is fixed exogenously, at least one of the two shocks, Z^{Y1}_{it} and Z^{Y2}_{it}, must be endogenized.
When $i \neq j$, b^A_{ij} varies yearly due to the first constraint

Where:
θ: share of each production mode.
γ_{ik}: annual change in θ.
k: index production mode, including: backyard, specialized household, and commercial intensive production.

3.3.3.2 Domestic Demand

On the demand side, the changes in urban economy have made urban consumers almost entirely depend on markets for their consumption need. In this sector, prices and income changes will likely be the fundamental forces driving change in consumption patterns.

Rural residents live in a very different environment from their urban counterparts and exhibit a different kind of demand behavior. Taking this fact into account, the demand models for urban and rural areas are given separately, which differ in the inclusion of the food market development index.

Among the domestic demand models, grain consumption is divided into two parts: grain that is directly consumed for food and grain that is fed to animals and consumed indirectly which is inputted from underlying demand equations for pork, beef, mutton, poultry, fish, eggs and milk.

Similar to supply side, this part of the analysis uses econometrically estimated parameters. Demand parameters are estimated using an Almost Ideal Demand System framework and based on household survey data. Elasticities of expenditure are estimated to vary according to the level of income.

Food Demand

Food demand is a Cobb-Douglas function of consumer prices, per capita income and food market development index in rural area. At first, per capita demands in rural and urban areas are calculated separately, then, national per capita demand is calculated by using rural and urban population as weights.

$$\log d^R_{it} = a^{RD}_{i0} + \Sigma_j b^R_{ij}(\log p^D_{jt}) + e^R_i \log Y^R_t + m_i \log (MKT_t)$$
$$\log d^U_{it} = a^{UD}_{i0} + \Sigma_j b^U_{ij}(\log p^D_{jt}) + e^U_i \log Y^U_t$$
$$d_{it} = \theta^R_t d^R_{it} + \theta^U_t d^U_{it}$$
$$D_{it} = d_{it} * Pop_t$$

Where:
d^R, d^U: per capita demand in rural, urban.
d: national per capita demand.
D: national total demand.
p^D: consumer price.
Y^R, Y^U: per capita income in rural, urban.
MKT: food market development index.
b^R, b^U: price elasticity matrix of demand in rural, urban.
e^R, e^U: income elasticity vector of demand in rural, urban.
m: market development elasticity of demand in rural.
θ^R, θ^U: rural share, urban share in the total population.

Pop: total population

i: index non-livestock food, including: rice, wheat, maize, sweet potato, potato, other coarse grain, soybean, sugar, oil, fruit, vegetable, and other food, pork, beef, mutton, poultry, egg, milk, and fish.

Constraints:

When $i \neq j$, b^R_{ij} = Expenditure Share$_j$ * (b^R_{ji} / Expenditure Share$_i$ + Real income$_j$ - Market development$_i$).

Cournot$_j$ = $\sum_i b^R_{ij}$ *Expenditure Share$_i$ + Expenditure Share$_j$ (The properties of Cornot and Engel aggregation). It means that total expenditure cannot change in response to a change in prices.

The constraints on b^U_{ij} are the same as those on b^R_{ij} except there is no Market Development in the first constraint.[1]

Total Feed Demand

In this model, feed demand in different grains is obtained by tracing the quantity of grain consumed by different livestock produced in different production modes. Once the demand for meat and other animal products is known, the implied feed demand is calculated by applying a set of feed conversion ratios. Then total feed demand is calculated by using the grain's share as weight. The feed/meat ratio, efficient gain in feeding livestock and grain i's share in total feed grain are estimated from other surveys out of CAPSiM. The feeding efficiency of hogs is expected to increase slightly over time. Meat products are assumed to be produced in China and to be sufficient to satisfy demand. The alternative assumption of net import of meat is also made to investigate the effects of meat imports on the demand for total grain.

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

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

$D^{FeedG}_{t} = \sum_j D^{FeedG}_{jt}$

$D^{FeedG}_{it} = \sum_i f_{it} D^{FeedG}_{t}$

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

Where:

D^{FeedG}: Total Feed Demand.

θ: share of each production mode.

γ_{ik}: annual change in θ.

β: Feed/meat ratio.

δ: Efficient gain in feeding livestock.

f: grain i's 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 grain, and soybean.

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[1] When $i \neq j$, b^R_{ij} and b^U_{ij} vary yearly due to the first constraint.

j: index meat product, including: pork, beef, mutton, poultry, egg, milk, and fish.
k: index production mode, including: backyard, specialized household, and commercial intensive (company) production.

Other Grain Demand
Other grain demand includes grain used as seed, grain used in industry and grain wasted due to post-harvest loss. Quantity of grain used as seed depends on the crop-harvested area. Quantity of grain used in industry this year is calculated based on that used last year. Quantity of grain wasted is calculated as share of crop production.
$D^{Seed}_{it} = (1 + \beta^{S}_{t})^{t} d^{Seed}_{i(t-1)} A_{it}$
$D^{Ind}_{it} = (1 + \beta^{I}_{i})^{t} D^{Ind}_{i(t-1)}$
$D^{Waste}_{it} = (1 + \beta^{W}_{i})^{t} d^{Waste}_{i(t-1)} Q^{S}_{it}$

Where:
A: Crop harvested area.
D^{Seed}: Seed grain use.
D^{Ind}: Industrial grain use.
D^{Waste}: Grain post-harvest loss.
d^{Seed}: Seed grain use (kg) per hectare.
d^{Waste}: Waste (loss) as share of production.
β^{S}: annual growth of seed use per ha.
β^{I}: annual growth of industrial grain use.
β^{W}: annual growth of post-harvest loss.
i: index individual grain, including: rice, wheat, maize, sweet potato, potato, other coarse grain, soybean.

Total Grain Demand
Total grain demand is the summation of total food demand, total feed demand, seed use, industry use and total wasted which exhaust total grain consumption:
$D^{G}_{it} = D^{FoodG}_{it} + D^{FeedG}_{it} + D^{Seed}_{it} + D^{Ind}_{it} + D^{Waste}_{it}$

Where:
D^{G}: Total Grain Demand.
D^{FoodG}: Total Food Grain Demand.
i: index individual grain, including: rice, wheat, maize, sweet potato, potato, other coarse grain, soybean.

3.3.3.3 Grain Stock

Grain stock this year is inferred by referencing the increase in gain demand and grain stock last year as well as the effect of change in price on grain stock.
$B^{G}_{it} = B^{stock}_{i(t-1)} (1 + \Psi D^{G}_{it} / D^{G}_{i(t-1)}) - \Psi B^{stock}_{i(t-1)} + Lp^{D}_{it}$
Where:
B^{G}: Grain stock.
p^{D}: consumer price.

L: marginal change in grain stock due to grain price change.[1]
$\Psi = 0$ if long-term grain stock is constant over time. That is, $B^{G}_{it} - B^{stock}_{i(t-1)} = Lp^{D}_{it}$, implying the change in stock is a linear function of consumer price. It is this formula that is used in this study since we are doing long-term simulation and projection.
$\Psi = 1$ if the proportion of grain stock to consumption is constant over time. That is, $B^{G}_{it} / D^{G}_{it} - B^{stock}_{i(t-1)} / D^{G}_{i(t-1)} = Lp^{D}_{it}$, implying the change in the ratio of stock to consumption is a linear function of consumer price. This formula is used in short-term (usually less than 5 years) simulation and projection.

In terms of this formula, the stock change will be directly affected by domestic consumer price, and indirectly affected by world market price through trade because domestic consumer price will be affected by world market price via trade model. Because the value of L is negative, if the consumer price keeps decrease, the stock will keep increase (in the case of $\Psi = 1$, if the stock grows faster than consumption). In this case, according to the government stock policy, we give a maximum stock for each commodity (30% of each product production). If the stock grows so that the stock level is greater than the maximum, the export will be forced to increase exogenously while the stock level will be maintained unchanged. In the opposite case, the minimum stock level is set at 5% of production. In this case, if the stock decreases due to the increase in consumer price so that the stock level is less than the minimum, the import will be forced to increase while the stock level will be maintain unchanged.

3.3.4 Trade Behavior

After estimating the changes in production of and demand for agriculture products by using the models given above, we can get the percentage changes in import and export by decomposition equation derived from constant elasticity of substitution (CES) mechanism, in response to the percentage changes in their prices domestically and abroad. In this trade model, FOB and CIF prices are first translated into domestic currency. After that, they are transformed into domestic market prices at the national level by deducting producer subsidy expenditure. Then, the percentage changes in the quantities imported and exported are given in the form of equation (V.7), in which the percentage changes in composite quantity and price are the percentage change in total quantity demanded and weighed averages percentage changes in producer price, consumer price, import price and export price by using their cost share in the last year as weights, respectively.[2]

$$\hat{X}_{it}^{import} = \sigma(\hat{p}_{it} - \hat{p}_{it}^{import}) + \hat{q}_{it}$$
$$\hat{X}_{it}^{export} = -\sigma(\hat{p}_{it} - \hat{p}_{it}^{export}) - \hat{q}_{it}$$
$$X^{netimport}_{it} = X^{import}_{it} - X^{export}_{it}$$
$$p^{import}_{it} = p^{ib}_{it}(1 + PSE^{import}_{it})$$
$$p^{export}_{it} = p^{xb}_{it}(1 + PSE^{export}_{it})$$
$$p^{ib}_{it} = XR_{t}p^{cif}_{it}$$

[1] L: rice -0.19, wheat -0.2, maize -0.3, sweet potato -0.3, potato -0.3, other grains -0.2, soybean -0.35.
[2] CIF price and FOB price are subject to changes in the prices of traded commodities in world market which are estimated based on projection of world market prices made by World Bank. Alternatively, in trade liberalisation experiments we use estimates of border prices from the GTAP model.

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

Where:
X^{import}: Import.
X^{export}: Export.
$X^{netimport}$: Net import.
XR: Exchange rate.
p^{rural}: Rural consumer price.
p^{cif}: CIF price.
p^{fob}: FOB price
PSE: Producer subsidy equivalent
σ : the elasticity of substitution between domestic and imported varieties.

The circumflex ^ denotes a relative change.
i: index individual grain, including: rice, wheat, maize, sweet potato, potato, other coarse grain, soybean, sugar, pork, beef, mutton, poultry, egg, and fish.

3.3.5 Market Clearing

Finding a market equilibrium in any simulation period entails the solution of a simultaneous system of demand and supply equations. The equilibrating variables are the prices in each market.

Supply equations, which are decomposed by area and yield, grain and meat, allow producer own price and cross market responses as well as the effects of shifts in technology stock of agriculture, irrigation stock, ratio of erosion area to total land area, ratio of salinity area to cultivate area, yield change due to exogenous shock of climate, and yield change due to other exogenous shock.

Demand equations, which are decomposed by urban and rural areas, grain and meat, allow consumer own price and cross market responses as well as the effects of shifts in income, population level, market development and other shocks.

The market clearing equation also establishes the fundamental link between domestic Chinese markets and the world market for each of the commodities distinguished. It assures that the overall demand - supply balances are satisfied and it implicitly determines market prices. Schematically:

Total demand equals final demand plus stock changes:
$D_{it} = D(p_{it}, p_{jt}, \text{income}_t, \text{other demand factors}_t) + B_{it} - B_{i(t-1)} \qquad i \neq j$

Total supply equals domestic supply plus net imports:
$X^{netimport}_{it} + S_{it} = S(p_{it}, p_{jt}, \text{investment}_t, \text{other supply factors}_t)$

Equilibrium:
$D_{it} = X^{netimport}_{it} + S_{it} \qquad \text{for all } i = 1..n$

3.3.6 Welfare

A measure of welfare changes in CAPSiM is obtained from the traditional producer and consumer surplus calculations. Total welfare is the summation of the producer's surplus and the consumer's surplus.

3.3.6.1 Producer Welfare

From section 3.2.1 we obtain the supply equations for each commodity. For crops, these will depend on yield, and factors that influence yield such as salinity. Similarly, for livestock, the feed conversion rate will enter into the picture.

As shown in Figure 3.5 (in the market of product i), the equilibrium point will move from P^0 to P^1 when the producer free market price of product i changes from p^S_{it} to $p^S_{i(t+1)}$, ceteris paribus. If the prices of other products or other factors change also, the supply curve will shift from S^0 to S^1 and the equilibrium point will change to P^2. Our method takes into account both the movements along the supply curve and shifts of the supply curve (as in figure 3.5). Let A^P_t be the area between O and p^S_{it} and to the left of S^0, $A^P_{(t-1)}$ the area between O and $p^S_{(t+1)}$ and to the left of S^1. Therefore, the change in the producer welfare will be the difference between the area A^P_t and $A^P_{(t+1)}$. In the case of crops, this becomes:

$$A^P_t = \int_0^{p^S_{it}} Q^S_{it}\, dp^S_i = \int_0^{p^S_{it}} A_{it} * Y_{it}\, dp^S_i$$

$$= \frac{1}{b^A_{ii} + b^Y_{ii} + 1} * A_{it} * Y_{it} * p^S_{it}$$

$$A^P_{t+1} = \int_0^{p^S_{i(t+1)}} Q^S_{i(t+1)}\, dp^S_i = \int_0^{p^S_{i(t+1)}} A_{i(t+1)} * Y_{i(t+1)}\, dp^S_i$$

$$= \frac{1}{b^A_{ii} + b^Y_{ii} + 1} * A_{i(t+1)} * Y_{i(t+1)} * p^S_{i(t+1)}$$

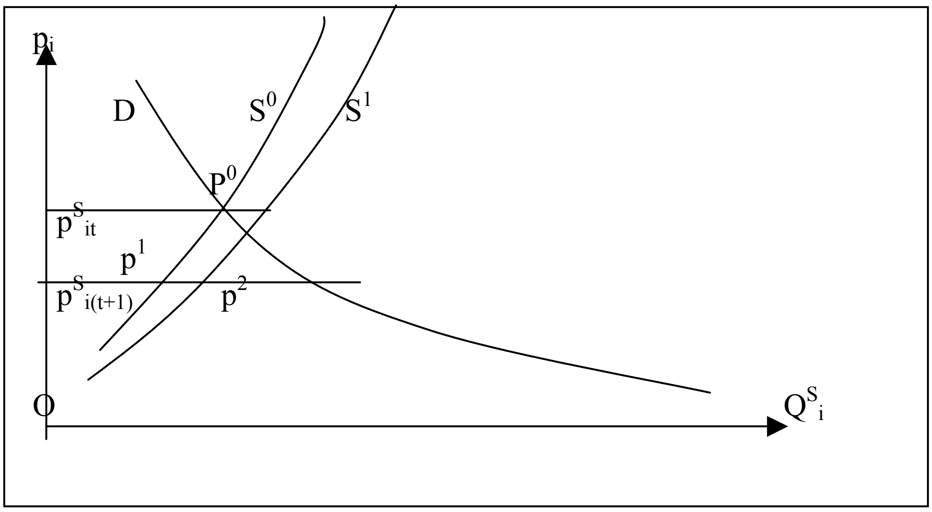

Figure 3.5 Welfare analyses: producers

3.3.6.2 Consumer Welfare

From section 3.2.3.2 (Food Demand), we can derive total demand:

$$D_{it} = pop_t(\theta_t^R e^{a_{i0}^{RD}} \prod_j p_{it}^{D\, b_{ij}^R} Y_t^{R\, e_i^R} Z_t^{MKT\, m_i} + \theta_t^U e^{a_{i0}^{UD}} \prod_j p_{it}^{D\, b_{ij}^U} Y_t^{U\, e_i^U})$$

As shown in Figure 3.6 (in the market of product i), the equilibrium point will move from P^0 to P^1 when the consumer price of product i changes from $p^D{}_{it}$ to $p^D{}_{i(t+1)}$, ceteris paribus. If the prices of others products or other factors change also, the demand curve will shift from S^0 to S^1 and the equilibrium point will change to P^2.

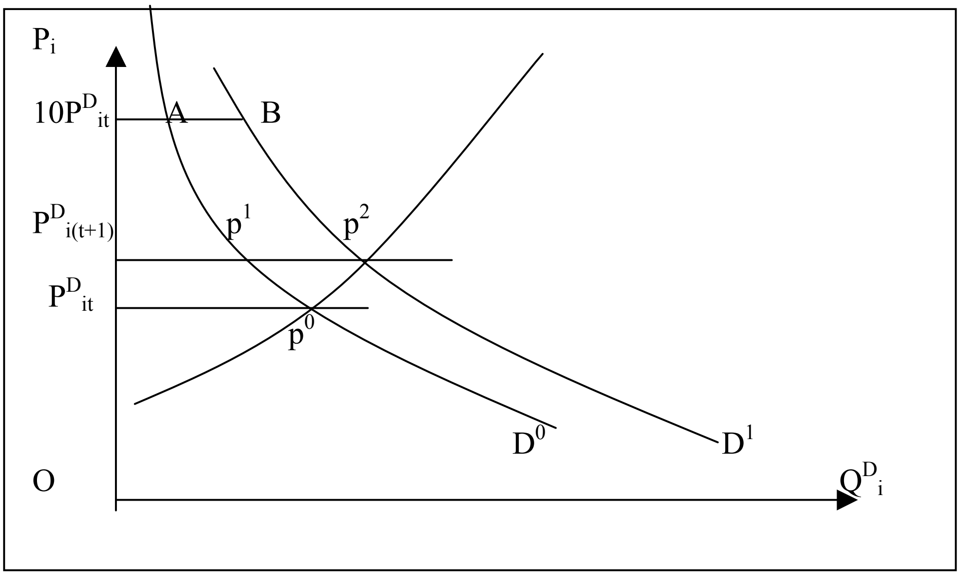

Figure 3.6 Welfare analysis: consumers

Taking into account that there is no intersection between the demand curve and the price axis and that these two lines get closer as the price goes up, we can approximately calculate the consumer welfare as the area below the price $10P^D_{it}$, the error resulting from the approximation in the change in consumer welfare will have the second order and higher order derivative property and can be ignored. Therefore, when consumer price is P^D_{it}, the consumer welfare is the area A^C_t between $10P^D_{it}$ and P^D_{it} and to the left of D^0. When consumer is $P^D_{i(t+1)}$, the consumer welfare is the area A^C_{t+1} between $10P^D_{it}$ and $P^D_{i(t+1)}$ and to the left of D^1. Then, the change in consumer welfare is the difference between the area A^C_t and A^C_{t+1}.

$$A^C_t = \int_{p_{it}^D}^{10p_{it}^D} D_{it} dp_i^D$$

$$= pop_t \theta_t^R d_{it}^R \frac{(10p_{it}^D)^{b_{ii}^R+1} - p_{it}^{D\, b_{ii}^R+1}}{p_{it}^{D\, b_{ii}^R}(b_{ii}^R+1)}$$

$$+ pop_t \theta_t^U d_{it}^U \frac{(10p_{it}^D)^{b_{ii}^U+1} - p_{it}^{D\, b_{ii}^U+1}}{p_{it}^{D\, b_{ii}^U}(b_{ii}^U+1)}$$

$$A^C_{t+1} = \int_{p_{i(t+1)}^D}^{10p_{it}^D} D_{i(t+1)} dp_i^D$$

$$= pop_{t+1} \theta_{t+1}^R d_{i(t+1)}^R \frac{(10p_{it}^D)^{b_{ii}^R+1} - p_{i(t+1)}^{D\;\; b_{ii}^R+1}}{p_{i(t+1)}^{D\;\; b_{ii}^R}(b_{ii}^R+1)}$$

$$+ pop_{t+1}\theta^{U}_{t+1}d^{U}_{i(t+1)}\frac{(10p^{D}_{it})^{b^{U}_{ii}+1}-p^{D}_{i(t+1)}{}^{b^{U}_{ii}+1}}{p^{D}_{i(t+1)}{}^{b^{U}_{ii}}(b^{U}_{ii}+1)}$$

3.4 Linkage between CAPSiM and GTAP

In order to gain a better understanding of China's capacity to feed its growing population given its limited natural resources, and the impact of China's growing economy on the rest of the world and vice versa, the CAPSiM model is used in tandem with the GTAP model.

Linking -or even coupling- two models with different theoretical starting points and consequently different statistical concepts to support the modeling is not easy, and may sometimes even be foolish. In our case, linking has two dimensions. First, the commodity classifications and content should be comparable for those sectors where the two models overlap, i.e. in primary agriculture in China. Second, since CAPSIM is a PE model for China, while GTAP is a GE model of the world economy, there can be a fruitful exchange of model output between the two models. While we do not attempt a full-fledged coupling of the two models, we aim for a maximum amount of compatibility between them, such that endogenous results of one model can fruitfully be utilized as input into the other model. For example, GTAP generates changing border prices in the wake of global trade liberalization. These estimates can be fed into CAPSIM to generate the detailed supply and demand responses for Chinese agricultural sectors.

Clearly, the two models differ in many respects as should be evident from the foregoing sections. In the following we summarize key conceptual differences, and, we discuss our approach to bridge them where this is a sensible strategy.

While CAPSiM is a partial equilibrium model within agricultural sector, GTAP is a computable general equilibrium (CGE) model that covers all industries in the economy worldwide.

CAPSiM focuses on the agricultural sector. It is based on a more detailed database and it includes more agricultural sector-specific modeling than GTAP. It is therefore better positioned to simulate sector-specific developments in the Chinese agricultural sector. CAPSiM is obviously limited as regards the impact of shocks to non-agricultural industries and with regard to the impact of shocks that occur outside China. Those two aspects are the *raison d'être* for a general equilibrium model such as GTAP. There is, therefore, a clear complementarity between the two models.

By modeling the entire economy, GTAP can provide insights into interdependencies between agricultural and non-agricultural sectors. Of course, results obtained from a general equilibrium analysis will only differ significantly from partial equilibrium results if agricultural and trade policies lead to noticeable price shifts in other sectors. Even in industrialized countries, where agriculture typically contributes only a small share of GDP and employment, important indirect effects occur through factor markets, most notably the land markets. In developing economies, the second-round effects through labor markets, and to a lesser extent capital markets, are potentially significant. For example, if a reduction of border protection by main trading partners improves export and growth prospects of certain industrial sectors, the increase in labor demand will typically raise economy-wide wage rates. This in turn raises the opportunity cost of farm labor, and will influence the farm-household decisions on allocating their resources between farm and off-farm activities. CGE models provide the only coherent way to analyze these general equilibrium effects. In contrast to CAPSIM, the GTAP model includes factor markets.

More directly, agriculture has strong linkages with sectors that are closely related, either because they deliver key inputs such as fertilizers, herbicides, agricultural machinery, or because they process primary agricultural products, such as beef processing and dairy industries. Typically, these backward and forward linkages are stronger in industrialized economies.

Approach to model linkage

Given the conceptual differences and the consequent differences in data, a full-fledged linking of the two models does not seem to be very informative. Essentially we have chosen to design a model closure for GTAP that has as exogenous certain variables from CAPSiM, such as agricultural production and at the same time we use a model closure for CAPSiM that has as exogenous certain variables from GTAP such as border price changes. Table 3.1 shows which variables are liable to exchanging between the two models.

Feeding into CAPSiM border price changes, GDP and factor prices from GTAP is essentially a tops-down approach. If we go one step further, we can let CAPSiM determine Chinese import demand and export supply for agricultural commodities, and subsequently feed those into GTAP. GTAP, in turn, will then produce a new set of import and export prices for China - next to all the other variables that characterize global equilibriums in all the markets. These in turn can be fed into CAPSiM to find a new equilibria on Chinese markets. This iterative process can be continued until prices and volumes do not change anymore. Convergence is in fact guaranteed by the convexity of the system. While none of the simulations reported in this report exploits this iterative procedure Ninghui (2002) discusses its use at great length.

In order to assure consistency in the trade response between the two models, CAPSiM has been modified to bring its modeling of trade more in line with GTAP (see section 3.2.4) The procedure chosen is grossly consistent with GTAP results, as long as the elasticities are derived from GTAP itself.

Table 3.1 Interfacing variables

	CAPSIM	GTAP
Output	import by commodity export by commodity	Export prices (fob) by CAPSiM commodity Import prices (cif) by CAPSiM commodity Volume of GDP Factor prices, land, labor and capital
Input	Export prices (fob) by CAPSiM commodity Import prices (cif) by CAPSiM commodity Volume of GDP Factor prices, land, labor and capital	import (by CAPSiM commodity) export (by CAPSiM commodity)

CAPSiM is a recursive-dynamic model for projections with equilibriums being attained within the period of one year. GTAP is a static model for comparative static simulations.

Generally speaking, dynamic models allow the analysis of lagged transmissions and adjustment processes over time. Alternatively, the comparative static approach studies the differences between equilibria resulting from different assumptions on exogenous data or policy variables. The time path between equilibria is ignored in comparative static models.

CAPSiM specifies a recursive sequence of temporary equilibria. That is, in each time period the model is solved for an equilibrium, given the exogenous conditions prevailing for that particular period. In between periods, stock variables are updated, either exogenously (e.g. population) or as a result of the equilibrium outcomes of the preceding period (e.g. in CAPSiM grains stock develops as functions of past stocks and stock to consumption ratios).

Comparative static models are sometimes used to generate projections of policy impacts at some future point in time. Such projections are achieved by constructing an artificial future dataset that is consistent with the model's assumptions –a so called baseline-, and subsequently conducting a policy experiment on the basis of this projected dataset. The artificial future dataset is constructed by making assumptions on the growth of exogenous variables and parameters and subsequently letting the model solve for an equilibrium that is consistent with these assumptions.

This is precisely the approach followed in this study. The GTAP baseline projection for the whole world, including country projections for China until the year 2020 and its underlying assumptions is more fully discussed in Chapter 5. As far as China is concerned, we make full use of the detailed information generated along the time path of the CAPSiM projection. Some of the important inputs being the implications of changing rural-urban consumption behavior and the implied aggregate income and price elasticities for food demand.

Differences in data and parameters
Some variables used in the two models are incomparable, and coverage given by the same variable between the two models is different. Differences may result from the difference in demarcation of variables into various categories, the difference in prices used, the difference in quantities referenced, and also to the difference in the definitions of variables between the two models.

Next to defining which variables can travel between the two models, it is important to make the databases compatible. A successful interfacing can only be realized if the definitions of variables are clear (and preferably identical across the models), and if the discrepancies in variable definition and measurement errors are weeded out. This process of tallying the two databases has resulted in numerous adjustments.

Classification of commodities and data sources of GTAP and CAPSiM listed in Appendix 3.1 shows that the sector categories in each model are different. Some of the GTAP categories are broader; some of the CAPSiM categories are broader. Based on this information, we have developed bridge tables that allow us to exchange information between the two models in a way that is as consistent as possible from a statistical point of view. The work on the data bridge entails first of all the matching of commodity classifications, followed by data adjustments (see also Appendices 3.2, 3.3 and 3.4).

Besides constructing bridge tables, we have updated the Chinese component of the GTAP database from its base year 1997 to the year 2001. In this process, we have been able to incorporate more micro-data based information into the input-output table. This information has led to an improved representation of the cost structure of Chinese agriculture in the GTAP database. Table 3.2 summarizes the differences of cost share estimates between the original GTAP data and our adjusted data. Note that the bulk of the adjustment occurs in the primary factor cost (land, labor capital). According to the new estimates primary factors account for a larger share of total cost, whereas intermediate deliveries are relatively less important compared to the original GTAP database.

Next to adjustments to the IO table, we have been able to incorporate recent information on Chinese international trade.

The so-called baseline simulation starts from the base data for 2001 and adds to it many assumptions on policies, technology development and so on. These are documented in Chapter 5. In order to assure consistency between the CAPSiM-generated baseline and the GTAP baseline we use common assumptions on the developments of the following variables over time:

- GDP;
- Population;
- Education (skilled, unskilled labor);
- Factor productivity by agricultural sector;
- Trade policies China;
- Industry and services policies China.

The model results are checked for consistency along the baseline path. Specifically, we pay attention to the net trade position by sector and to output growth by sector.

Table 3.2 Cost shares in agriculture, China

Using sector ► / Inputs from ▼	Rice	Wheat	Coarse grains	Oilseeds	Sugar	Plant fibers	Other crops	Cattle and beef	Pig & poultry	Dairy	Fish	Other food
Adjusted data for 2001												
Land and natural resources	0.23	0.24	0.25	0.14	0.16	0.22	0.21	0.13	0.13	0.14	0.01	0.00
Labor	0.37	0.36	0.37	0.31	0.30	0.42	0.41	0.28	0.30	0.29	0.42	0.07
Capital services	0.08	0.08	0.07	0.08	0.10	0.05	0.07	0.08	0.06	0.11	0.06	0.13
Agri-food	0.07	0.16	0.14	0.18	0.30	0.07	0.09	0.36	0.43	0.28	0.27	0.62
Extraction	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing	0.21	0.11	0.11	0.15	0.10	0.22	0.15	0.03	0.02	0.03	0.14	0.10
Services	0.04	0.05	0.05	0.14	0.06	0.03	0.07	0.12	0.06	0.15	0.10	0.07
TOTAL	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
GTAP data for 1997												
Using sector ► / Inputs from ▼	Rice	Wheat	Coarse grains	Oilseeds	Sugar	Plant fibers	Other crops	Cattle and beef	Pig & poultry	Dairy	Fish	Other food
Land and natural resources	0.08	0.14	0.20	0.10	0.12	0.12	0.19	0.12	0.12	0.11	0.24	0.00
Labor	0.24	0.28	0.41	0.21	0.26	0.24	0.39	0.26	0.25	0.25	0.31	0.07
Capital services	0.14	0.06	0.08	0.06	0.09	0.05	0.08	0.09	0.06	0.11	0.05	0.12
Agri-food	0.38	0.42	0.06	0.39	0.36	0.03	0.09	0.36	0.50	0.34	0.22	0.65
Extraction	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing	0.08	0.07	0.17	0.12	0.10	0.39	0.17	0.03	0.02	0.03	0.11	0.09
Services	0.08	0.03	0.08	0.11	0.06	0.18	0.08	0.14	0.05	0.16	0.07	0.07
TOTAL	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Source: GTAP database version 5, Dimaranan and McDougall (2002), and own calculations.

3.5 Data Improvement in CAPSiM: adjusting livestock statistics[1]

It is obvious that a good result produced by CAPSiM will heavily depend on high quality database used in CAPSiM. Most analysts believe that China's production side statistics for grain are relatively reliable (Fan and Agcaoili, 1997; Huang and Rozelle, 1999). Data examination also shows that crops data are of reliability and consistency. Unfortunately, China does not have a good record in the generation of reliable and consistent data on the demand and supply of livestock products (Fuller et al., 2000; ERS, 1999).

An examination of livestock data derived from national statistical sources reveals that the discrepancy between published demand and supply series has become larger over the past fifteen years. Although China's National Statistical Bureau (CNSB) has already implicitly admitted that its data series are flawed by making substantive revisions after the late 1990s, their changes still have not changed the growth rates of the nation's livestock production. By 1999, China's production series reached a level 2 to 3 times as high as its consumption series. In contrast, national statistics show that the consumption of pork did not rise during the 1990s, even though per capita income in real term during this time period rose by 6 percent annually. Recognizing weaknesses in the national government's official statistics, several statistical users have spent time adjusting and revising livestock databases and rerunning baseline projections on China's grain production, demand and trade (e.g., FAPRI, 1999; USDA, 1999). One of the tasks of China's 1997 census of agriculture was to assess and adjust livestock production data (FAO, 2000). Despite this effort, however, the lack of consistent data is almost certainly affecting the quality of research. For example, Zhong (1997) suggests that projections made by previous studies on food demand and supply could be subject to serious bias because of faulty data on livestock and should be re-examined. If so, the policy recommendations that have been derived from the previous studies also may have to be re-examined.

3.5.1 Livestock Demand and Supply Discrepancies

In order to assess the validity of any given set of livestock statistics, several criteria need to be met. First, after adjusting for trade and storage, domestic supply must equal demand. Second, the production of meat must be consistent with feed statistics. Third, the numbers must be consistent with observed trends in the economy. In this section, we show the China's official published livestock demand and supply data fail to meet these criteria.

Supply does not Equal Demand

If China's official statistics on livestock were correct, the supply of livestock products during the past two decades would have increased at a rate almost unparalleled in history (Table 3.3). Based on production statistics from China Statistical Yearbook, China's official publication of major agricultural statistics (managed by a division of CNSB), aggregate pork supply rose by 2.4 times, from 11.34 mmt in 1980 to 38.91 million metric tons (mmt) in 1999 (column 2). Other livestock products grew even faster. For example, poultry supply rose 10.9 times, from 0.94 mmt in 1980 to 11.16 mmt in 1999 (column 5). Egg, beef, and mutton supplies rose by at least 5 times (columns 8, 11 and 14).

[1] Part of this study was published in Ma et al., 2004

Table 3.3 Comparisons between Aggregate Livestock Supply and Demand Statistical Series in China, 1980 to 1999 (Million tons) a)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	Pork			Poultry			Eggs			Beef			Mutton		
Year	Demand	Supply	Ratio	Demand	Supply	Ratio	Demand	Supply	Ratio	Demand	Supply	Ratio	Demand	Supply	Ratio
1980	10.47	11.34	1.08	0.88	0.94	1.07	2.13	2.57	1.20	0.28	0.27	0.97	0.42	0.45	1.05
1981	11.84	11.88	1.00	1.02	1.03	1.00	2.24	2.69	1.20	0.30	0.24	0.82	0.46	0.48	1.03
1982	13.23	12.72	0.96	1.25	1.18	0.94	2.31	2.81	1.22	0.37	0.27	0.72	0.50	0.52	1.04
1983	14.63	13.16	0.90	1.35	1.30	0.96	2.69	3.32	1.23	0.41	0.31	0.77	0.52	0.55	1.04
1984	16.07	14.45	0.90	1.52	1.44	0.95	3.15	4.32	1.37	0.53	0.37	0.70	0.57	0.59	1.03
1985	16.73	16.55	0.99	1.77	1.60	0.90	3.57	5.35	1.50	0.66	0.47	0.71	0.63	0.59	0.93
1986	18.76	17.96	0.96	1.95	1.88	0.96	3.63	5.55	1.53	0.74	0.59	0.79	0.66	0.62	0.94
1987	18.40	18.35	1.00	2.03	2.19	1.08	4.05	5.90	1.46	0.87	0.79	0.91	0.69	0.72	1.04
1988	17.56	20.18	1.15	2.27	2.74	1.21	4.38	6.96	1.59	0.98	0.96	0.98	0.71	0.80	1.13
1989	18.13	21.23	1.17	2.45	2.82	1.15	4.60	7.20	1.57	1.07	1.07	1.00	0.77	0.96	1.25
1990	18.91	22.81	1.21	2.68	3.23	1.21	4.78	7.95	1.66	1.19	1.26	1.06	0.85	1.07	1.26
1991	20.20	24.52	1.21	2.82	3.95	1.40	5.10	9.22	1.81	1.33	1.54	1.16	0.92	1.18	1.29
1992	19.69	26.35	1.34	3.18	4.54	1.43	5.51	10.20	1.85	1.39	1.80	1.30	0.90	1.25	1.39
1993	19.95	28.54	1.43	3.41	5.74	1.68	5.44	11.80	2.17	1.46	2.34	1.60	0.90	1.38	1.53
1994	19.49	32.05	1.64	3.64	7.55	2.07	5.94	14.79	2.49	1.41	3.27	2.32	0.94	1.61	1.72
1995	20.03	36.48	1.82	3.95	9.35	2.36	6.22	16.77	2.69	1.44	4.15	2.88	0.96	2.02	2.09
1996	21.81	31.58	1.45	4.28	8.96	2.09	6.40	19.65	3.07	1.52	3.56	2.35	1.08	1.81	1.67
1997	20.54	35.96	1.75	4.92	9.55	1.94	7.34	18.97	2.58	1.82	4.41	2.42	1.23	2.10	1.71
1998	21.50	38.84	1.81	5.02	10.23	2.04	7.71	20.21	2.62	1.76	4.80	2.73	1.23	2.35	1.90
1999	21.94	38.91	1.77	5.58	11.16	2.00	8.02	21.35	2.66	1.86	5.05	2.71	1.19	2.51	2.12

Source: Livestock production statistics come from Statistical Yearbook of China, 1981-2000. Consumption estimates come data that are found in China National Statistical Bureau's rural and urban Household Income and Expenditure Survey, 1981-2000, and calculations that are shown in detail in Annex 3.5 (for pork and poultry), Annex 3.11 (for eggs), Annex 3.14 (for beef) and Annex 3.15 (for mutton).

a. All figures reported in carcass weight. Retail weight figures (the original units for consumption data) are converted to carcass weight (the original units for production data) by use of standard conversion coefficients (0.77 for pork; 1.0 for poultry; 0.74 for beef; and 0.89 for mutton-see Fuller et al., 2000).

As supply grew, China's statistics show that the demand for livestock products also increased (Table 3.3, columns 1, 4, 7, 10 and 13). According CNSB's officially sanctioned urban and rural Household Income and Expenditure Surveys (HIES-urban and HIES-rural), total pork consumption doubled from 10.47 mmt in 1980 to 21.94 mmt in 1999. Likewise, consumption of other animal products grew. For example, poultry consumption rose 5.3 times, while eggs, beef and mutton all grew by at least 2 times.

Comparison of initial levels of livestock demand and supply in the early 1980s (which were nearly equal through 1987) and analysis of the trends for the past 15 years (which were sharply different) illustrate that CNSB's livestock demand and supply data are inconsistent. The rising ratio of supply to demand throughout the entire period demonstrates the extent to which supply figures are growing faster than those of demand (Table 3.3). For example, in most years in 1980s (1980 - 1987), the ratio of pork supply to demand averaged 0.97, near 1.00 (column 3). China's pork statistics during the time met the criteria that the supply equals demand. Between 1988 and 1999, however, the ratio increased monotonically from 1.15 to 1.77. China's reported pork supply exceeded the reported demand by 77 percent in 1999. The ratios of other livestock commodities increased even faster (columns 6, 9, 12 and 15).

Statistical tests of the rising gap between demand and supply provide further confirmation of the observation that China's supply figures are growing faster than those of demand. Our statistical tests are derived from the following equations,

$$R_{it} = \beta_0 + \beta_1 T_{t \le 1987} + \beta_2 T_{t > 1987} + u_i, \quad (1)$$

and $R_{it} = \alpha_0 + \alpha_1 T_t + \varepsilon_i$ (2)

where R_{it} is the ratio of supply to demand over time; $T_{t \le 1987}$ is a time trend variable for the period from 1980 to 1987; $T_{t>1987}$ is a time trend variable for the period from 1988 to 1999; T_t in equation (2) is either the first time period (1980 to 1987) or the second one (1988 to 1999). In equation (1), the coefficient on the early time trend variable, β_1, would demonstrate that supply equals demand between 1980 and 1987 if $\beta_1=0$. It would be greater than 0 if the ratios were rising and the growth rate of supply was growing faster than demand during the early part of study period. If the ratios were accelerating during the late time period, 1988 to 1999, the coefficient, β_2, on the second time trend variable, $T_{t>1987}$, would be positive and significantly different from 0 (and significantly different from $T_{t \le 1987}$). In equation (2), if α_1 equals 0 and α_0 equals 1, then the ratios of supply to demand series converge to one (which means that supply and demand series are equal).

Table 3.4 Consistency Tests for the Reported Livestock Supply and Demand Series, 1980-99 [a]

Independent Variable	Dependent Variable, R_{it} = Supply / Demand				
	Pork	Poultry	Eggs	Beef	Mutton
Tests for structural change					
$T_{t \leq 1987}$	0.02	0.03	0.08^{***}	0.08	0.02
	(0.98) b)	(1.12)	(3.06)	(1.55)	(1.08)
$T_{t>1987}$	0.04^{***}	0.07^{***}	0.09^{***}	0.11^{***}	0.05^{***}
	(7.23)	(6.44)	(10.01)	(6.20)	(6.70)
Adjusted R^2	0.86	0.70	0.89	0.77	0.82
Tests for convergence of supply/demand ratio to one c)					
Before 1987:					
$T_{t \leq 1987}$	-0.01	-0.00	0.06^{***}	-0.01	-0.01
	(0.86)	(0.29)	(6.01)	(0.50)	(1.49)
Intercept	1.01^{***}	1.00^{***}	1.09^{***}	0.83^{***}	1.06^{***}
	(21.64)	(18.80)	(23.44)	(10.35)	(33.44)
F-Statistic (Test: Intercept =1)	0.04	0.00	3.97	4.21^{**}	2.84
After 1987:					
$T_{t>1987}$	0.07^{***}	0.10^{***}	0.12^{***}	0.19^{***}	0.08^{***}
	(6.89)	(5.23)	(6.38)	(7.67)	(6.78)
Intercept	0.51^{**}	0.12	0.53^{*}	-0.94^{*}	0.37
	(3.48)	(0.96)	(1.90)	(2.49)	(1.98)
F-Statistic (Test: Intercept =1)	11.61^{***}	6.58^{**}	2.72	26.42^{***}	11.67^{***}

*** Significant at 1 percent level; ** significant at 5 percent level; * significant at 10 percent level.

a) For the tests of structural change (rows 1 to 3), the equation regressing a time trend from two periods on the supply/demand ratio, is run with an intercept; parameters are not shown for brevity. Two separate within period equations are used to test for convergence of supply/demand ratio to one (rows 4 to 6; and rows 7 to 9).

b) The figures in parentheses are *t*-statistics.

c) To test the null hypothesis that the supply/demand ratio is equivalent to one, we test for the significance of the intercept. If F-statistics (rows 6 and 9) are greater than 4, we reject the null hypothesis.

Table 3.4 clearly displays that China has a problem with its statistical reporting system and that the problem appeared in the late 1980s and 1990s. In the case of all livestock products (except eggs), the ratios between demand and supply remained constant between 1980 and 1987 (the coefficients of $T_{t \leq 1987}$ are not significantly different from 0 -- row 1). Meanwhile, in all cases between 1988 and 1999, the ratios rose significantly (the coefficients of $T_{t>1987}$ differ significantly from 0 -- row 2). The F-tests demonstrate that in all cases (except beef), the ratios between 1980 and 1987 statistically converge to 1 (row 6) while the ratios (except eggs) between 1988 and 1999 do not (row 9).

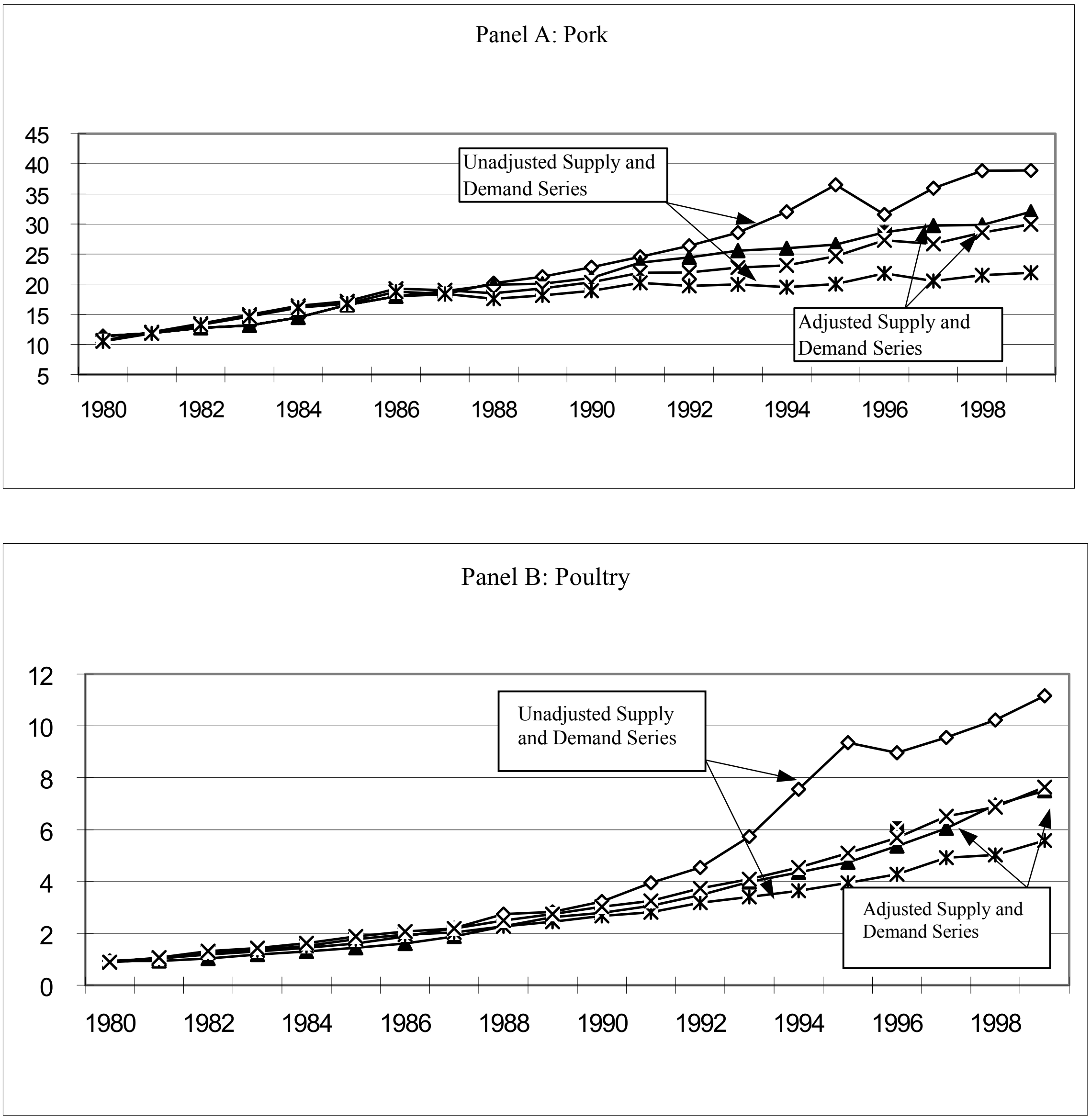

Figure 3.7 Comparison of Pork and Poultry Supply (Production) and Demand (Consumption) Statistical Series Before and After Adjustments, 1980-99 (million metric tons)

Note: Unadjusted pork (poultry) supply and demand statistical series come from Table 3.3, columns 1 and 2 (columns 4 and 5). The adjusted pork (poultry) supply and demand series come from Table 3.7, columns 3 and 5 (Table 3.8, columns 3 and 5).

A graphical presentation also clearly illustrates the growing gap between supply and demand statistical series (Figure 3.7). Although the two unadjusted series for pork (the uppermost and lowermost graph lines on the figure) trend together in the early and mid-

1980s, supply begins to rise much faster than demand after the late 1980s (Panel A). The same rising gap appears for poultry (Panel B).

The Failure to Meet Other Criteria

China's official livestock figures also fail to pass two other consistency tests. First, official demand and supply data clearly fail to provide consistent series of livestock output and feed availability data. To show this, we generated approximate feed consumption figures by aggregating the feed consumption numbers that are implied by various livestock output series.[1] Next, China's supply of feed is assumed to come from its domestic sources and trade.[2] Based on these figures, we see that although the feed supply and consumption data are nearly the same until the late 1980s, the gap widens noticeably through the 1990s. By 1999, feed demand is 32.6 percent higher than feed supply. Since most analysts believe that China's production side statistics for grain are relatively reliable (Fan and Agcaoili, 1997; Huang and Rozelle, 1999), it would appear from this exercise that livestock production statistics are becoming increasingly overstated in the 1990s.

Second, when examining both demand and supply figures, neither reflects the reality of what is being observed in the field. Official output statistics say that from 1990 to 1999 the livestock production rose by 117 percent, which would mean that herd size would have had to almost double, on average, in every part of the nation. While certainly there has been a healthy expansion of hog production in some areas, at the same time farmers in many other areas have reduced their herd size or stopped raising animals altogether.[3] On the demand side, although people may not be eating any more pork at home, there has been

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[1] The first step in creating the estimates involves choosing feed to meat conversion coefficients (Wailes et al., 1998). Second, we assume that feed-meat conversion coefficient is declining over time due to technology progress in livestock sector, the coefficient that is supposed to be consistent with grain consumption of per unit live hog gain based on Cost and Return of Agricultural Production Survey of China. Third, we assume that feed use that are not included in our study account for 10 percent of aggregate feed consumption. Though our study includes major animals that are used for meat production (e.g., swine, poultry, beef cattle and sheep and goats), there are still some animals that are either used in dairy farm (e.g., cows) or as agricultural draught (e.g., horses, mutes). As Fuller et al (2000), we assume this part of feed approximately accounts for 10 percent of total feed consumption.

[2] After calculating annual food and feed grains available in the economy for consumption use, we approximate estimated feed supply figures primarily from corn, wheat bran and sweet potato series. We assume that all corn and sweet potato is available for feed (Huang et al., 2000). Ten percent of the wheat production (and imports), which is assumed to be mostly the bran after milling, is supposed to be used for feed.

[3] For example, a recent survey (henceforth the Rural China 2000 Survey), run by a joint team, the Center for Chinese Agricultural Policy of Chinese Academy of Sciences, Department of Agricultural and Resource Economics of University of California-Davis and Department of Economics of University of Toronto in 2000, covered six provinces (Hebei, Shanaxi, Liaoning, Zhejiang, Sichuan, and Hubei) and 1199 rural households. In this survey, we asked farmers about changes in the number of hogs that they slaughtered between 1990 and 2000. We found that while 10.4 percent of the households who engaged in hog raising during the last decade increased their herd size, 18.4 percent decreased. The number of slaughtered hogs per household rose but slightly from 0.96 in 1990 to 1.01 in 2000. Coupled with the expansion of commercial operations (thought to have expanded by about 63 percent), our estimates of hog production expansion that are based on in-field observations fall far short of the CNSB's production figures. Based on the Rural China 2000 Survey, among 677 households that raised hogs, 2.5 percent are specialized or commercial operations (more than 8 hogs) in 1990, and this percentage reached to 4.1 percent in 2000. It means that commercial enterprises expanded 63 percent during the 1990s.

a veritable explosion of restaurants in China's cities and in many rural areas. The per capita retail value of the catering industry rose more than 130 percent from 1991 to 1998 (China's Catering Industry Yearbook, 1992; 1999), and as anyone who is familiar with China knows that when one goes into a restaurant, meat dishes almost always fill the table. Moreover, the population of migrants has also risen rapidly. In terms of its impact on consumption, Huang and Bouis (1996) show that holding income and prices constant, one salient characteristic of the demand behavior of migrants is that they invariably consume larger quantities of livestock products. The surge in consumption that must have come with the increased presence of migrants in urban areas (more than 100 million in 2000), however, does not seem to appear in either published rural or urban consumption statistics. In summary, with all of this new consumption occurring, it seems doubtful that consumption could be flat.

Data

Although our new data series will ultimately differ from the current ones, we still assume there is valid information in the existing series and build on them throughout our analysis. The current production series are based primarily on year-end reports produced annually by village accountants who use a variety of means to estimate the slaughter rates of livestock in their villages. Village officials send these reports to the township where they are aggregated. In the most typical case, the township statistical officer reviews the production reports before adding them up to form the township's estimated production figure. This procedure is repeated at each successive level of government (i.e., county, prefecture, and province) before turning into a national set of livestock production data. Although this procedure provides an annual census of livestock activities, the main weaknesses of the data collection system are that there are no absolute criteria upon which local accountants based their estimates and there are no procedures in place to verify the accuracy of the year-end reports at any level to ensure that they have not been altered by local officials. Without rigorous data collection procedures and verification processes, observers believe that the current system has allowed local officials to artificially inflate production figures as a way of helping them meet income and food production growth targets (Fuller et al., 2000; Zhong et al., 1997).

The current consumption series are based on data that are collected on a more conventional basis by the CNSB. Called the Household Income and Expenditure Survey (HIES), each year CNSB's personnel across the nation randomly choose more than 40,000 urban and 65,000 rural households. Based on year-round diary methods, in addition to all other consumption goods, households record the quantities and expenditures of the livestock products that they consume. They also record the expenditures that each household member makes on food consumed out of the home. National aggregate consumption series for each commodity (e.g., pork or chicken), however, are estimated only from that part of the data that households have recorded on the quantities of the livestock products that they directly consumed at home. Such figures do not include the part of consumption that is consumed during meals out of the home. We also believe that respondents systematically miss some of the livestock products that they consume as part of processed foods. Although China's statistical reporting system has made great progress for the past 10 years and the HIES is thought to be fairly reliable (FAO, 1993; Heilig, 1999), our main concern here is whether or not the categories on which the national aggregates are created are complete.

The sample size and the coverage of China's HIESs are changing over time in a number of ways (Fang et. al., 1998), all of which might have some effect on data quality. For example, the sample size for the rural household survey before 1985 was less than half of its current size (and that during the 1990s). Especially when the sample was first being formulated, there was some concern that it might not be representative and favored richer areas. Moreover, since data are collected primarily on the basis of self-recorded diaries, there is also the possibility even after 1985 (when the locality selection is thought to have become less biased) that the sample is somewhat biased in favor of richer households. On the urban side, the urban HIES initially covered only those households who lived in cities, excluding those who lived in county-level towns. If richer rural or urban households have both higher production and consumption of livestock products, these features of the data system would lead to a sample bias, most likely overestimating production and consumption before 1985.

In order to adjust the current official livestock demand and supply series, we will rely on several different sets of data (Table 3.5). Our adjustments depend heavily on information that is included in China's urban and rural HIES data sets, but which currently is not used in creating the national production and consumption series. For example, on the urban side (HIES-urban - row 1), since 1991, urban respondents recorded in their expenditure diaries their out-of-home food expenditures. We will use this information in conjunction with other information from our own surveys to make adjustments to our urban animal product consumption series.

Two additional pieces of information are used from the HIES conducted in rural areas (HIES-rural - Table 3.5, row 2). First, as in the case of the urban survey, we use a variable that has been asked of rural households about their total expenditures on out-of-home consumption. In the case of the rural survey, this question has been asked since 1983. This information is used to adjust rural livestock consumption series.

We also use information from the rural survey's production block (Table 3.5 row 2). At the end of each year, enumerators from the CNSB make a special visit to the respondents to ask a series of question about the household's annual production activities. In particular, the survey asks questions about the household's livestock output, including the number of animals that they slaughtered and the quantity of meat that they produced. Such data are collected on a disaggregated basis for swine, poultry, beef cattle, sheep and goats, and eggs. We use this information in conjunction with data from 1997 Ag Census (described below) to make adjustments to the livestock production series.

As a check on (and point of calibration for) the production information from the HIES-rural data, we also use information generated by the 1997 national census of agriculture (Table 3.5, row 3). Supported by both international and domestic funding sources and run by national and provincial Agricultural Census Offices, the main objective of this survey was to provide sectoral officials with an accurate and unbiased baseline that reflects the state of China's rural sector (FAO, 2000). The survey covered all rural households plus all non-household agricultural enterprises (e.g., state-owned farms and commercial firms engaged in agricultural production). One of the main specific objectives of the survey was

Table 3.5 *Summary of Data Sources and Uses in Adjusting China's Livestock Supply and Demand Series*

(1) Data Source	(2) Acronym	(3) Data Collection Entity	(4) Years of Coverage	(5) Sample Size (households)	(6) Uses
Household Income and Expenditure Survey - Urban	HIES – urban	China National Statistical Bureau - Urban Survey Team	1980-99	In 1999, 40044 urban households.	-- *Baseline* for annual urban household livestock commodity consumption (by commodity) -- Trends for *out-of-home consumption* of livestock products for urban households
Household Income and Expenditure Survey - Rural	HIES – rural	China National Statistical Bureau - Rural Survey Team	1980-99	In 1999, 67430 rural households	-- *Baseline* for annual rural household livestock commodity consumption (by commodity) -- Trends for *out-of-home consumption* of livestock products for rural households -- Annual number of *slaughtered animals* and *meat production* by rural households (by commodity)
Agricultural Census (31 Provincial Agricultural Census Publications)	1997 Ag Census	National and Provincial Agricultural Census Office	1996	Complete census data (214 million households) [a]	-- Number of slaughtered animals (by commodity)
CCAP and CARD livestock supply and demand survey [b]	CCAP Survey	Primary data collection by CCAP/CARD	1998	-- 250 rural households -- 250 urban households	-- Composition of out-of-home consumption for both rural and urban households (e.g., allows us to know how much meat urban and rural households are consuming when they eat outside the home). -- Provides alternative (more comprehensive) estimates of total consumption of livestock commodities against which we can compare HIES demand levels. We use our information to make additional adjustments to pork, poultry and egg consumption series.

[a] In addition to the 200 million rural households, the census also surveyed all agricultural enterprises, including commercial livestock enterprises.
[b] CCAP is the Center for Chinese Agricultural Policy in the Chinese Academy of Science's Institute of Geographical Sciences and Natural Resource Research in Beijing, China, and CARD is the Center for Agricultural and Rural Development, in Iowa State University, Ames, Iowa, USA.

to come up with an accurate estimate of the size of the livestock economy. To meet this objective, the survey asked all rural households and non-household agricultural enterprises about the number of animals that they slaughtered (though not the quantity of meat produced) during the census period, January 1, 1996 to December 31, 1996. As in the HIES, census respondents provided their annual production information for swine, poultry, beef cattle, and sheep and goats (but did not supply information on egg production). In CAPSiM's database, we assume that these data provide the most accurate and complete picture of China's livestock production in the 1990s, and all data series are calibrated using these numbers. In all cases, the 1996 observations in our revised data series are exactly those figures generated by the agricultural census.

However, even with access to the data from national surveys, we still found ourselves lacking two key pieces of information: the composition of out-of-home consumption and estimates of total consumption of livestock products by urban and rural household (both direct and indirect including that which is embodied in processed foods). In order to have a basis for estimating these two variables, we conducted our own survey in 1999 (Table 3.5, row 4).[1] In addition to information about the basic characteristics of the household and its individuals, enumerators asked detailed information about its in-home food expenditures and consumption of pork, poultry, beef, mutton, and eggs. Since our survey was focused on livestock product consumption, and since livestock products in most rural households in China are consumed unequally throughout the year, we also specifically asked households about their expenditures and consumption of livestock products during major festivals and holidays.

In another section, enumerators asked households about their consumption of livestock products when they were not at home. Using the same strategy as the HIES, enumerators asked households to report their total expenditures on out-of-home consumption. In addition, our survey asked detailed information about the composition of each household member's out of home consumption. Using this information in conjunction with our estimates of in-home consumption, we were able to create estimates of total per capita animal product out-of-home consumption.

Finally, we also need to estimates of the consumption by migrants. Based on our work elsewhere (deBrauw et al., 2001), we come up with estimates of the number of migrants that are living and working in cities. We then use these data with information about the consumption patterns of migrants (Huang and Bouis, 1996).

3.5.2 Adjustments of Demand and Supply Series

In this section, we discuss how we adjust data series for China's livestock demand and supply. To do so, we first lay out our assumptions for the demand side. Next we discuss the strategy to adjust the supply side. Based on these strategies, in the next section, we empirically make adjustments to the official livestock demand and supply series. Overall, the

[1] Jointly run by enumeration teams from the Center for Chinese Agricultural Policy (CCAP), Chinese Academy of Sciences (Beijing, China) and the Center for Agricultural and Rural Development, Iowa State University, the survey covered 250 urban households in 5 cities, Chengdu (Sichuan Province), Jiangjin (Chongqing Municipality), Changchun (Jilin Province), and Weifang and Feixin (Shandong Province). The information was asked on a one-week recall basis.

strategy has three main parts. First, we adjust existing consumption data upward to account for livestock products that are consumed out-of-home (including animal products consumed in restaurants and those consumed by rural migrant laborers). Second, we adjust existing production downward, eliminating the biases that have been introduced by the statistical reporting system for output since the late 1980s. Finally, in the case of pork, poultry and eggs, we also make an additional upward adjustment to consumption in order to account for the animal products that are missed by the HIES survey (for example, pork, poultry and eggs that are consumed in processed foods).

To create new series of believable data for China's livestock sector, we need to rely on several categories of assumptions regarding the source and nature of the discrepancies. In particular, we make assumptions about economic behavior, especially when adjusting the consumption data. In addition, we also make a series of assumptions about statistical accuracy and misreporting and how they have changed over time. Finally, we rely on several implicit assumptions about changes (or consistency) of technical parameters over time.

Demand Side Assumptions and Strategies

To make the initial adjustment to the demand side data, we rely on three specific assumptions. First, we assume that the HIES data, both urban and rural, accurately measure total out-of-home food expenditure. Second, although we know how much the household spent on out-of-home consumption, we do not believe that commodity-specific consumption statistics based on HIES data account for the part of the consumption that takes place outside of the household. In other words, statistics that report the quantity of meat consumed that are based on HIES data are underreported primarily because respondents generally failed to include their out-of-home food consumption in this statistical category. Zhong (1997) also believes this is the case. Third, to get an assessment of the impact that the trend towards more out-of-home expenditure has on animal product demand, we assume that meat consumption that is embodied in out-of-home expenditures rises at the same rate as total expenditures on out-of-home consumption. In fact, this is probably a conservative assumption since over time as food expenditures have risen we would expect that meat demand would rise relatively faster than that of other foods (Ma, Huang and Rozelle, 2002). Based on these three demand side assumptions, we can see that two pieces of information that are needed to adjust the demand side of meat data series are precisely those that we discussed in the previous section: the trend in out-of-home consumption during the last two decades; and the proportion of total food that is consumed out-of-home that is made up of animal products (Table 3.6, rows 1 to 5).

Table 3.6 Evidence of Underreporting of Out-of-Home and In-Home Urban and Rural Livestock Consumption by the China National Statistical Bureau's Household Income and Expenditure Survey (HIES), 1998.

	Urban Residents				Rural Residents			
	National HIES [a]	Four Province HIES Mean [b]	CCAP Survey [c]	Yuan et al. Data [d]	National HIES [a]	Four Province HIES Mean [b]	CCAP Survey [c]	Yuan et al. Data [d]
	Per Capita Consumption, 'Out-of-Home'							
Pork	-	-	5.30	8.17	-	-	1.38	1.85
Poultry	-	-	1.10	5.25	-	-	0.76	0.70
Eggs	-	-	1.20	2.06	-	-	0.41	0.94
Beef	-	-	1.00	-	-	-	0.10	-
Mutton	-	-	0.45	-	-	-	0.18	-
	Per Capita Consumption, 'In-Home'							
Pork	15.88	18.33	21.88	22.55	11.89	11.95	12.42	17.19
Poultry	7.22	7.86	7.99	4.99	2.33	2.27	2.54	4.13
Eggs	10.76	11.00	15.85	13.78	4.11	7.05	7.04	6.10
Beef	2.10	-	3.08	-	0.59	-	1.40	-
Mutton	1.24	-	0.69	-	0.72	-	0.30	-

Note: Beef and mutton data are not disaggregated by province. Yuan et al (1998) also do not provide separate estimates for beef and mutton. For complete discussion of data sources, see text and Table 3.4

[a] Per capita consumption data (average for all of China's provinces) come from China's national urban and rural Household Income and Expenditure Survey (HIES-Urban and HIES-Rural) 1999. HIES per capita consumption data only provide the quantities of animal products that are consumed in the home and exclude per capita quantities that are consumed out of the home..

[b] Average of 1998 HIES per capita consumption for four provinces in which the CCAP Survey was conducted. Provinces include Jilin, Shandong, Sichuan and Chongqing.

[c] CCAP Survey data were collected by a joint data collection effort between the Center for Chinese Agricultural Policy (CCAP), Chinese Academy of Sciences, in Beijing and the Center for Agricultural and Rural Development (CARD), Iowa State University.[d] Yuan et al. data are reported in Yuan et al. (2001).

After the corrections for out-of-home consumption, we also need to correct that data to account for the increasing fraction of the rural labor force has temporarily moved into urban areas working as migrant laborers.[1] Although in 1990 only 9 percent of the rural la-

1 We actually have to make one more adjustment to the consumption data between 1980 and 1984. Before 1985, the CNSB's urban household study did not include urban households that lived in county-level towns or below. Implicitly, if one were to take per capital consumption levels from the CNSB surveys and multiply them by the urban population, the figure would be assuming that the consumption patterns in small county-level cities are the same as those of larger metropolises. In fact, from our own survey, we know that this is not true. Consumers in county-level towns consume only about 67 percent of the meat as those residents in larger cities. Using population data of both larger and middle-size cities and county towns from the 1982 and 1990 national population censuses, we are able to estimate the proportion of population that reside in these

bor force migrated, by 2000 nearly 20 percent lived outside their home while they were working (de Brauw et al., 2001). As shown by Huang and Rozelle (1998), when migrants move from the countryside to the city, within a very short time, changing preferences make them alter their dietary patterns (even holding constant income and price changes). The average rural migrant almost immediately increases the proportion of income spent on meat products. Following estimates provided in Huang and Bouis (1996; 2001), we assume that the meat consumption of migrants is halfway between the level of consumption for rural and urban individuals. This new consumption pattern is assumed to be adopted by all of the laborers in the migrant labor force and their family members. It is assumed that (on average) a family member accompanies one in every five migrants.

Adjustments also need to be made for China's growing consumption of processed food products at home. Many of these products contain meat, such as, frozen meat-filled pastries, dumplings, and pre-cooked noodle mixes, etc. When questioning CNSB survey respondents about how they recorded such products, most said they often did not count them as meat products. In fact, during our own field survey we found that the average level of consumption of animal products was significantly more than that recorded by HIES enumerators (Table 3.6, rows 6 to 10). For example, our survey found that per capita pork consumption for urban residents was 21.9 kg, about 37 percent more than that reported in HIES (row 6). Yuan et al. (2001) found the same result in their survey of rural and urban consumers (columns 4 and 8). Therefore, for the cases of pork, poultry and eggs, we believe that we are justified in making further adjustments based CCAP survey data.[1]

Supply Side Assumptions and Strategies

To make supply side adjustments, we also rely on three assumptions. First, we assume that the data published in China's national statistical and agricultural yearbooks were correct in the early- and the mid-1980s (although they began to be overstated in the late-1980s). During this period, we are assuming that the annual census of livestock that was carried out each year by village accountants was subject to less distortions and that the HIES's production data were based on information that is less representative than that generated by the current HIES. Indeed, in the early 1980s, CNSB only surveyed 15,000 rural households while currently they sample more than 65,000.

Second, we assume that the production data collected by the rural HIES in the late 1980s and 1990s accurately captures the household's livestock production activities, a fact that can be used to check the accuracy of the 1997 Ag Census data. Hence, for those livestock categories for which production is dominated by household production (e.g., swine), trends after the late 1980s based on the rural HIES production data provide a reasonably accurate estimate of national production. We recognize, however, that in the case of some livestock categories (e.g., poultry and beef), non-household enterprises contribute a significant part of the production. In these cases, when we compare our data to the 1997 Ag

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different areas. We then are able to adjust the total urban meat consumption for the part of meat consumed by those consumers in smaller towns.

1 Actually, it is a widespread finding that for certain commodities, the estimate from the household survey falls short of the known consumption total calculated from data on production, imports, exports and excise duties. For example, in the British Family Expenditure Survey, total tobacco expenditure was underestimated in 1976 by 21 percent (Deaton and Irish, 1984).

Census data (which contains both household and commercial output), we can use the proportion of total production that comes from commercial sources (which is reported separately in the Ag Census) to get an estimate of commercial production. The commercial production from the Ag Census can then be added to an estimate of household production from the HIES survey to assess the overall accuracy of the 1997 Ag Census data. Interestingly, this exercise shows that, in fact, rural household livestock production data are overstated somewhat (perhaps, we conjecture, because the sample misses the poorest households who, as shown by Chen, 2001, produce relatively fewer animals).

Finally, since the 1997 Ag Census was the most comprehensive and carefully monitored agricultural and rural development data collection effort that China has ever undertaken, we assume that the number of slaughtered animals for each category (e.g., swine, poultry, etc.) from this source constitutes our best estimate of livestock production. Unfortunately, the Ag Census only provides animal numbers (slaughtered), unlike the Yearbook and the HIES production data that provide both animal numbers (e.g., how many hogs were slaughtered) and meat production estimates (that is an estimate of how much pork came from the hogs that were slaughtered). In order to provide an estimate of the meat produced in 1996 that is consistent with the 1997 Ag Census' animal production data, we multiplied the number of animals by a coefficient representing the average weight of carcass. This coefficient is derived from the Yearbook by dividing China's meat production for each animal product by the number of animals.[1]

Based on the assumptions above, we believe that we have a strategy that can create a complete and consistent picture of China's livestock production that has three defining characteristics. First, our estimates from 1980 to 1986 are exactly those that appear in the CNSB's Yearbook during that time. Since we assume that 1986 to 1988 are the last years that the data generated by the statistical yearbooks were accurate, we set 1987 equal to the average of 1986 to 1988 (doing so to avoid distortions that might have arisen had we chosen a single year). Since we assume that we have an accurate assessment for the numbers of animals for 1996 (based on the 1997 Ag Census), the 1996 data point in our production series is always exactly that found in the Ag Census. Furthermore, we believe that the rural HIES production data tell us something about livestock's year-to-year production variability. Hence, with the information that we believe is accurate (that is, observations from 1980 to 1987 and an observation in 1996), the remaining challenge is to figure out a way to estimate accurately livestock production trends since the late-1980s.

To provide estimates of production from 1988 to 1999 (except for 1996), we create point alpha (α), which is our estimate of 1987 production. Next, we define point beta (β), which is set equal to the figure reported in data from the 1997 Ag Census. In the third step, we fit a linear trend line from α (1987) through β (1996) extending to the final point of our

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1 Throughout our analysis, when we refer to the Ag Census, we use national numbers that are sums of the figures from China's 31 provinces and provincial-level municipalities (without Taiwan). For example, pork production based on the sum of provincial Ag Census pork production figures in 1997 was 28.6 million tons. For some reason, when CNSB uses the Ag Census data, they use numbers that they claim are national numbers that differ from those based on the sum of provincial figures. In the case of pork production, for example, their national figure is 31.6 million metric tons, 10 percent above that reported by the provinces. Since we have no reason to believe that provinces would purposely underreport their Ag Census data on livestock production, in this paper we use the information that is based on the sum of provincial Ag Census data.

adjusted data series in 1999. Finally, in order to maintain the year-to-year variability contained in the HIES household production data in our adjusted data series, we fit a regression line through the HIES household production data (from 1987 to 1999), and we add the residuals (except for those for 1987 and 1996) from the regression to the fitted trend line in step three. It is in this way that our adjusted production data have the special characteristic that they always pass through two key points, α and β, and retain the variability of the HIES data.

3.5.3 Revised Livestock Demand and Supply Series

In this section, we present the results of our work to create adjusted series for China's livestock demand and supply. To do so, we first examine how demand and supply series converge as we make our three adjustments (defined above). At each step we will assess how well our adjusted series are doing in terms of the equivalency criterion. If our adjustments help the demand and supply data become more consistent with one another, we should find the ratios in the late period that were reported in Table 3.3 (and tested in Table 3.4) should improve by moving more closely together (or becoming closer to one). In addition, we also examine whether or not the revised series meet the other criteria (i.e., whether or not the feed use implied by livestock production figures are roughly equivalent to the nation's feed grain production; and how well the series seem to reflect the trends that we are observing in China).

Correcting aggregate consumption data to reflect that fact that urban and rural residents consume significant quantities of meat outside the home is partly responsible for shifting the consumption series up and begins to close the gap between demand and supply (Appendices 3.6 and 3.7). Based on the CCAP survey (which asked about the composition of food eaten out of the home) and the HIES-urban and HIES-rural surveys (which asked about total out-of-home expenditure data), urban residents consumed 1.00 kilogram more pork in 1990 and 5.83 kilograms more of pork in 1999 out of the home (Appendix 3.6, column 5). In 1999, rural residents consumed 1.45 kilograms more pork (Appendix 3.6, column 6). According to these findings, when compared to the HIES-based per capita pork consumption figures, a significant fraction, 34 percent of China's urban pork consumption (5.83/16.91) is consumed in restaurants and other places out of the home. Likewise, rural out-of-home consumption accounts for 12 percent of pork consumption by rural residents (1.45/11.68). Similar patterns of out-of-home consumption were found for poultry (Appendices 3.6, columns 7 and 8) and other animal products (Appendices 3.11 and 3.12 for egg and Appendices 3.14 and 3.15 for beef and mutton).

The rise of migration also has played a role in increasing the divergence between livestock supply and demand statistics. While counted as rural residents by the HIES system, and implicitly assigned per capita consumption levels of pork of 10.5 kilograms in 1990 and 11.7 kilograms in 1999, migrants actually consumed significantly higher levels (Appendix 3.8, column 6). For example, the average migrant consumed 14.3 kilograms per capita in 1999, an increase of 22 percent over his counterpart that still lived in rural China (column 5). When this gap multiplied by more than 100 million migrants (column 3) and their families (assumed to be an additional 20 percent more), it can account for a lot of the 'missing' pork demand. The similar pattern can be found for poultry (columns 8 and 9) and other animal products (Appendices 3.12 and 3.17).

After making adjustment for out-of-home consumption and the increased consumption by migrants, aggregate pork consumption rises to 27.21 mmt in 1999 instead of 21.94 mmt (Table 3.7, columns 1 and 2). Between 1987 and 1998, the adjusted consumption series rises at 2.96 percent annually, more than twice as fast as the unadjusted one (bottom row).[1]

The rises in pork consumption significantly affect the observed supply-demand ratio for pork. Whereas the ratio of supply to demand of the unadjusted data rises to 1.83 by 1999 (Table 3.7, column 6), after correcting the data for out-of-home consumption and the increased consumption by migrants, the ratio falls to 1.47 (column 7). The first correction to consumption, then, is important and helps reduce the gap between demand and supply, but it does not close it entirely.

A similar narrowing is found when the same adjustments are made for poultry (Table 3.8) and the other livestock products (Appendices 3.11, 3.14 and 3.15). For example, the ratio for poultry (the consumption of which rises annually by 4.7 percent instead of 6.2 percent--Table 3.8, columns 1 and 2) falls from 1.94 for the unadjusted series (column 6) to 1.53 after we adjust the consumption data to account for out-of-home consumption and the increased consumption by migrants (column 7). Like for the case of pork, the adjustments close the poultry gap, but do not eliminate it.

Adjustments to production affect the demand and supply series even more (Tables 3.7 and 3.8). When production trends are forced to go through and become consistent with Yearbook data in the late 1980s and the 1997 Ag Census data in 1996 (the data points that we believe to be relatively accurate), the reported increases in production are dampened considerably. For example, whereas the unadjusted pork production data was shown to have risen by 6.57 percent annually between 1987 and 1998, after adjusting the data, the pork production series rose only 4.45 percent (Table 3.7, columns 4 and 5). The growth rates in production for other animal products, such as poultry, fell even more (by nearly 3 percentage points from 14.74 to 11.62 percent--Table 3.8, column 4 and 5). When comparing pork demand adjusted for out-of-home consumption (Table 3.7, column 2) to both the unadjusted and adjusted production data series (columns 4 and 5), the consistency ratio falls sharply from 1.43 to 1.18 (columns 7 and 8). The poultry ratios collapse even more, falling from 1.58 to 1.17, implying the degree of overreporting of poultry was even greater than that for pork (Table 3.8, columns 7 and 8).

Underreporting of total animal product consumption due to incomplete enumeration of in-home consumption of pork, poultry and eggs (for example, due to significant quantities of pork being incorporated into prepared goods that are not recorded by the HIES survey as pork consumption) also has played a role in the slow growth rates of animal product consumption (Appendices 3.14 and 3.17). In the case of urban pork consumption, according to CCAP survey, in 1998 households were consuming 3.33 kilograms per capita annually more than they actually were reporting to HIES enumerators (Appendix 3.14, column 6). By 1999 (we extended estimates back to 1988 and forward to 1999—see dis-

[1] In this section, whenever we report growth rates from 1987 to 1998, we are using three-year averages centered on these years. In other words, we compare the average of 1986-88 to 1997-99.

cussion in previous section) unreported in-home urban pork consumption reached 3.63 kilograms, 21 percent higher than the HIES number (3.63/16.91). Although less than the amount unreported due to the omission of out-of-home consumption (e.g., omission of out of home urban pork consumption was 34 percent), the impacts in 1999 on rural pork consumption (5 percent) and urban and rural poultry consumption (9 and 12 percent, respectively) are significant.

After making the final adjustment for in-home consumption to pork, poultry and eggs, the supply and demand series for the 5 animal product categories nearly show complete convergence. For example, the annual growth rate of pork consumption from 1987 to 1998 increases from 2.96 (which was the growth rate after adjustments were made due to out-of-home consumption) to 3.76 percent (Table 3.7, column 2 and 3).

The rise in consumption due to adjustment for the omission of in-home consumption also leads to another decline in the consistency ratio of pork production to consumption. The consistency ratio for pork supply and demand in 1999 falls from 1.18 to 1.07 (column 8 and 9). In fact, the consistency ratios after the final adjustments are almost one after 1987 (the average of the ratio is only 1.07 from 1987 to 1999). The other animal products, such as poultry, show similar patterns of convergence. The final adjustment for poultry consumption (which increases the 1987 to 1998 poultry consumption annual growth rate to 10.87) makes the consistency ratio fall from 1.17 to 1.08 (Table 3.8, columns 8 and 9).

A final set of statistical tests show that after making the adjustments to supply and demand, our new series almost certainly meet the equivalency criteria. Like the series between 1980 and 1987 (which displayed the characteristic of supply equaling demand), after the final adjustments to the demand and supply series, the statistical tests for the consistency ratios demonstrate that the revised series meet the equivalency criteria (Table 3.9). Though the coefficients of $T_{t>1987}$ are still significant, the absolute effect of this variable is small. For example, the consistency ratios for pork and poultry are only 0.01 between 1988 and 1999, meaning that the ratio only increased by 0.01 annually after 1987 (row 2). More important, F-tests show that the coefficients of intercept are convergent to 1 (row 6 and 9). Although the coefficient of $T_{t>1987}$ for poultry is still significant, its impact on the ratio is almost equal to 0.

Graphically, our adjusted series in Panels A and B of Figure 3.7 (represented by the two graph lines that are now 'inside' that two unadjusted series) show the result of our work to make livestock demand and supply series consistent. Since the late 1980s, the unadjusted pork production series (uppermost) that was reported by CNSB has increased more rapidly than the adjusted one (the second uppermost); in contrast, the unadjusted pork consumption series (lowermost) has increased but much more slowly than the adjusted one (the second lowermost--Panel A). In addition to differing from the unadjusted series, both the adjusted production and the adjusted consumption series follow strikingly common paths during the entire reform era (both the 1980s and the 1990s). At its widest gap, unadjusted production had grown to a level 82 percent higher than unadjusted consumption. In contrast, the gap in the adjusted series is trivially narrow. The trends for the unadjusted and adjusted poultry series are similar; the gap in the unadjusted series that reached its peak in 1998 (104 percent) is virtually gone in the adjusted series (Panel B). The data series for eggs, beef and mutton create similar pictures (Appendix Figure 3.2).

Table 3.7 Reconciling China's Pork Production (Supply) and Consumption (Demand) Statistical Series, 1980 to 1999.

Year	(1) Aggregate Demand Based on HIES and Trade (mmt) [a]	(2) Adjusted Demand	(3)	(4) Aggregate Supply	(5)	(6) Various Supply/Demand Ratios (to Assess the Consistency of Data Series Adjustments)	(7)	(8)	(9)
		for omission of *out- of-home* and *migrant* consumption (mmt) [b]	for omission of *in-home* consumption (mmt) [c]	Reported from Yearbook (mmt)	Adjusted for over reporting (mmt)	(4)/(1)	(4)/(2)	(5)/(2)	(5)/(3)
1980	10.47	10.63	10.63	11.34	11.34	1.08	1.07	1.07	1.07
1981	11.84	12.04	12.04	11.88	11.88	1.00	0.99	0.99	0.99
1982	13.23	13.46	13.46	12.72	12.72	0.96	0.94	0.94	0.94
1983	14.63	14.91	14.91	13.16	13.16	0.90	0.88	0.88	0.88
1984	16.07	16.39	16.39	14.45	14.45	0.90	0.88	0.88	0.88
1985	16.73	17.14	17.14	16.55	16.55	0.99	0.97	0.97	0.97
1986	18.76	19.23	19.23	17.96	17.96	0.96	0.93	0.93	0.93
1987	18.40	19.01	19.01	18.35	18.83 [d]	1.00	0.97	0.99	0.99
1988	17.56	18.30	18.47	20.18	19.92	1.15	1.10	1.09	1.08
1989	18.13	18.97	19.31	21.23	20.06	1.17	1.12	1.06	1.04
1990	18.91	19.79	20.31	22.81	21.01	1.21	1.15	1.06	1.03

Table 3.7 Reconciling China's Pork Production (Supply) and Consumption (Demand) Statistical Series, 1980 to 1999 (continuation)

Year	(1) Aggregate Demand Based on HIES and Trade (mmt) [a]	(2) Adjusted Demand: for omission of *out- of-home* and *migrant* consumption (mmt) [b]	(3) Adjusted Demand: for omission of *in-home* consumption (mmt) [c]	(4) Aggregate Supply: Reported from yearbook (mmt)	(5) Aggregate Supply: Adjusted for over reporting (mmt)	(6) Various Supply/Demand Ratios (to Assess the Consistency of Data Series Adjustments): (4)/(1)	(7) (4)/(2)	(8) (5)/(2)	(9) (5)/(3)
1991	20.20	21.18	21.90	24.52	23.58	1.21	1.16	1.11	1.08
1992	19.69	20.98	21.92	26.35	24.43	1.34	1.26	1.16	1.11
1993	19.95	21.58	22.75	28.54	25.58	1.43	1.32	1.19	1.12
1994	19.49	21.74	23.13	32.05	25.98	1.64	1.47	1.20	1.12
1995	20.03	23.02	24.65	36.48	26.59	1.82	1.58	1.15	1.08
1996	21.81	25.43	27.31	31.58	28.59 [d]	1.45	1.24	1.12	1.05
1997	20.54	24.53	26.67	35.96	29.75	1.75	1.47	1.21	1.12
1998	21.50	26.15	28.56	38.84	29.82	1.81	1.49	1.14	1.04
1999	21.94	27.21	29.91	38.91	32.00	1.77	1.43	1.18	1.07
Growth [e]	1.43	2.96	3.76	6.57	4.45	5.04	3.50	1.45	0.66

[a] Figures in column 1 are the same as Table 3.3, column 1. They are calculated from the CNSB's urban and rural HIES data as shown in Appendix 3.5, column 9.
[b] Adjustments to create figures in column 2 are shown in Appendix 3.6, column 9 and Appendix 3.8, column 16. Adjustments include those due to omission of out-of-home consumption of urban and rural residents, and for adjustments made due to the differences in consumption patterns of traditional rural households and those of rural migrants and their families.
[c] Adjustments to create figures in column 3 are shown in Appendix 3.9, column 12.
[d] The bold figures are the three-year averages of Yearbook production data from 1986 to 88 and the production supply generated from 1997 Ag Census.
[e] Annual growth rate between 1987 and 1998, where 1987 and 1998 are three-year averages centered on 1987 and 1998.

Table 3.8 Reconciling China's Poultry Production (Supply) and Consumption (Demand) Statistical Series, 1980 to 1999.

Year	(1) Aggregate Demand Based on HIES and Trade (mmt) [a]	(2) Adjusted Demand	(3)	(4) Aggregate Supply	(5)	(6) Various Supply/Demand Ratios (to Assess the Consistency of Data Series Adjustments)	(7)	(8)	(9)
		For omission of *out- of-home* and *migrant* consumption (mmt) [b]	For omission of *in-home* consumption (mmt) [c]	Reported from Yearbook (mmt)	Adjusted for over reporting (mmt)	(4)/(1)	(4)/(2)	(5)/(2)	(5)/(3)
1980	0.88	0.88	0.88	0.94	0.94	1.07	1.06	1.06	1.06
1981	1.02	1.07	1.07	1.03	1.03	1.00	0.96	0.96	0.96
1982	1.25	1.32	1.32	1.18	1.18	0.94	0.90	0.90	0.90
1983	1.35	1.43	1.43	1.30	1.30	0.96	0.91	0.91	0.91
1984	1.52	1.62	1.62	1.44	1.44	0.95	0.89	0.89	0.89
1985	1.77	1.88	1.88	1.60	1.60	0.90	0.85	0.85	0.85
1986	1.95	2.07	2.07	1.88	1.88	0.96	0.91	0.91	0.91
1987	2.03	2.19	2.19	2.19	2.27 [d]	1.08	1.00	1.04	1.04
1988	2.27	2.46	2.50	2.74	2.78	1.21	1.12	1.07	1.05
1989	2.45	2.67	2.75	2.82	3.08	1.15	1.06	1.05	1.02
1990	2.68	2.91	3.03	3.23	3.44	1.21	1.11	1.05	1.01

Table 3.8 Reconciling China's Poultry Production (Supply) and Consumption (Demand) Statistical Series, 1980 to 1999 (continuation)

Year	(1) Aggregate Demand Based on HIES and Trade (mmt) [a]	(2) Adjusted Demand	(3)	(4) Aggregate Supply	(5)	(6) Various Supply/Demand Ratios (to Assess the Consistency of Data Series Adjustments)	(7)	(8)	(9)
		For omission of *out- of-home* and *migrant* consumption (mmt) [b]	for omission of *in-home* consumption (mmt) [c]	Reported from Yearbook (mmt)	Adjusted for over reporting (mmt)	(4)/(1)	(4)/(2)	(5)/(2)	(5)/(3)
1991	2.82	3.08	3.25	3.95	3.91	1.40	1.28	1.13	1.07
1992	3.18	3.52	3.73	4.54	4.44	1.43	1.29	1.13	1.07
1993	3.41	3.84	4.09	5.74	4.78	1.68	1.50	1.13	1.06
1994	3.64	4.23	4.54	7.55	5.09	2.07	1.78	1.12	1.04
1995	3.95	4.73	5.09	9.35	5.57	2.36	1.97	1.13	1.05
1996	4.28	5.28	5.69	8.96	6.06 [d]	2.09	1.70	1.15	1.06
1997	4.92	6.05	6.51	9.55	6.67	1.94	1.58	1.15	1.07
1998	5.02	6.35	6.86	10.23	6.86	2.04	1.61	1.18	1.09
1999	5.58	7.05	7.63	11.16	7.35	2.00	1.58	1.17	1.08
Growth [e]	8.61	10.15	10.87	14.74	11.62	5.70	4.23	1.37	0.71

[a] Figures in column 1 are the same as Table 3.3, column 4. They are calculated from the CNSB's urban and rural survey data as shown in Appendix 3.5, column 10.
[b] Adjustments to create figures in column 2 are shown in Appendix 3.6, column 10 and Appendix 3.8, column 17. Adjustments include those due to omission of out-of-home consumption of urban and rural residents and for adjustment made due to the consumption of rural migrant labors and their families.
[c] Adjustments to create figures in column 3 are shown in Appendix 3.9, column 13.
[d] The bold figures are the three-year averages of Yearbook production data from 1986 to 88 and the meat production generated from 1997 Ag Census.
[e] An annual growth rate between 1987 and 1998, where 1987 and 1998 are three-year averages centered on 1987 and 1998.

Table 3.9 Consistency Tests for the Adjusted Supply and Adjusted Demand Series, 1980-99 [a]

Independent Variable	Dependent Variable, R_{it} = Adjusted Supply / Adjusted Demand				
	Pork	Poultry	Eggs	Beef	Mutton
Tests for structural change					
Before 1987:					
$T_{t\leq 1987}$	-0.01	-0.00	0.00	-0.01	-0.01
	(1.03) [b]	(0.06)	(0.21)	(1.19)	(1.56)
After 1987:					
$T_{t>1987}$	0.01^{*}	0.01^{*}	-0.00^{**}	0.01^{**}	-0.01
	(2.36)	(3.66)	(1.96)	(3.76)	(0.63)
Adjusted R^2	0.64	0.69	0.34	0.75	0.20
Tests for convergence of supply/demand ratio to one [c]					
Before 1987:					
$T_{t\leq 1987}$	-0.01	-0.01	-0.00	-0.00	-0.01
	(0.98)	(0.55)	(0.05)	(0.01)	(1.89)
Intercept	1.01^{***}	0.97^{***}	1.09^{***}	0.72^{***}	1.05^{***}
	(20.46)	(15.87)	(22.06)	(11.45)	(27.22)
F-Statistic (Test: Intercept =1)	0.03	0.24	3.64	18.99^{***}	1.82
After 1987:					
$T_{t>1987}$	0.00	-0.00^{**}	-0.00	0.00	-0.00
	(0.20)	(2.85)	(1.79)	(0.53)	(0.21)
Intercept	1.07^{***}	0.99^{***}	1.06^{***}	0.96^{***}	1.02^{***}
	(24.35)	(43.44)	(59.62)	(12.10)	(20.57)
F-Statistic (Test: Intercept =1)	2.57	0.11	3.18	0.20	0.32

*** Significant at 1% level; ** significant at 5 percent level; * significant at 10 percent level.

[a] For the tests of structural change (rows 1 to 3), the equation regressing a time trend from two periods on the supply/demand ratio, is run with an intercept; parameters are not shown for brevity. Two separate within period equations are used to test for convergence of supply/demand ratio to one (rows 4 to 6; and rows 7 to 9).

[b] The figures in parentheses are *t*-statistics.

[c] To test the null hypothesis that the supply/demand ratio is equivalent to one, we test for the significance of the intercept. If F-statistics (rows 6 and 9) are greater than 4, we reject the null hypothesis.

Interestingly, although our adjustments cut the gap dramatically that appeared between the official supply and demand statistics (e.g., pork from 81 percent to less than 5 percent in 1998), the magnitude of our 'cuts' would have been larger had not CNSB adjusted their output data in response to the 1997 census. In the 1997 yearbook, official statistics reported 1996 meat output to be 40.38 mmt. This figure is a staggering 85 percent greater than CNSB's 1996 consumption figure. After the publication of the census data, the 1998 yearbook revised the 1996 meat output statistics to be 31.6 mmt (the figure we report on Figure 3.7, Panel A for hog output). In making these adjustments, CNSB is implicitly admitting that their production figures were overstated, even though they made the adjust ment without any explanation. However, even after the adjustment, two facts still make the CNSB production series questionable. First, although they apparently adjusted their output statistics to make their series more consistent with the census data, their 1996 hog output figure (31.6 mmt) is still 10 percent higher than the figures published by the national census office. Even more troubling, after 1996, despite the fact that it was the unbelievably high rate of growth of reported supply that led to the inflation of national livestock statistics, the growth rate of CNSB's production data are almost as fast as before, even though the economy noticeably slowed in the late 1990s. Hence, the actions of CNSB to adjust their data give credibility to our strategy and their inability to reduce the growth rate from their statistical sources means that our adjusted series may be of greater value to those wanting to understand China's livestock economy.

A decomposition analysis summarizes our adjustments and accounts for the changes in the livestock supply and demand series that makes them consistent with one another (Table 3.10). In the case of pork in 1999, for example, when using the unadjusted series supply is more than 17 mmt more than demand (column 1, row 1). In the course of our adjustments, the adjustment down of supply, accounted for 41 percent of the reconciliation effort (column 5). Of the adjustments to consumption, 29 percent of the gap was eliminated by adjusting for out-of-home (column 2). Adjustments for migration and in-home consumption, account for 5 and 16 percent (column 3 and 4). There is a residual of 9 percent after the four adjustments (column 6). Clearly according to this analysis, the over reporting of supply has created the most problems for not only pork, but in 1999 it accounts for an even a larger part of the discrepancies for poultry (52 percent), eggs (53 percent), beef (69 percent), and mutton (65 percent-column 5, rows 2, 3, 4, and 5).

Table 3.10 Decomposition of Total Gap Between Unadjusted Supply (Production) and Unadjusted Demand (Consumption) Livestock Statistical Series in China in %, 1990 and 1999.

	(1)	(2)	(3)	(4)	(5)	(6)
Series	Total Gap [a] (mmt)	Source of Total Gap (in percentage terms)				
		Out-of-Home [b]	Migrant [c]	In-home [d]	Production [e]	Other
In 1999:						
Pork	16.97	29	5	16	41	9
Poultry	5.58	21	6	10	52	10
Eggs	13.33	3	7	34	53	3
Beef	3.19	21	6	-	69	4
Mutton	1.33	30	2	-	65	3
In 1990:						
Pork	3.89	17	6	14	46	17
Poultry	0.55	32	11	22	30	5
Eggs	3.17	4	4	66	17	9
Beef	0.14	48	20	-	30	2
Mutton	0.22	26	13	-	44	17

[a] The figures are total gap between reported production data from Yearbooks and reported consumption from HIES and trade statistics, measured in carcass weight. For example, the total gap for pork is pork supply (Table 3.3, column 2) minus pork demand (Table 3.3, column 1).
[b] Due to the omission of out-of-home consumption. For example, percent of total pork gap accounted for by out-of-home pork consumption is calculated by dividing adjustments made to pork consumption due to omission for out-of-home pork consumption (Appendix 3.6, column 9 minus Appendix 3.5, column 9) by total pork gap (this table, column 1).
[c] Due to the omission of migrant consumption. For example, percent of total pork gap accounted for by migrant pork consumption is calculated by dividing adjustments made to pork consumption due to omission for migrant pork consumption (Appendix 3.8, column 16 minus Appendix 3.6, column 9) by total pork gap (this table, column 1).
[d] Due to the omission of in-home consumption. For example, percent of total pork gap accounted for by in-home pork consumption is calculated by dividing adjustments made to pork consumption due to omission for in-home pork consumption (Appendix 3.9, column 12 minus Appendix 3.8, column 16) by total pork gap (this table, column 1).
[e] Due to over-reported production. For example, percent of total pork gap accounted for over reporting pork production is calculated by dividing the overreported number (Table 3.10, column 4 minus column 5) by total pork gap (this Table, column 1).

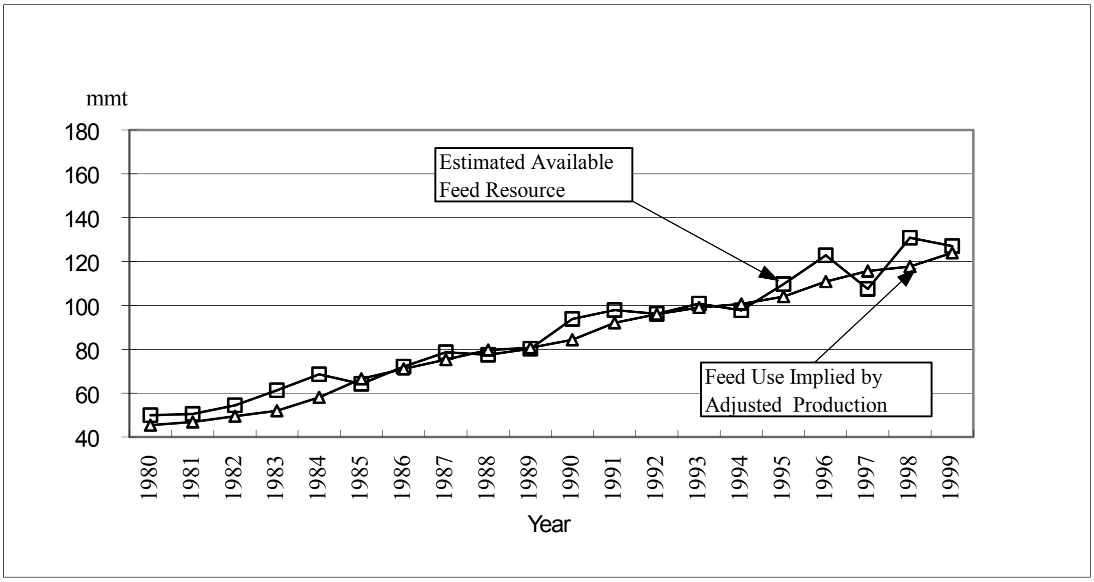

Figure 3.8 Estimated Available Feed Grains and Feed Use Implied in Adjusted Production in China, 1980-99.

Note: *Estimated Available Feed Resource* mainly includes corn, wheat bran, sweet potato, rice and other coarse grains. *Feed Use Implied by Adjusted Production* is estimated using livestock production statistics reported in Table 3.6, column 5 (pork), Table 3.7, column 5 (poultry), Appendix 3.11, column 5 (eggs), Appendix 3.14, column 5 (beef), and Appendix 3.15, column 5 (mutton) and standard feed-meat conversion coefficients. See text for details.

In addition to meeting tests for consistency, our new series also meet the two other criteria. To demonstrate that our new livestock production series are consistent with national feed grain statistics, we use the same assumptions about feed grain consumption that we used in Appendix Figure 3.1. Applying these feed grain use conversion to the animal production trends, the revised livestock supply series generates a derived demand for feed series that is much more consistent than the unadjusted one (Figure 3.8). While at its widest point, the unadjusted feed demand was 53 percent greater than feed supply, when using the adjusted livestock numbers, after 1988, the average gap between feed supply and demand are only 3 percent. Our data series are also consistent with some commonly observed trends in society. Unlike the unadjusted figures, the rise in pork consumption that appears in our revised series is what one expects given the rapid rise in incomes and the noticeably increase in meat consumption during the 1990s. Unsurprisingly, the single biggest source of upward adjustment of pork (and poultry) is in the consumption of meat out of the home. Any one who is in China for any appreciable length of time will notice not only the large and growing number of restaurants, but also the high level of meat consumption in them. Furthermore, while livestock production has risen in recent years, there is absolutely no way that the growth rates implied by the Yearbook production figures could have occurred and been sustained for the entire 1990s. In short, the new rates are more believable.

3.5.4 Implications of the Adjusted Series for China's Cereal Trade Predictions

To assess the importance of making adjustments to livestock data, we show how the use of different data series can affect the results of analyses that depend on accurate estimates of China's livestock numbers. In this section, we demonstrate how alternative livestock series influence predictions of China's agricultural trade in the future. To do so, we use three alternative sets of data on meat estimated by CNSB, Fuller et al. and ours to predict China's cereal trade through 2010. The differences among the predictions will show the importance of having accurate information on the number of animals and the production of meat and eggs that come from them.

Three sets of predictions on free trade model are run using the CAPSiM model-one using CNSB livestock numbers, one using those in Fuller et al. (2000), and one using those created in this paper (henceforth, CCAP). In addition to the basic assumptions in the baseline model (which were designed to simulate China's economy prior to the nation's accession to the WTO), we simulate China's trade regime if all trade restrictions were removed. The only difference among the three sets of comparative forecasts is the different levels of meat and feed grain demands that are in the base year. Starting from these base year initial conditions and using the assumptions under a free trade scenario, we predict supply and demand for China's main crop and meat commodities. We generate net import forecasts for all commodities by taking the gap between consumption and production.

There are large differences in simulated agricultural trade forecasts among the three sets of comparisons (Table 3.11). According to predictions made when the initial livestock production holdings are those generated by CNSB, China's imports will surge to 73.5 mmt in 2005 and continue to rise to 98.7 mmt in 2010. The large livestock herd size implied by the official national statistics could only be fed by a sharp rise in grain imports. In contrast, if the figures of Fuller et al. (2000) were used, China would be exporting grain in every year between 2005 and 2010. The livestock production figures reported in Fuller et al. are more than 30 percent lower than those reported in this paper. The lower herd size numbers, however, would imply that under the baseline assumptions, China's producers could produce more than enough feed to supply all of its livestock throughout the next 10 years. Finally, when we use our supply predictions, imports rise under a free trade scenario. With our animal herd size used as a baseline, the CAPSiM model predicts that under free trade, importers will bring in 24.2 mmt in 2005, a reasonable amount of imports, given the China's TRQ for major grains will be between 20 and 30 mmt in 2004. By 2010, imports rise to 44.1, but are still substantially under (less than half) the predictions that are derived when using CNSB statistics. In other words, because of the importance of livestock in China's future import regime, differences in initial levels of livestock make large differences in grain supply, demand, and trade predictions.

Table 3.11 Cereal Net Import Predictions Based on Various Meat Estimate Datasets.

Year	CNSB	CCAP	Fuller et al.
	Million metric ton		
2005	73.5	24.2	-15.4
2006	76.8	26.7	-13.5
2007	82.0	30.9	-10.3
2008	87.8	35.6	-6.6
2009	93.4	40.0	-3.2
2010	98.7	44.1	-0.1

Source: Simulation results from CAPSiM model developed by Center for Chinese Agricultural Policy, Chinese Academy of Sciences (Beijing China). See Huang et al. (1999).
Notes: Cereal net imports only include milled rice, wheat, maize, potatoes, sweet potatoes and other coarse grains.

There are also significant differences in grain trade patterns due to different livestock production estimates. Since maize is major feed grain source, the levels of livestock production estimates will play an important role in determining future maize trade. Hence, the higher the livestock production estimates, the higher the projected maize imports. In the cases of CNSB and CCAP's datasets, China is forecast to import maize. The figures of Fuller et al., however, suggest that China will be able to export maize through 2007.

3.5.5 Concluding Remarks

In this section, we first demonstrate that China's livestock supply and demand statistics are not consistent with even the most basic criteria-supply equals demand; the implied derived demand for feed equals the supply of feed; and that the series are somewhat intuitive. We then use a number of data sources to create new supply and demand series. After correcting demand upward to make up for three omissions in the data, we correct supply down. The changes, which are all carefully documented, narrow the gap for all livestock products. The adjusted supply and demand series also meet the other criteria. A decomposition analysis shows that the single largest source of the discrepancy was the adjustment to supply and the adjustment to demand to account for the out-of-home consumption that the CNSB's survey failed to account for.

If our adjusted data sets are correct, there are implications for the validity of past statistics and the accuracy of alternative forecasts. We have shown how differences in livestock statistical series can create such great discrepancies in predicted feed grain imports, that some analysts believe China will export feed grain for the next 5 years or more, while others predict that the nation may have import over 80 mmt. Meat trade would be subject to similar differences in forecasts. Beyond supply, demand and trade, gross domestic product (GDP) figures could be significantly influenced. Since livestock makes up 30 percent of agricultural GDP (AGDP), and since the growth rate of livestock was overstated by 37 percent, the reported growth rate of AGDP (which according to CNSB was 4 percent annually between 1987 and 1999) would have to be lowered by 1 percentage point to 3 percent annually. GDP growth would have to be lowered by 0.11 percent.

Making corrections to China's livestock statistics, however, may not be the end of the story. Li and Liu (2002) show that fishery statistics are subject to similar statistical problems. Zheng (2001) says that township and village enterprise output and employment statistics were overstated. All of these would support the recent findings by Rawski (2001) that China's overall growth data are overestimated.

In short, as China develops, and as the correlates of growth move in a direction that forecast continued future growth, there will be a continuing and rising demand for higher quality data. Clearly, some of the data sets - the livestock data, in particular – are so poor that without adjustments it is impossible to have a firm base for investment and policy planning. Especially in an economy that is changing so fast and will continue to do so in the future, the challenge to improve data collection is more important now than ever.

3.6 Conclusions

This chapter has attempted to explain the collection of methods used in this study. Our main tools are two economic models. The CAPSiM model of Chinese agriculture provides great detail on the production structure in crops and livestock. Next to 'standard' production relationships, it incorporates numerous environmental constraints to agricultural production. Since it is a partial equilibrium model, it takes as exogenous the developments outside agriculture. The model is also less suited to model the impacts on world markets. The non-agricultural developments inside China and world market developments are the realm the second model used in this study, the GTAP model. This chapter has discussed our approach to exchanging information between these two models.

Naturally there are many differences in approach and databases used. The databases of both models have been updated, and where deemed necessary, they have been adjusted to reflect the recent situation in China. This is important as the Chinese economy is growing at such a rapid pace that structural changes are surfacing within even relatively short time intervals of several years. Not capturing important structural changes would imply that our future projections will be grossly besides the mark.

Chapter 4 Projections of food supply and demand and impacts of green policies

4.1 Introduction

China's per capita food availability has reached the level of developed countries, and since the mid 1980s China has been a net food exporter. While successful growth in the past should instil optimism, there are still great challenges ahead. On the production side of the agricultural sector, the annual growth rates declined from over 7 percent in the early 1980s to 3-4 percent in the late 1980s. The most significantly decline was experienced in the grain sector: grain production recorded almost zero growth in 1996-2000 and declined in 2000-2002 (NSBC, 2003). On the demand side, economic growth and rising income will continue to boost the demand for agricultural and food products. Trade liberalization further challenges China's food and agricultural economy. China's recent accession to the WTO has led to a broad debate on its potential effects on both the domestic and the global economy. Accession affects all areas of China's economy, but is widely expected to have a particularly dramatic effect on agriculture.

Concerns about China's food economy have raised a number of questions. What are the driving forces behind China's food demand, supply, and trade? What are the prospects for China's food economy in the coming decades? Will China be able to feed its growing population under a more liberalized economy? Which measures and policies will be the most effective in improving China's food security situation in the future? The answers to these questions are by no means clear. The overall goal of this chapter is to project China's food and agricultural economy in the coming two decades. Because China's future agricultural economy is subject to both domestic policy changes and external environments, this chapter focuses on China's food and agricultural economy in the next two decades under several scenarios, which consider the majors shifters of demand and supply as well as trade liberalization.

This chapter is structured as follows. The following section presents an overview of food consumption patterns and food balance in China in the past 20 years. Because the production or supply of the food economy and major sources of production growth in the past 20 years have been extensively discussed in Chapter 2, the discussions of production in Section 3 are limited to three supply shifters, namely agricultural technology, irrigation, and environment stress (i.e., erosion and salinity). The fourth section presents the development of scenarios and assumptions embodied in various scenarios. The baseline embodies China's WTO accession, as China has been a member of the WTO since December 2001. Under the baseline, major driving factors of demand and supply are assumed to follow the 'business as usual' rule. Alternative scenarios focus mainly on supply shifters, particularly the productivity-enhanced investment. Section 5 presents the results of our baseline projections (with different income growths) based on a partial equilibrium model of the agricultural sector (CAPSiM). The impacts of alternative assumptions of agricultural productivity investment - such as agricultural R&D, irrigation, and land erosion control -

are explored in Section 6. Because CAPSiM is a country model that does not fully consider the impacts of China's trade on the world market, the results presented in this chapter should be interpreted with caution. The impacts of China's trade on the world market are taken into account in Chapter 5.

4.2 Changing Food Consumption Patterns and Improving Food Balance in the Past

4.2.1 Food Consumption Patterns in China

Food consumption patterns in China have changed significantly since the early 1980s (Fan et al., 1995). These changes have occurred at the national aggregate level as the urban sector expanded and the share of the urban population expanded (Huang & Bouis, 1996). The changes also occurred in rural and urban areas as a result of income growth and changes in other demand factors (Huang & Rozelle, 1998; Halbrendt et al., 1995).

Within rural areas, the pattern of food consumption changed rapidly. In rural areas per capita food consumption increased for all products except for maize, other cereal grains, and sweet potato (Table 4.1). A decline in coarse grains consumption is expected as the income elasticities of demand for these grains are negative. While per capita rice and wheat consumption reached the highest points between the mid 1980s and the late 1990s (rice 104 kg and wheat 86 kg; Table 4.1 the increase in the population has caused the absolute level to continue to rise. The consumption of meat and non-staple foods increased more rapidly during the 1980s and 1990s. For example, per capita pork consumption in rural areas was less than 10 kg in 1981 and reached 20.7 kg in 2000 (Table 4.1).

While the consumption of other meats such as beef, mutton, poultry, and aquatic products is still very small, the annual growth rates in the past 20 years were much larger than the growth rates of pork. The consumption of horticultural products has also been rising. Among them, fruit consumption growth has been dramatic, increasing from 2 kg in 1981 to more than 18 kg in 2000. Our previous studies (Huang & Rozelle, 1998; Huang & Bouis, 2001) showed that income growth and food market development in rural areas are the key driving forces behind food consumption changes.

The situation is different in cities. In urban areas, per capita grain consumption has been declining since the late 1980s (Table 4.2). At the same time, the consumption of meat and non-staple foods has grown rapidly. The most significant increases in demand have been for meat, fish, and fruit. In 2000, per capita pork and poultry consumption reached 32 kg and 10 kg, respectively, which is several times more than is consumed in rural areas. Per capita fruit consumption tripled in just 20 years, to reach 61 kg in 2000 (Table 4.2).

Table 4.1 Per capita food consumption (kg) in rural China, 1981-2000

	1981	1985	1990	1995	2000
Milled rice	88.2	105.0	103.4	103.7	103.8
Wheat	55.8	75.3	82.8	86.2	85.3
Maize	30.5	18.2	18.7	14.3	11.2
Other cereal grains	26.7	19.8	16.5	14.5	13.0
Sweet potato	9.0	7.1	4.3	3.3	2.4
Potato	2.2	2.3	2.8	3.7	4.5
Vegetables	132.8	131.5	134.0	124.4	169.7
Fruit	2.0	3.4	5.9	13.0	18.3
Edible oil	3.1	4.0	5.2	5.8	6.2
Pork	9.9	12.0	14.4	16.5	20.8
Beef	0.2	0.3	0.4	0.6	1.0
Mutton	0.4	0.4	0.4	0.5	1.1
Poultry	0.7	0.9	1.8	3.0	5.3
Egg	1.7	2.8	4.0	5.4	7.2
Aquatic products	1.4	1.9	2.7	4.8	6.7
Share of food in total expenditure	60%	58%	59%	59%	49%

Note: Fruits and oil consumptions and food expenditure data are from NSBC, the rest are from the CAPSiM database. Per capita fruit consumption data (26 kg) from CAPSiM is higher than NSBC's figure because the former includes the consumption away from home.

Table 4.2 Per capita food consumption (kg) in urban China, 1981-2000

	1981	1985	1990	1995	2000
Milled rice	77.3	79.1	67.4	69.7	57.7
Wheat	61.3	58.3	59.7	43.0	44.4
Maize	3.3	3.1	2.6	3.0	2.6
Other cereal grains	5.9	3.6	3.3	3.7	2.7
Sweet potato	3.0	2.0	1.2	1.3	0.9
Potato	3.6	5.6	7.3	9.2	11.5
Vegetables	160.8	146.7	138.7	145.6	188.1
Fruit	21.1	28.9	44.7	48.4	61.4
Edible oil	3.1	5.8	6.4	7.1	8.3
Pork	14.8	22.2	27.8	30.2	31.9
Beef	0.5	1.2	1.8	3.6	4.8
Mutton	0.9	1.1	2.0	2.2	2.0
Poultry	2.2	3.3	5.2	7.2	11.5
Egg	5.6	9.8	12.6	16.6	20.1
Aquatic products	4.4	9.2	11.1	15.3	19.5
Share of food in total expenditure	57%	52%	54%	50%	39%

Note: Fruits and oil consumptions and food expenditure data are from NSBC, the rest are from the CAPSiM database. Per capita fruit consumption data (71 kg) from CAPSiM is higher than NSBC's figure because the former includes the consumption away from home.

Across Asia, consumer behavior changes dramatically as countries urbanize (Huang & Bouis, 2001; Huang & David, 1993). Urban dwellers consume less grain and demand more meat, milk products, and fish than their rural counterparts, even after accounting for the differences in income and prices. This is clearly demonstrated by the comparison of per capita food consumption between rural and urban areas in China (Tables 4.1 and 4.2). Tables 4.1 and 4.2 show that urbanization could lead to a substantial decline in the direct consumption of grains. On the other hand, the demand for meat (and for feed grain) and other non-staple foods will increase significantly with the increase in the share of urban residents in the total population.

The ratio of urban to rural residents in China is changing fast. The urban population grew from 19 percent of the total population in 1980 to 27 percent in 1990, and to 26 percent in 2000 (NSBC, 2001). The impact of this population shift on consumption in China has been documented (Huang & Bouis, 1996 and 2001) and can also be derived from Tables 4.1 and 4.2. While the structural transformations of the economy should be taken into account in any predictions of future consumption patterns, few projections explicitly consider the differences in the consumption between rural and urban consumers. In this study, we project food consumption levels for rural and for urban areas.

Table 4.3 Market development and per capita food consumption (kg) in rural China, 1997-2001

	Percentage of food purchased from market (%)			
Per capita consumption	<30	30-45	45-60	>60
Grain (unprocessed)	276.2	265.6	249.4	211.3
Edible oils	6.6	6.8	7.0	7.5
Meat	22.3	21.5	23.0	29.0
Aquatic products	1.8	3.1	4.2	8.5
Vegetables	131.0	119.6	111.5	102.2
Sugar	1.2	1.7	2.0	2.3
Fruits	14.5	18.0	22.0	28.6

Source: Computed by authors based on rural income and expenditure survey data of 1997 and 2001 conducted by the National Statistical Bureau of China.

Urbanization occurred not only through the expansion of urban areas, but also within the rural sector. One of these changes is rural food market development. Table 4.3 shows how food market development is associated with food consumption in rural China. The food market development can be expressed in the percentage of food consumption purchased from the rural market by rural households. The consumption of grain and vegetables - which are largely home-produced commodities - declines with food market development (Table 4.3), while other food consumption increases with the expansion of food markets in rural areas.

4.2.2 Food Supply and Demand Balance

Chapter 2 shows that the increase in food consumption in China was almost entirely a result of the growth in domestic production. In 1980, China imported nearly USD 2.9 billion of food from world markets (Chapter 2). In the same year, China exported more than USD 3 billion to the rest of world. Since then, China has been a net exporter. Moreover, during the 1980s and 1990s, net exports of food increased significantly. In 1999, China's food net exports reached USD 4.5 billion.

Even in the grain sector - in which China has less of a comparative advantage - the nation has been able since the 1950s to almost achieve self-sufficiency. Table 4.4 shows the annual cereal grain supply and utilization food balance sheet in China for the past 20 years. The improved national grain self-sufficiency has mainly come from the rapid growth of domestic supply since the early 1980s. Because per capita consumption of cereal grains was already very high by the early 1980s, although average income elasticity of cereal grains was still positive (but small) for both rural and urban consumers, the increase in grain consumption due to income growth was offset by a decrease in its consumption as the food market rapidly developed, the later increased varieties of non-staple foods available in the markets (Huang & Rozelle, 1998). The growth in non-staple food consumption - such as meat, vegetables, edible oils, and other foods – has been substantial (Tables 4.1 and 4.2).

The grain balance sheet also shows that cereal production increased by 37 percent during the past two decades (row 3). Driven almost entirely by yields, the increase in production has come even though the sown area has remained constant (rows 1 and 2). Between the early 1980s and late 1990s, consumption in China increased by 30 percent. Although this was a large increase, it was less than the rate of production increase. With production rising faster than consumption, China - the nation with the world's largest population – became grain self-sufficient in 1995 (bottom row). The annual production of food (in tons) exceeded the annual consumption that year and has done so ever since. The self-sufficiency level increased to 104.1 percent in the late 1990s. During this time, China also was a net exporter of food (row 5).

Table 4.4 also shows that in the past two decades about one-fifth of the increase in grain production was effected to meet the increase in demand for cereal grain as food (mainly to meet the increase in total population). By reducing the supply pressure on food grain demand, China has been able to release a large share of its own produced grains (mainly maize) for feed use. The shares of grain as feed use in total grain consumption nearly doubled between the early 1980s (14 percent) and the late 1990s (27 percent) (Table 4.4), which implies that more than 70 percent of the growth in grain production was allocated to feed use.

Many factors, including domestic policies, have helped China improve its food security in the past 20 years. The increase in yields may have contributed as much as anything else has. As discussed in Chapter 2 and as shown in the literature, China's domestic policy has played a major role. Decollectivization, new agricultural technologies, irrigation investments, and increasing access to inputs have helped provide the incentives and materials for raising production per fixed unit of land (Lin, 1992; Fan, 1991; Huang & Rozelle, 1996). With the equal distribution of land in China, the higher yields have meant that the incomes of farmers have risen as a result of the increased output.

Table 4.4 Annual cereal grain supply and utilization food balance in China, 1981-2000.

	Unit	1981-85	1986-90	1991-95	1996-00
Crop area	1000 ha	95848	94539	93156	93817
Yield	tons/ha	3.0	3.4	3.8	4.1
Production	1000 tons	284420	317765	352278	388695
Stock change	1000 tons	5756	4741	1553	11999
Net import	1000 tons	9416	8391	2787	-3147
Import	1000 tons	11906	13828	12265	5027
Export	1000 tons	2490	5436	9477	8174
Consumption	1000 tons	288080	321416	353513	373550
Food use	percent	72	67	65	61
Feed use	percent	14	20	23	27
Seed use	percent	5	4	4	3
Industry use	percent	3.0	3.1	3.1	3.2
Waste	percent	6.2	5.9	5.7	5.7
Per cap. food	kg/person	202	196	194	183
Urban	kg/person	149	137	126	109
Rural	kg/person	217	217	220	215
Self-sufficiency level	percent	98.7	98.9	99.7	104.1

Source: CCAP's database and authors' estimates.

4.3 Productivity-enhanced Investments and Agricultural Growth

4.3.1 Agricultural Research Investment and Technology Changes

Agricultural research in China is overwhelmingly financed and undertaken by the public sector (Huang, Hu & Rozelle, 2003). Table 4.2 shows that total investment (including government fiscal expenditure and research institutes' commercial income) in agricultural research[1] grew from 1355 million Yuan in 1985 to 6368 million Yuan (current price) in 1999, an increase of over 400 percent (Table 4.5). However, expenditure on agricultural research grew in real terms by only about 4 percent annually between the mid 1970s and the late 1990s. Recent concern about China's future ability to meet the growing demand for agricultural products has resulted in a significant growth in public investment in agricultural research since the late 1990s.

[1] Including agriculture, forestry, animal husbandry, water conservancy, and agricultural service.

Table 4.5 China's agricultural research investment in public research system in 1985-1999

	At current price (million Yuan)			At 1998 price (million Yuan)		
Year	Total	Fiscal	Commercial	Total	Fiscal	Commercial
1985	1355	1015	340	3923	2939	984
1986	1346	958	388	3676	2617	1059
1987	1403	948	455	3572	2413	1159
1988	1782	1189	593	3827	2554	1273
1989	2095	1400	695	3820	2553	1267
1990	2050	1243	807	3661	2220	1441
1991	2381	1283	1098	4133	2227	1906
1992	2761	1442	1319	4548	2375	2173
1993	3273	1558	1715	4763	2267	2496
1994	4409	2072	2337	5272	2478	2794
1995	4856	2441	2415	5058	2543	2515
1996	5238	2754	2484	5143	2704	2439
1997	5377	2789	2588	5237	2717	2520
1998	5847	3060	2787	5847	3060	2787
1999	6368	3358	3010	6565	3462	3103
Annual growth rate						
1985-95	13.3 %	8.4 %	20.9 %	3.6 %	-1.3 %	11.2 %
1996-99	6.7 %	6.9 %	6.5 %	8.4 %	8.6 %	8.2 %
1985-99	12.5 %	9.6 %	17.1 %	4.0 %	1.1 %	8.6 %

Source: MOST.

Because the size of sectoral investment is related to its size in the economy, internationally, investment intensity (i.e., the percentage of agricultural research investment as the agricultural GDP) is usually used to measure the level of government investment in agricultural research. Table 4.6 shows that the investment intensity of China's agricultural research has been about 0.4-0.5 percent. While this is lower than in the developed countries (typically 2-4 percent) and above the average of developing countries, it has resumed growth since the mid 1990s. On the other hand, the above discussion also implies that there might be a lot of room for China to boost its agricultural productivity through increasing agricultural research investment in the future.

Table 4.6 Intensity (%) of investment in agricultural research and technical extension service in China, 1985-1999

Year	Agricultural research			Agricultural technical extension
	Government fiscal expenditure	Commercial income and others	Total	
1985	0.40	0.13	0.53	NA
1986	0.35	0.14	0.49	0.41
1987	0.30	0.14	0.44	0.40
1988	0.31	0.15	0.47	0.37
1989	0.33	0.16	0.50	0.36
1990	0.25	0.16	0.41	0.33
1991	0.24	0.21	0.45	0.34
1992	0.25	0.23	0.48	0.34
1993	0.23	0.25	0.48	0.32
1994	0.22	0.25	0.47	0.30
1995	0.20	0.20	0.40	0.27
1996	0.20	0.18	0.38	0.29
1997	0.20	0.18	0.38	0.31
1998	0.21	0.19	0.40	0.42
1999	0.23	0.21	0.44	0.46

Source: Ministry of Finance and Center for Chinese Agricultural Policy of the Chinese Academy of Sciences

Despite relatively lower levels of agricultural research investment in China compared to those in many developed countries, the progress in agricultural technology has been remarkable. China's agricultural scientists and public financed R&D system developed and disseminated technology throughout the People's Republic period (MOA, 1999). Before the rest of the world had experienced the Green Revolution, China's breeders released improved, semi-dwarf rice varieties (Stone, 1988). Yuan Longping made his breakthrough on hybrid rice in Hunan Province in the early 1970s (Lin, 1991). Agricultural officials also pushed hybrid maize as early as the late 1950s and early 1960s. Although the diffusion path was not entirely smooth until the mid 1970s, following the release of the new corn-blight-resistant, single-cross hybrids, by the mid 1980s virtually all of the temperate production zones in northern China were planted with hybrids. Somewhat later, wheat varieties enjoyed similar technological transformations (Rozelle & Huang, 2000). Technologies in other crops and livestock have also progressed substantially (MOA, 1999).

China's R&D system for agriculture reached its peak in the mid 1980s. Although crop yield growth has slowed down since the late 1980s, farmers in China have continuously been adopting new varieties developed by the government's research system. For example, in the 1990s rice farmers used about 400 'major' varieties each year (Huang, Hu & Rozelle, 2003).[1]

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[1] A 'major' variety in our sample is any variety that covers at least 100,000 mu (6,667 hectares) in a province. Since our database is built on this concept, we do not have full coverage. In fact, for the rice, wheat, and most maize growing sample provinces, the proportion of area covered by major varieties exceeds 90 percent in

China's breeding efforts also have enhanced the quality of its seed stock. Using the experimental stations' yields of each major variety during the year the variety was certified, two measures of quality were developed by Jin et al. (2002): a 'yield frontier' variable and an 'adopted yield potential' variable.[1] The yield frontier - which is created by using 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 provinces in each province's research system. The other variable - the adopted yield potential – is the average of the experimental station's yields of all major varieties that have been adopted by farmers.

Table 4.7 Experimental stations' yields (yield frontiers and adopted yield potential), actual yields, and yield gaps in sample provinces in China, 1980 and 1995

	1980 (tons/ha)	1995 (tons/ha)	Annual growth rate (%) c)
Rice			
Yield frontier a)	6.6	9.1	2.3
Adopted yield potential b)	6.1	7.2	1.4
Actual yield	4.2	6.2	2.1
Percent gap between adopted yield potential and actual yields	31 %	14 %	
Wheat c)			
Yield frontier a)	6.3	7.5	1.3
Adopted yield potential b)	4.6	5.2	1.0
Actual yield	1.9	3.6	3.2
Percent gap between adopted yield potential and actual yields	58 %	31 %	
Maize			
Yield frontier a)	7.6	11.0	2.5
Adopted yield potential b)	6.1	7.9	1.8
Actual yield	3.0	4.9	3.2
Percent gap between adopted yield potential and actual yields	51 %	38 %	

a) 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. In this table, the figure is the average of sample provinces. See Appendix Table 4.8 for a complete national series for each crop.
b) Adopted yield potential is the *average* experiment station yields of *all* varieties being adopted by farmers. In this table, the figure is the average of sample provinces (Appendix Table 4.9).
c) Annual growth rates are calculated by running a regression of natural log of various yields on a time trend.
Source: Jin et al., 2002.

each province (except in some of the southern soybean provinces).

[1] 'Yield frontier' is defined to be non-decreasing. If a major variety is 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 drop, even in the rare case that farmers have stopped using that variety and all other varieties have lower certified yields in the following years.

According to both measures, China's research system has created a steady stream of quality technology (Table 4.7). The yield frontier for rice moved up by 2.3 percent per year and that for maize by 2.5 percent per year between 1980 and 1995, most likely a function of the development of hybrid cultivars. Although more modest, the yield frontier of wheat has also increased significantly during the reforms (1.3 percent).

4.3.2 Water Control Investment and Irrigation Development

China is not particularly well endowed with water, yet water has been used as a cheap resource to expand agricultural and industrial production. China ranks fifth in total water resources among the countries in the world, but on a per capita basis, it is among the poorest. The nation's water resources are overwhelmingly concentrated in southern China, while northern China (the area north of the Yangtze River Basin) has one-fourth of the per capita water endowment of the south and one-tenth of the world average (Bryan et al., 2003).[1] Northern China, however, remains an important agricultural region and the site of much of China's industrial production. Increasing demand for water from the industrial sector and for domestic use has challenged China agricultural water use.

Because of the scarcity and importance of water in agricultural production, China has invested substantially in water control and irrigation expansion, which has contributed to crop yield increases. The national government invests in developing the water resources from all large rivers and lakes, as well as in projects that cover more than one province. Local governments are in charge of projects that are within their administrative district. Historically, investment from national funding sources has been heavily biased towards new investments, while local governments have been responsible for maintenance funds.

China launched the first nationwide, massive-investment water infrastructure project in the late 1950s. Investment increased from 0.8 billion (in constant 1990 Yuan) in 1955 to 7.5 billion in 1960 (Figure 4.1). Although irrigation investment declined in the 1960s, the irrigated area continued to expand (Table 4.8). By the late 1980s, serious attention was being paid to the problem of waning irrigation investment after several successive years of poor harvests. Post-reform grain production peaked in 1985, then stagnated in the late 1980s (Wang, 2000). Some people blamed the low investment in agriculture for this decline (Wen, 1993). Estimates of the impact of irrigation investment on total factor productivity show that China's irrigation system was losing its ability to increase output and productivity (Huang et al., 2000).

[1] Loosely speaking, northern China includes three main geographic regions according to China's own definitions: Northwest, North, and Northeast China.

Table 4.8 Areas of cultivated, irrigated and salinized land in China, 1973-1996

Year	Total cultivated land area (1000 ha) (1)	Salinized cultivated land (1000 ha) (2)	Percentage of salinized land in total cultivate land (%) (3)=(2)/(1)*100	Irrigated land areas (100 ha) (4)
1973	100,212.7	6754.0	6.7	39,222.7
1974	99,912.0	6705.3	6.7	41,269.3
1975	99,708.0	6970.3	7.0	43,284.0
1976	99,388.0	7062.0	7.1	44,981.3
1977	99,247.3	7153.7	7.2	44,999.3
1978	99,389.3	7245.3	7.3	44,965.3
1979	99,498.0	7302.0	7.3	45,003.3
1980	99,305.3	7145.3	7.2	44,888.0
1981	99,037.3	7243.3	7.3	44,574.0
1982	98,606.7	7243.3	7.3	44,176.7
1983	98,359.3	7357.3	7.5	44,650.7
1984	97,854.0	7331.3	7.5	44,452.7
1985	96,846.3	7692.7	7.9	44,036.0
1986	96,229.9	7606.7	7.9	44,226.0
1987	95,888.7	7636.0	8.0	44,403.0
1988	95,721.8	7672.0	8.0	44,375.9
1989	95,656.0	7535.5	7.9	44,917.0
1990	95,672.9	7539.0	7.9	47,403.1
1991	95,653.6	7614.0	8.0	47,822.1
1992	95,425.8	7660.3	8.0	48,590.1
1993	95,101.4	7655.8	8.1	48,727.9
1994	94,906.8	7655.8	8.1	48,759.1
1995	94,975.1	7655.8	8.1	49,281.2
1996	95,466.5	7724.8	8.1	50,381.4

Source: Ministry of Water Resources, various publications.

After implementation of the 1988 Water Law, investment increased from 4.9 billion Yuan in 1990 to 12 billion in 1995 (Figure 4.1). In the Ninth Five-Year Plan (which took effect in 1996), officials increased investment from 8 billion Yuan in 1996 to 17.2 billion Yuan in 1997 (in real 1990 prices; Ministry of Water Resources, 1999), and the plan is to increase investment even more in first decade of the 21st century (interviews with MWR officials).

The increase in investment has led to the enlargement of the irrigated area. The irrigated area increased steadily from about 44 million hectares in the mid 1980s to 47 million hectares in 1990, and to more than 50 million hectares in 1996 (Table 4.8). Using the earlier, official cultivated area figures, the percentage of land irrigated increased from less than 40 percent in the early 1970s to 45 percent in the 1980s, and to 53 percent in 1996

(Table 4.8). The multiple cropping index - one of the main ways irrigated area affects production and productivity - increased from 1.55 in 1990 to 1.65 in 1999.

More importantly, the increase in food output and productivity since the late 1970s can be linked with rising public investment, including investment in irrigation. Huang et al. (1995) established a direct link between new investment in water infrastructure and China's grain output. The results of their studies have been incorporated into CAPSiM to simulate the impacts of irrigation investment on crop yields.

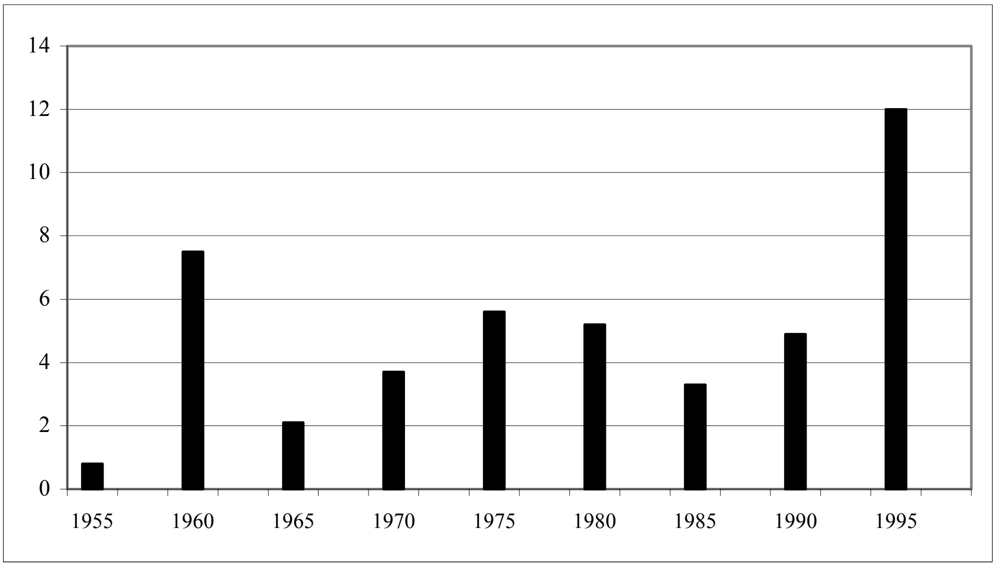


Figure 4.1 Investment in water infrastructure (in 1990 billion Yuan), 1955-1995
Source: Ministry of Water Resources, 1996.

4.3.3 Soil Erosion and Salinization

China suffers from serious land degradation problems. Despite the great efforts made to prevent soil erosion and salinity since the 1950s, serious agricultural land degradations - particularly erosion and salinization - seem to be getting worse (Rozelle et al., 1997).

Erosion. Almost all case studies show that the area of land suffering from both water and wind erosion has increased significantly in the last decades, mostly ranging from 20 percent to 30 percent (Peng & Xu, 1993). While time series data are not available for the land area suffering from wind erosion, Table 4.9 shows the trend of eroded land area due to water erosion in China in 1973-1997. As Table 4.8 shows, China has experienced a significant increase in the eroded area since the 1980s. The average annual growth rate of eroded area reached 1.8 percent in 1973-96.[1] By 1996, the area of water-eroded land reached 1,826,640 km^2. Recently, however, the growth rate has declined to about 1.5 per-

[1] A large increase in 1991 may reflect a readjustment of eroded area with better information obtained from the second soil census (conducted in the early 1980s) and a large study by CAS in Loess Plateau in 1988-90.

cent. The percentage of water-eroded area was about 12.3 percent in the 1970s, 12-14 percent in the 1980s, and 17-19 percent in the 1990s (Table 4.9).

Salinization. Since the 1970s, the area of salinized cultivated land has been fairly constant compared to the eroded land areas. The total increase in the area of salinized land was 14.4 percent in the period 1973-96 (Table 4.8). The average annual growth rate of the salinized area based on MOWR's data set was 0.54 percent in 1973-96. The growth rate declined from 1.1 percent in the 1970s to 0.65 percent in the 1980s, and to only 0.3 percent in the 1990s (computed based on the figures in Table 4.8). However, the share of salinized land in total cultivated land has increased from 6.7 percent in 1973 to more than 8 percent since the early 1990s.

Impacts of erosion and salinization. Erosion and farmland salinization can cause significant declines in farm productivity, and can become serious enough to induce producers to remove land from production (Wang, 1991). Erosion leads to a decline in soil fertility. Poorly-constructed irrigation systems commonly lead to salinization in some environments, either because of the inadequate application of water or because of substandard drainage. Therefore, despite the extent of salinization, the problem is less serious than that of soil erosion in the country as a whole. Salinization has, however, caused serious damage to crop production in many provinces in China.

Three recent studies (Huang & Rozelle, 1995; 1996; Rozelle et al., 1997) have shown that the increase in erosion and salinity problems affects the output of grain, rice, and other agricultural products. These studies show that environmental factors have had a much greater impact on the output of non-rice grains and cash crops (rather than rice), reducing growth by 25 and 15 percent, respectively, between 1976 and 1995. These results support the evidence contained in Huang and Rozelle (1995), namely that environmental stress is having an important impact on agricultural yields. This means that sector officials may need to be more concerned about reducing the adverse consequences of environmental stresses, even if their primary goal is food production.

Table 4.9 Water-caused land erosion area in China, 1973-1996

Year	Water-eroded land area (1000 km^2) (1)	Percentage of water-eroded area in total land
1973	1176.50	12.3
1974	1165.19	12.1
1975	1196.30	12.5
1976	1192.02	12.4
1977	1187.74	12.4
1978	1183.46	12.3
1979	1181.72	12.3
1980	1183.04	12.3
1981	1203.33	12.5
1982	1208.97	12.6
1983	1203.43	12.5
1984	1210.37	12.6
1985	1292.23	13.5
1986	1310.77	13.7
1987	1320.18	13.8
1988	1338.06	13.9
1989	1348.30	14.0
1990	1364.00	14.2
1991	1623.02	16.9
1992	1626.21	16.9
1993	1630.40	17.0
1994	1630.45	17.0
1995	1630.47	17.0
1996	1826.64	19.0

Note: Interview with officials from the Ministry of Water Resources revealed that the statistics on eroded land (soil) areas reported by the Ministry are water-eroded land area. Wind-eroded land or soil areas are not included.
Source: Ministry of Water Resources, various publications.

4.4 Scenario Formulations

The purpose of this section is to formulate scenarios for projection and to provide key assumptions underlining various scenarios. We project China's food economy in the early 21st century under four alternative sets of scenarios: a baseline run (WTO accession) with alternative income growths; the scenarios with different assumptions on agricultural R&D investment; the scenarios with different assumptions on irrigation investment; and the scenarios with alternative soil improvements (erosion and salinity control). We formulate WTO accession as the baseline because China joined the WTO in December 2001. The baseline year is 2001 and the projection periods are 2001-2010 and 2011-2020. A complete detailing of the structural elasticities used in CAPSiM is available on request.

4.4.1 Baseline Scenario

On the demand side, based on the discussions in the previous section, the major factors affecting food consumptions are population growth, rural to urban migration (or urbanization), income growth, and demand responses to price, income, and market development (or demand elasticities). On supply side, the major factors considered in the projection include agricultural technology, irrigation, environment factors (i.e., erosion and salinity), and production responses to inputs and output prices.

4.4.1.1 Demand Shifters

Population growth. Population and income growth will remain an important determinant of food balance in the future. Population growth peaked in China in the late 1960s / early 1970s. Since then, fertility rates and the natural rate of population growth have begun to fall. Throughout the 1990s, the annual population growth rate was only 1 percent (Table 4.10). Relying on the UN's demographic predictions, the nation's population will increase from 1.27 billion in 2001 to 1.36 billion in 2010 – an annual growth rate of 0.72 percent (Table 4.10). This rate of growth is considered moderate, as the annual population growth rate was only 0.70 percent in 2001 (NSBC, 2002). According to the UN's projection, while the population will continue to grow after 2010, the annual growth rate will decline to 0.60 in 2011-2020, a level above the recent projections made by China's demographers. By 2020, China's population will reach about 14.5 billion.

Table 4.10 Annual growth rate (%) of population and income in recent years and assumptions for 2001-2020

	Recent period	Projection period	
	1991-2000	2001-2010	2011-2020
Population	1.0	0.72	0.60
Per capita real income: baseline			
- Rural	5.7	5.0	4.5
- Urban	6.9	6.0	5.0
Per capita real income: low growth			
- Rural	5.7	4.0	3.5
- Urban	6.9	5.0	4.0
Per capita real income: high growth			
- Rural	5.7	6.0	5.5
- Urban	6.9	7.0	6.0

Note: Population estimates are based on United Nations, *World Population Prospects, 2002*, (New York, NY: United Nations, 2002).

Urbanization. China's urban sector has expanded rapidly. For example, the share of the urban population increased from 27 percent in 1990 to 36 percent in 2000. Based on the population projections made by the UN (2002), urbanization will continue to expand. The shares of urban population will increase from 36 percent in 2000 to 44 percent in 2010, and to 51 percent in 2020 (Table 4.11). Because the consumption patterns in urban areas differ considerably from those of rural residents (Huang & David, 1993; Huang & Bouis, 2001), we expect that urbanization will have significant impacts on the national food demand in the coming decades.

Income growth. Given the past trends of urban and rural income growth and recent government concerns about the growing income gap between rural and urban (Chapter 2), we assume that the growth of income in urban and rural areas will gradually converge over time in the next two decades. We also assume that the growth rates in the future will be lower than they were in the 1990s. Under the baseline, per capita real income growth rate is assumed to be 5 percent and 4.5 percent in rural areas for the periods 2001-2010 and 2011-2020, respectively (Table 4.10). In the urban areas, the corresponding figures are 6.0 percent and 5.0 percent, respectively. The impacts of a 1 percent higher or lower growth rate are also simulated to check the sensitivity of the projections to the alternative income growth assumptions (Table 4.10).

Market development. Market development has had significant impacts on food consumption in China (Huang & Rozelle, 1998). Recent changes in the urban economy have made urban consumers almost entirely dependent on markets for their consumption needs. In this sector, prices and income changes will most likely be the fundamental force driving consumption pattern changes. Rural residents live in a different environment than their urban counterparts, and exhibit different demand behavior. Farmers in many areas face limited choices in their consumption decisions since many of the products they desire on a daily basis - such as meat and fresh fruit – are not always available, even as their incomes rise. Even with rapid changes in rural markets, in 2000 China's farmers still purchased only 41 percent of their food (Table 4.11). As markets develop and activity on rural consumption markets increases, apart from changes in income and prices, consumption patterns will be affected. In this study, we assume that China's farmers will purchase 70 percent and 80 percent of their food in 2010 and 2020, respectively (Table 4.11).

Table 4.11 Urbanization and rural food market development in 1990 and 2000, and assumptions for 2001-2020

	Previous period		Projection period	
	1990	2000	2010	2020
Population share (%)				
- Urban	27	36	44	51
- Rural	73	64	56	49
Rural food market development (% of food purchased from market)	45	59	70	80

4.4.1.2 Supply Shifters

Following the discussion in Chapter 2 and in Section 3 of this chapter, supply will respond most sharply to new technology and irrigation investment, and to some extent to environmental factors, such as erosion and salinity control.

Agricultural research investment. In the past 20 years, agricultural research investment in real terms grew by about 4 percent annually. As discussed in the previous section, the growth has fluctuated over time. The annual growth rate of investment slowed down in 1985-95 to only 3.6 percent. But the high growth rate resumed after the late 1990s (Table 4.5). The recent recovery in research investments, together with the experience of other Asian countries and China's commitment to a strong domestic grain economy, leads to the expectation that China will sustain its recent upturn in investment funding over the long run. Moreover, with China's membership of the WTO and the recent concern about the country's future food security under a more trade-liberalized environment, the government has been convinced that agricultural productivity can be boosted considerably by investing in R&D.

Under the baseline, we assume that the annual growth rate of crop research expenditure (excluding the livestock sector) in real terms will be 5 percent in 2001-2020, which is slightly higher than that in the 1990s (average 4.7 percent in 1991-99). But given the significant increase in agricultural research expenditure from the government in recent years, an annual growth rate of 5 percent should not be considered too high.

Irrigation investment. Public irrigation expenditures financed a large part of the construction of the national water control network. The investment in irrigation facilities has been by far the largest component of total construction investment in agriculture, and is several times larger than the investment in agricultural research. Changing agricultural strategies and periods of fiscal control, however, have made public expenditure on water control follow a more variable path (Figure 4.1).

Under our baseline, we assume that the growth of irrigation investment will continue. The annual growth rate will remain at 4.5 percent in 2001-2020. This growth rate is higher than the average growth rate in the past 30 years, but lower than the rates that have been achieved since the late 1990s.

Land erosion and salinity. Trends in environmental degradation – including erosion, salinization, and loss of cultivated land – show that considerable stress may be being put on the agricultural land base. Recognizing the seriousness of soil erosion problems in recent years, China's leaders have begun organizing a national effort to rectify soil erosion. Anti-erosion efforts include afforestation programs, improved pasture management schemes, terracing projects, silt dam construction, and policies that encourage the removal of vulnerable land from cultivation (e.g., the 'Green for Grain' program[1]). The government has also been developing varieties of programs that aim at controlling the salinization

[1] This is a large national program aimed at transferring the use of sloped land from agriculture to forestry. The program was implemented in 1999.

problem in major salinized regions. These include improving the irrigation and drainage system, improving irrigation management, and improving the cropping pattern and management.

Table 4.12 The annual growth rates (%) of agricultural research investment, irrigation expenditure, and areas of erosion and salinized land in recent years and assumptions for 2001-2020

	Recent period in 1990s a)	Projection period	
		2001-2010	2011-2020
Crop research investment			
- Low		3.0	3.0
- Baseline	4.7	5.0	5.0
- High		7.0	7.0
Irrigation investment			
- Low		2.5	2.5
- Baseline	n/a	4.5	4.5
- High		6.0	6.0
Erosion area			
- Low		0.5	0.25
- Baseline	1.5	1.0	0.5
- High		2.0	1.0
Salinized land area			
- Low		0.1	0.05
- Baseline	0.2	0.2	0.1
- High		0.4	0.2

a) The period is 1991-99 for agricultural research investment and erosion area, and 1991-96 for salinized area.

While the growth rate of eroded land increased by about 1 percent in the 1980s, recent efforts to control erosion by the government has reduced the erosion area expansion to about 0.2-0.8 percent, and the efforts to control salinization have kept the growth of the saline area to a very low level (0.2 percent annually). Our baseline assumes a moderate increase but a declining annual growth (1 percent in 2001-2010 and 0.5 percent in 2011-2020) in the area of eroded land. For the salinized area, the rate of growth in the 1990s (0.2 percent) is assumed for 2001-2010, and declines to 0.1 percent only in 2011-2020 (Table 4.12).

4.4.1.3 Trade Liberalization

Under our baseline, the current tariff rates and non-tariff barriers are assumed to change in 2002-2010. For those agricultural commodities that have positive nominal protection rates

(NPRs; see Chapters 2 and 5 for details), their prices are assumed to decline as China changes its policies to meet its commitments resulting from WTO accession. These commodities include wheat, maize, other course grains, soybean, edible oils, and sugar crops (see Chapter 2). The prices of other commodities such as rice, vegetables, fruits, livestock products (except milk), and fish are expected to rise with China's WTO accession.

To incorporate the results of the study on NPR presented in Chapter 2 into CAPSiM and to formulate our baseline on the protection rates in the baseline year (2001), we slightly adjusted the figures on NPRs, as the figures presented in Chapter 2 are NPRs in October 2001. The adjustments are based on the price trends of both domestic and international prices in the entire year of 2001.

Table 4.13 summarizes the NPRs of major agricultural commodities in the baseline year (2001) and the assumed NPRs in 2005 and 2010. In the period 2002-2005, the nominal protection rates of all agricultural products will fall by 50 percent (after deducting the difference in VAT between import and domestic products for importable commodities, and adding the costs related to SPS for exportable commodities). Trade liberalization is expected to continue after 2005. We assume that the remaining border distortion will be further reduced by half in 2010 over 2005. It is expected that the increase in agricultural import will increase and the increase in export will lower the international market prices. This is not taken into account because the CAPSiM model is a country model. The impacts of China's trade liberalization on the world market prices are examined through its linkage with GTAP model, which is discussed in Chapter 3. See also Chapter 5.

The fertilizer price is assumed to decline by 1 percent in 2002-2005 (as the import tariff is lowered, following China's WTO accession) and then to be constant for the remainder of the projection period. The opportunity costs of land for crop production are assumed to grow by 1.5 percent in 2002-2005, by 1 percent in 2006-2010, and by 1 percent in 2011-2020. The opportunity costs of labor for the whole agricultural sector are also assumed to increase by 1 percent throughout the projection period.

Table 4.13 NPRs of agricultural commodities in 2001 and assumptions in 2005 and 2010

	NPRs in 2001	Import: VAT_i -VAT_d	Export: SPS ompliance	NPRs	
				2005	2010
	(1)	(2)	(3)	(4)	(5)
Rice (export + import)	-3.3			-1.6	-0.8
Wheat	12.0	3.0		4.5	2.3
Maize: export (w/ subsidy)	30.0		0.0	15.0	7.5
Maize: import	20.0	3.0		8.5	4.3
Sweet potato	5.0	3.0		1.0	0.5
Potato	10.0	3.0		3.5	1.8
Other course grain	5.0	3.0		1.0	0.5
Soybean	15.0	3.0		6.0	3.0
Rapeseed	27.0	7.0		10.0	5.0
Sugar: high quality	40.0	7.0		16.5	8.3
Sugar: medium quality	25.0	7.0		9.0	4.5
Cotton	17.0	3.0		7.0	3.5
Vegetables	-10.0		4.0	-3.0	-1.5
Fresh Fruit	-10.0		4.0	-3.0	-1.5
Pork	-27.0		8.0	-9.5	-4.8
Poultry	-17.0		4.0	-6.5	-3.3
Beef	-10.0		4.0	-3.0	-1.5
Mutton	-5.0		4.0	-0.5	-0.3
Egg	-4.0		4.0	0.0	0.0
Milk: products	30.0	7.0		11.5	5.8
Fish	-15.0		4.0	-5.5	-2.8

Note: (2) is the estimated difference between value added tax rate (%) on import and domestic products. (3) is the costs related to prices (%) to meet SPS. (4) = [(1)-(2)-(3)]/2; (5)=(4)/2.

4.4.2 Alternative Scenarios

High and Low Agricultural Research Investment. Under high and low productivity growth scenarios, all assumptions embodied in the baseline are maintained except for the assumptions on the growth of agricultural research investment. Previous studies show that China's ability to feed its growing population, maintain its current high level of national food security, and keep its agricultural sector healthy will highly depend on whether the country can continuously generate the technologies that reduce the cost of agricultural production and increase agricultural productivity.

In order to see how agricultural production, consumption, and trade are affected by agricultural research investment policies, the high productivity growth scenario assumes an improvement in crop productivity, due to an increase of the annual growth rate of agricultural research expenditure in crop sector from 5 percent (the baseline assumption) to 7 percent throughout the projection period (Table 4.12). The low productivity growth scenario assumes that the annual growth rate of crop research expenditure will decline from 5 percent in the baseline to 3 percent.

High and Low Irrigation Investment. Investment in agricultural infrastructure, especially irrigation, has been an important determinant of China's agricultural growth in recent decades. The Eleventh Five-Year Plan (2001-2005) and the Long-Term Economic Development Plan also call for substantial increase in public investment in water control. If this is realized, it is likely that China will invest more in irrigation than we assume in the baseline (4.5 percent annual growth of irrigation expenditure). On the other land, China has been facing increasing financial stress and it is not unlikely that the investment in irrigation might fall if the domestic policy moves from productivity-enhanced investment to domestic price or income support policies. To explore the role of irrigation investment in agricultural production and trade, we add two alternative annual growth rates of irrigation investment: the high growth scenario - which assumes the average annual growth rate of irrigation investment will reach 6 percent in 2001-2020 – and the low growth scenario, which assumes 3 percent (Table 4.12).

High and Low Expansion of Eroded and Salinized Land. To test the sensitivity of our baseline assumptions on erosion and salinity, we developed two alternative scenarios: doubled rates of growth in erosion and salinity are assumed for unsustainable use of agricultural land, and 50 percent of baseline growth rate is assumed for much more effort to control the erosion and salinity problems in the future (Table 4.12).

4.5 The Results of Baseline Projections

The purpose of this section is to report the projection results of the three sets of scenarios discussed in the previous section based on a projection model developed at the Center for Chinese Agricultural Policy (CCAP), namely the Agricultural Policy Simulation and Projection Model (CAPSiM).

4.5.1 Baseline Scenario

Our baseline projections show that the national average of China's per capita food grain consumption will decline throughout the projection period. But the trends differ between rural and urban consumers. In rural areas, per capita food grain consumption will decline after peaking in 2010 (225 kg; Table 4.14), while it has been declining since the mid 1980s and will continue to decline in the next two decades. Rising income will not lead to an increase in food grain consumption in urban areas, simply because the income elasticity of demand for all grains (rice, wheat, maize, and other coarse grains) are negative. In rural areas, the negative income elasticities of demand for rice and wheat are also estimated to be negative after 2010. The decline of per capita grain consumption in urban areas combined with the rapid urbanization, decreases the national average per capita consumption.

Table 4.14. Projections of per capita major food consumption (kg) under baseline scenario, 2001-2020

	2001	2010	2020
Rural:			
Grain	221	225	219
Cereal	214	218	212
- Rice	105	106	104
- Wheat	85	92	92
- Other	24	20	16
Edible oil	6	9	10
Sugar	1.8	2.4	2.9
Vegetables	182	216	246
Fruit	26	33	40
Pork	21	25	29
Beef	1.0	1.4	1.8
Mutton	1.2	1.6	1.9
Poultry	6	8	10
Fish	7	10	13
Urban:			
Grain	120	112	104
Cereal	107	98	90
- Rice	58	53	49
- Wheat	44	41	38
- Other	5	4	3
Edible oil	8	11	13
Sugar	3	4	5
Vegetables	196	234	262
Fruit	72	88	105
Pork	32	37	42
Beef	5	7	8
Mutton	2	3	4
Poultry	12	16	20
Fish	21	27	33

Note: Grain includes rice, wheat, maize, sweet potato, potato, and other course grain
Source: Authors' projection

In contrast, the per capita demand for meat and all non-staple foods (non-grain foods) is forecast to increase throughout the projection period. Except for vegetables and pork, the consumptions of most non-staple foods in both rural and urban areas will increase by 60-80 percent in the next two decades (Table 4.14). In the same period, per capita vegetable and pork consumption will increase by about 25 percent and 35 percent, respectively. The relatively lower growth of per capita vegetable and pork consumption is due to the higher consumption level of vegetables (182 kg in rural and 196 kg in urban areas) and pork (21 kg in rural and 32 kg in urban areas) (Table 4.14). Although the consumption of other meats (i.e., except pork) will grow more rapidly, the consumption will still be small even by 2020. For example, per capita beef, mutton, and poultry consumption are projected to be 1.8 kg, 1.9 kg, and 10 kg, respectively, in rural areas in 2020; combined (13.7 kg), this is less than today's consumption of pork by rural people (21 kg in 2001) and about half of the pork consumption in 2020 (Table 4.14). It is worth noting that the projected increase in fish consumption is more than the increase in aggregate meat consumption, a food trend that has existed in the Far East region since the 1960s (i.e., Japan, South Korea, and Taiwan). The consumption of other foods, such as edible oils, sugar, and vegetables, also increases over time.

Both income growth and urbanization are major driving forces. The income elasticities of meat and other foods range from 0.4 to 0.7 in 2001-2020 and from 0.2 to 0.6 in 2011-2020 in both rural and urban areas. As more people living in urban areas and urban consumers have a higher level of non-staple food consumption, the national average consumption of non-staple foods is projected to increase with urbanization.

The projected increase in meat demand will stimulate aggregate feed grain demand. Baseline projections of the supply of grain show that although China's domestic total grain production will increase from 388 million metric tons (mmt) in 2001 to 438 mmt in 2010, and to 460 mmt in 2020 (2^{nd} row, Table 4.1), it falls below the domestic grain consumption. Consequently, grain net imports will rise to 44 mmt in 2010 and continue to expand to 56 mmt in 2020. Despite this high level of grain import, grain self-sufficiency will still remain as high as 90 percent in the early 21st century. While this level of import is more than the government's target (95 percent self-sufficiency), it is not unexpected as China is a very land-scarce country (in terms of per capita land).

Indeed, for food grains (rice and wheat) that have the most significance for national food security, baseline projection shows that net import will be minimal in the future. With the gradual opening of the Far East japonica rice market (including Japan, South Korea, and Taiwan), China will be the major beneficiary of rice trade liberalization. Its export will increase from the current less than 2 mmt to about 2 mmt in 2010, and then to as high as 8 mmt in 2020. Since it peaked in the late 1980 (at about 15 mmt), the wheat import has been declining (except for 1995 when China's food prices increased by over 40 percent in just one year). In 1999-2001, the annual wheat import was less than 1 mmt. Baseline projection indicates that while the wheat import will increase in the next decade, the annual import will be less than 10 mmt until 2010 (Table 4.14). The wheat import, however, will decline after 2010. The projected declining wheat import after 2010 comes from the declines in both population growth (Table 4.10) and per capita wheat consumption (Table 4.14), and a moderate growth of wheat yield in the coming decades.

Table 4.15 Projections of grain production, demand, and net imports under baseline scenario, 2001-2020

	2001	2010	2020
Baseline:			
Production a) (mmt, rice in paddy)	441	496	521
Production a) (mmt, rice in milled form)	388	438	460
Net import (mmt)	-5	44	56
- Rice	-1.6	-2	-8
- Wheat	0.7	10	5
- Maize	-6	34	57
Stock change (mmt)	-33	0	0
Demand (mmt)	415	482	516
Food	233	240	233
Feed	126	181	216
Others b)	56	61	66
Grain self-sufficiency (%)	101	91	89

a) Grain includes rice, wheat, maize, sweet potato, potato, and other course grain. Grain production is reported in two alternatives, as rice is measured in both paddy rice (consistent with the official statistics) and milled rice (consistent with all other statistics reported in this chapter). The conversion rate is 1kg paddy = 0.7 kg milled rice.
b) 'Others' includes seed, industrial use, and waste.
Source: Authors' projection.

Baseline projection indicates that the increasing grain import is nearly entirely from increasing feed demand, particularly maize. While maize production will continue to increase - and indeed increase more than rice and wheat (not shown in the tables) – in the next two decades, it will fall much below domestic feed grain demand as demand for livestock (both domestic an export demands) grows. In 2001, China used 126 mmt grain as feed (Table 4.15), of which 78 percent was maize (CAPSiM database). At this level of feed demand, feed accounted for only 30 percent of total grain demand in China. With only a 3 percent increase in food grain demand in 2010 over 2001 (from 233 to 240 mmt), feed grain demand is projected to increase from 126 mmt in 2001 to 181 mmt in 2010 (Table 4.15), which will account for nearly 38 percent of total grain consumption in China. After 2010, all increase in domestic grain production is to meet the increasing feed demand, as total food grain consumption will decline in the 2010s. By 2020, feed will account for about 42 percent of the total grain utilization in China.

The projected increase in feed demand causes domestic maize production to fall below maize demand, which will lead China to import an increasing amount of maize from the international market. Baseline projections indicate that China will soon change its status as one of major maize exporters to that of a major maize importer after 2005. Maize import will reach 34 mmt in 2010 and further increase to 56 mmt in 2020 (Table 4.14). Increasing imports imply a decreasing self-sufficiency level. Baseline projections indicate that China will import 20 percent of its domestic maize demand from the international market in 2010, and that the percentage will reach 28 percent in 2020 (or 72 percent self-sufficiency; Table 4.16).

Table 4.16 Self-sufficiency in major agricultural commodities under baseline scenario, 2001-2020

	2001	2010	2020
Rice	101	102	106
Wheat	99	90	96
Maize	105	80	72
Soybean	61	64	60
Edible oil crop	84	69	66
Sugar	96	83	76
Vegetables	101	103	104
Fruit	100	105	107
Cotton	100	94	86
Pork	101	110	105
Beef	100	98	96
Mutton	99	96	95
Poultry	99	106	105
Milk	97	83	79
Fish	105	110	107

Source: Authors' projection.

Not only will self-sufficiency in maize decrease over time, but also most land-intensive crops with positive income elasticities of demand will decline over the projection period. In the non-grain-crop sector (excluding horticulture), China will have to import large amount of products from the international market to meet the growing domestic demand. For example, while China imported 26 percent (or 84 percent of the self-sufficiency level) of its edible oil consumption in 2001, this figure will rise to 31 percent in 2010 and to 34 percent in 2020. In other words, the self-sufficiency level in edible oil will fall from 84 percent in 2001 to 69 percent in 2010, and to 66 percent in 2020 (Table 4.16). This concerns soybean, rapeseed, and other edible oil crops. The impact has already been felt in the soybean sector. After the nearly complete liberalization of the country's soybean sector in the last three years, the import of soybean increased to over 10 mmt in 2000 and to 14 mmt in 2001 (NSBC, 2002); the figure in the mid 1990s was almost zero. Although we project that the soybean import will continue to increase in the coming years, the increase will be less than the increase in domestic demand, which will result in a slight improvement in the soybean self-sufficiency rate. By 2020, China will still need to import about 40 percent of the soybean demanded by the domestic market (Table 4.16). Sugar and cotton imports will also increase and their self-sufficiency levels will fall. The increase in the cotton import is mainly due to the rapid expansion of textile industry in the early 21st century.

Baseline projections indicate that labor-intensive agricultural production will expand more than domestic demand. Trade liberalization will help China to boost its horticultural, livestock, and fishery sectors as the nominal protections of these products are negative

(Chapter 2 and Table 4.13). The increase in the prices of these products accompanying the rising productivity will enable China's production to exceed its demand in the coming years. Exports will increase.

Currently, China exports about 1 percent of its vegetable production to the world market, and has only minimal amount of fruit for exports. Baseline projections are that although the domestic demand for both vegetables and fruits will increase with income growth, China will gradually become an important player in vegetable and fruit export markets. We project that about 3 percent of vegetable production in China will be exported in 2010, and that this share will increase to 4 percent in 2020. Fruit will enjoy an even higher rate. Although China currently is just about self-sufficient in fruit production, its export will account for 7 percent of domestic production by 2020.

In the livestock sector, the increases in domestic production nearly match the increases in demand for beef and mutton. In the next 20 years, although the growth of the domestic production of beef and mutton will remain high, China will need to import 2-5 percent of its beef and mutton from world markets to meet the increasing domestic demand (Table 4.16). However, the annual production growth rates of pork and poultry will exceed the demand growth. In the next 20 years, China will be able to export about 5-10 percent of its pork and 5-6 percent of its poultry to world markets (Table 4.16). Obviously, some of the meat export is due to China's willingness to import maize as is projected under the baseline. Cheaper maize and other feed from the world markets will help China to boost its livestock sector.

Fish has been the number one agricultural export commodity in China. Baseline projection shows that the export trend will continue in the future. Fish exports will expand. The export/production ratio will increase from the current 5 percent to a peak of 10 percent in 2010, and remain at 7-10 percent in 2010-2020 (Table 4.16)

4.5.2 Alternative Income Growth Scenarios

Although most of the increases in food availability were mainly a result of China's domestic production during the past 20 years (while China was experiencing its rapid economic growth), strong income growth has often been regarded as a warning message concerning China's ability to feed itself in the future (OECF, 1995; OECD, 1996; World Bank, 1997). Contrary to earlier pessimism about China's food economy, recent studies show that the country's ability to feed itself has been declining even under a more liberalized economy with higher economic growth (Rosegrant, 2001). For example, Huang et al. (2003) show that by the late 1990s, China had strengthened its ability to feed itself. Food, as a share of total imports, had fallen. Total exports far exceeded imports, and by the late 1990s China had accumulated the second largest foreign exchange reserves (after Japan). Although food imports increased (from 3 billion in the 1980s to 6-8 billion in the late 1990s), China needed only about 5 percent of its foreign exchange earnings to pay for them. Hence, imports were playing a bigger role in supplementing national food supply. Its relative cost to the economy, however, was substantially lower.

In this section, we are examining one of the critical issues on whether the policy should concern the national food security (particularly grain) that might result from an even more rapid economic growth (high income growth scenario) in the future. On the other hand, we are also trying to explore what the impact will be on China's food supply and demand balance if the country's economy does not grow as fast as the baseline assumed - a situation that we call the low income growth scenario. The impacts of both high and low income growth scenarios on food consumption and food self-sufficiency levels were simulated with CAPSiM. The results are presented in Tables 4.17 and 4.18.

Table 4.17 Projections of per capita major food consumption (kg) under alternative income growth scenarios, 2020

	Per capita consumption (kg)		Percentage changes over baseline (%)	
	High	Low	High	Low
Rural:				
Grain	221	219	0.6	0.1
Cereal	214	212	0.7	0.1
- Rice	105	104	0.7	-0.1
- Wheat	94	91	2.1	-1.2
- Other	15	17	-7.7	8.3
Edible oil	11	9	8.1	-7.0
Sugar	3	3	8.3	-7.9
Vegetables	264	229	7.2	-6.7
Fruit	44	37	9.9	-9.0
Pork	32	27	8.6	-7.9
Beef	1.9	1.6	10.9	-9.7
Mutton	2.1	1.8	9.3	-8.8
Poultry	11	8.5	11.5	-10.3
Fish	45	11.4	10.9	-9.6
Urban:				
Grain	103	107	-1.4	3.1
Cereal	88	94	-1.9	3.8
-- Rice	48	51	-1.6	3.7
- Wheat	37	42	-1.7	3.5
- Other	2.9	3.4	-8.3	8.9
Edible oil	11	12	8.1	-5.8
Sugar	5.3	4.5	7.1	-7.3
Vegetables	277	248	5.8	-5.2
Fruit	112	98	7.1	-6.8
Pork	45	40	6.3	-6.0
Beef	9.2	7.7	9.3	-8.6
Mutton	3.8	3.2	8.3	-7.7
Poultry	22	17.8	9.9	-9.1
Fish	36	30.2	9.2	-6.9

Note: Grain includes rice, wheat, maize, sweet potato, potato, and other course grain.
Source: Authors' projection.

Our analyses show that changes in income growth assumptions have very minimal impacts on grain production, consumption, and trade. Under the high income growth scenario, the per capita meat consumption in both rural and urban areas in 2020 will be about 10 percent higher than those of the baseline projection for the same year. Additional growth in income does not lead to any meaningful changes in food grain demand. This should be expected as income elasticities are either nearly zero or negative in the projection period. In fact, an increase in urban consumers' income would result in a decline in food grain demand (Table 4.17). While per capita food grain consumption will increase with higher income growth in rural areas, changes are minimal.

Earlier studies (i.e., OECF, 1995; Huang et al., 1999) claimed that a rapid growth of the economy would lead to a higher growth of meat demand and therefore feed demand. Consequently, grain supply and demand balance could worsen and grain imports would rise strongly, even though food grain demand would not increase. This may be partially true as demand for meat increases with income growth, which is also confirmed by our analyses (Table 4.17).

Table 4.18 Self-sufficiency in agricultural commodities under alternative income growth scenarios in 2020

	High income growth scenario	Baseline	Low income growth scenario
Grain	88	89	90
Cereal	89	89	89
- Rice	106	106	105
- Wheat	96	96	96
- Maize	71	72	73
Soybean	56	60	65
Edible oil crop	62	66	70
Sugar	74	76	79
Vegetables	99	104	109
Fruit	100	107	114
Pork	99	105	114
Beef	87	96	105
Mutton	88	95	103
Poultry	96	105	116
Milk	73	79	87
Fish	97	107	118

Source: Authors' projection.

However, the earlier studies did not fully consider the dynamics of China's agricultural economy and the linkage between domestic meat demand and export. High-income growth increases domestic meat demand, which also leads to higher meat prices. Under a more open economy, higher meat prices also imply that China's livestock products are less competitive in the international markets. Meat export declines with higher domestic meat demand. Table 4.18 shows that in 2020 China's pork self-sufficiency level would change from 105 percent under baseline to 99 percent under a high-income growth scenario. China changes from being a major pork exporter to a pork importer. A similar result is found in the poultry and the fish sector (Table 6.18). For other livestock products (such as beef, mutton and milk), higher income growth will result in higher imports or an even lower self-sufficiency level. Because income growth will have impacts mainly on livestock demand and trade, the grain economy will remain nearly the same under alternative income growths.

Alternative income growths are also found to have a significant impact on the consumption and trade of edible oil, sugar, vegetables, and fruits. For these commodities, the high and the low income scenario will lead to a 7-10 percent increase or decrease, respectively, in per capita consumption compared to the baseline projection (Table 4.17). Under the high income growth scenario, China will have to import some of its domestic demand for all food and agricultural products except for rice and vegetables (Table 4.18). Low income growth could increase China's exports of meat and horticultural products, and reduce the imports of edible oils, sugar, and cotton, but this is clearly not a goal that China should pursue.

In sum, the alternative income growth scenario could result in significant changes in China's food demand and trade for nearly all commodities except grain. With the central goal of grain food security in the nation's agricultural policies, China should not be too concerned about the impacts of rapid income growth on national grain security: higher income growth will boost meat demand, which will be offset by lower meat exports. The grain supply and demand balance will keep nearly stable, at about 90% in 2020.

4.6 Alternative Productivity-enhanced Investment Scenarios

4.6.1 Agricultural Research Investment

Before presenting our simulation results, it is worth explaining how the impacts of agricultural research and irrigation investment on agricultural production are estimated. Because our assumptions on the alternative crop productivity growth scenarios are based on the changes in agricultural research investment growth rate in 2002-2020, the impacts will not occur in the early years of the projection period. This is shown by how the research stocks are generated based on the research expenditure:

$$\text{Stock}_t = \sum^{n}_{k=0} \alpha(t-k)\ \text{Expenditure}_{t-k}$$

where Stock_t is the research stock in year t, Expenditure t-k the research expenditure in year t-k, and α(t-k) the timing weight for accumulation of new research expenditures to the stock of research. Under the CAPSiM framework, the timing weights α(t-k) accumulate the previous 17 years' investment into current research stock and are based on an empirical study in Indonesia by Pardey et al. (1992). The values of the α(t-k) are: 0.0 (for Expenditure in year t), 0.0, 0.0, 0.0, 0.010, 0.061, 0.086, 0.112, 0.142, 0.137, 0.120, 0.091, 0.079, 0.071, 0.051, 0.030, and 0.010 (for Expenditure in year t-17).

Because of lags, the increase in investment in the early years will not have impacts on agriculture in the early projection period, and the investment after the early 2010s will not come to a full effect before 2020. However, there are a number of other alternatives that could boost China's agricultural productivity growth in the short run, such as investment in agricultural extension and improvement in the seed distribution system. Therefore the results presented below should be considered as the impacts that represent a lower limit of R&D policy effect.

The results of simulations show that agricultural research could play important roles in increasing domestic production and China's agricultural comparative advantage in the world market. Under the high research investment scenario (7 percent annual growth of crop research expenditure vs. 5 percent under the baseline), for example, grain and sugar production in 2020 will increase by 1 percent (1st column, Table 4.19). The impacts of agricultural research investment on other crops are even greater. The differences in production between low and high research investment scenarios will range from 2 percent for sugar to 3.4 percent for soybean and edible oils, and to 5.2 percent for fruit. Soybean and edible oil crops will gain more from the technological change mainly due to the far less progress achieved in the past 20 years. Therefore the potential gains are expected to be larger than for such other crops as rice and wheat that have high yields in the baseline year.

An increase in production from higher crop research investment will reduce grain imports and increase grain self-sufficiency levels in 2020 from 89 percent of the baseline to 90 percent, while the low agricultural research investment scenario will increase imports by about 1 percent of domestic consumption compared to the baseline (Table 4.18, and 2nd column of Table 4.19). For other crops, the increases in crop self-sufficiency levels are even higher, ranging from about 2 percent for soybean to 3 percent for fruits.

The significance of the impact can be clearly demonstrated by comparing the costs and benefits of research investment. An additional 2 percent increase in total crop research expenditure costs less than 36 billion Yuan (in 2000 constant price) in the entire projection period of 2001-2020. However, return on this investment will be as high as over 40 billion Yuan in 2020 (in just that one year).

Food security has been and will continue to be one of the central goals of China's policy. While food security has many dimensions, one of the targets set by the Chinese government in the late 1990s was to achieve a grain self-sufficiency level of over 95%. Although this level of grain self-sufficiency has since been widely debated, any changes - including trade liberalization - that could result in the grain self-sufficiency level falling in the long term far below 95% would be hardly adopted by the current government if there are no alternative solutions available. The results of our simulation indicate that this high level of grain security will be achieved in the next 20 years only if China's investment in agricultural research growth at annual rate of over 12 percent (the results are not shown in Table 4.19).

Table 4.19 Production of and self-sufficiency in major crop commodities with alternative assumptions on crop research and irrigation investments in 2020

	Agricultural research		Irrigation investment	
	High	Low	High	Low
	Percentage production changes (%) over the baseline			
Grain	1.0	-1.0	1.8	2.3
Cereal	1.0	-0.9	1.8	-2.2
- Rice	0.8	-0.8	1.0	-1.3
- Wheat	1.1	-1.1	1.7	-2.1
- Maize	1.1	-1.1	2.6	-3.2
Soybean	1.7	-1.7	3.1	-3.8
Edible oil crop	1.7	-1.7	4.3	-5.3
Sugar	1.0	-1.0	3.4	-4.1
Vegetables	1.6	-1.6	3.9	-4.8
Fruit	2.6	-2.6	5.5	-6.7
Cotton	1.5	-1.5	3.3	-4.1
	Self-sufficiency (%)			
Grain	90	88	91	87
Cereal	90	88	90	87
- Rice	107	105	107	105
- Wheat	97	95	97	94
- Maize	73	71	74	69
Soybean	62	58	63	56
Edible oil crop	67	65	69	62
Sugar	77	76	79	73
Vegetables	106	103	107	100
Fruit	110	105	113	101
Cotton	88	85	89	83

Source: Authors' projection.

4.6.2 Irrigation Investment

Table 4.19 also presents the changes in China's crop production and self-sufficiency rates under alternative irrigation investment scenarios in 2020. Before proceeding to the discussion on the impacts of irrigation investment on agricultural production and trade, we should bear in mind that the public investment in irrigation is more than 10 times higher than public crop research expenditure in the baseline year. Therefore the same percentage increase in irrigation and research expenditure makes a large difference in the expenditure in real terms. The high investment scenario assumes a 6 percent annual growth of irrigation expenditure, while under the low investment scenario it is assumed to be only 2.5 percent. The annual growth rate is 4.5 percent in the baseline simulation.

The high irrigation investment scenario generates a 4.1 percent (1.8 + 2.3) higher grain production than under the low irrigation investment scenario (last 2 columns, Table

4.19). Irrigation investment will have more impact on maize and wheat than on rice. This is because all rice is irrigated in China, while in many areas this is not the case for maize and wheat.

Irrigation investment also has significant impacts on the production of other crops. The high investment scenario increases crop production by about 3-4 percent compared to the baseline, while the low irrigation investment scenario reduces crop production by 4-7 percent.

Although the high irrigation investment scenario or the policies would ensure the higher level of grain and other crops self-sufficiency than the high research investment scenario, the higher costs related to the high irrigation scenario should also be considered. The other caution on the availability of water for agricultural production should be taken into account when we compare the irrigation investment scenario with the research investment scenario. In some areas (e.g., the North China Plain) additional investment in the water sector may not bring additional land under irrigation because of the scarcity of water.

4.6.3 Agricultural Research and Irrigation Investment

So far we have discussed the impacts of alternative assumptions of either crop research expenditure or irrigation investment on crop production and trade or self-sufficiency. In this subsection, we explore the other alternatives that combine research and irrigation investment. We assume high research investment is accompanied by a high irrigation investment scenario, while low research expenditure is accompanied by a low irrigation investment scenario.

Table 4.20 Production of and self-sufficiency in major crop commodities with alternative assumptions on crop research and irrigation investments in 2020

	Percentage production changes over the baseline (%)		Self-sufficiency (%)	
	High research and irrigation investment	Low research and irrigation investment	High research and irrigation investment	Low research and irrigation investment
Grain	2.86	-3.27	92	86
Cereal	2.75	-3.14	91	86
- Rice	1.78	-2.05	108	104
- Wheat	2.80	-3.18	98	93
- Maize	3.72	-4.27	75	68
Soybean	4.83	-5.46	65	55
Edible oil crop	6.10	-6.87	70	61
Sugar	4.36	-5.04	80	72
Vegetables	5.54	-6.27	109	99
Fruit	8.33	-9.16	115	98
Cotton	4.87	-5.54	91	82

Source: Authors' projection

Several interesting points can be derived from Table 4.20. Under the baseline scenario, while the grain self-sufficiency rate will decline over time, China will be able to achieve one of the major components of its food security target (grain self-sufficiency) in the future under high research and irrigation investment scenarios. Maize is the only grain that will fall below the self-sufficiency level of 95 percent in the long term. Even under this high-high scenario, the maize self-sufficiency rate will continue to decline significantly from the current 100+ percent to about 75 percent 2020.

Table 4.20 also shows that the most effective policy that could improve China's food security and increase grain the self-sufficiency level in the long term is to increase the agricultural productivity enhancement investment, including both agricultural R&D and irrigation. For example, Table 4.20 shows that China could maintain its grain and wheat self-sufficiency at 92 percent and 98 percent, respectively, in the long term (after 2020) if the annual growth rate in agricultural research and irrigation investments is increased to 7 percent and 6 percent, respectively.

The import of edible oils, sugar, and cotton could also be significantly reduced under the high investment scenario. The difference in production between high and low scenarios may reach 7 percent for grain and over 10 percent for edible oils, cotton, vegetables, and fruits.

4.6.4 Alternative Erosion and Salinity Control Scenarios

Table 4.21 presents the results of alternative scenarios on erosion and salinity control efforts. Assuming a constant response of production to erosion and salinity as the level of environmental deterioration increases, moderate increases in their trends (e.g., an increase of 0.2 percent (i.e., from 0.2 to 0.4) percent for salinity and an increase of 1 percent (i.e., from 1 to 2 percent) for erosion in 2001-2010, see Table 4.12) have a large impact on crop output. Compared with other scenarios presented in Tables 4.19 and 5.20, the impact of environmental deterioration is quite substantial.

Table 4.21 Production of and self-sufficiency in major crop commodities with alternative assumptions on erosion and salinity control in 2020.

	Low growth scenario	High growth scenario
	Percentage changes (%) in production over the baseline	
Grain	0.92	-1.82
Rice	0.34	-0.69
Wheat	0.79	-1.57
Maize	1.39	-2.73
Soybean	1.62	-3.17
Edible oil crop	1.74	-3.40
Sugar	1.63	-3.17
Vegetables	1.60	-3.13
Fruit	1.60	-3.13
	Self-sufficiency (%)	
Grain	90	88
Rice	106	105
Wheat	97	95
Maize	73	70
Soybean	61	57
Edible oil crop	67	64
Sugar	78	74
Vegetables	106	102
Fruit	109	104

Source: Authors' projection.

4.7 Concluding Remarks

Significant changes have occurred in China's food consumption in the past, and it is expected that such changes will continue in the next 20 years. Over the past 20 years, China has had the ability to feed its growing population, despite the changing consumption patterns during this period of reform. Increased domestic food and agricultural supply is almost entirely responsible for increasing the nation's demand for food and agricultural products. China's experience demonstrates the importance of technological development, institutional change, price and market liberalization, rural economic development, and other conducive policies in improving agricultural productivity, farmer income, and food security in a nation with limited land and other natural resources. Technology has been one of major driving forces of productivity growth and the engine of China's agricultural economy development.

Our baseline projection shows that China will experience significant structural changes in its agricultural production in the coming decades. For such labor-intensive commodities as horticulture, livestock, and fishery, China's food self-sufficiency rates will increase over time despite the growing domestic demand for these products. However, the imports of many land-intensive commodities such as feed grain, sugar, edible oils, and cotton will increase significantly in the coming decades. The trade liberalization will facilitate these trends.

The future import levels of some commodities such as maize, sugar, and edible oils under our baseline are substantial and might be considered as reasonable for the world's most populous country with such a land shortage, but some of them might not be acceptable to the country's leaders, who regard food security in general and food self-sufficiency in particular as the central goal of food and agricultural policies. Indeed, the new national leaders who took over their responsibilities in early 2003 have been trying to establish effective ways for China to improve its agricultural competitive position and to maintain high food security in the coming years.

Limited options to increase food supplies, however, intensify the challenge of meeting China's food security target for many land-intensive commodities. Decollectivization and fiscal reform have already been tapped for most of their gains. Fiscal constraints may preclude leaders from implementing some of the planned policies. The nation's budget crises, above all, bind the hands of officials even if many public investments promise high returns. Chronic budget shortfalls and looming trade agreements also effectively shut off the option of using East Asian-style price policies to maintain production levels.

When countries near input plateaus, further growth in output must begin to rely more on technological change. The country has less than 10 percent of the world's arable land and only 25 percent of the world's per capita water availability, but feeds more than 20 percent of the world's population. To keep pace with increased demands from projected population increases, food production in China will have to increase with fewer alternatives. Given the limited amount of arable land, productivity increases will have to be the primary source of increases in output.

The constraints imposed on leaders by resource scarcity and politico-economic realities increase the need to understand the scope for supply expansion from one of the most important sources of past supply growth, namely investments in agricultural productivity, and particularly in agricultural technology and irrigation. Improved technology has been by far the largest factor behind agricultural production growth, and as such is a major source of increased food availability in China. The analyses and results presented in this chapter and in our various recent studies establish a basis for China's leaders and policy makers to confidently invest in the nation's agricultural research system.

On the other hand, the enormous increase in the quantity and the diversity of food production has come at tremendous environmental cost. Many analyses reveal that most of the trends in the management of agricultural resources are going in the wrong direction for the sustainability of the agrifood system, namely the erosion of cultivated land; the salinity of irrigated land; the depletion of groundwater aquifers; soil and water pollution from fertilizers, pesticides, and livestock wastes; grassland degradation; and the burning of crop stubble. New technology alone is unlikely to reverse these trends. Policy and institutional changes that embody appropriate incentives and regulations for improved environmental management are needed.

Chapter 5 Projections of the Chinese economy: the impact of agricultural and trade policies and implications for global trade

5.1 Introduction

This chapter simulates the future development of China's food economy and its global implications, under the assumption that no new policy measures are taken either within China or with regard to world trade policies. This simulation is the baseline scenario. The possible impacts of changes in trade policies are discussed in Chapter 6, and those in Chinese agricultural policies in Chapter 4.

We use the GTAP model as research instrument for the projection. The structure of this model and its adaptation to this project is described in Chapter 3. Here, this model is updated to the year 2001 (5.2). Next, assumptions are made for the simulations. An important assumption is that recent policy decisions, China's accession to the WTO, and the phasing out of the Multi Fiber Agreement (MFA) are taken into account. These and other assumptions are discussed in section 5.3. The results of the simulations for China and for the world markets are presented in sections 5.4 and 5.5. The first-mentioned section deals with 2001-2005 and decomposes the simulated developments into economic growth in China and other internal developments, China's accession to the WTO, and the phasing out of the MFA. Section 5.5 deals with the changes during the entire period 2001-2020. The consequences of these changes for the EU are presented in section 5.6. Some conclusions are presented in the final section.

5.2 The base year (2001)

For this project we have regrouped regions and sectors of the GTAP database. These adaptations are described in the following section. This project's base year is 2001, while the last available year in the GTAP database is 1997. The updating of the database to 2001 is summarized in the following section. Part of the database deals with trade distortions. These distortions in the trade with China in 2001 are described in more detail in the final section.

5.2.1 Sectors and regions

The starting point for this study was version 5 (public release) of the GTAP database. This version's base year is 1997 (Dimaranan & McDougall 2002). The GTAP database contains detailed bilateral trade, transport, and protection data characterizing economic linkages among regions, accounting for intersectoral linkages among the 57 sectors in each of the 65 regions. All monetary values are in USD million (see Chapter 3 for more detailed information).

For the purpose of this study, the GTAP database has been aggregated into 12 regions and 17 sectors, and has been updated to the base year of this study (2001). The 12 regions are:

- China (Mainland)
- Hong Kong (China)
- Taiwan
- Japan and Korea
- Southeast Asia
- Other Asian countries
- Australia and New Zealand
- NAFTA countries
- South and Central America
- European Union (15 Member States)
- Central European Associates
- Rest of the world

More detailed information is given in Appendix 5.1

The aggregation into 12 sectors is shown in Table 5.1 and more detailed information is given in Appendix 5.1

Table 5.1 Sectoral Aggregation

Rice	Rice
Wheat	Wheat
Cgrains	Coarse grains
Oilseeds	Soybeans & other oilseeds
Sugar	Sugar (plants and processed)
Pfb	Cotton & other plant-based fibers
OthCrop	Horticulture & other crops
Ctl	Beef (cattle and beef products)
Oap	Pork & poultry
Milk	Milk & Diary
Fish	Fish
Ofood	Other food products
Extracts	Mining and extraction
TexLea	Textiles, leather, and garments
LabintMan	Labor-intensive manufacturing
CapintMan	Capital-intensive manufacturing
Svces	Services

5.2.2 Updating of the database to 2001

For all these sectors and regions, the 1997 data have been updated to the year 2001 with new data for the Chinese economy. We have incorporated an updated input-output table for China, which better reflects the size and input structure of agriculture (see Chapter 2). An important feature of the new table is an improved estimate of primary factor cost shares in agriculture and improved estimates of crop yields. The new estimates use micro data from farm surveys conducted by a number of ministries led by the State Price Bureau. Another feature of the adjusted database is a drastic adjustment of agricultural trade data for China, which incorporates trade information for 2001. Between 1997 (the base year for GTAP version 5) and 2001, both the structure and the size of Chinese trade changed dramatically, and we have adjusted the GTAP data to reflect this. We have also incorporated econometric estimates for income elasticities for livestock products, rice, and wheat (Huang & Rozelle, 1998). The updated estimates for income elasticities are lower than the original GTAP estimates, and are provided in Appendix 5.2. This concerns especially the medium-term projections for livestock consumption.

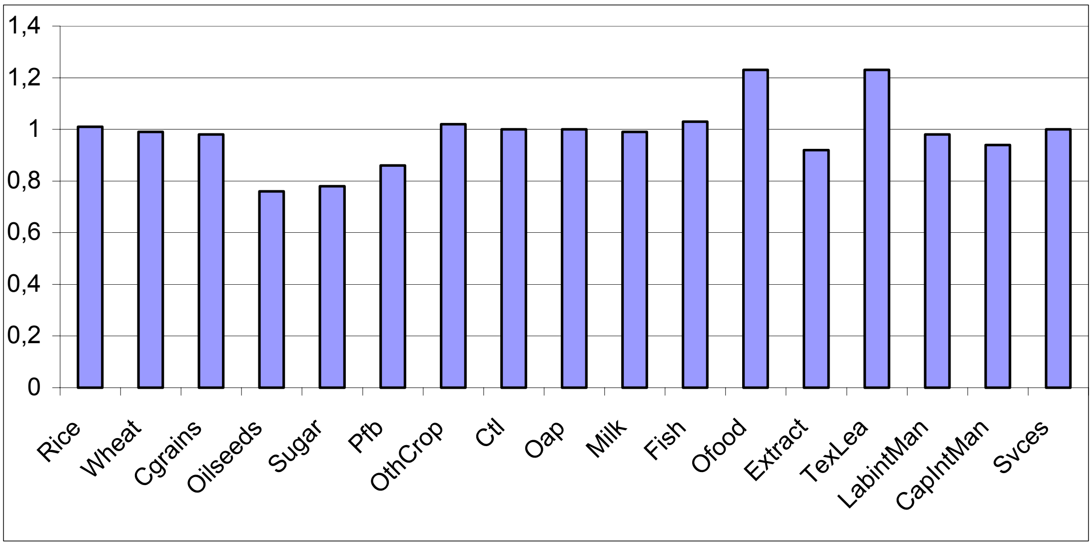


Figure 5.1 Self-sufficiency ratios, China (base situation 2001)
Source: GTAP v5, calculations LEI.
Note: self-sufficiency is defined as the domestic production:domestic absorption ratio.

One of the results of the updating is the self-sufficiency index.[1] This index illustrates the specialization pattern and indicates which activities present a country with a comparative advantage (Figure 5.1). Those products of which China imports a large share of domestic consumption - such as in the oilseeds, sugar, cotton, oil (Extract), and capital-intensive industries (CapintMan) - have a self-sufficiency ratio below 1. Here, we will see intensified competition with foreign suppliers and an increase in imports if trade barriers are lowered as a result of China's accession to the WTO.

On the other hand, the processed food industry (Ofood) and textile industries (TexLea) are clear net-export products, where self-sufficiency exceeds 1, indicating a comparative advantage in these products. To a lesser extent, other crops (horticulture) and

[1] Self-sufficiency is defined as the domestic production:domestic absorption ratio.

fish are also net-export products. For all these sectors, access to foreign markets is important.

The middle ground is occupied by those sectors in which China is approximately self-sufficient in production, namely where trade does not play a large role. Here, we cannot expect a large impact from improved market access. The share of exports or imports in sales is often simply too low to yield a huge production impact from export or import growth. This applies especially to services, as well as to rice and the meat products.

5.2.3 Agricultural trade distortions

An important issue for the update of the database is the estimate of trade distortions in 2001, that is, at the time when China joined WTO**.** In one of their background papers, Huang and Rozelle (2002) estimate a new set of national protection rates (NPRs) on the eve of China's accession to the WTO. In particular, they endeavor to understand in a more disaggregated way the part of certain markets (in terms of varieties or commodity type) that China is protecting. Such an analysis helps us to assess more accurately what the impacts will be after China implements its WTO commitments.

Tables 5.2 and 5.3 summarize the major findings of Huang and Rozelle (2002). These findings are used as an estimate of the trade distortions in the GTAP database for the base year 2001. The results show that for some crops, China's WTO commitments will likely lead to a fall in prices and a increase in imports. Maize and cotton may be the most affected. It is possible that soybeans and sugar will be significantly affected in the longer run. There are also commodities in which China has considerable advantage (e.g., rice, meats, and horticulture products) and, hence, accession could benefit those engaged in these activities. The prospect of increased imports of feed grains (e.g., maize and soybeans) at lower prices means that livestock producers could become more competitive.

Table 5.2 Disaggregated nominal protection rates (NPRs) for selected grains in China, October 2001

	Variety or quality	Comparable domestic price		Border prices (USD/ton)		NPR (%)
		Yuan/ton	USD/ton	C.I.F	F.O.B	
				Estimated at official exchange rate a)		
Rice	Weighted average					-3
	Thai jasmine rice	3690	446	380		17
	High quality japonica	2930	354		398	-11
	Medium quality indica	1519	184		185	-0.5
Wheat	Weighted average					12
	US DNS	2350	284	190		49
	Canadian #3	1800	218	181		20
	Australian soft	1625	196	175		12
	US hard red	1550	187	169		11
	UK	1350	163	145		12
	China - high quality	1350	163	145		12
	China - medium quality	1250	151	140		8
	China - low quality	1100	133	133		-0.1
Soybean	Common variety	1950	236	205		15
Maize	Common variety	1150	139		105	32

a) The estimated official exchange rate is 8.28
Data source: Authors' survey.

Table 5.3 Average nominal protection rates (NPRs) for major imports and exports in China, October 2001

Major imports and exports	Domestic price (Yuan/ton)	NPR (%)
Imports		
Wheat [a]	1250	12
Maize	1150	32
Soybeans	1950	15
Cotton	9500	17
Sugar	2612	40
Exports		
Rice [a]	1954	-3
Pork [a]	11442	-30
Beef [a]	13743	-10
Poultry [a]	9904	-17
Fresh fruits	5472	-4

[a] Average NPRs are created by adding the NPRs of individual varieties' weighting with the sown area (production) share
Source: Authors' survey.

Table 5.4 shows how we arrive at the initial agricultural import protection estimates. Column 1 shows the nominal ad valorem tariff for grains. This is the very low in-quota tariff, as tariff rate quotas (TRQs) were not binding in 2001. For other sectors, we use tariff estimates supplied by CCAP and the WTO accession documents. We add the difference in domestic taxes and VAT on imports.[1] Finally, we add an estimate of price increases resulting from State Trading Enterprises (STE) dominating the import market.

Table 5.3 shows the updated export protection rates for the base year 2001.

Table 5.4 Agricultural import protection estimates for 2001[2]

	Import tariff ad valorem	VAT import	VAT domestic	Other (e.g., STE rent)	TARGET: import tariff equivalent
	(1)	(2)	(3)	(4)	(5=1+2-3+4)
Rice	1	13	10	3	7
Wheat	1	13	10	0	4
Cgrains	1	13	10	26	30
Oilseeds	3	13	10	14	20
Sugar	40	17	10	0	47
Pfibers	8	15	13	-2(*)	8
OthCrop	16	15	10	0	21
Cattle	45	15	13	0	47
Oanimalp	20	15	13	0	22
Milk	25(**)	17	15	0	27
Fish	14	13	10	0	17
OthFood	30	15	13	0	32

*Some imports are duty-free. Included as an implicit subsidy here, ** average preferential rates.

[1] Earlier NPR estimates used only the VAT on imports, but we consider this a wrong approach since the goal of the protection estimate is to estimate the price wedge between domestic produce and imports created by taxation and tariffs. China does not have a VAT system, but currently has a not very transparent taxation system that taxes output and inputs at various stages along the production chain. The main visible taxation occurs in production, not in consumption. Nevertheless, the consumer/buyer is facing a tax burden on domestic produce that must be taken into account in the protection estimates. It is a matter for fiscal experts to sort out exactly how big the tax burden on domestic produce is relative to imported products. For our baseline we use estimates supplied by CCAP for domestic taxes and VAT on imports. For example, for rice the domestic taxation component is estimated as: intermediate share * tax + income tax + turnover tax retail, leading to: l0.4*0.17 +(4653/249200)+0.01

[2] The aggregate ad valorem estimates in Table 5.4 have been converted to bilateral rates for each trade flow by proportional adjustments of the original bilateral estimates found in the GTAP database.

5.3 Macro-economic and policy assumptions

5.3.1 Macro-economic variables

The exogenous macro-economic assumptions on developments of factor endowments, growth in GDP, and population growth are from Walmsley et al. (2000). The macro assumptions for Asia have been updated with information from *Economic Outlook* (Asian Development Bank).

The decision in December 1978 to open up the Chinese economy was a major stimulant to economic growth: The pre-reform rate of per capita GDP growth of 3.1% more than doubled and has remained above 7% for the last two decades. We assume that this high growth rate will continue between 2001 and 2005 (average yearly growth rate of 7.1%). Table 5.5 shows that the growth rate of real GDP of China is the highest of all regions (31.4% between 2001 and 2005). The expected growth rate for the other Asian regions (except Japan-Korea) is also high. For such developed countries as EU, NAFTA, and Japan-Korea, the annual growth of real GDP is about 2.5%, while for Australia-New Zealand it is somewhat higher. The population growth for China slows to less than 1% a year.

Table 5.5 Assumptions on exogenous variables: 2001–2005 (% per year)

	Endowments					Real GDP	Population
	Land	UnSkLab	SkLab	Capital	NatRes	GDP	POP
China	0	1.4	3.9	9.2	0.4	7.1	0.7
HonKong	0	-0.2	4.6	5.0	0.4	5.4	0.0
Taiwan	0	0.9	1.2	6.6	0.4	5.8	0.8
JapKor	0	-0.4	0.2	2.0	0.4	2.3	0.3
SEA	0	1.5	5.6	3.4	0.4	5.5	1.4
OthAsia	0	2.1	5.5	5.2	0.4	5.1	1.6
AusNzl	0	1.1	0.9	3.2	0.4	3.4	0.9
NAFTA	0	1.3	1.2	3.8	0.4	2.6	1.0
SAM	0	1.5	5.7	2.9	0.4	4.3	1.4
EU	0	-0.1	0.0	2.5	0.4	2.6	0.0
CEEC	0	0.2	0.5	3.2	0.4	4.6	0.2
RestofWorld	0	2.4	3.2	2.1	0.4	4.2	2.0

5.3.2 Policy variables

The assumption for the policy variables in the baseline projection is that no new policies will come into force during the projection period. This holds also for the foreign exchange policy: We assume that the RMB / USD exchange rate will not change during the projection period. However, the baseline projection includes a continuation of existing policies and the effectuation of important policy events, as they are known to date. The important policy changes are: Implementation of the remaining commitments from the GATT Uruguay Round agreements; China's and Taiwan's accession to the WTO between 2002 and 2005; the global phase-out of the MFA under the WTO Agreement on Textiles and Clothing (ATC) by January 2005; and the EU enlargement resulting from the accession of Central and Eastern European countries (CEECs). For the baseline projection, this results in a number of assumptions with regard to import tariffs, TRQs, and export subsidies. Most important in this respect are China's commitments deriving from its accession to the WTO. We discuss these commitments first, and then the policy assumptions for the baseline projection.

China's accession to the WTO

China's commitments affecting the agricultural sector can be classified into three major categories: market access, domestic support, and export subsidies. As for market access, China has committed itself to lower tariffs on all agricultural products, to increase access by foreign producers of some commodities through TRQs, and to remove quantitative restrictions on others. The import market access commitments made by China appear to be substantial (Tables 5.6 and 5.7). Overall agricultural import tariffs (in terms of simple averages) will be reduced from about 21% in 2001 to 17% by 2004 (having already declined from 42.2% in 1992 to 23.6% in 1998). Quotas under low tariff will be expanded while shares of State trading will be reduced significantly.

With a few exceptions (e.g., in the case of some commodities considered to be 'national strategic products'), most agricultural products will come under a tariff-only regime. For this commodity group, all non-tariff barriers and licensing and quota procedures will be eliminated, and effective protection will be lowered substantially by January 2002 and fall further by 2004 (Table 5.6). However, imports will not necessarily increase correspondingly.

The real challenge for agricultural products with tariff-only protection will be for such crops as barley and wine and for dairy products. The case of soybeans, for which China has no comparative advantage, may be instructive. Before 2000, the import tariff for soybeans was as high as 114%, importers required licenses, and Chinese farmers met most of the nation's soybean demand. However, in anticipation of China's WTO accession, tariffs were lowered to 3% in 2000 and subsequently import quotas were phased out. Consequently, prices fell and the nominal protection rates declined from 44% in early 2000 (Table 5.3) to less than 15% in October 2001 (Huang & Rozelle, 2001). As a result, imports increased from 4.32 million metric tons (mmt) in 1999 to 10.42 mmt in 2000 and yet further in 2001.

Table 5.6 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
Soybean	3 b)	3	3
Citrus	40	20	12
Other fruits	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 license and import quotas, the tariff rate was 3% for import within the quota and no above-quota barley with 114% tariff was imported in 2001.
b) Tariff rate was as high as 114% before 2000 and lowered to 3% in early of 2000
Source: China's WTO *Protocol of Accession*, November 2001.

Such dramatic movements, however, can expected to be limited for the commodities considered to be 'national strategic products'. Indeed, China's WTO agreement allows the government to manage the trade of rice, wheat, maize, edible oils, sugar, cotton, and wool with TRQs. As shown in Table 5.7, while the in-quota tariff is 20% for sugar and 9% for edible oils, it is only 1% for rice, wheat, maize, and wool, but the amount brought in at these tariff levels is restricted. The in-quota volumes, however, are to grow over a three-year period (2002-2004) at annual rates ranging from 4% to 19%. At the same time, tariffs on out-of-quota sales will drop substantially in the first year of accession and fall further between 2002 and 2005.

Four or five years after accession, a number of other changes will take place. For example, after 2006 China will phase out its TRQ for edible oils. State trading monopolies will also be phased out for wool after 2004, and will gradually disappear for most of other agricultural products (Table 5.7). Although China National Cereals Oil and Foodstuffs Import & Export Co. will continue to play an important role in rice, wheat, and maize, in the future there will be an increasing degree of competition from private firms in importing and exporting grains.

China's accession agreement also contains a number of other commitments, some of which are specific to China. First, unlike other countries, China must phase out all export subsidies.[1] Second, despite its status as a developing country, China's de minimis exemption for product-specific support[2] is equivalent to only 8.5% of the total value of

[1] The Uruguay Round Agreement on Agriculture (A.o.A.) foresaw the gradual reduction, at different rates for developed and developing countries, but not elimination, of export subsidies. Least developed countries are exempt from export subsidy reduction commitments.
[2] According to the A.o.A., member countries were obliged to reduce certain categories of domestic support to agriculture. Total support under these categories is referred to as the aggregate measure of support (AMS). However, a member country is not required to include in the total AMS nor to reduce the product-specific support if it does not exceed a given percentage (5% for developed and 10% for developing countries). See Agreement on Agriculture, article 6, 4(a).

production of a basic agricultural product (as compared to 10% for other developing countries and 5% for developed countries). Third, investment and input subsidies for the low-income and resource-poor farmers who are not subject to reduction commitments, must be included as part of its aggregate measurement of support (AMS).

Table 5.7 China's market access commitments on farm products subject to TRQs

	Import volume (mmt) (State trading share, %)			Quota growth (%pa)	In-quota tariff (%)	Out-of-quota tariff (%) (%, as of 1 January)		
	Actual 2000	Quota 2002	Quota 2004			2002	2003	2004
Rice	0.24 (100) [a]	3.76 (50)	5.32 (50)	19	1	74	71	65
Wheat	0.87 (100)	8.45 (90)	9.64 (90)	8	1	71	68	65
Maize	0.0 (100)	5.70 (67)	7.20 (60)	13	1	71	68	65
Cotton	0.05 (100)	0.82 (33)	0.89 (33)	5	1	54.4	47.2	40
Wool [b]	0.30	0.34	0.37	5	1	38	38	38
Edible oils [c]	1.79 (100)	5.69 (40)	6.81 (10)	15	9	75	71.7	68.3
Sugar [d]	0.64	1.68	1.95	8	20	90	72	50

a: Figures in parentheses are the share (%) of non-State trading in import quota.
b: Designated trading in 2002-2004 and phased out thereafter.
c: TRQ regime will be phased out in 2006. In 2005, import quota will be 7.27 mmt with 9% in-quota tariff and 65% out-of-quota tariff.
d: Phased-out quota for State trade.
Source: China's WTO *Protocol of Accession*, November 2001; *Statistical Yearbook of China*, 2001.

China also agreed to a series of specific conditions for anti-dumping and countervailing duties. For 15 years, China will be subject to a different set of rules that make it easier for countries to bring, prove, and enforce dumping cases against China. China will, however, benefit from the same rights in dealing with other countries, such as reciprocity.

Also Chinese WTO commitments and privileges in other areas of the agreement will directly or indirectly affect its agricultural sector. For example, China has committed itself to replace quantitative import restrictions on three types of fertilizers (DAP, NPK, urea) by TRQs. Also, tariffs will be cut upon accession and further cuts will be phased in by 2005 for almost all industrial products (e.g., tractors, pesticides). Furthermore, China will significantly reduce its non-tariff measures and eliminate all quotas, tendering, and import licensing on non-farm products by no later than 2005. 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 rapidly as they would under a less restrictive regime. Substantial commitments to open up services markets in China have also been made.

Policy assumptions: market access[1]

Table 5.8 summarizes the market access policy landscape in 2001 for China and the assumptions for the baseline projection period 2001-2020.[2] The protection estimates change mainly between 2001 and 2005 as a result of China's accession to the WTO.

Table 5.8 Summary of import protection estimates and baseline assumptions

	Import tariff equivalent %			
	Original GTAP rates 1997 a) (1)	Base2001 (2)	Baseline 2005 (3)	Baseline 2010-2020 (4)
Rice	105	7	4	1
Wheat	113	4	4	1
Cgrains	90	30	4	1
Oilseeds	64	20	9	6
Sugar	29	47	27	20
Pfibers	3	8	3	1
OthCrop	22	21	11	6
Cattle	13	47	14	12
Oanimalp	15	22	14	12
Milk	17	27	18	11
Fish	14	17	15	12
OthFood	32	32	17	15
Extract	0	1	1	1
TexLea	24	23	12	12
LabintMan	15	12	9	9
CapintMan	13	11	6	6
Services	0	19	9	9

a) GTAP rates are trade-weighted averages. New rates are trade-weighted averages.

All the changes in import protection between 2001 and 2005 are a result of China's accession. Accession has the following implications:

- Lower nominal tariffs for a number of products (livestock, industry, services). In in dustry and services we follow, respectively, Martin and Ianovichina (2002), and Francois (2002) (basically halving pre-accession rates in services).
- Lower price increasing effect of State trading enterprises (especially coarse grains and oilseeds).
- No reduction of the gap between value added on imported and domestic products in 2001-2005.

[1] Exports - modelled as export subsidy equivalent. The construction of these estimates is explained below.

[2] Note that our estimates for grains and oilseeds are lower than the GTAP estimates, while our estimates of protection in livestock are higher. The new industrial protection estimates do not deviate significantly from the GTAP estimates.

The import tariffs, difference in VAT, and other elements relevant to the degree of import protection in 2005 are given in Appendix 5.3.

Some TRQs may become binding in 2005 (Table 5.9 gives the in-quota and out-of-quota rates). If a quota does become binding in 2005, the imports will be fixed at the quota level and a quota rent will be introduced to balance supply and demand. Furthermore, we take into account that the TRQs grow by x% each year in 2001-2005. The binding quota levels and the growth rates are given in Appendix 4.4. For 2005-2010, we assume that the differences in VAT on imports and domestic products disappears under pressure from the WTO rules.

Table 5.9 Trade weighted import tariffs on Chinese imports in 2001 and after WTO accession

		WTO Accession	
	2001*	In-quota rates	Out-of-quota rates
Rice	7	1	65
Wheat	4	1	65
Cgrains	30	1	65
Oilseeds	20	3	4
Sugar	47	20	50
Pfibers	8	1	40

* Adjusted from GTAP 1997 data.

Policy assumptions: export competition

On the export subsidy side, we incorporate both existing export subsidies (on coarse grains and cotton) and implicit export taxation resulting from non-compliance with importer's quality and phytosanitary standards (PSS).[1] Also included is an ad valorem estimate of the effect of the export quota under the MFA for textiles and leather.

As a result of China's accession to the WTO, we assume the complete abolition of any remaining export subsidies between 2001 and 2005. MFA quota rents are also completely reduced to zero for *all regions* as a result of the phasing out of the MFA between 2001 and 2005. This means that we are frontloading the complete elimination of restrictions on textiles and garments exports from China to 2005 instead of 2008. Furthermore, we assume for each period a 4% reduction of implicit export taxes (if applicable) resulting from better compliance with PSS, as long as there is a positive NPR.

Policy assumptions: EU enlargement

In Europe, the import barriers between the EU15 and the CEEC region are eliminated, as is any export subsidization between them. CEEC import protection and export subsidization against third countries are increased to the EU15 level.

[1] The estimates of implicit export taxation are necessarily rough and should ideally be placed on the importing side as an NTB.

Table 5.10 Summary of export protection estimates and baseline assumptions

	Original GTAP rates 1997 a)	Base 2001	2005	2010	2015	2020	
Rice	0	-10	-5	0	0	0	export tax, PSS and quality issues
Wheat	0	0	0	0	0	0	
Cgrains	0	31	0	0	0	0	export subsidy
Oilseeds	0	0	0	0	0	0	
Sugar	0	0	0	0	0	0	
Pfibers	0	10	0	0	0	0	export subsidy
OthCrop	0	-7	-3	0	0	0	export tax, PSS and quality issues
Cattle	0	-8	-4	0	0	0	export tax, PSS and quality issues
Oanimalp	0	-26	-22	-10	-6	-2	export tax, PSS and quality issues
Milk	0	0	0	0	0	0	
Fish	0	-15	-11	-7	-3	0	export tax, PSS and quality issues
OthFood	0	-10	-6	0	0	0	export tax, PSS and quality issues
Extract	0	0	0	0	0	0	
TexLea	-5	-5	0	0	0	0	export tax; MFA quota*
Labint-Man	0	0	0	0	0	0	
Capint-Man	0	0	0	0	0	0	
Services	0	0	0	0	0	0	

a) import tariff with duty exemption calculated from Martin & Ianovichina (2002)

5.4 Prospects for China's Food Economy, 2001-2005

In the first period we take into account some important policy changes (e.g. China's WTO accession and the phase-out of the MFA). In the discussion of the projection results, we will focus on the decomposition of these policy effects. Therefore, we discuss the first period more extensively than the second period (2005-2020).

5.4.1 Policy shocks

The developments in 2001-2005 are driven by assumptions on the development of macroeconomic variables, such as GDP growth, population growth, growth of factor endowments (Table 5.5), and the policy changes. In this section we summarize the policy changes. Some of the major policy events for China are, as explained previously, its accession to the WTO, the phasing out of the MFA, and to a lesser extent the enlargement of the EU. China's accession includes changes in import tariffs, export subsidies, and TRQs. Figure 5.2 presents the change in import tariff and export subsidy equivalents between 2001 and 2005. All the changes in import tariff equivalents are a result of China's accession. The reductions are highest for cattle, coarse grains, sugar, textiles, and services. In these sectors, it can be expected that the change in imports is highest. For the TRQ commodities, the import volume (e.g. coarse grains and sugar) is limited by the import quota in combination with the prohibitive out-of-quota tariff. On the export subsidy side, Figure 5.2 incorporates both the reduction of exports subsidies (31% for coarse grains, 10% for cotton) resulting from accession, and a reduction in the implicit non-tariff barriers by 4% resulting from better compliance with importer's quality standards and PSS (for rice, other crop, cattle, other animal products, fish, and processed food). Also included in the export subsidy equivalent is an ad valorem estimate of the effect of the phasing out of the export quota under the MFA (reduction of export quota rent to zero for textiles). The reduction in export subsidies in coarse grains and cotton resulting from WTO accession is expected to reduce the exports of these sectors. The phasing out of the export quota combined with better compliance with importer's quality standards and PSS are expected to increase exports.

5.4.2 Development of output between 2001 and 2005

Table 5.11 gives the percentage change of sectoral output in China between 2001 and 2005 (first column). This is the total impact, which includes the mentioned policy changes and the changes in exogenous macro variables. All the other columns give the contribution of the policy changes to the output change. The total contribution of China's accession to the WTO is given in the second column. The third to fifth columns split this total accession contribution between the impact of the reduction of import tariffs and export subsidies, better compliance with PSS and quality issues, and the increase in import quota, respectively. The sixth column gives the impact of the phasing out of the MFA under the WTO-ATC, and the last column gives the incremental contribution of EU enlargement. As an example of how to read this table, we describe the changes for oilseeds. Between 2001 and 2005, the production of oilseeds grows by 5.3%. The impact of China's accession on the production of oilseeds is – 3.9%, the impact of WTO-ATC is -1.3%, and EU enlargement is 0.1%. The impact of non-policy changes (technical change, increase in macro variables) can be calculated as the difference between the total and the three policy changes (added together) = 5.3 - (-3.9) - (-1.3) - (0.1) = 10.4%. Without the policy changes, the increase in output in the oilseeds sector would have been equal to 10.4%.

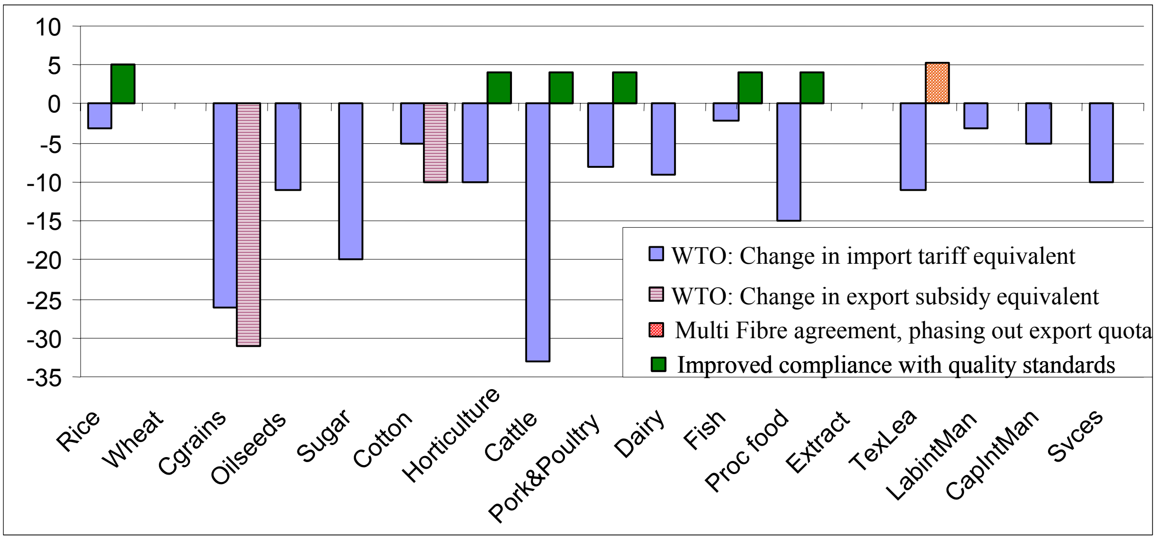


Figure 5.2 Change in China's import tariff and export subsidy equivalents between 2001 and 2005 (% point change).*

* Change in export subsidy equivalent indicates: 1) Abolition of an export subsidy for coarse grains and cotton; 2) a reduction of an implicit export taxation resulting from better compliance with importer's quality and PSS for rice, other crops, cattle, other animal products, fish, and processed food; an ad valorem estimate of the effect of phasing out of the export quota (reducing export quota rent) under the MFA.

Table 5.11 Development of output in China between 2001 and 2005 (% changes)

	Base 2001-2005	Contribution of: China's accession: Accession total	Import tariffs & export subsidies	PSS and quality issues	Increased import quota	MFA phase-out	EU enlargement
Rice	11.5	1.1	0	1	0.1	-0.6	0.0
Wheat	8.1	1.1	0	1	0.1	-0.6	0.0
Cgrains	1.6	-4.3	-2.5	0.4	-2.2	-0.1	0.0
Oilseeds	5.3	-3.9	-4.5	0.4	0.2	-1.3	0.1
Sugar	4.9	-5.6	-5.7	0	0.1	-1.2	0.0
Pfibers	31.7	-8.8	0.9	-0.8	-8.9	8.7	-0.3
OthCrops	15.8	1.1	-0.1	1.1	0.1	-0.7	0.0
Cattle	25.9	0.4	0.3	-0.2	0.3	3.6	-0.1
Oanimalp	13.7	0	-0.3	0.1	0.2	-0.1	0.0
Milk	20.6	-0.3	-0.4	-0.1	0.2	0.3	-0.1
Fish	20.3	1.4	-0.1	1.4	0.1	-1	0.0
OthFood	22.8	3.6	-0.1	3.5	0.2	-1.7	0.0
Extract	13.6	-0.1	0	-0.1	0	-0.8	0.1
TexLea	41.8	0.7	0.9	-0.8	0.6	8.1	-0.2
LabintMan	28.2	0.6	0.9	-0.3	0	-2	0.1
CapintMan	23.6	-0.9	-0.5	-0.3	-0.1	-1.7	0.1
Services	24.9	-0.2	-0.1	-0.1	0	-0.1	0.0

General trends

The first column in Table 5.11 shows that the restructuring of the Chinese economy continues between 2001 and 2005. The manufacturing and service sectors grow faster than the agricultural sectors do. The driving factor behind this restructuring is the relatively low income elasticity for agricultural products. When income rises, people spend relatively more on services and on manufactured products than they do on agriculture products (Engel's Law). Exports could be a way around this tendency and an engine of growth. However, the domestic market remains the most important source of growth for almost all sectors (except for textiles and processed food; see Figure 5-1), because exports represent only a small proportion of output.

Growth rates in the textile and leather industries are especially high (41.8%), as they are in the related upstream cotton sectors (31.7%). The growth is relatively high also in the labor-intensive industries and, within agrifood, for the processed food products. The growth in primary crops is relatively minor. It seems that the Chinese economy restructures in line with comparative advantage. Relatively labor-intensive industries expand and land-intensive industries contract. Put in another way, sectors that already showed a comparative advantage in the past (high self-sufficiency ratios in Figure 5.1) belong to the product groups that expand relatively fast. Within agriculture, cotton, meat, milk, fish, horticulture, and processed food grow faster than primary commodities do.

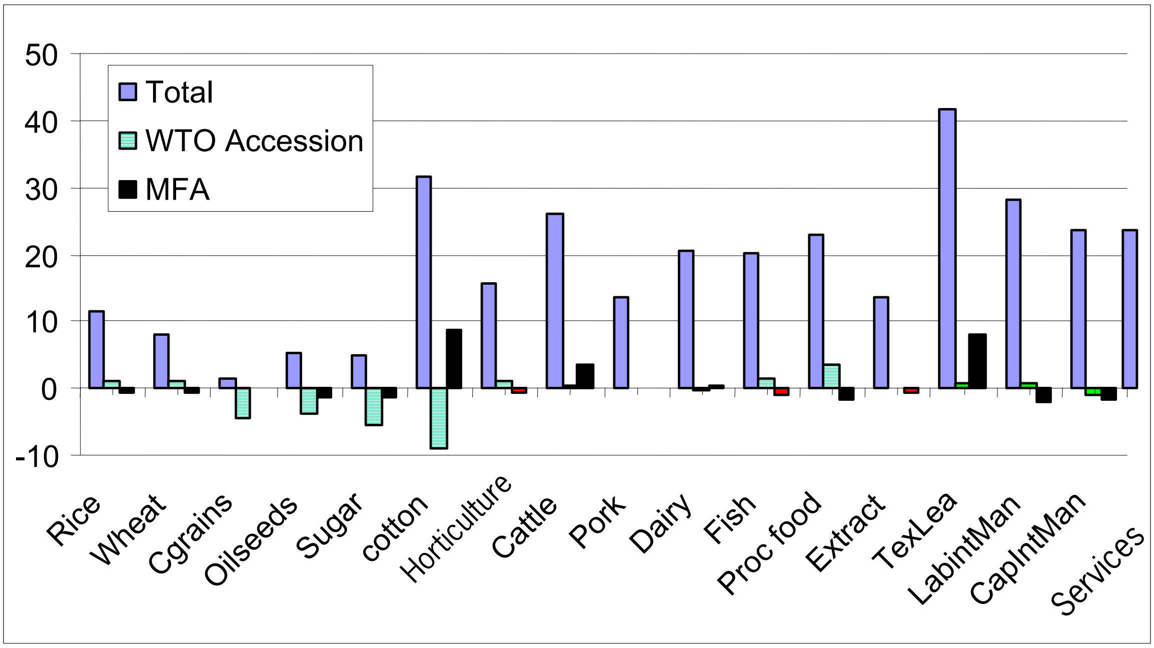


Figure 5.3 Production growth 2001-2005

WTO accession

The impact of accession on output changes in China is, in general, small (column 2 Table 5.11, or Figure 5.3). The exceptions are the negative impact in the cotton, oilseeds, coarse grains, and sugar sectors. The driving forces behind this negative output growth are that there are relatively high reductions in import tariffs or export subsidies in these sectors (see Figure 5.2). In addition, imports are relatively important (see low self-sufficiency ratio in Figure 5.1). Combined, these factors imply that import competition will be stronger as a result of accession, and that imports will partly replace domestic production (imports are given in Table 5.12). For cotton, it is especially the increase in the import quota that causes the negative result (column 5). The impact on the cattle sector is surprisingly positive despite the highest tariff cut in Figure 5.2. On the one hand, this is because imports are very small and the negative impact of the increase in imports on production is small, and on the other hand because exports increase due to better compliance with PSS and quality standards.

The WTO accession is positive for sectors that comply better with international PSS and quality standards (column 4). In general, the sector for which exports represent an important share of demand gain the most of the assumed 4% reduction in non-tariff barriers. The growth is therefore highest for the processed food sector (3.5%), and lower for the fish, other crop, and rice sectors. The growth is surprisingly positive for the wheat sector, which does not improve its quality. However, this is caused by an increase in demand from the downstream processed food sector. Accession is also positive for the textile and labor-intensive manufacturing sectors. This is not a result of better compliance with international standards, but of the general trend that an economy restructures according to comparative advantage when distortions within the economy are removed. As in many countries, in the past policies in China have introduced the highest distortions in sectors that have no comparative advantage.

Phasing out of the MFA and the enlargement of the EU
China has a comparative advantage in textiles and is already one of the world's most important exporters. However, its export expansion is limited by the MFA. The phasing out of the MFA is clearly important because it has a large positive output impact on the textile complex (column 6). As a result of the MFA phase-out, the textiles and leather industries, and the cotton sector, grow by almost 9%. Not surprisingly, the impact of EU enlargement on China is limited. There is a small negative output effect in the textile complex as a result of the trade diversion effect (Eastern European countries get free access to the EU15 markets, and vice versa).

Development of imports 2001-2005
Import growth is projected to be high in China between 2001 and 2005, especially for the agricultural sector and the extraction industry. A large part of the increase in imports is a result of WTO accession. This is in contrast to the development in output, where policy changes had only a minor impact. The growth in imports is closely related to the reduction of import tariffs resulting from accession and the expansion of import quotas (within TRQs). The highest growth of imports is in the cattle sector, where the reduction in import tariff was highest (see Figure 5.2). The second highest reduction of import tariffs was in the coarse grains sector, but the import growth in this sector is limited by the annual growth of the TRQ, which becomes binding. The high import growth in the extraction industry is caused not by one of the policy changes, but by the high growth rate of the overall

economy. Imports increase quickly due to limited resources (oil, gas, etc.) within China and a huge demand to fuel the overall economic growth.

Table 5.12 Change in import quantity of China (% changes, 2001-2005)

	Base 2001-2005	Contribution of: China's accession				MFA phase-out	EU enlargement
		Total	Import tariffs & export subsidies	PSS and quality issues	Increased import quota		
Rice	40	9	4	5	0	2	0
Wheat	28	0	-3	4	-1	3	0
Cgrains	40	40	0	0	40	0	0
Oilseeds	35	14	13	1	0	2	0
Sugar	42	19	18	1	0	2	0
Pfibers	56	56	0	0	56	0	0
OthCrop	58	24	21	3	0	9	0
Cattle	157	104	102	3	-1	15	-1
Oanimalp	48	18	17	3	-2	5	0
Milk	41	17	16	2	-1	5	0
Fish	21	5	2	3	0	3	-1
OthFood	52	35	32	3	0	4	0
Extract	53	-2	-1	-1	0	-3	0
TexLea	42	28	28	0	0	9	0
LabintMan	9	4	4	0	0	3	0
CapintMan	20	7	7	0	0	1	0
Services	28	15	15	0	0	2	0

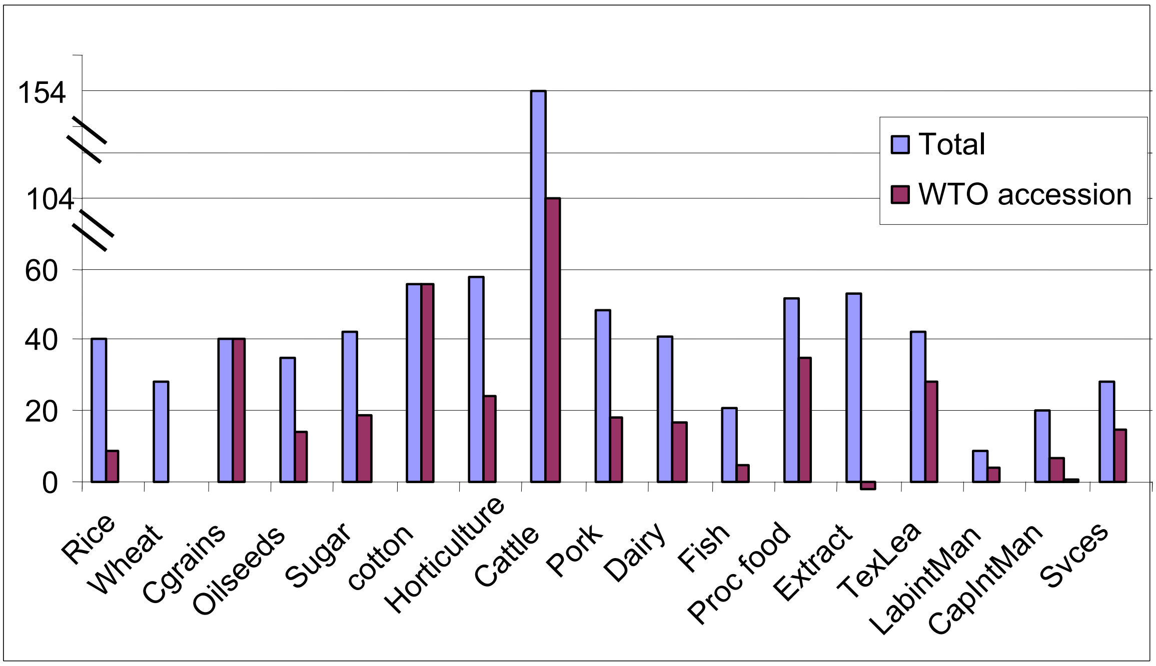


Figure 5.4 Import growth resulting from WTO access import concessions, 2001-2005

Table 5.13 Change in export quantity in China (% changes, 2001-2005)

	Base 2001-2005	Contribution of: China's accession: Total	Import tariffs & export subsidies	PSS and quality issues	Increased import quota	MFA phase-out	EU Enlargement
Rice	-1	22	4	17	1	-3	-2
Wheat	-31	0	4	-5	1	-5	-1
Cgrains	-65	-54	-53	-3	2	-3	0
Oilseeds	-6	4	7	-3	0	-4	0
Sugar	0	5	7	-3	1	-3	-1
Pfibers	-48	-19	-25	-2	8	-9	0
OthCrop	22	17	4	12	1	-5	0
Cattle	16	22	4	16	2	-9	-1
Oanimalp	15	28	5	20	3	-7	1
Milk	14	2	4	-3	1	-6	0
Fish	28	20	4	16	0	-5	0
OthFood	34	22	5	16	1	-6	0
Extract	-36	3	3	0	0	2	0
TexLea	72	10	10	-1	1	20	-1
LabintMan	66	11	13	-2	0	-11	0
CapIntMan	31	6	7	-1	0	-5	0
Services	40	5	6	-1	0	-5	1

Change in exports between 2001 and 2005
The pattern of exports changes a lot between 2001 and 2005. The exports of all land-intensive crops and of the extraction industries decline, while textiles and the labor-intensive industries obtain very high growth rates. This is in line with the patterns of comparative advantage. The decline is especially large in the coarse grains sector, where export subsidies are reduced by 31%, and in the cotton sector, where export subsidies are reduced by 10%. The reduction of export subsidies is the major driving force within coarse grains. For cotton, the increased domestic demand resulting from an increase in the textile sector is another explanatory factor. The reduction in exports of the extraction industry is caused by increased domestic demand.

The moderate export growth of 15-20% in the meat sectors can largely be explained by better compliance with international quality standards. In the other crop (horticulture), fish, and processed food sectors this quality effect is only part of the story; the other part is the better exploitation of comparative advantage. The growth in exports is very high in the other sectors with a comparative advantage, namely textiles (72%) and labor-intensive industries (66%). The phasing out of the MFA contributes 20% to the total growth in textiles; this leaves a large part to be explained by better exploitation of the comparative advantage.

5.5 Prospects for Chinese Food Economy, 2005-2020

In this section we describe some characteristics of the baseline projection between 2001 and 2020. Given the base information for 2001 and all the macro and policy assumptions, we project the model in four steps to 2020. The 2001-2005 step was discussed at length in the previous section.

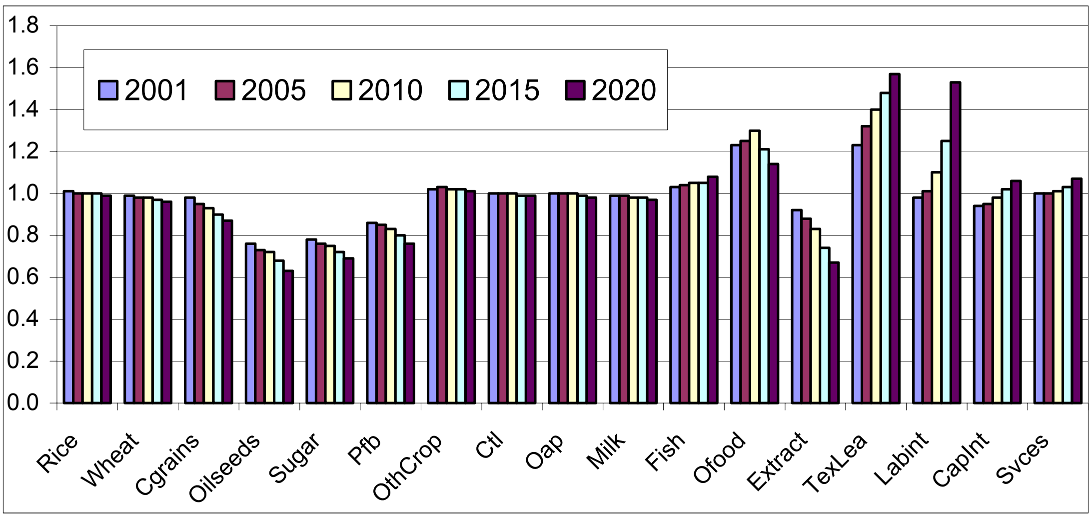


Figure 5.5 Development of self-sufficiency ratios, 2001-2020
Source: GTAP v5, calculations LEI.
Note: self-sufficiency is defined as the domestic production:domestic absorption ratio.

Self-sufficiency ratios 2001-2020
Self-sufficiency is an important indicator of developments within the economy. Figure 5.5 clearly demonstrates that most of the trends that we observed in 2001-2005 continue in the period to 2020. China will rely more and more on imports for its land-intensive products and its extraction industry. Among the land-intensive products, this is especially true for oilseeds, sugar, cotton, and (to a lesser extent) coarse grains.

On the other hand, the textile-leather complex and the labor-intensive industries become increasingly net exporters. The increase in the self-sufficiency ratio for the labor-intensive industries is extraordinary: In 2001, the ratio was just below 1 and in 2020 the projection shows that it increases to 1.5. The incremental increase in the index gets larger as time progresses. The story is different for the processed food sector. In 2001, it – together with textiles - was one of the sectors with a comparative advantage and a high self-sufficiency ratio. This ratio increases until 2010 and then declines, because labor resources are moving to the more profitable textiles and labor-intensive industries. Therefore, China's rising stars in terms of comparative advantage are the labor-intensive industries, and the processed food sector is losing share on export markets.

All the sectors in the middle ground stay close to a self-sufficiency level of unity. It will take a while before international trade becomes very important for a sector. In general, the self-sufficiency ratios for all food products (except fish) decline in the long run. China will become more dependent on the world markets for its food products. The industrial and services sectors will slightly increase their self-sufficiency ratio.

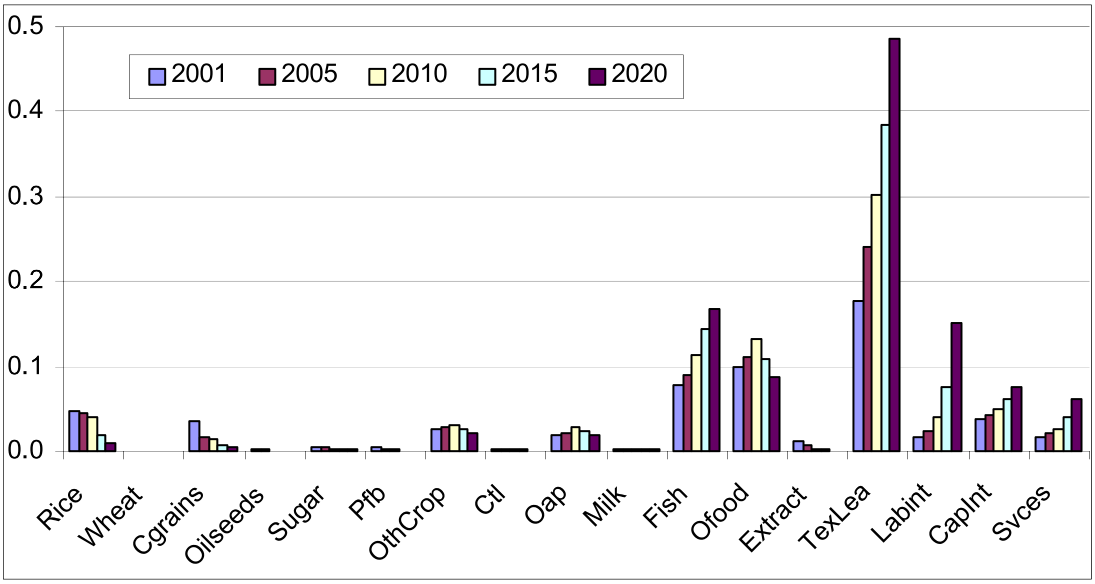


Figure 5.6 Development of China's share in world exports (2001-2020)

Developments of exports 2001-2020
The world export share of China moves with its comparative advantage (Figure 5.6). A first glance at this picture shows that even in 2020, the world market shares of China are low for most of the agricultural and extraction products. The world market shares decline

for these products (the exception within agriculture is fish). The export share for services and for capital-intensive manufacturing is also low (about 5%), but increases slightly over time. The export share of the labor-intensive industries increases rapidly and will be about 15% in 2020. For textiles, China will become the world's major exporter: Its export share is projected to increase from about 20% in 2001 to almost 50% in 2020.

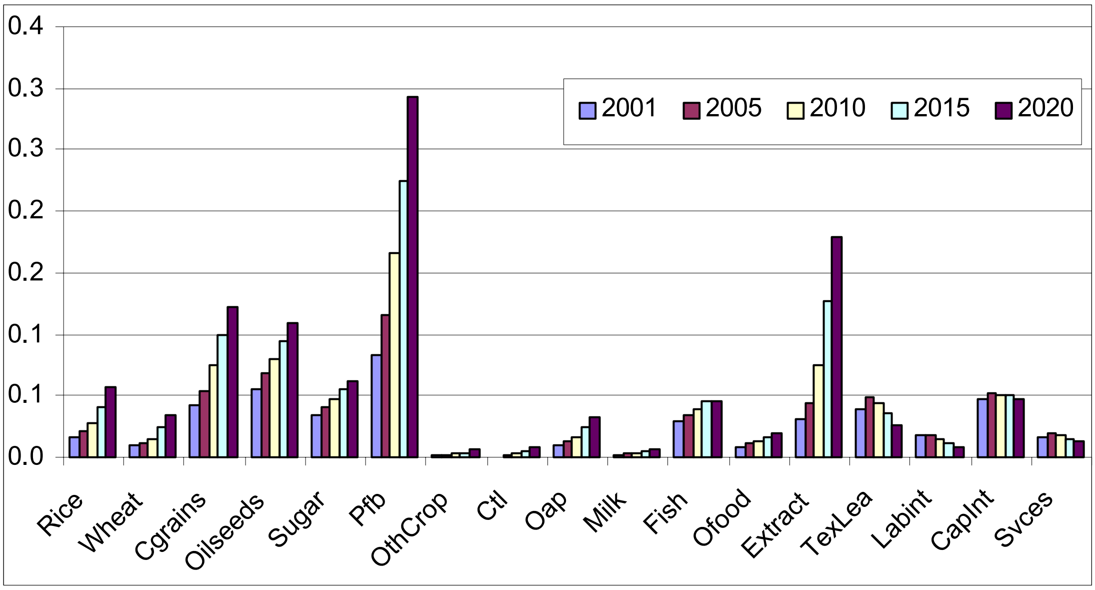


Figure 5.7 Development of China's share in world imports (2001-2020)

Developments of imports 2001-2020

Will China deprive the world of its food, as Lester Brown suggested? Our projection results for China's world import share show that this will probably not be the case (Figure 5.7). The world import share in land-intensive products increases for all agricultural products. However, for almost all agricultural, manufacturing, and services products, the world market share is still below 5% in 2020. The exceptions are coarse grains and oilseeds, where the import share is projected to be about 10% in 2020. However, this is not a very large share, although the growth is impressive. The world import share is high and increases quickly for cotton and the extraction industries. The cotton is imported to be used in the expanding textile industry, and the extraction products (oil) are used in the expanding manufacturing sectors as a result of high economic growth.

Development of net trade 2001-2020

Figure 5.8 shows the development of net trade in China. It shows where China is a major player in the world market, whether it is a net exporter or importer, and whether this changes over time. China is a relatively large player in the textile complex (exporter of textile and leather products, and importer of cotton) and the extraction industries. The labor-intensive manufacturing sectors develop their role in world markets quickly. The role in all the other sectors is limited.

We can conclude that high-income growth rates and WTO accession increase China's role in world trade, although for most products its world market share is less than 10% in 2020 (except for the textile complex and the extraction industries).

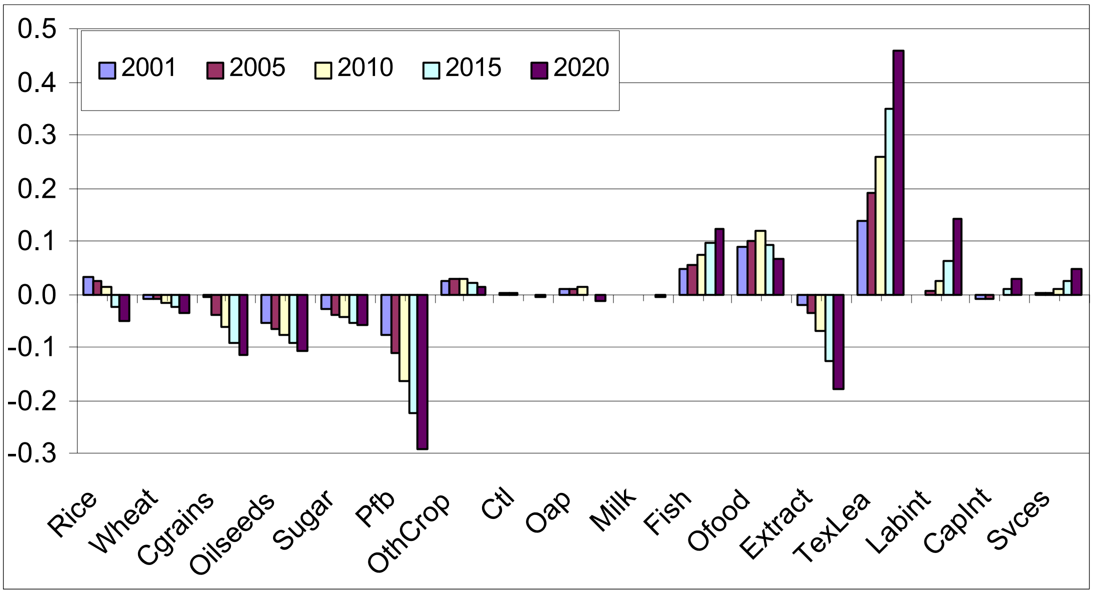


Figure 5.8 Development of 'world export share minus world import share' for China, 2001-2020

5.6 China and the rest of the world

As a result of China's high economic growth rate, its share in global GDP in constant prices will gradually increase from 4% in 2001 to 7% in 2020. In current prices, this increase will be a little less, as China specializes in products with relatively decreasing world prices. Notwithstanding its rising share in world income, China's average income per capita in 2020 will still be below world average. Not only China's share but also that of the Southeast Asian countries in world output will increase. On the other hand, the share of the developed countries shows a decline. These changes are mainly determined by the assumptions on economic growth (Table 5.5).

For almost all product groups, China's share in world output will increase, particularly its share in plant fibers (cotton) and textiles. Only for oilseeds, sugar, and dairy will its share in world output not change. On the other hand, the share in world output of plant fibers of the NAFTA countries and other non-Asian countries will decrease. For textiles, all developed countries will show an important decline in their share in world output.

Table 5.14 Share in world export market (%) a)

	China		Jap-Kor		SEA		NAFTA		EU	
	2001	2010	2001	2010	2001	2010	2001	2010	2001	2010
Rice	8	7	2	2	18	19	21	23	5	7
Cgrains	5	3	0	0	0	0	66	65	9	12
OthCrop	4	5	1	1	6	4	16	17	10	13
Oanimalp	4	6	1	1	3	2	28	27	33	37
Fish	15	23	4	9	10	5	10	8	11	18
OthFood	17	23	3	3	7	6	16	17	29	28
TexLea	26	39	10	6	10	10	5	5	13	8
LabintMan	3	8	35	27	5	5	20	28	24	20
CapintMan	6	8	25	21	9	10	17	20	23	21
Services	2	3	12	9	10	10	25	32	24	20
Total	6	9	19	15	9	9	18	22	21	19

a) World exports excluding intra-regional trade. Products/product groups with an export share of 2% or more for China in 2001 and countries/country groups with a total share in world exports of 9% or more in 2001 and excluding the RoW category (rest of world).

China's role in world trade increases as a result of its high rate of economic growth. China's share in world export of products and services (excluding intra trade) will increase gradually from 6% in 2001 to 9% in 2010 (Table 5.14). Its share in world imports (excluding intra trade) will increase slightly, from 5% in 2001 to 6% in 2010 (Table 5.15).

China's world export market share in textiles, fish, processed food, and labor-intensive industrial products increases as a result of its comparative advantage in these products. For Japan-Korea and the EU, this will result in an important decrease in export share of textile and labor-intensive industrial products. For land-intensive products, China's share in world export decreases.

In world imports, China will increase in particular its share in plant fibers (cotton) and oil. The increase in the import of plant fibers is driven by the strong growth of China's textile industry. China's import shares in fish and land-intensive products will also grow, but to a lesser extent. Also the Southeast Asian countries will increase their share in world imports of plant fibers. On the other hand, Japan-Korea and the EU will lose import market share for plant fibers. These developments are strongly related to the reallocation of the textile industry.

Table 5.15 Share in world import market (%) a)

	China		Jap-Kor		SEA		NAFTA		EU	
	2001	2010	2001	2010	2001	2010	2001	2010	2001	2010
Rice	3	5	8	7	4	4	8	7	17	11
Cgrains	6	9	41	37	6	8	1	1	6	4
OthCrop	0	0	11	9	5	8	20	20	42	34
Oanimalp	2	3	27	34	5	7	6	6	17	12
Fish	5	8	35	27	4	10	12	14	23	13
OthFood	1	2	21	21	7	8	18	15	20	18
TexLea	6	6	9	9	4	4	4	27	28	31
LabintMan	4	3	8	8	7	7	24	16	24	28
CapintMan	7	8	8	8	10	11	22	19	22	22
Services	2	2	10	10	5	6	21	16	37	38
Total	5	6	11	10	8	8	22	18	27	27

a) Excluding intra-regional trade. Products/product groups with an important share of 2% or more for China in 2001 and countries/country groups with a total share in world import of 4% in 2001 and excluding the RoW category (rest of world).

5.7 Chinese trade relation with the EU

5.7.1 Introduction

As far as trade is concerned, China is important to the EU in three respects: Firstly, the development of China's exports and imports may have an important impact on world market prices; secondly, the EU may meet increased competition from China on its export markets; and thirdly, the developments in China may have a direct impact on the EU's trade with China.

In 5.5.2 was concluded that China's share on the world's import and export market will increase for many products. However, for most products these shares will remain limited. The only exceptions are oil and cotton for imports and textile for exports. On the basis of these shares, the impact on world market prices will be limited. This is an important general conclusion for the EU's world market trade.

It was also concluded in 5.5.2 that China will export, though to a limited extent, such labor-intensive agricultural products as horticultural products (vegetables), pork and poultry meat, fish, and processed food. With some of these products, the EU will meet China on its export markets. It might be expected that some of these markets will be the developed countries in East Asia, such as Japan and Korea. However, it will be a challenge for China to improve the quality of its products in order to meet high quality standards in these countries. In this section, we focus on direct trade between China and the EU.

5.7.2 Bilateral trade in 2001

The EU is an important export destination for Chinese exports: More than a fifth of all Chinese exports go to the EU (Table 5.16). Half of these exports are products from the capital-intensive manufacturing sector, mainly electronics and machinery products. Textiles (25%) and services (20%) are two other important Chinese export products to the EU. Within agriculture, processed food (Ofood) and to a lesser extent horticulture (OthCrop) and pork-poultry are the main export products. For especially services (50%) and the industrial sectors (23%), the EU is an extra important export destination, while for agricultural products it is less important. These Chinese imports account for only 5% of extra-EU imports. Chinese imports are relatively important for textiles (16%) and processed food (9%).

Table 5.16 Bilateral trade relation between China and the EU in 2001

	EU exports to China			Chinese exports to EU		
	Value (USD million)	Share in EU exports by commodity (%)	Share in extra-EU exports (%)	Value (USD million)	Share in Chinese exports by commodity (%)	Share in extra-EU imports (%)
Rice	0	0.0	0.0	36	11.1	5.6
Wheat	4	0.1	0.3	2	37.4	0.3
Cgrains	34	1.0	3.5	7	0.7	1.1
Oilseeds	308	2.5	7.1	7	10.3	0.1
Sugar	11	0.3	0.6	2	4.1	0.2
Pfibers	2	0.3	0.4	1	1.5	0.0
OthCrop	3	0.0	0.1	238	10.6	1.1
Cattle	1	0.0	0.0	5	9.4	0.2
Oanimalp	72	0.3	1.0	125	13.5	2.8
Milk	27	0.1	0.4	8	13.5	0.7
Fish	91	2.5	14.9	38	4.7	2.7
OthFood	367	0.4	1.2	1817	10.5	8.9
Extract	128	0.5	1.6	151	3.5	0.2
TexLea	650	0.5	1.4	14184	18.8	16.1
LabintMan	3324	0.8	2.4	4125	23.1	3.0
CapintMan	17865	1.5	3.6	28008	23.5	6.3
Services	7500	1.9	3.3	10471	50.3	3.0
Total	30386	1.3	3.1	59225	22.7	5.0

China is a less important export destination for the EU: Only 3% of all extra-EU exports go to China. Again the very aggregated capital-intensive manufacturing sector accounts for over half of the exports. Trade in services accounts for a quarter of total trade. China is a minor export destination for EU agricultural products. Only for fish and oilseeds is China a relatively important export destination. In total, China has a large trade surplus with the EU: The value of exports to the EU is twice the value of Chinese imports from the EU.

5.7.3 Baseline projection of development of bilateral trade 2001-2020

Table 5.17 shows the export growth rates of EU exports to China for the main export products. Exports of capital-intensive manufacturing increase by 14% in 2001-2005. Half of this can be attributed to China's accession to the WTO, which provides trade opportunities for the EU. Service exports grow by 22% in the same period; 14% of this can be attributed to China's accession. Exports growth rates for agriculture are higher. Export growth in processed food is over 90%. Lower import tariffs resulting from WTO accession contribute 77%. China's accession also opens possibilities for coarse grains (44%) as a result of the expansion of the import quota, and half of the growth in oilseeds (45%) can be attributed to China's accession. Also the exports of pork and poultry (Oanimal p.) might increase by 63%. In this case, China's accession contributes 23%, while macroeconomic growth and especially increased consumption contribute the remainder (40%).

Table 5.17 Development of EU exports to China between 2001 and 2020 (quantity, % changes)

	Value 2001 (USD million)	Base 2001-2005	2005-2010	2010-2015	2015-2020
CapintMan	17865	14	4	3	-2
Services	7500	22	-1	-8	-16
LabintMan	3324	-2	-15	-19	-26
TexLea	650	25	-9	-15	-24
OthFood	367	94	23	38	36
Oilseeds	308	45	32	59	52
Extract	128	83	128	159	113
Fish	91	20	20	42	32
Oanimalp	72	63	49	106	86
Cgrains	34	44	49	102	93
Milk	27	28	16	14	5

Section 5.5 shows that for 2005-2020, China might specialize in labor-intensive industrial products and services, and it might import especially land-intensive products (see Figure 5.7). These trends are reflected in the developments of EU exports to China. Exports of the EU in labor-intensive products will decline, while exports of agricultural products and extraction industries will continue to grow.

Table 5.18 shows the development of Chinese exports to the EU between 2001 and 2020. The developments are in general the opposite of the developments described above. Chinese exports of labor-intensive industries, textiles, and services will continue to grow. Growth of textiles is the highest in the first period (105%). Half of this growth can be explained by the phasing out of the MFA. After 2005, textile exports will continue to grow, but the growth in labor-intensive manufacturing and services will become higher because the products provide better opportunities. The prospects for agricultural exports are less in the long run. Better opportunities in industries and services shift resources to these sectors and China will become a net importer of most agricultural products.

Table 5.18 *Development of Chinese exports to the EU between 2001 and 2020 (quantity, % changes)*

	Value 2001 (USD million)	Base 2001-2005	2005-2010	2010-2015	2015-2020
CapintMan	28008	32	40	38	42
TexLea	14184	105	57	51	53
Services	10471	39	62	76	88
LabintMan	4125	72	111	127	147
Othfood	1817	35	45	-25	-28
OthCrop	238	10	-8	-50	-50
Extract	151	-39	-58	-62	-46
Oanimal p.	125	0	48	-39	-34
Fish	38	32	48	15	10
Rice	36	-15	-22	-71	-73

5.8 Concluding remarks

China's production and trade in agricultural products will undergo an important increase in 2001-2020. Part of this development can be attributed to China's accession to the WTO and the phasing out of the MFA. Both accession and the phasing out of the MFA will allow China to exploit more fully its comparative advantage.

However, the impact of China's accession will be limited because many policy changes directed to more international trade took place during the reform period in the run-up to accession. China's accession will have a negative production impact in land-intensive sectors, such as coarse grains, oilseeds, sugar, and cotton. Positive production impacts, by increasing exports, are to be expected in food processing, horticulture, fish, and labor-intensive industries, such as the textile industry. Positive impacts in agriculture will to a large extent be a result of the assumed better compliance with PSS. This underlines the importance for China to strive to better comply with these standards.

China's accession to the WTO will lead to a large increase in imports, especially those of cattle, cotton (for the fast growing textile industry), coarse grains, and processed food. The production impact of these imports will be limited, however, as in most sectors imports are still relatively small. The exceptions to this are the land-intensive sectors mentioned above: For these products, accession will have, as said, a clear negative effect on production growth.

The phasing out of the MFA will have a positive impact on the labor-intensive textile/cotton complex: The export of textiles will show strong growth, and the production of textile and cotton will increase. This will have limited negative production effects on some land-intensive products as the production of cotton becomes more competitive.

In the longer term, self-sufficiency in almost all agricultural products will decline. For most of China's agricultural export products, the country's share in world exports will be less than 10%. The only exception will be fish and temporarily processed food. For the labor-intensive industries, and particularly the textile industry, the position will be different: The Chinese share in world textile exports will grow to over 40%.

On the import side, China's share on world markets will grow but remain below 10%, with the exception of cotton. In the longer term, this limit will be exceeded somewhat for coarse grains and oilseeds. For cotton, China's share in world imports will grow to over 30%. For non-agricultural products, China's share on world import markets for oil will grow considerably. In the longer term, the share in oil will reach over 20%.

China's role in world trade will increase further in the course of time. This will be a result of China's high income-growth rates and accession to the WTO. However, for most agricultural products, the world market share will be less than 10%. In other words, China will continue to be able to feed its population, also in the longer term. At the same time, China will make use of its competitive advantages, resulting in changes in the composition of production without having big consequences for the development of world markets for agricultural products. The only exception to this will be cotton.

The EU is an important export market for China; however, for agricultural and food products China's exports to the EU are limited. High growth rates of China's export to the EU are foreseen. For agricultural and food products, growth will be much lower and for some products will even become negative. Higher growth rates are expected for the EU export of agricultural and food products to China. Both the accession to the WTO and macro-economic growth are major explanatory factors for this development.

Chapter 6 Beyond the Uruguay Round: An evaluation of Doha Development Round proposals

6.1 Introduction

China has become a member of the WTO in November 2001 and has committed itself to binding its trade policies and domestic policies in many areas of the economy. See also chapter 2 and chapter 4. As part of its WTO commitments China has also agreed to substantially reduce barriers to international trade. Given these recent developments, what can China expect from the new Doha development round?

To address this question, this study provides insights in the economic effects of the new WTO Doha round for China on basis of the policy proposals of the major participants in the negotiations. It places the analysis for China against the background of worldwide effects. The study provides insights into the nature and magnitude of the impacts of the WTO Doha Round for international trade and the resulting welfare improvements. The study focuses on agricultural liberalization, but also includes liberalization in industrial tariffs and liberalization in services trade. It uses the baseline developed in chapter 4 as the benchmark against which the effects of a new WTO round are assessed.

After the failed attempt in Seattle in late 1999, the Ministerial Meeting of the World Trade Organization (WTO) in Doha, in November 2001 launched the agenda for a new comprehensive round of multilateral trade negotiations. The ministerial declaration (WTO, 2001) emphasizes that this new round provides a major opportunity for developing countries. Consequently the agenda for the new WTO round has been coined the 'Doha Development Agenda'.

The Doha ministerial declaration sets down an ambitious agenda, with a number of milestones. The agenda for the agricultural negotiations is especially tight, with frequent meetings and deadlines to be met. For example, in the last week of March 2003, an agreement was scheduled on so called 'Formulas and other 'modalities' for countries' commitments on agriculture'. This meeting has not resulted in an agreement, despite the efforts of the chairman, Mr. Stuart Harbinson, to draft a compromise proposal that integrates the main elements of the proposals that are discussed in this chapter.January 1st 2005 is the deadline for concluding negotiations as part of the Doha agenda's single agricultural policy under-taking.

Many countries and coalitions of countries have tabled modalities proposals for agriculture in the run-up to the Cancun ministerial meeting of September 2003. As this meeting was also not successful it will become more difficult to conclude the negotiations at the scheduled time. This study provides a partial assessment of three of these proposals, the USA proposal, the CAIRNS group proposal, and the proposal put forward by the European Union (EU). Together they give a picture in particular for China of the implications of possible comes out of the negotiations.

6.2 The Uruguay Round Agreement

The Doha negotiations start where the Uruguay round finished. The most important item on the agenda is market access.

Tariff negotiations in the GATT/WTO have generally been based on tariff bindings, or schedules of concessions tabled under GATT rules. A bound tariff is the maximum allowed tariff for the import of a product. The coverage and level of these bindings is an important element of the initial conditions for the negotiations. Industrial tariffs in the OECD are generally bound. As a result of the Uruguay Round the increase of the coverage for industrial products in developing countries was more than four-fold. Industrial tariffs in Latin America are nowadays generally bound. However, many tariffs in Asian and African economies remain unbound. (Abreu 1996). Besides, for almost all developing countries, existing bindings are, on average, well above applied rates. This reflects a combination of relatively high initial bindings, and the subsequent wave of reductions in applied rates. (See Blackhurst et al 1996, Francois 2001).

The gap between bound rates and current applied rates is called a '*binding overhang*.' This overhang is typically very small in OECD countries, but for developing countries, the binding overhang is large enough that reductions in the range of 50% are necessary to force reductions in average applied rates for countries like Brazil, see Francois et al. (2003). For many countries, even this will have little or no effect, as tariffs are largely unbound. For example, one-third of India's manufacturing tariffs and 90 percent of Sri Lanka's tariffs are unbound. Of course, this limits severely the negotiating leverage of developing countries in the WTO. This is also why the debate of using bound, applied, or 'historic' rates as a starting point is important.

A major accomplishment of the Uruguay round was the embedding of agriculture into the rules-based system of the GATT. This implies that since the Uruguay Round Agreement on Agriclulture (URAA), WTO members face rules that discipline their leeway on agricultural policies in the areas market access, export subsidies and domestic support. As in the case of industrial tariffs, the stage for any future agriculture negotiation was also set by the Uruguay Round outcome. The most important results of this agreement are summarised in table 6.1.

One key difference from industrial products is that essentially all agricultural tariffs are bound. The next round of agricultural negotiations was already scheduled in the URAA as a 'built-in agenda', while the negotiating parameters (tariffs, tariff-rate-quota levels, subsidy commitments, etc.) must also be viewed in the context of the schedules of URAA commitments.

The system that has emerged is complex and similar to arrangements in the textile and clothing sectors, featuring a mix of bilaterally allocated tariff-rate-quotas (TRQs), with associated quota rents and tariffs. Viewed in conjunction with industrial protection, the basic pattern is that the industrial countries protect agriculture and processed food, while protection in developing countries is more balanced (though also higher overall) in its focus on food and non-food manufactured goods.

Table 6.1 Pillars of the URAA, 1994

Commitment	Developed countries (1995-2000)	Developing countries (1995-2004)
Market access		
- Average tariff reduction	-36%	-24%
- Minimal tariff reduction	-15%	-10%
- Expanding tariff rate quota	From 3% to 5%	
Export support		
- Budget of export support	-36%	-24%
- Volume of export support	-21%	-14%
Domestic support		
- Amber box (AMS)	-20%	-13%

The URAA had a stated goal of no backsliding and modest liberalization. However, negotiating parties (generally the relevant agriculture ministries) gave considerable leeway to themselves with regard to selection of the appropriate reference period from which to measure export subsidy reductions and other reductions. In addition, the move to a price-based system for protection has, in many cases, been subsumed into an effective adoption of explicit quotas.

The disciplines on domestic subsidies have also been weakened by a relatively soft definition of the AMS vis-à-vis individual subsidies and the scope for reallocation of expenditures within the AMS. (See Tangermann 1998 for discussion.) Despite the goals of subsidy reductions and a shift toward price-based border measures, one of the more striking features of the regime that has actually emerged is the prominent role that quantity measures have taken in the new architecture. Basically, the agricultural trading system is complicated and still evolving. Policy measurement in this area has converged on the use of price-based measurements that emphasize the tax/subsidy equivalent of policy. (As this approach reflects available data, this is the approach we employ in this study as well.)

6.2.1 The proposals compared

As the Doha round has unfolded between late 2001 and early 2003, the most important players in the negotiations were the USA, the EU and the CAIRNS group. In this paragraph we compare the proposals for agricultural liberalisation of these participants in the negotiations. Tables 6.2, 6.3 and 6.4 summarize the main elements of these proposals.[1]

The USA proposal is perhaps the most straightforward of the three.
Three features distinguish it from the other 2 proposals discussed. A first distinction is that all reductions have to be from *applied* levels of policy measures, as opposed to bound rates, which resulted from the URAA. A second one is that its main trust is the harmonization of protection levels across sectors and countries. This also implies the elimination of special safeguards and the limitation of special and differential treatment of developing countries. A third distinction is that it consists of two stages, with the 1st stage paving the ground for the 2nd stage of complete liberalisation.

[1] The text of these proposals can be obtained from the WTO website at www.wto.org.

To increase *market access* the USA proposes a Swiss formula reduction of tariffs for all countries, such that the maximum applied tariff will be 25%. It wants to expand tariff rate quota and like the two other proposals, it wants to improve TRQ management. The features of the Swiss formula are highlighted in the box.

In the area of *export competition* it wants to eliminate export subsidies, and puts discussions on disciplines on export taxes and state trading enterprises (STEs) on the agenda.

BOX: Different Types of Tariff Reduction (Swiss Formula)

A widely used form to reduce tariffs in trade negotiation rounds is a proportional reduction:

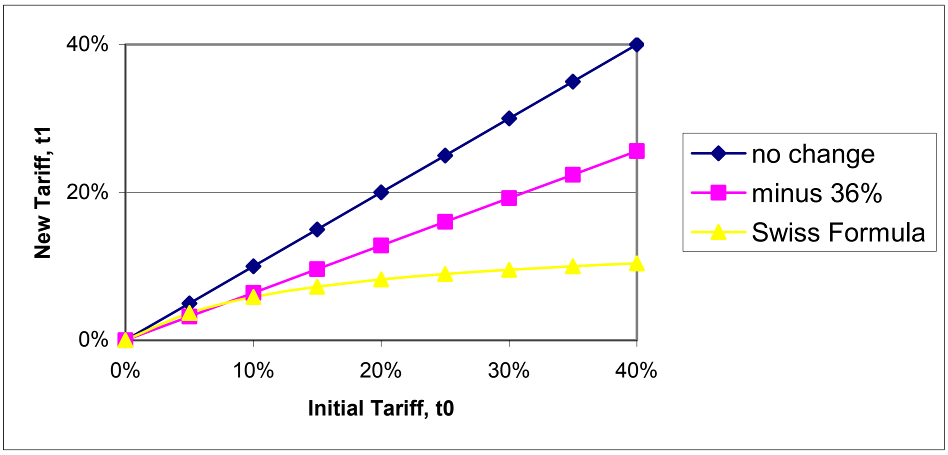
$$t_1 = k * t_0$$

The initial tariff (t_0) is multiplied with a constant factor k, whose value is between 0 and 1. In the URAA an average tariff reduction of 36 % was decided, with a minimum of **???**% per tariff line. Hence, the average value of k was 0.64, but it could differ per tariff line. A mayor drawback of proportional tariff reduction is that high tariffs are not reduced substantially. In the Tokyo-Round (1973-1979) of the WTO several procedures were discussed in order to reduce high tariffs more drastically. The negotiations resulted in the so-called Swiss Formula:

$$t_1 = \frac{a * t_0}{a + t_0}$$

a is a positive parameter. In the Tokyo Round a value of 0.14 was chosen. *a* is also the limit for t_1 as t_0 approaches infinity. This implies that no tariff would remain above *a* applying the Swiss Formula. Following Francois and Martin (2002) the Swiss formula has a number of desirable features. It is simple, with a single application of the formula being sufficient to bring about the required transformation of tariff rates. It is particularly effective in reducing peak tariffs. And, finally, it has the desirable feature of reducing higher tariff rates by more, in both absolute and relative terms, than lower tariff rates.

Different Tariff Reductions



The figure above depicts both types of tariff reduction. While the horizontal axis presents the initial tariff, t_0, and the new reduced tariff, t_1, is shown on the vertical axis. A linear reduction of 36 % results in a straight line, which is intersected by the Swiss Formula reduction at a certain point (in this case the intersection is at an initial tariff of 7.9%. The figure shows that a) high tariffs are reduced more under the Swiss Formula, and (b) small tariffs are reduced less by the formula compared to a linear reduction.

In the area of *domestic support*, the USA wants to eliminate the so-called blue box, which contains domestic subsidies exempt from reductions commitments under the URAA. It wants to limit the aggregate measurement of support (AMS) to 5% of the value of domestic production, while maintaining 'de minimis' exemptions for OECD countries. Special and differential treatment for developing countries is to be limited according to the USA proposal.

The proposal of the CAIRNS group[1], an association of major agricultural exporting countries, is similar to the USA proposal in the demands for market access in OECD countries, i.e. a Swiss formula reduction of tariffs and expansions of TRQs to increase *market access*. Unlike the USA proposal, the CAIRNS proposal mentions final URAA *bound rates* as the basis for discussions on further reductions. For OECD countries, the CAIRNS proposal calls for elimination of *export subsidies*, and like the USA proposal it wants as far as *domestic support* concerns to eliminate the blue box. A distinguishing feature of the proposal is its demand for a 50% down payment of reductions in tariffs and domestic support by OECD countries in the first implementation year. That is, OECD countries should avoid back loading of commitments by acting already in the first year of implementation.

However, unlike the USA proposal the CAIRNS proposal specifies more limited reductions of tariffs for developing countries, as it is recognizing the difficulty for developing countries to reduce the sometimes extremely high tariffs (e.g. above 250%) to just 25%. The special and differential (S&D) treatment for developing countries, and especially LDCs, is mentioned in all areas of discussion, not only for market access but also for export competition and domestic support.

The proposal of the European Union looks like a repetition of the URAA outcomes, except for the fact that proposal contains numerous exceptions for developing countries. For example, the OECD countries are asked with regard to *market access* to reduce their bound tariffs on average by 36% (with an minimum of 15% per tariff line), but LDCs would be completely exempted from such reduction commitments. Also, the EU proposes unrestricted access, i.e. tariff- and quota free, to OECD markets by LDCs. The proposal also addresses tariff escalations in OECD markets and improved management of TRQs.

The formulation of 'average reductions' in tariffs deserves some attention. An average reduction percentage of 36% can in practice be achieved by reducing - or even eliminating - very low tariffs of, say, 2% to 1% while keeping high tariffs largely intact. In contrast, *a reduction of the average* provides much more scope to reducing tariffs across the board.

In terms of *export competition*, the EU proposes a 45% reduction of the budget expenditures on export subsidies, and a complete elimination of subsidies for some key products such as wheat and oilseeds. The EU also calls for disciplines on export credits, food aid and STEs.

In the area of *domestic support*, the EU proposes a reduction of AMS by 55% from final bound rates for OECD countries, and elimination of 'de minimis' exemptions for OECD countries. The EU wants to maintain the blue box.

[1] Argentina, Australia, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Fiji, Guatemala, Indonesia, Malaysia, New Zealand, Paraguay, Philippines, South Africa, Thailand and Uruguay

Table 6.2 Proposals to improve market access

	USA	CAIRNS	EU
Tariffs, OECD	Swiss formula, max tariff = 25%	Swiss formula, max tariff = 25%	-36% average reduction -100% on LDC imports
Tariffs, LDC	Swiss formula, max tariff = 25%	3 types of reductions, allowing import protection (max tariff = 125%)	No change
Base	Applied rates	Final bound rates URAA	Final bound rates URAA
Other	TRQ management TRQ volumes + 20% Eliminate special safeguard	TRQ volume + 20 % (LDC+14%) of domestic consumption 50% down payment of total reduction in first year	TRQ management Tariff escalation

Table 6.3 Proposals to improve export competition

	USA	CAIRNS	EU
Export subsidies, OECD	Elimination	Elimination	-45% value 'Substantial' reductions volume Eliminate for key products (wheat, oilseeds)
Export subsidies, LDC	n.a.	S&D treatment	n.a.
Base	Applied rates	Final bound rates URAA	Final bound rates URAA
Other	Disciplines on: Export credits, export taxes, STEs		Disciplines on export credits, food aid, STEs

Table 6.4 Proposals to reduce domestic support

	USA	CAIRNS	EU
OECD	AMS ceiling <= 5% of value of domestic production	Formula reduction for AMS	AMS ceiling –55%
	Eliminate blue box	Eventually eliminate blue box	Maintain blue box
LDC	Limit S&D treatment	S&D treatment	Development box: no reductions
Base	Applied rates	Final bound rates URAA	Final bound rates URAA
Other	Maintain green box	Maintain green box 50% down payment by OECD countries in first year	Eliminate de minimis for OECD

The proposal of the USA for reduction of domestic support will have more consequences for the EU than for the USA. Although table 6.5 may suggest otherwise, the USA proposal implies that the US does not have to make much reductions of domestic support. This follows from the fact that most payments are already 'green', and the rest is within the 5% *de minimis* provision (excluded from table 6.5). The EU, in contrast, will have to make substantial reductions under this proposal. For CAIRNS group countries and developing countries very small reductions arise, if at all, because they do not use their de miminis.

The EU proposal implies that both the EU (-38%) and the USA (–17%) will have to reduce their applied domestic support. Developing countries are basically exempt from reductions. Compared to the USA proposal, the proposal of the EU will result in a more limited decrease in domestic support for the EU and, during the first 5 years, in a bit higher reduction of domestic support in the USA.

Table 6.5 Proposals for reduction domestic support compared, billion US$

	Current AMS ceiling	AMS as percentage of production value	Current amber box and blue box payments	USA proposal Limit after 5 years	Cairns group proposal	EU proposal
USA	19.1	5%	10.4 (year 1998)	10.0	0	9
EU	67.2	20%	48.9 (amber) +20.6 (blue)	10.9	0	30 (maintain blue)

Source: Josling, 2003(table 1 and table 2), and own calculations from EU notification to the WTO: G/AG/EEC/38 (27 June 2002) and US notification to the WTO: G/AG/USA/36 (26 June 2001)
Note: current AMS excludes de minimis support.

6.2.2 Modelling issues

The evaluation of the proposals will be concentrated on the proposals to reduce import tariffs (and to increase TRQs), export subsidies and domestic support. Other proposals as more disciplines on food aid (EU) and export credits (EU and USA) will have also an impact on international trade. However, modelling of these proposals is difficult and they will remain out of the scope of the model simulations in this study.

The evaluation of *market access* proposals is not based on evaluations by detailed tariff line, but is applied to GTAP aggregate sectors. This is admittedly a crude approximation, as it does not allow the study of certain tariff peaks that may exist within the broader product groups that we distinguish. Although the GTAP database does not distinguish bound and applied rates, we nevertheless treat the binding overhang by using scaling factors from Francois and Martin (2002) to approximate difference between bound and applied rates. This implies that the tariff reductions for OECD countries, except Japan, follows the reduction of bound rates (zero binding overhang), and for developing countries the actual reduction of applied rates depends on the size of the binding overhang. By and large, this means that developing countries have to make only minor reductions in their applied rates.

The modelling of reductions of *domestic support* necessarily relies on some approximations. This is so, because the actual rules for AMS calculations are not only very product specific, but also allow for some leeway in the calculations and the notifications. Table 6.5 provides some background on the current AMS and the implications of the various proposals for the AMS ceilings. The table also includes the Harbinson compromise proposal as a reference. For the simulations in this chapter, we have used the countries' AMS commitments for the year 2000. In order to break down the implications for the domestic support categories (amber, blue and green box) according to the USA and CAIRNS proposals we have used information from Brink (2002). For EU proposal we calculated these ourselves from EU (2002). The aggregate AMS reductions had to be translated to GTAP subsidy parameters, mainly payments to land, capital and output. This makes it necessary to identify the portion of exempt payments (green and blue if applicable) included in the GTAP data. This is done by using information from Jensen 2002 (in the GTAP data documentation) and from ERS (2002,Appendix table 2.1).

While our study attempts to assess the impact of the proposals of the USA, the EU and the CAIRNS-group on agriculture, it maintains also assumptions on reductions of barriers in manufacturing and services. This involves a 50 % reduction in industrial tariffs and export subsidies, a 50% reduction in the tariff-equivalent of services barriers and a partial reduction in trading costs, related to trade facilitation measures. Estimates of services protection are taken from Francois et al. (2003). The results of the evaluation have to be seen as the combined effect of liberalisation in all three sectors.

The simulations are relative to the baseline situation for 2010. That is, we assume a successful completion of the Doha round in 2005, and an implementation period between 2005 and 2010. Our results in the subsequent section reflect the situation in 2010 with the proposals implemented relative to the baseline without further liberalisation.

No matter how complex, an economic model remains a necessary simplification of reality. Thus this model is heavily dominated by clearly quantifiable factors, such as reduced import tariffs, reduced export subsidies and reduced domestic support. Non-quantitative trade restrictions, such as those facing the services sector, are usually not included in quantitative analyses. This carries the risk of underestimating the importance of these less visible trade restrictions. Effects of and reducing administrative barriers facing exporters and importers at border-crossings, effects of Sanitary and Phyto-sanitary standards, and effects of quality standards in food trade may be attempted in the future.

6.3 Assessment of global effects

The implementation of the proposals would increase global trade volumes in all commodities and services by 3% to 3.5% in 2010 (Figure 6.1 and Figure 6.2). This is a positive result as such, as more trade enables countries to better utilize their own strengths. Agricultural exporters, such as South America and Australia, are expected to gain most from improved market access to agricultural markets. The more drastic market access proposals by the USA and CAIRNS yield the largest export effects.

Asian countries are expected to show more export growth also in manufactures. Especially poor Asian countries that currently limit their participation in the global trade system and other developing countries start to compete on the global market with supplies of labour intensive manufactures.

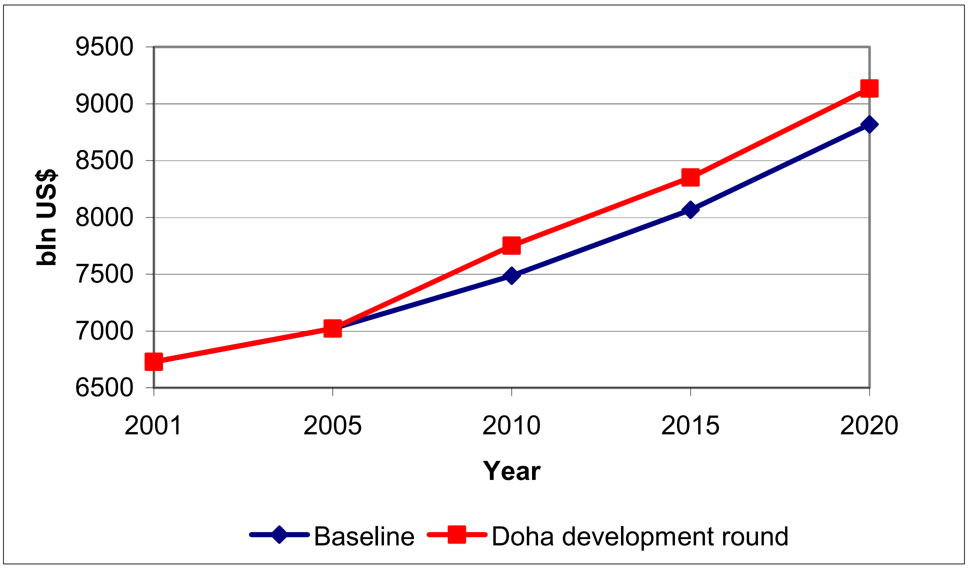


Figure 6.1 Expansion of global trade volumes
Source: Model simulations.

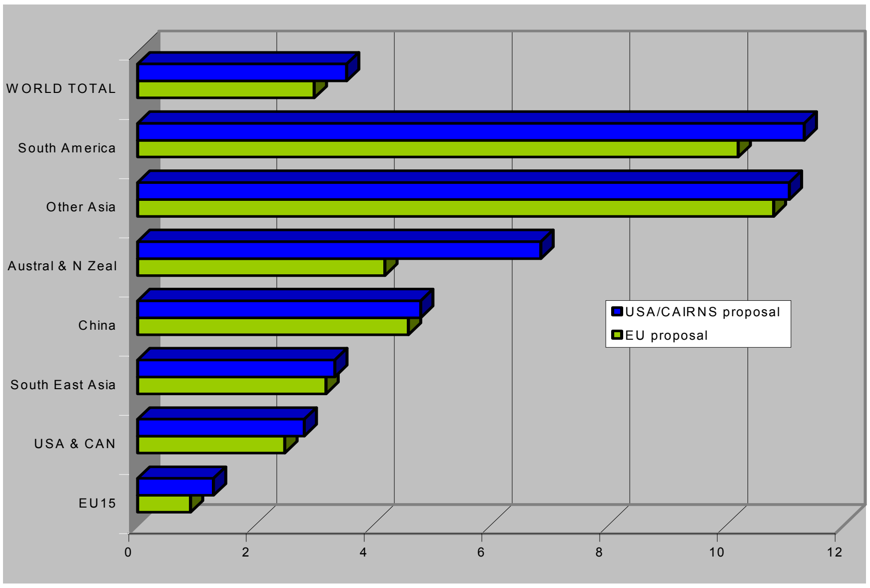


Figure 6.2 Export trade effects in 2010 (%)
Source: model simulations

As a result of liberalisation worldwide static income gains from the proposals are estimated to be in the order of magnitude of 0.3% of world GDP (100 billion USD) in 2010 (Table 6.6). Dynamic gains and scale economies, which are not included in this study, potentially multiply these gains.

The global income effect of the EU proposal is about ¾ of that of the USA and CAIRNS proposal. In particular the income gains for the OECD countries are less than those of both other proposals. In all three proposals the income gains for the non-OECD countries amount between 35 and 40 billion dollar. Although the absolute income gains in this group are not as high in dollar terms as the gains for the OECD group, the non-OECD countries register the higher benfits relative to their current income levels.

In table 6.6 a distinction is made in liberalisation in OECD countries and in non-OECD countries. About sixty percent of the income gains are the result of liberalisation by the OECD countries and about 40% of these global income gains can only be realized if non-OECD countries participate actively in the reform process. The developing countries not only profit from the liberalisation in the OECD countries, but they profit also from participation in the liberalisation process. About 37% of there own gains are a consequence of own reforms. So it is important for developing countries themselves to participate actively in the liberalisation process.

For developed countries even more than forty percent of the income gains depend from active participation of developing countries in the liberation process. The smaller income gains of the EU proposal for the OECD countries is due to both a limied liberalisation effort by OECD countries and to a smaller contribution of liberalisation of non-OECD countries.

In table 6.7 a decomposition of income gains is made by sectors, and in table 6.8 we decompose by liberalisation measures and group of countries. Both tables provide insight to which extent sector policies in OECD countries effect income in non-OECD countries and the other way around.

Table 6.6 National income effects of implementation in OECD and non-OECD countries in 2010 in billions of dollars (based on equivalent variation), relative to baseline 'no Doha'

		TOTAL (%)	OECD	non-OECD
OECD	EU proposal	40 (53)	22	19
	USA proposal	62 (61)	36	26
	CAIRNS proposal	64 (63)	39	26
Non-OECD	EU proposal	35 (47)	22	12
	USA proposal	39 (39)	25	14
	CAIRNS proposal	38 (37)	24	14
WORLD	EU proposal	75 (100)	43	32
	USA proposal	101 (100)	61	40
	CAIRNS proposal	102 (100)	62	41

Source: model simulations.

About one third (EU proposal) to about the half (USA/CAIRNS proposals) of the income gains are due to agricultural liberalisation. On average 24% of the global income gains are from manufactures and 32% from services. Liberalisation in manufacturing in developed countries will result in income gains for non-OECD countries, however in income losses for OECD countries themselves (see Appendix 6.1). On the other hand OECD countries will benefit of liberalisation in manufacturing in non-OECD countries. Within in the services sector in particular OECD countries will gain from liberalisation in developed countries (see Appendix 6.1).

Liberalisation in agriculture appears, as far as income gains are concerned, to be more important for developed countries than for the developing countries. The same holds for the services sector. On the other hand liberalisation in the manufacturing sector is more important for the developing countries as about 50% of their income gains comes from liberalisation in this sector.

Table 6.7 National income affects for OECD and non-OECD countries in 2010 in billions of dollars (based on equivalent variation), relative to baseline 'no Doha'

		TOTAL (%)	Agriculture	Manufactures	Services
OECD	EU proposal	40 (53)	15	4	22
	USA proposal	62 (61)	37	3	22
	CAIRNS proposal	64 (63)	40	3	22
Non-OECD	EU proposal	35 (47)	7	18	9
	USA proposal	39 (39)	11	19	9
	CAIRNS proposal	38 (37)	10	19	9
WORLD	EU proposal	75 (100)	23	22	30
	USA proposal	101 (100)	49	22	30
	CAIRNS proposal	102 (100)	51	22	30

Source: model simulations.

As said above agricultural liberalisation appears to be particularly profitable for the OECD countries. To a large extent this will be the fruit of liberalisation in the OECD countries themselves (see table 6.8). The contribution of decreasing domestic support is almost equal to the contribution of trade barriers. Hence, domestic agricultural reform benefits mostly the taxpayers and consumers in OECD countries, because these countries have the highest distortions. However, agricultural liberalisation in the non-OECD countries also contributes to income gains in the OECD countries.

Table 6.8 National income effects of reduction agricultural protection according proposals for OECD and non-OECD countries in 2010 in billions of dollars (based on equivalent variation), relative to baseline 'no Doha'

		TOTAL (%)	Total Agriculture	Reduction trade barriers by OECD	Reduction domestic support by	
					OECD	Non- OECD
OECD	EU proposal	40 (53)	15	5	4	6
	USA proposal	62 (61)	27	14	10	13
	CAIRNS proposal	64 (63)	40	14	13	13
Non-OECD	EU proposal	35 (47)	7	5	-1	3
	USA proposal	39 (39)	12	7	-1	5
	CAIRNS proposal	38 (37)	10	7	-2	5
WORLD	EU proposal	75 (100)	23	10	3	10
	USA proposal	101 (100)	39	21	10	18
	CAIRNS proposal	102 (100)	41	21	11	19

Source: model simulations.

For the non-OECD countries the effect on income of agricultural liberalisation in OECD countries is as important as agricultural liberalisation within their own group of countries. The income gains to non-OECD countries from better market access to OECD countries are expected to be limited to USD 5-7 billion. However, agricultural reform in OECD countries is not necessarily beneficial for developing countries. As trade barriers are lowered, domestic support is reduced and export subsidies are lowered, world prices for staple commodities such as grains are expected to rise. As a consequence, importers will witness higher import prices.

Table 6.9 Agricultural income, Percent change in 2010, relative to baseline 'no Doha'

	Proposal:		
	EU	USA	CAIRNS
EU15	-5%	-11%	-11%
USA	1%	7%	3%
AUS & New Zeal	8%	23%	24%
South America	2%	5%	6%
China	3%	4%	5%
LDCs	7%	2%	3%

Source: model simulations.

Zooming in on the effect of implementation of the proposals on agricultural incomes, we estimate wide differences between the proposals (see table 6.9). Each proposal maximizes benefits for the own agricultural sector, or in the case of the EU minimizes the loss, by maintaining the blue box support. Even with maintenance of the blue box, the EU appears to be willing to accept a reduction of agricultural incomes by 5%. Both the USA and CAIRNS proposal benefit agricultural exporting countries by improving market access, and world prices are rising more than under the EU proposal.

The EU proposal appears to be the most favourable for LDCs, by allowing substantial exemptions and by limiting the upward effects on world market prices. Not too high world prices are beneficial for agriculture-importing LDCs.

The effects on China's agricultural incomes are not estimated to be very large. The USA and CAIRNS proposal have comparatively greater effects, because they more aggressively open the protected markets of Japan and Korea through the Swiss formula approach.

6.4. Assessment of effects on China

Given that China has already reduced its own import barriers in the WTO accession process, there is not much to gain on the import side. Most gains can be expected on the export-oriented industries. However, the share of exports relative to domestic production is rather low, except for some processed food products and textile and garments. Hence, even substantial tariff cuts by importers will have only a small impact on production.

6.4.1 National income effects

In terms of national income, China belongs to the countries that gain most from the new round. China is estimated to capture about 8% of the global income gains in 2010 (static gains, measured as equivalent variation), while its share in world GDP is around 3%. The estimated income gains amount to about US$ 8 billion, or US$ 6 per head. This is about 0.8% of national income while, as mentioned above, total global gains amount to 0.3% of global income.

More than seventy percent of the gains for China are due to liberalisation in the manufacturing sector. About 60% of the gains are attributed to improved market access for manufacturing products in OECD markets, and 12% is due to liberalisation in the manufacturing by non-OECD countries. About 13% (EU proposal) to 17% (USA proposal) of the income gains are due to agricultural liberalisation (see figure 6.3). This is to a large extent the result of increased access to OECD markets. The contribution of domestic agricultural reforms in OECD countries is very limited and smaller than 2% of the total national income gains to China. Also for services the income gains are limited.

An important share in the gains is due to the textile sector. While export quota for textiles and garments are (supposed) to be eliminated under the phase out of the MFA under the WTO-ATC by 31 December 2004, there are currently still import tariffs in developed countries and developing countries. Under the Doha round proposals these are expected to be reduced, and this will lead to an additional boost for Chinese textiles and garments industries. Additional export growth under the Doha proposals is estimated at around 8% in 2010. This will have also an effect on agriculture, as it will increase the demand for cotton.

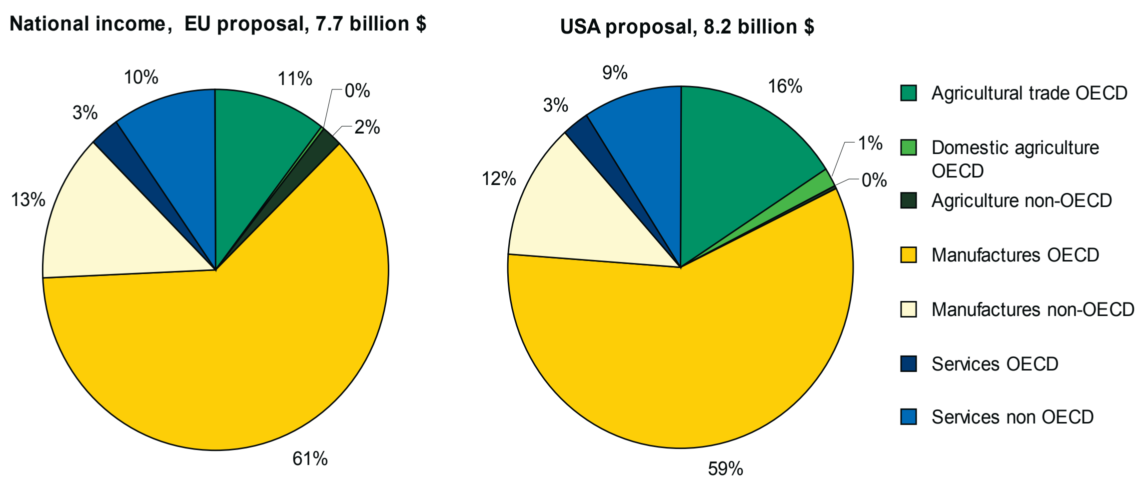


Figure 6.3 Liberalisation proposals, size and sources of national income gains for China
Source: Model simulations.

However, an important observation has to be made with regard to the development of Chinese competitiveness. The Chinese manufacturing industries sees an erosion of their terms of trade, driven by its growth in textile exports, combined with increased competition from other low wage countries. Natural competitors, such as India, currently limit their participation on world markets through a mix of import and export barriers. Rationalization in this area by developing countries leads to heightened competition against China in a number of sectors, with the result being income losses for China driven almost entirely by manufacturing and agricultural liberalization in the developing world.

The differences in estimated income gains between the proposals is limited, for the USA and CAIRNS proposal it is a bit more and for the EU proposal a bit less than US$ 8 billion. This has to a large extent to do with differences in the proposal for agricultural liberalisation. Chinese exports encounter high tariffs on some agricultural products (see, Figure 6.4). This is mainly due to the high import barriers in the main export destinations Japan and Korea. Because import tariffs are very high for some agricultural products there will be a big difference between linear tariffs cut used in EU proposal and Swiss formula cuts in USA and CAIRNS proposal. Cuts will be much higher in the USA/Cairns proposals for these products.

6.4.2 Structural effects

In this section we explain the structural impact of the three WTO proposals. To increase understanding we first describe the policy landscape for China and the self-sufficiency index[1]. The policy landscape provides explanatory value for the developments of exports

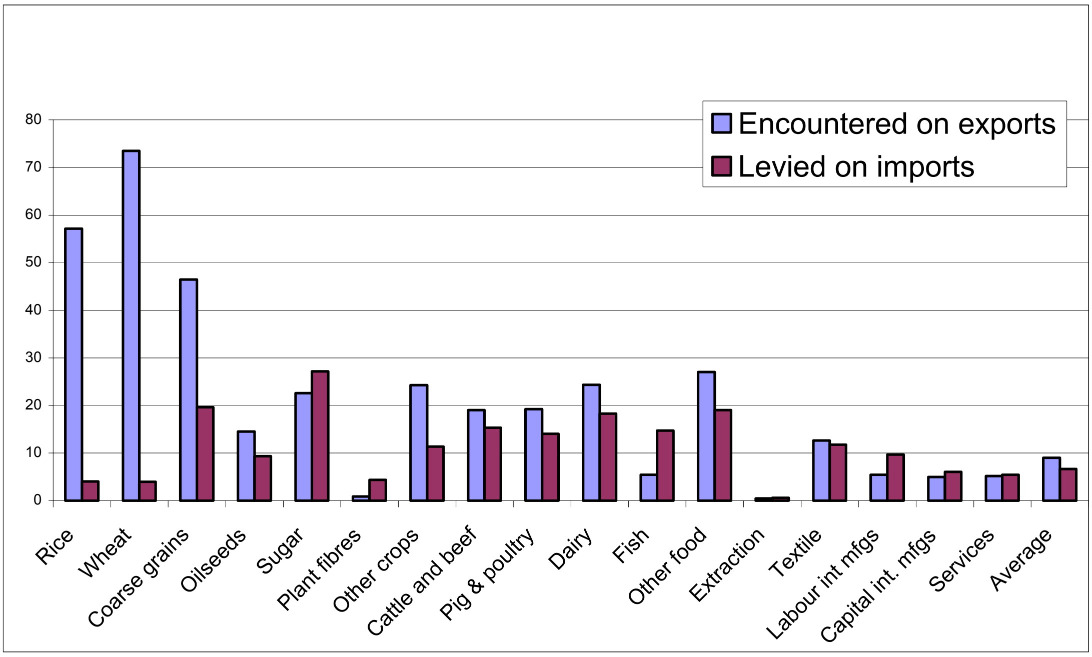


Figure 6.4 Average import tariffs (%), China, 2005

[1] self-sufficiency is defined as the ratio of domestic production over domestic absorption.

and imports. The development of exports and imports together with their importance, as measured by the self-sufficiency index, determines partly the production impact.

Figure 6.4 shows that in general the tariffs are higher on Chinese exports than on Chinese imports. Exceptions are sugar, cotton (plant fibres), fish and labour intensive manufacturing. Chinese exports encounter high tariffs for rice, wheat and coarse grains. This is mainly due to the high import barriers in Japan and Korea. Because import tariffs are very high for these products there will be a big difference between linear tariffs cut used in EU proposal and Swiss formula in USA and CAIRNS proposal. Cuts will be much higher in the USA/Cairns proposals for these products.

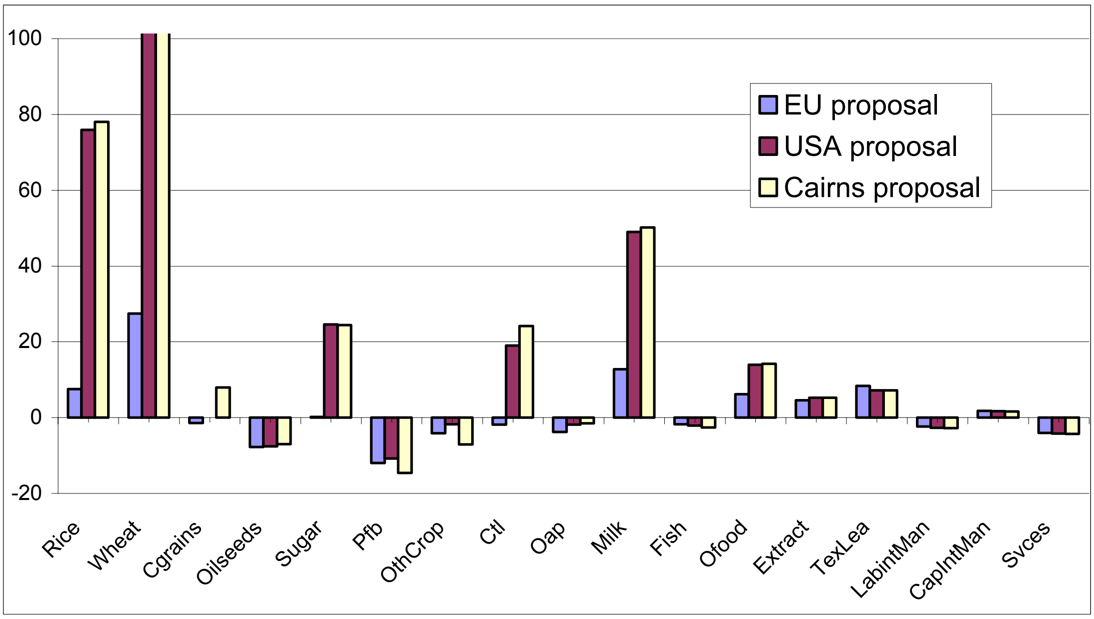


Figure 6.5 Growth in Chinese exports (% change)
Source: Model Simulations.

A reduction in these tariffs leads to expected export and import changes in China (see Figure 6.5 and Figure 6.7). It matters a lot which formula is used. With the Swiss formula (USA and Cairns proposal) the increase in Chinese exports of rice and wheat is very high (see Figure 6.5). However, we have to take into account that the wheat exports are almost zero, so the additional value of wheat exports is very limited. The higher initial tariffs on Chinese exports of sugar, cattle and dairy create also export opportunities, although the export value in these products is low. Within the non-agricultural sectors, processed food and textiles obtain the highest export growth rates. For example, exports of processed foods are estimated to grow respectively 6% (EU proposal), 16% (USA proposal) and 14% (CAIRNS proposals) in 2010. This growth is mainly attributed to improved access to OECD markets (see figure 6.6).

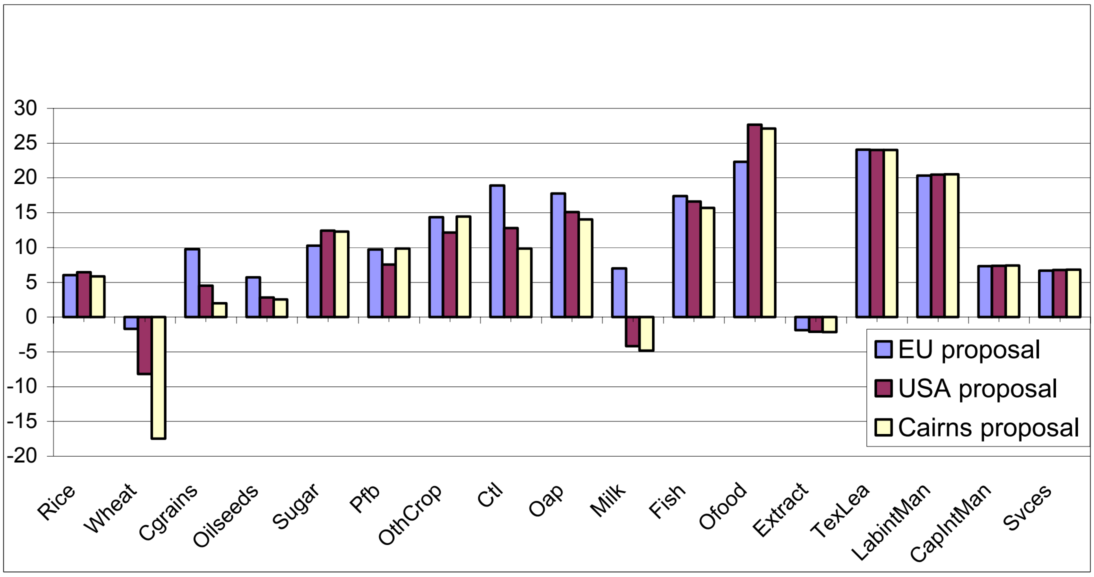


Figure 6.6 Growth in Chinese imports (% change)
Source: Model Simulations.

The growth is not so high as expected in 'other crops' (mainly horticulture) and coarse grains. For other crops the main reason is that competitors on Chinese important export markets SEA and to a lesser extent the EU encounter even higher protection (or other product mix) and they gain relatively more: i.e. they gain a price advantage over Chinese exports on these markets. For coarse grains the tariff is especially high on Japan-Korean market. However, after opening of the market, SAM and NAFTA profit more than China.

Imports increase for most products. This is due to the reduction in import tariffs and also to the relatively high increase in real factor prices. Real factor prices increase more in China because it benefits more (see previous section). However an implication is that it makes Chinese products more expensive relative to imports from other countries were the increase in factor prices is less.

Imports increase relatively fast in processed food and textiles. Tariffs are relatively high in these sectors and markets are very competitive. Imports decrease for extraction and wheat because tariff on imports are very low.

For oilseeds, sugar, cotton, extraction and capital-intensive industries imports are important as the self-sufficiency ratio is below one. Here, we observe an intensified competition with foreign suppliers and an increase in imports if trade barriers due to China's WTO accession are lowered. On the other hand, we have the processed food industry and textile industries. These are clear net-export products, where self-sufficiency exceeds one, and which indicate a strong comparative advantage in these products. To a lesser extent 'other crops' (horticulture) and fish are also net-export products. For all these sectors access to foreign markets is important.

Figure 6.8 displays the net effect of changing imports and exports in the sectoral trade balance for China. It is clearly seen that the trade balance for agricultural products is affected only very little, while the manufacturing an services trade balances show larger changes in dollar terms.

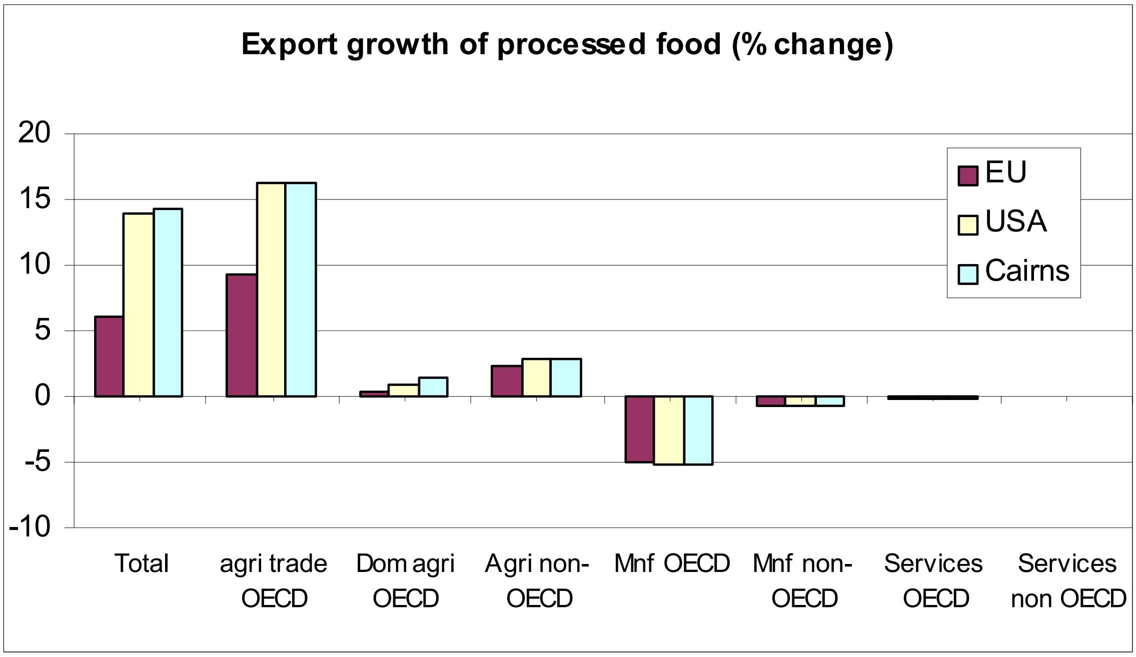


Figure 6.7 Liberalisation proposals: size and sources of Chinese export growth of processed food
Source: Model Simulations.

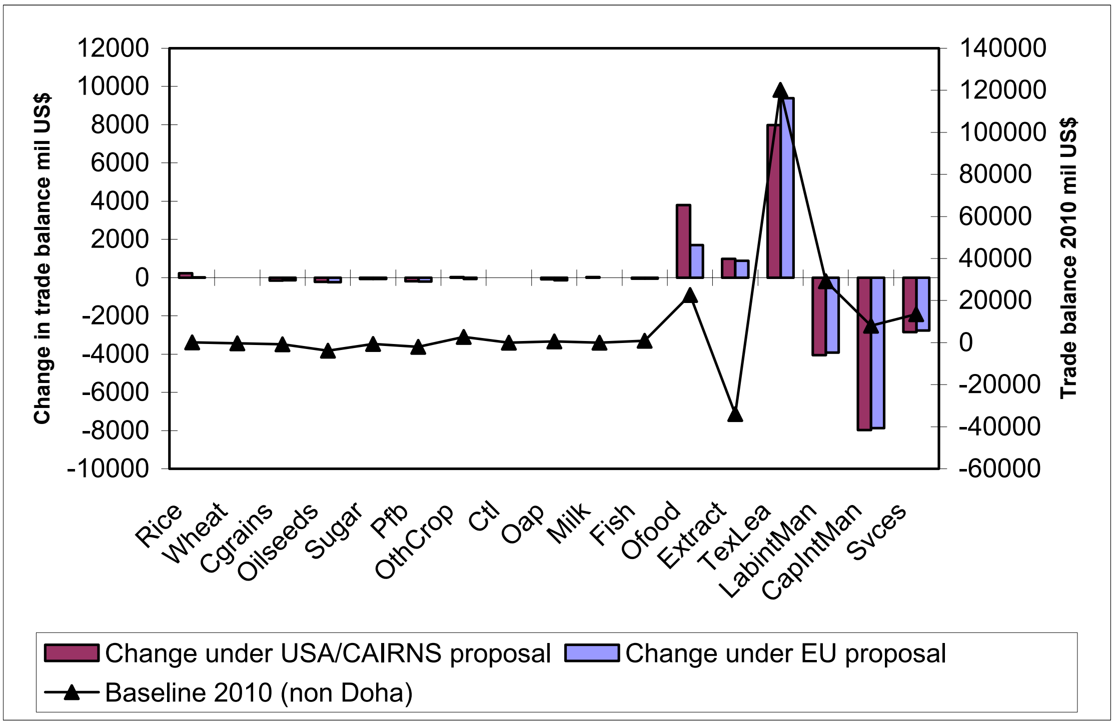


Figure 6.8 Chinese sectoral trade balance (exports minus imports)
Source: Model Simulations.

Figure 6.9 shows the impact of the three proposals on production. There are some important differences between the impact of the EU and USA/Cairns proposals. In the latter the larger cut in the higher tariffs due to the Swiss formula creates more trade and production opportunities for rice, wheat, coarse grains, and processed food. Coarse grains contracts in the EU proposal and grows in USA/Cairns proposal. The latter is caused by large reduction in Japan/Korea reductions in import tariffs, however other exporters profit more (SAM, NAFTA).

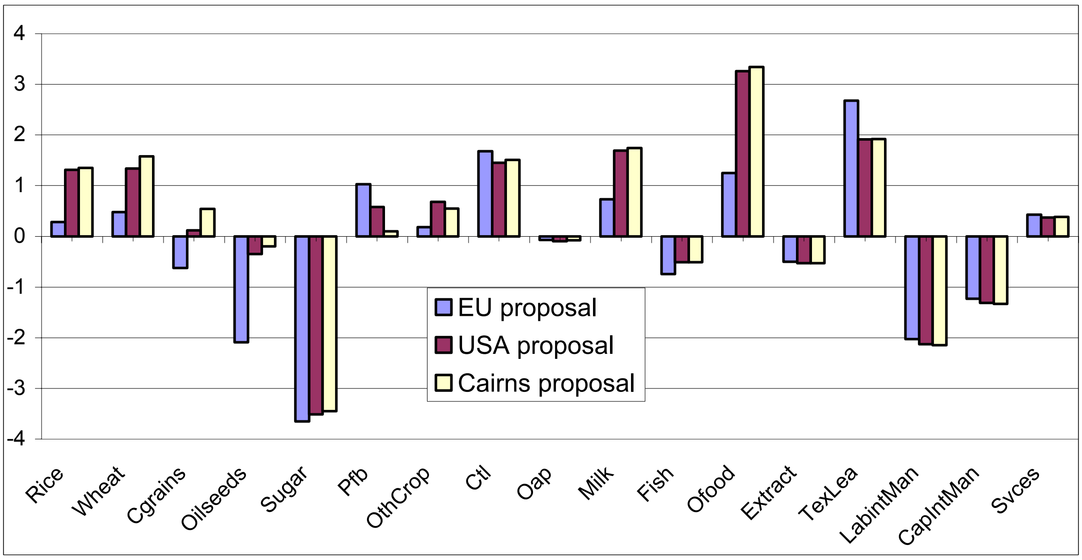


Figure 6.9 Growth in Chinese production (% quantity change)
Source: Model Simulations.

Processed food and textiles obtain the highest production gain. In these sectors, China has already a comparative advantage, and exports are an important part of total demand. For processed food tariffs cuts are relatively high and exports are important (see high self-sufficiency ratio). For textiles tariff cuts are modest but exports are very important, so export growth leads to growth production. There is also an increase in dairy and cattle which is driven by export growth.

6.4.3 Conclusion

By and large, the further liberalisation stimulates a development to exploit the comparative advantage of China in these sectors. This holds in particular for horticultural products and processed food. While exports are estimated to grow in some products, the further reduction of remaining import barriers also enables China to import more products. Imports in such commodities as coarse grains, sugar, cotton, dairy and intensive livestock products are expected to rise.

It can be concluded that China can gain a lot from a new WTO round, but most from liberalisation in manufacturing. Around 60% of the potential income gains can be attributed to improved market access for manufacturing goods into OECD countries. Labour intensive manufacturing and food processing industries have the potential to absorb labour and generate incomes in activities outside primary agriculture. Expanding labour intensive industries in rural areas may be part of a rural development strategy.

6.5 Effects on the European Union

The various proposals will have different impacts on the European Union. The European Union is a customs union, with a common external tariff against supplies from third countries, and practically zero tariffs within the union. The formation of the EU customs union leads, by definition, to trade preferences amongst the members of the free trade area. As a consequence the share of trade that is within the EU (intra-EU trade) is typically biased upward, and trade within the EU is larger than might be expected on the basis of geographic proximity and other trade promoting factors alone. With the recent eastward enlargement the preferences are extended from the current 15 EU members to the 10 new member states. Recall that the enlargement process has been incorporated in our baseline scenario.

The lowering of external trade barriers by the EU will inevitably lead to the erosion of the intra-EU trade preferences. Suppliers with lower cost will be able to enter the EU markets once the tariff barriers have come down that currently shield domestic producers from foreign competition. Consequently, we can expect the current bias towards intra-EU trade to be reduced. Table 6.10 nicely illustrates this effect by breaking down the simulated change in EU15 export values for two of the liberalisation scenarios.

The 1% growth in EU15 exports is small compared to the 3% - 3.5% growth in world trade. A first driver of this result is that EU countries mostly trade amongst themselves. The share of intra-EU exports amounting to more than 56%.The benefits from removing the intra-EU barriers have already been realised in the past and there are no additional gains for intra-EU trade in a new WTO round. A second driver of this result is the increased competition from non-EU countries on EU markets. Simulated intra-EU trade shrinks by more than 3% as other suppliers enter the EU markets.

Comparing the USA proposal and EU's own proposal reiterates that the more modest EU proposal leads overall to smaller increases in trade. The EU's exports typcially decrease in those agricultural sectors that are currently subject to much government intervention: Grains, sugar and beef. In contrast, 'other crops'(horticulture), processed foods and even dairy witness increased export revenues.

The dairy industry is an interesting case. Under the USA proposal dairy exports to China are simulated to decline, whereas under the EU proposal we simulate a slight positive growth. This indicates that the EUs dairy exports would benefit from less drastic reductions in export subsidies and in domestic compensation payments. Note, that table 6.10 reports export revenues f.o.b., i.e. including export subsidies.

However, the largest changes in EU-China exports are observed in manufacturing exports. One should not be mislead to the conclusion that EU manufacturers would

Table 6.10 Exports of the European Union in 2010

	Export values baseline 2010 (no Doha) (*)			USA proposal			EU proposal		
	Total (bln US$)	of which intra EU (%)	of which to China (%)	Change (%)	of which intra EU (%)	of which to China (%)	Change (%)	of which intra EU (%)	of which to China (%)
Rice	1.2	67.3	0.0	-35.4	-50.1	n.a.	-24.1	-35.4	n.a.
Wheat	4.9	56.6	0.2	-31.0	-33.8	-25.0	-13.8	-15.9	-12.5
Cgrains	3.6	64.1	1.9	-37.4	-29.8	-51.5	-15.9	-15.6	-13.6
Oilseeds	12.6	58.1	4.0	-8.1	-11.0	3.3	-4.1	-7.5	7.3
Sugar	3.4	41.0	0.4	-56.8	-55.0	-66.7	-28.2	-33.9	-25.0
Pfb	0.6	27.5	0.7	10.3	6.1	50.0	4.3	1.2	25.0
OthCrop	32.3	73.7	0.0	7.8	-1.1	33.3	0.9	-3.6	16.7
Ctl	10.8	72.6	0.0	-40.7	-42.8	-66.7	-11.0	-14.6	0.0
Oap	23.5	61.8	0.6	11.8	-1.3	20.3	5.4	-2.2	21.0
Milk	21.2	68.5	0.2	2.3	-14.4	-15.8	0.3	-5.3	2.6
Fish	4.2	77.8	2.8	-0.8	-1.6	9.5	-0.1	-1.7	12.9
Ofood	82.2	58.8	0.9	4.8	-11.1	50.4	1.2	-8.1	34.5
Extract	37.2	66.5	1.4	0.9	-0.4	3.1	0.6	-0.3	3.3
TexLea	100.5	59.4	0.7	-3.5	-12.1	30.2	-2.9	-11.4	29.3
LabintMan	445.3	66.9	0.6	1.3	-3.0	28.5	0.8	-3.3	26.9
CapIntMan	1197.1	55.6	1.6	1.2	-2.1	12.6	1.0	-2.2	12.0
Svces	413.9	41.3	2.1	2.0	-3.2	9.3	1.4	-3.6	8.6
Total	2394.5	56.2	1.4	1.0	-3.7	13.7	0.7	-3.4	12.8

Notes: (*) Values including export subsidies successfully compete with labour intensive Chinese produce. The imports from China are increasing much faster. However, the results indicate that there might still be certain market segments in the fast growing Chinese market that will be served by manufacturers from Europe.

6.6 Discussion and conclusion

This chapter shows that the static gains from global liberalisation in the Doha round may amount to about 0.3% of world GDP. This estimate does not take into account dynamic effects such as capital accumulation and technology spillovers. Relative to their GDP, low income countries are the greatest beneficiaries of improved market access and reduced domestic support to agriculture in OECD countries. For some poor African and Asian countries the income gains can be as high as 1.5% - 2% of their GDP. However, the realization of these potential gains for LDCs depends very much on an active participation of LDCs in the liberalisation effort.

Under the proposals studied here, the main beneficiaries from agricultural liberalisation are exporting countries, especially in the USA and CAIRNS proposals because they go further in improving market access than the EU proposal. As far as the effects of domestic reforms in OECD countries are concerned, the simulations show that the world market effects are not very big and are not always positive for everyone. Especially LDC food importers may witness rising world food prices.

China can clearly gain from the Doha round. It is estimated to capture 8% of global income gains while its share in world GDP is around 3%. However, its interests in agriculture seem to be covered by proposals that other players have already made. Therefore, China might very well want to free ride on proposals by others, rather than developing an own position in the negotiations on the 'classic' agricultural agenda. This may be quite different in the areas of food quality and food safety, where China clearly has an active interest in SPS and TBT issues. Modelling of food safety related impediments to trade is clearly an area of future research.

The largest gains for China are not to be found in the agricultural dossier, but in improved markets access for labour intensive manufacturing. As far as the textile industry and the food industry are concerned this will increase the demand for agricultural products like cotton and raw materials for the food processing industry. Expanding labour intensive industries, fostered also by new export opportunities, may be part of a rural development strategy that includes labour absorption into industries outside primary agriculture.

Chapter 7 Biotechnology boosts to crop productivity in China: trade and welfare implications

Genetically modified (GM) cotton is widely adopted and the list of GM technologies in trials is impressive in China.[1] At the same time there is an active debate on when China should commercialize its GM food crops. This chapter provides an economy-wide assessment of some of the issues surrounding the adoption and commercialization of biotechnology. Based on unique data from empirical micro-level study and field trials in China and a modified GTAP model, our results indicate that the development of biotechnology has an important impact on China's production, trade and welfare. Welfare gains far outweigh the public biotechnology research expenditures. Most gains occur inside China, and can be achieved independently from biotech-unfriendly polices adopted in some industrialized countries.

7.1 Introduction

Because biotechnology - one of this century's most promising and innovative technologies - employs genetic modification techniques, it has spurred worldwide debate. The debate has been going on for decades now and has had a significantly depressing impact on the supply of biotechnology. In the meantime, the demand for the technology has continued to grow rapidly: the global area of GM crops increased from 1.7 million ha in 1996 to 52.6 million ha in 2001 (James, 2002).

China was one of the first countries to introduce a GM crop commercially, and currently has the fourth largest GM crop area, after the USA, Argentina and Canada (James, 2002). China's agricultural biotechnology development is an interesting case and is unique in many respects. The public sector dominates the industry and the list of GM crops undergoing trials differs from those being worked on in other countries where the technologies are dominated by the private sector (Huang et al., 2002a). The Chinese government views agricultural biotechnology as a tool to help China improve the nation's food security, increase agricultural productivity and farmers' incomes, foster sustainable development and improve its competitive position in international agricultural markets (SSTC, 1990). In 2001, approximately four million small farmers in China adopted Bt cotton (Pray et al., 2002).

On the other hand, there is growing concern among policy makers regarding the impact of the ongoing global debate about biotechnology on China's agricultural trade, biosafety and the potential opposition derived from public concerns about the environmental and the food safety of GM products. Because of this, although GM crops are still cultivated in public research institutes, the approval of GM crops (and particularly of food crops) for commercialization has become more difficult since late 1998 (Huang et al.,

[1] The chapter has benefited from statistical support provided by Ninghui Li and Cunhui Fan.

2001). This reflects the influence of the global debate about GM crops on Chinese policy makers, in particular restrictions on imports to EU countries. China also appears to take a more cautious stance. For example, in January 2002 the Ministry of Agriculture (MoA) announced three new regulations on the biosafety management, trade and labeling of GM farm products. These regulations came into effect on 20 March 2002 and require importers of GM agricultural products to apply to China's MoA for official safety verification approval, leading US producers to accuse Beijing of using the new rules to hinder imports and protect Chinese soybean farmers.

China, like many other developing countries, now has to decide how to proceed on the further commercialization of GM crops. Policy makers have raised several issues. Should China continue to promote its agricultural biotechnology and commercialize its GM food crops (i.e. rice and soybean)? How important are the trade restrictions imposed on GM products, particularly those imposed by the EU and by other countries in East Asia? What will be the impact of alternative biotechnology policies (in both China and the rest of world) on China's agricultural economy and trade? Answers to these questions are of critical importance for policy makers and the agricultural industry.

The central theme of this paper is to provide a cost-benefit analysis of research and development of GM crops in China in the face of likely international policy developments. To achieve this, the paper is organized as follows. In section two, a general review of agricultural biotechnology development in China is provided. The impacts of Bt cotton adoption in China are presented in Section three. The results from the empirical studies on Bt cotton and the hypothesized results of GM rice commercialization are the data used for the later simulation analyses with a tailored version of the multi-country general equilibrium GTAP model. Section four presents the model and scenarios that are used in the impact assessments. The results of the impacts of alternative biotechnology development strategies are discussed in section five. The final section provides concluding remarks and areas for policy actions.

7.2 Agricultural Biotechnology Development in China

7.2.1 An overview

Biotechnology in China has a long history. Several research institutes within the CAAS (the Chinese Academy of Agricultural Sciences), the CAS (the Chinese Academy of Sciences) and various universities initiated their first agricultural biotechnology research programs in the early 1970s.[1] However, the most significant progress in agricultural biotechnology has been made since China initiated a national high-tech program (the '863' program) in March 1986. Since then, agricultural biotechnology laboratories have been established in almost every agricultural academy and major university. There are now over 100 laboratories in China involved in transgenic plant research (Chen, 2000). By 2000, eighteen GM crops had been generated by Chinese research institutes; four of these crops

[1] The research focus of biotechnology in the 1970s was cell engineering, tissue culture and cell fusion. Research in cell and tissue culture covered such crops as rice, wheat, maize, cotton, vegetables, etc. (KLCMCB, 1996). Several advanced rice varieties were generated through anther culture in the 1970s and 1980s.

have been approved for commercialization since 1997.[1] GM varieties in such crops as rice, maize, wheat, soybean, peanut, etc. are either in the research pipeline or are ready for commercialization (Chen, 2000; Li, 2000; Huang et al., 2002a).

A cotton variety with the Bacillus thuringiensis (Bt) gene to control the bollworm is one of the most oft-cited examples of the progress of agricultural biotechnology in China. Since the first Bt cotton variety was approved for commercialization in 1997, the total area under Bt cotton has reached nearly 1.5 million ha (2001), accounting for 45% of China's cotton area (Table 7.1). In addition, other transgenic plants with resistance to insects, disease and herbicides, or which have been quality-modified, have been approved for field release and are ready for commercialization. These include transgenic varieties of cotton resistant to fungal disease, rice resistant to insect pests and diseases, wheat resistant to the barley yellow dwarf virus, maize resistant to insects and with improved quality, soybeans resistant to herbicides, transgenic potato resistant to bacterial disease, and so on (Huang et al., 2002a).

Table 7.1 Bt cotton adoption in China

	1997	1998	1999	2000	2001
Cotton area (000 ha)	4091	4064	3423	3732	4447
Region I	1641	1530	1366	1655	2012
Region II	919	848	573	613	731
Region III	1531	1686	1484	1464	1704
Bt cotton area (000 ha)	27	254	633	1153	2011
Region I	21	237	594	1043	1704
Region II	0	1	8	33	131
Region III	6	16	31	77	176
Bt cotton (%)	1	6	18	31	45
Region I	1	15	43	63	85
Region II	0	0	1	5	18
Region III	0	1	2	5	10

Note: Region I includes Hebei, Shangdong and Henan, regional II includes Anhui, Jiangsu and Hubei, and all rest of China are in region III.
Source: Author's surveys.

Progress in plant biotechnology has also been made in recombinant microorganisms such as soybean nodule bacteria, nitrogen-fixing bacteria for rice and corn, and phytase from recombinant yeasts for feed additives. Nitrogen-fixing bacteria and phytase have been commercialized since 1999. In animals, transgenic pigs and carps have been produced

[1] These are Bt cotton, tomatoes with resistance to insects or with improved shelf-life, a petunia with altered flower colour, and sweet pepper resistant to diseases. However, before these four crops were approved for commercialization, the first commercial release of a GM crop in the world occurred in 1992 when Chinese farmers first adopted transgenic tobacco varieties. But Chinese farmers have not been allowed to grow GM tobacco since 1995 due to strong opposition from tobacco importers in the USA and certain other countries.

since 1997 (NCBED, 2000). China was the first country to complete the shrimp genome sequencing in 2000.

7.2.2 Research priorities

Rice, wheat and maize are the three most important crops in China. Each accounts for about 20 percent of the total area planted. The production and market stability of these three crops are a prime concern of the Chinese government as they are central to China's food security. National food security, particularly related to grains, is a central goal of China's agricultural and food policy and has been incorporated into biotechnology research priority setting (Huang et al., 2001).

China's biotechnology program has also selected cotton as a targeted crop because of its large sown area, its contributions to the textile industry and trade, and the serious problems with the associated rapid increase in pesticide applications to control insects (i.e., bollworm and aphids). Pesticide expenditures in cotton production in China increased considerably in the past decades, reaching RMB yuan 834 (approximately US $ 100) per hectare in 1995. In recent years, cotton production alone consumed about US$ 500 million annually in pesticides.

Genetic traits viewed as priorities may be transferred into target crops. Priority traits include those related to insect and disease resistance, stress tolerance, and quality improvement (Huang et al., 2002). Pest resistance traits have top priority over all traits. Recently, quality improvement traits have been included as priority traits in response to increased market demand for quality foods. In addition, stress tolerance traits - particularly resistance to drought - are gaining attention with the growing concern over water shortages in northern China.

7.2.3 GM cotton and rice

China is one of the world's leading countries in the production of GM cotton and rice and the related technology (Table 7.2). The Biotechnology Research Institute (BRI) of CAAS developed insect-resistant Bt cotton. The Bt gene's modification and plant vector construction technique was granted a patent in China in 1998. The Bt gene was introduced into major cotton varieties using the pollen tube pathway developed in China (Guo and Cui, 1998 and 2000). By early 2002, sixteen Bt cotton varieties with resistance to bollworms generated by China's public institutions and five Bt cotton varieties from Monsanto had been approved for commercialization in nine provinces.

The BRI of CAAS recently made the other breakthrough in plant disease resistance by developing cotton resistant to fungal diseases (Table 7.2). Glucanase, glucoxidase and chitnase genes were introduced into major cotton varieties. Transgenic cotton lines with enhanced resistance to V*erticillium* and *Fusarium* were approved for environmental release in 1999 (BRI, 2000).

More efforts have been put on the GM rice sector. Numerous research institutes and universities have been working on transgenic rice resistant to insects since the early 1990s. Transgenic hybrid and conventional Bt rice varieties, resistant to rice stem borer and leaf roller were approved for environmental release in 1997 and 1998 (Zhang, 1999). The transgenic rice variety that expressed resistance to rice plant hopper has been tested in field trials. Through the anther culture, the CpTi gene and the Bar gene were successfully introduced into rice, which expressed resistance to rice stem borer and herbicide (NCBED, 2000; Zhu, 2000).

Table 7.2 Research priority and available GM plant events in China by 1999.

Crop	Introduced trait	Field Trial	Environmental release	Commercialized
Cotton	Insect resistance			
	Bollworm (Bt)	Yes	Yes	Yes
	Bollworm (Bt+CpTI)	Yes	Yes	Yes
	Bollworm (CpTI)	Yes	Yes	No
	Bollworm (API)	Yes	No	No
	Disease resistance			
	Verticillium & Fusarium (Chi)	Yes	Yes	No
	Verticillium & Fusarium (Glu)	Yes	Yes	No
	Verticillium & Fusarium (Glu+Chi)	Yes	Yes	No
Rice	Insect resistance			
	Stem borer (Bt)	Yes	Yes	No
	Stem borer (CpTI)	Yes	Yes	No
	Rice planthopper	Yes	Yes	No
	Disease resistance			
	Bacteria blight (Xa21)	Yes	Yes	No
	Fungal disease	Yes	Yes	No
	Rice dwarf virus	Yes	Yes	No
	Herbicide resistance	Yes	Yes	No
	Salt tolerance (BADH)	Yes	No	No
	Ac/Ds (rice mutant)	Yes	No	No

Source: Authors' surveys.

Transgenic rice with Xa21, Xa7 and CpTi genes resistant to bacteria blight or rice blast were developed by the Institute of Genetics of CAS, BRI, and China Central Agricultural University. These transgenic rice plants have been approved for environmental release since 1997 (NCBED, 2000). Significant progress has also been made with transgenic plants expressing drought and salinity tolerance in rice. Transgenic rice expressing drought and salinity tolerance has been in field trials since 1998. Genetically modified nitrogen fixing bacteria for rice was approved for commercialization in 2000. Technically, various types of GM rice are ready for commercialization. However, the commercializing GM rice production has not yet been approved as the policy makers' concern about food safety, rice trade (China exports rice though the amount traded is small compared to its consumption) and its implication for the commercialization of other GM food crops such as soybean, wheat and maize.

7.3 Impact of Bt cotton in China: factor biased technical change

One cannot simply assume that the GM technologies imply a Hicks-neutral productivity boost.[1] The productivity impact of GM technologies in crops is typically factor-biased.[2] That is, cost reductions on some of the production factors can be achieved in varying degrees. See for example European Commission (2001) for a survey and Van Meijl and Van Tongeren (2002) for an application to Bt maize and Ht soybean technology.

To examine the impact of biotechnology on various input uses and crop yield (after control for input uses) in the cotton production, Pray et al (2001) and Huang et al (2002b) used both farm budget analysis and damage control production function approach based on the production practices of 282 cotton farmers (including Bt and non-Bt farmers) in 1999 in Hebei and Shandong provinces, where the bollworm has seriously damaged the local cotton production (Region I in Table 7.1). A budget analysis by Pray et al (2001) shows that while there is no significant difference in fertilizer and machinery uses between Bt and non-Bt cotton production, significant reductions were recorded in pesticide and labor use (labor used for spray pesticide). More sophisticated measures based on the same data that applied multivariate regression to estimate the pesticide use and cotton production functions show similar results for the effect of Bt cotton on input uses. The results of their studies demonstrate that Bt cotton adopters spray 67 percent fewer times and reduce pesticide expenditures by 82 percent (Huang et al. 2002b). Because the reduction on the farmers spraying pesticide time (from an average of 20 times during one crop season to eight times), Bt cotton technology is also considered as a labor-saving technology.

While costs of pesticides and labor inputs are reduced, seed costs of Bt varieties are higher than those of non-Bt cotton by about 100-250 percent (based on author's survey in 1999, 2000 and 2001 in 5 provinces where Bt cotton is adopted, the price difference between Bt and non-Bt cotton declined over time). But this is much lower than the market price ratio of Bt cotton seed (40-50 yuan/kg) and non-Bt conventional cotton seed (4-8 yuan/kg) in our sampled areas. The lower seed use per hectare in Bt cotton production and farmers' saved Bt cotton seed partly offset the seed price difference.

After controlling for all input differences and geographical location, Huang et al (2002b) found that adoption of Bt cotton also impacts on cotton yield. Bt cotton contributed to about 7-15% (with an average of about 10%) of yield increase in the Hebei and Shangdong (cotton region I) in 1999.[3] These results are re-confirmed by two similar surveys conducted in 2000 (which also covered Henan province) and in 2001 (which also covered Anhui and Jiangsu provinces, cotton region II). However, new surveys in 2000-2001 also revealed that the extent of the impacts (pesticide and labor inputs and yield) decline with moving Bt cotton from the region I to region II (authors' survey).

[1] For example Anderson and Yao (2001) recently investigated the potential economic effects of China's adoption of GMOs based on a hypothesized 5% Hicks-neutral gain in productivity with GMO adoption.

[2] Factor biased technical change was introduced by Hicks (1932) to describe techniques that facilitate the substitution of other inputs for a specific production factor. He called techniques that facilitated the substitution of other inputs for labor "labor saving" and those designed to facilitate the substitution of other input for land "land saving".

[3] The range of the impacts (7-15%) reflects the different specifications of the production function models used in the regression.

We derive productivity effects of Bt cotton based on our three years (1999-2001) surveys of primary cotton farmers (1052 farms) in five provinces, including the two major cotton producing regions (regions I and II). We compute the average inputs of pesticides, seed and labor and yield of cotton per hectare for both Bt cotton and non-Bt cotton. The productivity impacts are measured as the difference of input use and yield between Bt and non-Bt cotton. These differences or impacts for regions I and II are reported in the first row (2001) of Table 7.3. Impacts of Bt cotton in region III in 2001 was estimated by interviewing provincial agricultural bureaus in the region and from interviews of scientists from Biotechnology Research Institute of CAAS. We estimated the impacts separately by region because bollworm and other insect diseases differ among the three cotton production regions. The national level figures are the aggregation of the regional data based on the area shares observed in 2001.

7.3.1 Projecting adoption rates

Chinese farmers have adopted Bt cotton at an impressive speed. The question is whether and how the adoption behavior develops in the future and how the associated productivity differentials can be expected to behave. While we have the benefit of historic observations on Bt cotton, the likely technology diffusion of GM rice must necessarily be based on some assumptions.

Existing theory on technology diffusion provides some guidance. New technologies with superior characteristics compared to their predecessors are typically not adopted at once by all potential users. (see e.g. Karshenas and Stoneman 1995, Geroski 2000, Sunding and Zilberman 2001 for overviews). One approach that describes innovation adoption as a process of information spread is the epidemic diffusion model.[1] An alternative approach is to take different characteristics of potential adopters into account in a decision theoretic framework. Potential adopters vary over characteristics like farm size, market share, market structure, input prices, labor relations, farm ownership, and current technology. These factors affect the profitability of adoption, and hence the adoption behavior.

Given the uncertainty about adoption patterns we follow a rather stylized approach to the projection of adoption rates. Our basic projection assumes that technical change in GM technologies is higher than in non-GM technologies. The new technologies are assumed to be so attractive to farmers that the maximum technically feasible adoption will be realized. As this assumption may be too optimistic we subsequently subject the adoption rates to a sensitivity analysis.

[1] Markets for new technologies are characterized by a lack of transparency, by imperfect information and by uncertainty on the operating conditions, risks and performance characteristics of the new technology. The number of adopters of the innovation increases as information is generated in the process of innovation use and gradually spreads among potential adopters.

Table 7.3 Hypothesized yield and input difference (%) between GM and Non-GM crops and GM adoption in 2001-2010.

	Yield by region				Input cost at national level		
	National	Region I	Region II	Region III	Pesticide	Seed	Labor
Bt cotton							
2001	5.85	8.30	5.80	3.00	-51	120	-5.1
2002	5.97	8.47	5.92	3.06	-53	120	-5.3
2005	6.34	8.98	6.28	3.25	-58	120	-5.8
2010	7.00	9.92	6.93	3.59	-67	120	-6.7
GM rice							
2002	6.00				-52	50	-7.2
2005	6.37				-56	50	-7.9
2010	7.03				-65	50	-9.1

	Adoption rate (%)			
	National	Region I	Region II	Region III
Bt cotton				
2001	45	85	18	10
2002	51	90	30	15
2005	78	95	85	55
2010	92	95	90	90
GM rice				
2002	2			
2005	40			
2010	95			

Source: author's estimates.

For the impacts after 2001, we assume that the technical progress of Bt cotton will be continued as there is a range of forthcoming improved technologies (Table 7.2). Based on the above empirical study on Bt cotton adoption and its impacts on various inputs and yield, we hypothesize the future patterns of Bt cotton adoption by region and its impacts on inputs and yield as those presented in Table 7.3. All figures in this Table represent the difference (in percentage) of input and yield between Bt cotton and non-Bt cotton. For Bt cotton adoption, we estimated them by region as bollworm and other insect diseases differ among three cotton production regions. The national level figures are the aggregation of the regional data based on the area shares observed in 2001.

Because the commercialization of GM rice has not been approved yet, examination of its impacts on rice production inputs and yield are impossible from the farm level survey. However, the government has approved a number of insect, disease and herbicide resistant GM rice varieties for field trial and environmental release since the late 1990s. Interviews were conducted in the trial and environmental release areas by the authors. The results from these interviews are used to hypothesize the impacts of GM rice commercialization on rice yield and input uses (Table 7.3). It should be noted that Table 7.3 assumes the seed price difference between GM and non-GM varieties to be constant over time. This is a conservative assumption, which will tend to an underestimation of GM gains if seed prices will in fact converge to a lower level in the future. On the other hand, the hypothesized adoption rates for rice are perhaps overestimating the speed of GM rice adoption.

7.4 Methodology and scenarios

7.4.1 Baseline

The impact assessment of Chinese biotechnology developments has been done with the help of the GTAP modeling framework (see chapter 3).

The comparative static model has first been used to generate a so-called baseline projection for 2001-2010. In the second step, the impact of alternative biotechnology scenarios is assessed relative to the baseline projection for 2010. The baseline is constructed through recursive updating of the database such that exogenous GDP targets are met, and given exogenous estimates on factor endowments -skilled labor, unskilled labor, capital and natural resources- and population (see Chapter 5).

The baseline projection also includes a continuation of existing policies and the effectuation of important policy events, as they are known to date. The important policy changes are: Implementation of the remaining commitments from the GATT Uruguay round agreements, China's WTO accession between 2002 and 2005; global phase out of the Multifibre Agreement under the WTO Agreement on Textiles and Clothing (ATC) by January 2005; and EU enlargement with Central and East European Countries (CEECs).

7.4.2 Scenarios

The central question of this chapter is the assessment of economic benefits of research and commercialization of GM crops in the face of likely international policy developments. Towards this end four scenarios have been developed. The first scenario is designed to study the impact of Bt cotton adoption. This impact consists of the part that is already realized in 2001 (Tables 7.1 and 7.3) and the subsequent productivity gains during the period 2001-2010, as summarized in Table 7.3. Since the potential cost savings affect only farmers who have adopted the GM crop varieties, we weigh the productivity and seed cost estimates by adoption rates to arrive at an average impact on the cotton sector.

The second scenario adds the commercialization of GM rice during 2002-2010 to the adoption of Bt cotton. Again, we use the productivity estimates and adoption rates from Table 7.3. Given the uncertainty in the magnitude of the GMO impacts on input usage and yields and the uncertainty with regard to the adoption rates we conduct a sensitivity analysis on these parameters. The third scenario focuses on a possible import ban on GM products from China. Given that China has commercialized both Bt cotton and GM rice, an import ban on GM rice by the main trading partners is simulated.

Finally, we investigate the effects of the recent regulation on labeling of imported soybeans that came into effect in March 2002. This scenario is unfolding in the situation where both the cotton and rice crops have been commercialized. In addition to labeling imported soybeans, the scenario includes labeling of domestic GM rice. The scenario design is 'additive', by adding new elements one at a time, and we disentangle the separate effects of each new element where appropriate.

7.5 Economic impact assessment

7.5.1 The impacts of commercializing Bt cotton

The farmers' decision to adopt Bt cotton weighs the cost savings due to its increased yields, labor cost savings and reduced pesticides cost against increased seed costs. Table 7.4 shows the total impact of adopting Bt cotton and the contributions of these components to the supply price of cotton, relative to the situation without Bt cotton in 2010.

Table 7.4 Main sectoral effects of adopting Bt cotton (percent change, relative to situation without Bt cotton in 2010)

	Total impact	Yield increasing	Labor saving	Pesticide saving	Higher seed price
Cotton					
Supply price	-10.9	-7	-3.3	-1.7	1.1
Output	4.9	3.1	1.5	0.8	-0.5
Dom demand	4.8	3	1.5	0.8	-0.5
Exports	58	37.3	17.5	9	-5.8
Imports	-16.6	-10.8	-4.9	-2.5	3.1
Trade balance (million USD)	389	253	114	59	-71
Textiles					
Supply price	-0.3	-0.2	-0.1	0	0
Output	0.7	0.4	0.2	0.1	0
Exports	0.9	0.6	0.3	0.1	0
Imports	-0.3	-0.2	-0.1	0	0
Trade balance (million USD)	1067	670	341	155	-41

Source: model simulations

The supply price will be 10.9% lower in 2010. The yield increasing and labor saving impacts of Bt cotton contribute, respectively, 7%-point and 3.3%-point to this total effect. The pesticides saving impact lowers the price with 1.7% while the higher seed price increases the supply price with 1.1% (Table 7.4).

The lower supply price increases demand. Domestic demand increases with 4.8% and exports with 58%. However, the share of exports in total demand is very low at 0.24%, and export growth does therefore contribute only mildly to the total cotton demand growth. The rise in domestic demand is almost completely caused by increased demand from the textiles sector. The lower domestic price also implies that cotton imports decrease with 16.6%, relative to the 'no-Bt' case. Higher exports and lower imports imply that the trade balance for cotton will improve with 389 million USD (Table 7.4).

The textiles sector is the other main benefiting sector from adopting Bt cotton. The lower supply price of cotton implies that the supply price of textiles decreases with 0.3%. The cost share of cotton in textiles amounts to 2.5% of total cost. The 10.9% decrease in cotton price leads to 0.27% (-10.9% x 2.5%) decrease in textiles costs. Output and exports increase with 0.7% and 0.9%, respectively, while imports decrease with 0.3%. This causes the textiles trade balance to improve with 1067 million USD.

7.5.2 The impact of commercializing both Bt cotton and GM rice

7.5.2.1 Impact on the rice sector

This scenario assumes GM rice commercialization on top of the adoption of Bt cotton during 2002-2010. This mimics the current adoption process, where Bt cotton continues its rapid adoption path, but GM rice is yet to be released for commercial purposes. Consequently, the results incorporate both the Bt cotton effect and the GM rice effect, but the interaction effects between rice and cotton are negligible. This becomes evident by comparing the second and third column in Table 7.5. The adoption of GM rice generates cost savings due to its yield increasing, labor saving and pesticides saving impact. If the adoption will take place according to the assumed scenario the supply price of rice will be 12% lower in 2010. Almost 8 percent-points can be contributed to the yield increasing impact of GM rice, 4.4% to the labor saving impact, and 0.9% to pesticides saving (Table 7.5). The higher seed price increases the supply price with 1.1%. Despite the sharp decrease in price the output response is only 1.4%. This is due to the low income and price elasticities of domestic demand. People do not demand much more rice if the price decreases or their income increases. The increase in exports is very high (67%), but the impact on output is limited since only a small portion (1.2%) of production is exported.

Table 7.5 Impacts on rice sector of adopting GM rice (percent change, relative to situation without GM products in 2010

	Total impact Bt cotton & GM rice	Total impact GM rice	Yield increasing	Labor saving	Pesticide saving	Higher seed price
Rice						
- Supply price	-12.0	-12.1	-7.8	-4.4	-0.9	1.1
- Output	1.4	1.4	0.9	0.6	0.1	-0.1
- Dom. demand	1.1	1.1	0.7	0.4	0.1	-0.1
- Exports	66.9	66.2	43.5	24.1	5.2	-5.8
- Imports	-23.2	-23.4	-15.3	-8.4	-1.8	2.1
- Change rice trade balance (million USD)	173.2	175.1	113.8	63.1	13.7	-15.5

Source: model simulations.

7.5.2.2 Macro impact

The commercialization of both GM crops has substantial welfare effects. Table 7.6 separates aggregate macro effects into the Bt cotton and GM rice components. The adoption of Bt cotton enhances welfare in China by 1097 million USD in 2010. (equivalent variation, EV). The adoption of GM rice enhances welfare in China by 4155 million USD (Table 7.6). The impact is therefore 4 times larger than in the case of Bt cotton, which is explained by the larger size of the rice sector in 2010. This implies that with the same productivity gains more resources are saved in the rice sector.

The impact on factor prices varies across factors. Land is a 'sluggish' production factor that is not easily reallocated between alternative uses. Hence we allow for land rent differentials across crops. Land prices decline because factor demand is lower due to the yield increasing effect of the GM technology. At the same time, the output expansion falls short of the yield increase, and consequently less land is demanded in the aggregate.

Table 7.6 Macro impact of adopting Bt cotton and GM rice a)

	Bt cotton	GM rice	Total
Welfare (EV, million USD)	1097	4155	5249
Percent changes (%)			
Factor prices			
Land	-0.2	-2.1	-2.4
Unskilled labor	0.2	0.1	0.3
Skilled labor	0.3	0.4	0.7
Capital	0.3	0.4	0.7
Real exchange rate change (%)	0.2	0.1	0.3
Change aggregate trade balance, (million USD)	-671	-1223	-1894

a) Numbers do not exactly add up to the 'Total' column because of small interaction effects.
Source: model simulations.

Labor and capital are perfectly mobile across domestic sectors. Although the demand for labor decreases in both crops, the aggregate demand for labor increases. In the cotton case the additional labor demand originates mainly from the unskilled labor-intensive textiles sector. Due to the positive technical change impact the real exchange rate[1] improves in both experiments, and this leads to a deterioration of the trade balance.

7.5.2.3 Impact on other sectors

The two major price effects of adopting GM rice are the lower price of rice itself and the lower land price. Sectors that use rice or land intensively will therefore achieve the biggest cost gains and can lower their prices and expand output. Land intensive sectors such as wheat, coarse grains, cotton and other crops can use the extra land that is not necessary anymore to produce the demanded quantity of rice. Animal products (mainly pork and poultry) output will grow because they use land and can use the cheaper coarse grains. Especially the other food sector (mainly food processing) can lower its price because the rice they use as inputs has become much cheaper. This generates an output growth in the other foods sector, which in turn leads to more intermediate demand for its inputs such as wheat and other crops.

[1] The real exchange is defined as the ratio of the regional factor price index relative to a global factor price index. The global factor price index is taken to be the *numeraire* of the model

Table 7.7 Impacts of adoption of Bt cotton and GM rice on other sectors in 2010 (percentage change relative to situation without GM products)

	Supply price	Output quantity	Consumer demand	Exports (fob)	Imports (cif)
Rice	-12.0	1.4	1.1	66.2	-23.2
Wheat	-0.3	0.7	0.1	1.1	-0.2
Coarse grains	-0.4	0.6	0.8	0.9	0.0
Oilseeds	-0.1	0.6	0.2	0.0	0.4
Sugar	-0.1	0.5	0.4	0.3	0.3
Cotton	-11.4	5.1	7.2	61.9	-17.4
Other crops	-0.3	0.7	0.3	0.6	0.4
Cattle	-0.3	0.5	0.4	0.9	0.0
Other animal products	-0.4	0.5	0.4	1.6	-0.4
Milk	-0.3	0.5	0.4	0.8	0.0
Fish	-0.6	0.6	0.6	1.4	-1.0
Other food	-1.2	1.5	0.8	4.4	-2.1
Extract	0.1	0.0	0.5	-0.3	0.0
Textiles- leather	-0.2	0.6	0.6	0.7	-0.1
Labor intensive Manufacturing	0.2	-0.2	0.5	-1.7	1.0
Capital intensive Manufacturing	0.2	-0.2	0.5	-1.0	0.6
Services	0.3	0.3	0.4	-1.0	0.9

Source: model simulations.

Although not apparent from Table 7.7, it should be noted that the effects of GM adoption differ in one important aspect between the two crops. Not only is rice a much larger sector than cotton in terms of its contribution to agricultural output and employment, we also observe completely different demand side effects. Consumers demand not much more rice if price is lower or income higher. This means that consumer can spend their increased income and money they save on buying rice on other products. These income effects increase the demand for many other sectors. Such indirect demand effects are not much observed for Bt cotton.

Table 7.8 Impact in different periods: adoption of Bt cotton and GM rice (incremental contribution of adoption within a period in percent changes)

	Past impact (before 2001)		2001-2005		2005-2010	
	GM rice	Bt cotton	GM rice	Bt cotton	GM rice	Bt cotton
Rice						
Supply price	0	0.1	-5.1	0.1	-8.6	0
Output volume	0	0	0.7	0	1.2	0
Export volume	0	-0.3	23.6	-0.3	37.9	-0.2
Trade balance (mil. USD)	0	-1	74	-1	139	-1
Cotton						
Supply price	0	-5.3	-0.2	-4.8	-0.3	-3.6
Output volume	0	2.0	0	2.1	0.1	1.7
Export volume	0	24.4	0.7	19.4	1.1	13.3
Trade balance (mil. USD)	0	88	3	96	9	99
Macro						
Welfare (mil. USD)	0	410	1474	381	2697	314

Source: model simulations.

7.5.2.4 Impact in different periods

Table 7.8 shows the impact of adopting Bt cotton and GM rice over time. The incremental contribution of adoption within three periods is given. The first two columns show the impact of past adoption that is already achieved in 2001. In 2001 the welfare gain due to the adoption of Bt cotton is more than one third of the total welfare gain of Bt cotton realized by 2010. The additional gains from adopting Bt cotton in the other two periods slow down, as most farmers that potentially adopt have already switched to the new varieties. For GM rice all the benefits have still to come. Between 2001 and 2005, as adoption of GM rice starts to pick up, about one third of the welfare gains in 2010 are realized. In the period 2005-2010 the adoption rate increase from 40% to 95% and China is expected to arrive at the steep part of the adoption curve and a large part of the potential gains will be realized. Figure 7.3 shows the cumulative land productivity gains obtained endogenously from the simulations. Land productivity is defined here as the ratio of output to land use. Figure 7.3 displays the change of this ratio, cumulated over the simulation period. Again, the S-shaped curvature for Bt cotton and GM rice indicates that the productivity gains will level off in the future. This pattern is well known from the 'green revolution' that dramatically improved rice yields in the 1970s. The productivity growth is not perpetual.

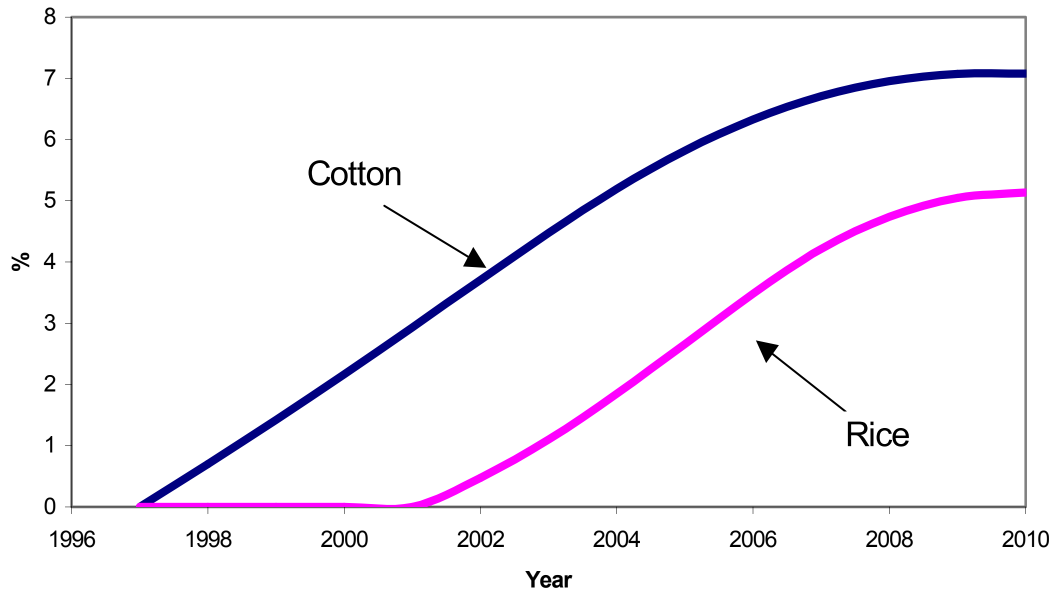


Figure 7.3 Simulated land productivity growth rates over time
Note: the graph is obtained from a Spline interpolation of simulated ratios of output growth over land use in 1997, 2000, 2005 and 2010.

7.5.2.5 Trade impact on other regions

Although China witnesses rising exports and/or reduced imports as a consequence of rapid GM adoption, the patterns of global trade in both the textiles and garments and the rice sectors are not affected very much. Table 7.9 presents the changes in the regional trade balance relative to the 'no-GM' case in 2010. The impact is negligible on major rice importers such as Africa and some rice deficit developing countries in Asia. Major rice. exporters in South-East Asia (i.e., Thailand, Vietnam and Burma) may witness a drop in net export revenues. The Chinese biotechnology research strategy has in the first place concentrated on crops that are of great importance to rural livelihoods, and not on those that are important in terms of export earnings. Rice exports from China represent only a small share in international rice trade

There is an immediate negative impact on other major cotton exporters, most notably India and Pakistan, which are part of our OthAsia region. The cost savings and yield increases from Bt cotton translate into lower production cost for the Chinese textiles and garments industry, but these cost reductions are not of such orders of magnitude that other garments producers (e.g., India and Bangladesh) are affected very much. The phasing out of the multifibre agreement by 2005 is of greater importance for global textiles and garments trade than Bt cotton commercialization in China.[1]

[1] The phase out of export quota under the ATC is included in our baseline. Chinese textile and garments exports are simulated to grow by 20% between 2001 and 2005 as a result of the ATC. In Other Asia (including India and Bangladesh) the growth is 35%.

Table 7.9 Impact of adoption of Bt cotton and GM rice in China on the commodity trade balance in various regions (year 2010, comparison against situation without GM crops)

	Rice		Cotton		Textiles	
	(million USD)	%	(million USD)	%	(million USD)	%
China	173	62	408	43	756	1
HongKong	1	0	1	-1	-25	-2
Taiwan	-1	-12	2	1	-73	-1
JapKor	-6	-2	6	1	-124	-10
SEA	-68	-14	7	0	-100	-1
OthAsia	-26	-2	-12	-19	-59	0
AusNzl	-5	-3	-51	-5	-4	0
NAFTA	-21	-4	-203	-8	-137	0
SAM	-10	-7	-6	-1	-50	-1
EU	-11	-2	1	0	-270	-1
CEEC	-2	-2	0	0	-20	-1
ROW	-23	-1	-132	-4	-67	1

Note: details of country groups are provided in Appendix 5.1.

7.5.2.6 Robustness of results: sensitivity analysis on productivity shocks

In this section we conduct a systematic sensitivity analysis (SSA) on the productivity parameters, given the uncertainty in the magnitude of the GMO impacts on input usage and yields and given the uncertainty with regard to the adoption rates. In section 7.3.1 we have argued that the maximum technically feasible adoption of the GM technology may not be realized. As a starting point for the SSA, we have taken a more conservative projection of the adoption rates of Bt cotton, which are obtained from estimating a logistic equation for each region.[1] The estimates that are based on historical adoption data do not take fully into account that the benefits of GM technologies over non-GM technologies increase over time and are therefore lower than those reported in Table 7.3. According to the logistic model 56% of the area would be Bt cotton by 2010, rather than the 92%, which is believed to be technically feasible given increased benefits of GM technologies. For rice, the same procedure has been followed, albeit that we do not have historical observations available. Here, we have also reduced the mean adoption rate in 2010 to 56%. The simulation results of the previous estimates, as described in section 7.5.2.2, and a scenario where the adoption rates are 56% for both cotton and rice are given in Table 7.10. The average effects vary almost linearly with the adoption rates. The lowering of adoption rates by about 40% compared to the optimistic scenario of Table 7.3, results also in a reduction of values of key variables by about 40% (compare the first two columns called 'Total impact').

[1] The estimated equation is $f(x) = \frac{a}{1 + b \cdot e^{-c \cdot x}}$ Where x denotes time. The estimated adoption rates asymptotically approach the value *a*. The estimation provide a rather good fit to the data, with more than 90% of the variance explained by the equation, in spite of the limited number of observations.

Table 7.10 Results of sensitivity analysis. Adoption of Bt cotton and GM rice

	Adoption rates: Cotton:92%; Rice:95 %	Adoption rates: Cotton: 56%; Rice: 56%		
	Total impact	Total impact	SSA Mean a)	SSA Standard deviation*
Cotton				
Supply price	-10.9	-7.2	-7.3	1.2
Output	4.9	3.2	3.2	0.5
Exports	58.0	35	34.9	6.7
Imports	-16.6	-11.1	-11.2	1.8
Trade balance	389	260	261	43
Rice				
Supply price	-12.0	-7.5	-7.5	1.3
Output	1.4	0.8	0.8	0.2
Exports	66.9	36.6	36.5	7.6
Imports	-23.2	-14.7	-14.9	2.6
Trade balance	173	101	101	19.5
EV	5249	3280	3289	939

a) Systematic sensitivity analyses in 56% scenario around cotton and rice productivity shocks (vary 60%, triangular distribution).
Source: model simulations.

Next, we performed an SSA to test the robustness of our results with regard to the productivity shocks due to uncertainty in GM impacts and adoption rates. The SSA procedure follows Arndt (1996), and uses a Gaussian quadrature. A main advantage of the SSA is that it produces estimates of means and standard deviations of model results, while requiring only a limited number of model runs. This approach views the adoption rates as random variables with associated distributions.

We assume that the productivity shocks fall within a band of plus and minus 60% of the mean and the distribution is assumed to be triangular around the mean. Table 7.10 shows that the standard deviation around the mean values is generally low, and the SSA results are very encouraging as regards the robustness of the simulation estimates. For example, if we subtract two times the standard deviation from the mean EV estimate, we still observe a positive macro economic welfare gain, of 1.4 billion USD in 2010.

7.5.3 Assessment: benefits of GM adoption

In the discussion above we have referred to the equivalent variation (EV) concept to provide a summary indicator of the potential economy-wide benefits of GM adoption. Of course, the conventional EV measure of welfare changes does not take into account other important aspects of human well-being. The welfare measurement is based on a comparison of utility derived from consumption with and without the simulated changes. The utility function[1] does not account for intrinsic, positive or negative, utility that might be attached to the introduction of new crop varieties.

Another clear benefit of Bt cotton adoption is the reduced application of insecticides. According to Huang, et al. (2000) pesticide poisoning affected between 53,300 to more than 123,000 persons each year in China in the past decade. On average China had about 10,000 deaths due to pesticide poisoning every year, though the number has declined significantly since the late 1980s and reduced to less than 4,000 in 1996.

Bt cotton has an enormous potential to reduce the health risks of insecticide use. According to Pray et al. (2002) Bt cotton has significantly reduced the number of farmers who are poisoned each year. Based on surveys these authors show that 22% - 29% of the non-Bt cotton farmers reported poisonings in 1999 and 2000, while only 5%-7% of the Bt cotton farmers reported poisonings.[2] Self-reported ailments are only the tip of the iceberg. Both visible acute health impairments and invisible chronic health diseases of rice farmers are closely linked with the extent of their exposure to pesticides (Hunbag et al. 2000).

The estimated macro-economic welfare gains of adoption far outweigh the biotech research expenditure in China. The optimistic scenario, with high adoption rates, results in an annual income gain of roughly 5 billion USD in 2010, while the lower range estimate with lower adoption rates still delivers 3 billion USD. These gains are recurring annually and may be compared to R&D expenditures reported in Huang and Wang (forthcoming). They estimate biotech research expenditures in 2000 at about 40 million USD. The accumulated expenditure between 1986 and 2000 amount to about 450 million USD (in real 2000 prices). The implied social rates of return to research are certainly very high.

On the other hand a number of limitations should be borne in mind when interpreting the results. Issues of biosaftey, environmental effects, and food safety are not entering our analysis. All these factors should be considered next to the economic assessment in order to arrive at a societal evaluation of GM technology.

7.5.4 GMO trade ban on GM rice

The question addressed in this section is whether it is still worthwhile for China to commercialize GM rice if consumer concerns in the enlarged EU, Japan, Korea and South East Asia lead to a ban on GM food products. Technically, this is modeled as a non-tariff-barrier against Chinese rice imports that reduces these countries' imports of Chinese rice to zero.

Under this scenario exports of GM rice from China decline substantially. Whereas an increase of rice exports volume of 67% was projected when both GM rice and Bt cotton are adopted, the trade ban results in a drop to just 5% above the baseline result for 2010 (Table 7.11). This follows immediately from the export shares in the baseline situation in 2010 (without all the biotech shocks), which amount to 21%, 8% and 9% for South East

[1] In the GTAP model, the utlity function is of the Constant Differecences of Elasticities (CDE) form.
[2] Farmers asked if they had headache, nausea, skin pain, or digestive problems when they applied pesticides.

Asia, Japan-Korea and the EU27 (enlarged EU with 27 counties), respectively. Rice output is also declining, by 0.5 percent points (1.4%-0.9%=0.5%, Table 7.11). The drop is limited, because the share of exports in production is only 1.2%.

Table 7.11 Impacts of GM import ban on China and other regions (comparison against situation without GM crops in 2010)

	Adopt Bt cotton and GM rice	GM trade ban
China		
Rice exports (% change)	67	5
Rice output (% change)	1.4	0.9
Change rice trade balance (million USD)	173	19
Welfare (million USD)	5249	5229
Other regions		
Japan & Korea welfare (million USD)	298	212
South East Asia welfare (million USD)	13	-33
EU-27 welfare (million USD)	-7	-52

Source: model simulations.

Table 7.11 also shows the welfare effects for the banning countries. The welfare impact is negative but not substantial in these countries. The three banning regions together forego 177 million USD. Again it should be stressed that our welfare measure does not include the (dis-) utility of having GM varieties. In the banning scenario this means that we are not taking into account the possible positive utility in the banning countries derived from not having the GM rice on the market.[1] Our method, in fact, does exactly the opposite. It counts the unavailability of GM rice as a negative contribution to welfare, as consumers' choices are more limited under the banning scenario. If we subtract this negative effect from the welfare loss of the banning countries, they still forego about 90 million USD. This results mainly from negative allocation effects because the banning of imports stimulates domestic production in the heavily protected rice sector.

Is it still worthwhile for China to invest in GM rice if other countries ban GM rice imports from China? The aggregate welfare measure against which the trade ban impact can be evaluated indicates that the export ban does not significantly change the benefits of adopting GM rice in China. Although output growth in the rice sector is somewhat dampened, the overall negative effect on China is small. The largest adoption gains are realized within China itself. As far as rice is concerned, the negative attitude towards GM food products in some high-income countries is of little concern to China.

7.5.5 Labeling

In this scenario, China requires labeling of soybean imports from NAFTA and South America. In January 2002 the Chinese Ministry of Agriculture has announced three new

[1] Some empirical evidence can be derived from willingness to pay studies that estimate the price premium for non-GM varieties. For example Lin (2002) estimates that Japanese consumers were willing to pay a price premium of up to 30% for non-GM soybeans in 2000.

regulations on the biosafety management, trade and labeling of GM farm products that took effect after March 20, 2002. These regulations require importers of genetically modified agricultural products to apply for official safety verification approval from China's Ministry of Agriculture. Since China is a large market for US soybean exports, buying more than $1 billion worth in 2001, it is not surprising that US producers have accused Beijing of using the new rules to hinder imports and protect Chinese soybean growers. After 2-month intensive negotiation between China and US, recently an interim deal was reached under which China will temporarily waive its regulations and has agreed to recognize US assurances that its soybeans are safe for human consumption. The other main sources of soybean imports into China are countries that also have embraced the benefits of herbicide tolerant (Round-Up Ready) GM soybeans: Argentina and Brazil.

However, labeling is not only introduced for imports. Domestic produce has to be labeled as well.[1] The simulation experiment in this section provides an assessment of the economic effects if indeed China is to label its own GM food crops, given that it exercises labeling requirements for imported soybeans. In our case, this means that China has to implement a labeling for GM rice only, as there is no GM soybean production within China.
We do not model separate production-consumption chains for GM and non-GM varieties. One consequence of this simplification is that we are unable to quantify any (positive or negative) price premium that GM varieties might achieve on the Chinese market. Our analysis is based on a rather straightforward assumption on labeling costs for both imported and domestic GM crops.

Labeling involves more than just attaching some information to the product. A complete system is needed to separate GM from non-GM products. This leads to an externality for non-GM farmers and processors, as they have to make sure that their product is actually GM-free. The incidence of labeling cost falls more on conventional farmers than on GM adopters. Costs of separation are due to changed agricultural practices (e.g. more space between fields etc.), monitoring and measurement (e.g . instituting a system for Hazard Analysis at Critical Control Points, HACCP), insurance, identity preservation in processing and transport. There exist some estimates of the cost of segregation for oilseeds, corn and potatoes. Such estimates for the European Union (European Commission, 2002), Canada (KPMG, 2000) and the USA (Economic Research Service, 2001; Lin, 2002) show that on average segregation may raise unit cost by as much as 28% for oilseeds and 22% for corn. These estimates appear to be rather high, and it is questionable whether it is realistic to assume that this high cost will have to be incurred in the Chinese situation. Using the corn estimates as a reference, we arrive at a rough approximation of extra cost that have to be incurred by non-GM rice producers, and we assume that total production costs will increase by 3 percent through labeling. [2,3] This is mo[4]deled as an increase in the cost of

[1] Hence, the Chinese labeling requirements are in accordance with the GATT principle of national treatment, as enshrined in article 3 of the GATT.
[2] If we have 40% GM rice farmers in 2005, then 60% * 22% = 13.2% is the average cost increase for the whole rice sector. In 2010, with an assumed adoption of 95%, this would become 5% * 22% = 1.1%.
[3] To make it even more complicated: In practice, the separation cost are not constant. As more adoption takes place it becomes harder and more costly for the non-adopters to assure a GM free product.
[4] To make it even more complicated: In practice, the separation cost are not constant. As more adoption takes place it becomes harder and more costly for the non-adopters to assure a GM free product.

services required for rice production. Labeling of imported GM soybeans is modeled as an increase in the 'transport/handling' margin between FOB and CIF for soybean exports from NAFTA and Southern America (SAM) to China. We assume that these handling costs will increase so much that the total import costs (CIF price from NAFTA or SAM to China) will increase with 5%. The size of the import cost increase is of course debatable. Existing studies on this issue have focused on the additional cost to insure that GM and non-GM products are not adventitiously mingled in the hold of ocean ships. This is not relevant in the Chinese case, as all US and SAM soybeans for the Chinese market are in fact GM varieties. However, the labeling requirement does undoubtedly lead to additional bureaucracy, which acts similar to a tariff in its effect on trade volumes (although no tariff revenue is involved). Indeed, the short run effects after the introduction of the new labeling requirements in 2002 have resulted in a considerable drop of US soy exports to China.

Table 7.12 Impacts of labeling in 2010 (percent change relative to baseline)

	Bt cotton & GM rice adoption with GM rice trade ban	Labeling soybean imports and domestic rice
Rice		
China		
- Supply price	-12.1	-9.3
- Output volume	1.4	0.6
- Export volume	5.3	-7.2
- Import volume	-23.7	-18.5
- Trade balance (million USD)	19	-14
Soybean		
NAFTA		
- Import price China (cif)	0.0	7.1
- Export volume to China	0.4	-14.1
South America		
- Import price China (cif)	0.0	6.2
- Export volume to China	0.4	-10.7
China		
- Supply price	-0.1	0.3
- Output volume	0.7	2.7
- Export volume	0.1	-1.5
- Import volume	0.4	-6.1
- Trade balance (million USD)	-13	58
- Welfare (million USD)	5229	3953

Source: model simulations.

The assumed cost increases are obviously a rough estimates, and the actual cost for the Chinese rice producers and for international suppliers of soybeans may be higher or lower. In the absence of better information, this assumption will be sufficient to illustrate the effects of labeling, and to give a sense of the order of magnitude of macro-economic effects.

Table 7.12 shows the economic costs of labeling both imported soybeans and domestic rice. The domestic supply price of rice increases relative to the previous experiment, but still a price decline of almost 10% relative to the baseline is projected. The higher domestic supply price leads to fewer exports, less output, and more rice imports. The labeling of imported soybeans increases the equilibrium price of imported soybeans from NAFTA and South America with 7.1% and 6.2%, respectively, resulting in a considerable drop of soybean exports from these regions. Total Chinese soybean imports decline with 6% because soybeans from NAFTA and SAM cover 77% of all Chinese soybean imports.

Labeling is costly. Measured in terms of equivalent variation, and bearing in mind that we do not include any positive utility effects that might exist when consumers have access to improved product information, the welfare loss to China is about 1.3 billion USD. However, even when a trade ban and labeling are occurring together, we still observe a very positive welfare impact of adopting GM crops (almost 4 billion USD).

This experiment highlights an important trade-off that China is facing. Labeling of imported soybeans raises the domestic price of soybeans, and benefits Chinese soybean farmers, who will see a shift towards domestic demand, and are able to increase output at higher prices. This also has an adverse effect on the users of imported soybeans in the livestock sector. However, domestic labeling of GM foods also raises the price of domestic rice, and this affects rice consumers. Hence, labeling improves the competitive position of domestic (non-GM) soybean farmers, as they become cheaper relative to imports, but it hurts rice consumers, as well as users of imported soybeans in the livestock industry.[1]

7.6 Conclusions

China is developing the largest public plant biotechnology capacity outside of North America. The international debate on GM technologies has its influence on Chinese policy making and on agricultural industry. Adoption of Bt cotton has been proceeding at a rapid pace in recent years. The largest part of the potential productivity gains from Bt cotton will be realized already by 2005, thereafter the productivity growth is slowing down. In contrast, GM rice is not yet available to farmers on a commercial basis, and our estimates indicate that large productivity gains are yet to be realized between 2005 and 2010.

This chapter uses productivity estimates for GMOs that are based on empirical micro-level data for the cotton sector and tentative experimental data for the rice sector in China. Biotechnology leads to crop specific factor biased technical change, and the results show that the distinction between yield and production factors effects is important. Factor markets for labor and land will witness different effects, depending on the type of biotechnology being adopted. The scarce land resources can be utilized more effectively with land-saving technologies. Even though labor is relatively abundant in China, the adoption of somewhat laborsaving GM crops does not necessarily lead to falling wages. This is especially the case in Bt cotton. Here, the expansion of the cotton sector itself, together with rising labor demand from the unskilled labor intensive textiles sector more than compensate for the savings in labor inputs obtained by adopting the GM crop. The use of empirical

[1] Our experiments considered only a unilateral GM labeling by China. As a consequence some soybean trade is diverted towards EU markets, which does not adopt labeling in our scenario. If this alternative outlet for US and South American soybeans does not exist, the price effects on imported soybeans would be smaller.

estimates that give a better indication of the magnitudes of the productivity impact of GMOs is certainly very important.

The economic gains from GMO adoption are substantial. In the most optimistic scenario, where China commercializes both Bt cotton and GM rice, the welfare gains amount to an additional annual income of about 5 billion US$ in 2010. This amounts to about 3.5 USD per person. This is not a small amount in a country, where according to the World Bank 18% of the population had to survive with less than 1$ per day in 1998.[1] If actual adoption rates are lower, we still observe an income gain of 3 billion USD in 2010. Given the importance of rice for agricultural production, employment and food budget shares, the gains from GM rice adoption are orders of magnitude larger than the Bt cotton gains. The estimated macro economic welfare gains far outweigh the public biotechnology research expenditures.

Although the productivity gains for China are significant and translate to rising exports or reducing imports, the patterns of global trade in both the textiles and garments and the rice sectors are not affected very much. The impact is negligible on major rice importers such as Africa and some rice deficit developing countries in Asia, but major rice exporters (i.e., Thailand, Vietnam and Burma) may experience a drop in net export revenues. The Chinese biotechnology research strategy has in the first place concentrated on crops that are of great importance to rural livelihoods, and not on those that are important in terms of export earnings. Rice exports from China represent only a small share in international rice trade. There is an immediate impact on the export revenues of major cotton exporters, most notably India and Pakistan. The cost savings and yield increases from Bt cotton translate into lower production cost for the Chinese textiles and garments industry, but these cost reductions are not of such orders of magnitude that other garments producers (e.g., India and Bangladesh) are affected very much. The phasing out of the multifibre agreement by 2005 is of greater importance for global textiles and garments trade than Bt cotton commercialization in China.

Our results indicate that trade restrictions do not significantly lower the gains from biotechnology research in China. A trade ban on GM rice (food crop) has only a minor effect since the portion of rice exported is very small. The effects of unilateral labeling of soybean imports are larger and it has clear distributional impacts. Our experiments highlight an important trade-off that China is facing. If China wants to label GM products, this raises the domestic price of soybeans, and benefits Chinese soybean farmers. However, domestic labeling also raises the price of domestic GM rice, and this affects rice consumers. Our findings suggest that it would be economically advantageous for China to continue the promotion of its GM biotechnology, including commercializing its GM food crops. The economy-wide benefits associated with more productive crops outweigh R&D expenditures by a wide margin.

Our findings also suggest that most gains occur inside China, and can be achieved independently from biotech-unfriendly polices adopted in some industrialized countries. This stands in contrast to the findings of Anderson and Yao (2001), who argue that the effects of GM adoption depend to a considerable extent on the trade policy stance taken in high-income countries opposed to GMOs.

[1] World Development Indicators. International poverty line of 1$ (PPP adjusted) in 1998.

This chapter offers an economic analysis of some of the issues surrounding rapid adoption of biotechnology in China. Despite being based on the comprehensive general equilibrium model and an associated global database, a number of limitations should be borne in mind when interpreting the results. First of all, in this paper no utility is attached to improved product information. We are therefore unable to quantify the possible positive effects that labeling may have on consumer's welfare. We are also unable to provide estimates of the price premium that may occur due to preference shifts, because we do not consider the separation of GM and non-GM supply chains. While we have concentrated on trade policy issues relating to primary products, more complicated issues may arise with respect to trade in processed foods.

Chapter 8 Mapping Dutch FDI and trade in China

8.1 Introduction

One of the objectives of this study is to identify business opportunities for the Dutch agribusiness sector. In this chapter we identify in only a very general way a number of business opportunities, as the study is focused more on product categories than on products. In addition, the realization of business opportunities depends on a wide range of factors, such as institutional aspects, regulations, tax regime, cultural aspects, etc. In this chapter we take into account only general economic aspects and changes in trade regime.
There are three kinds of business opportunities for the Dutch agribusiness sector, namely trade in products and services, trade in property rights (such as licenses), and foreign direct investment. Here, the focus is on trade in products and on direct investment.

In the first part of this chapter we present some considerations regarding the general economic background because to a large extent this background determines the opportunities for the agribusiness sector. In the second part we present an analysis of the development of trade with China since 1990. For this analysis we used TSA-Express (Time Series Analysis-Express), a software package developed by LEI based on the UNCTAD trade database. We then discuss the business opportunities for the Dutch agribusiness sector on the basis of the simulated development of Chinese demand, Chinese exports, and Chinese imports in the scenarios analyzed in the previous sections. In the third part of the chapter, we sketch the development of foreign direct investment (FDI) in China since it opened up in the 1980s. Also the reasons for FDI and the relations with trade are elaborated on the basis of a literature study. Finally, the possible implications for FDI in China are analyzed against the background of the simulated development of the Chinese economy and of the Chinese agribusiness sector and the Chinese market for agricultural products and food. We end the chapter with some concluding remarks.

8.2 General economic background

Opportunities for the Dutch agribusiness sector in China must be seen against the background of the development of the Chinese economy. The development toward a socialist market economy and the gradual opening up of the Chinese market to foreign companies since 1978 have made an important contribution to China's strong economic growth in the past 25 years. Both international trade and FDI have contributed to this development. The importation of inputs required by the export-processing industries grew as a result of reductions in trade barriers.

On the other hand, China's exports grew at an annual average rate of 16 percent during the period 1979-2000. The relatively low, fixed exchange rate of the Chinese yuan against the US dollar contributed to this development. If this rate of export expansion continues, China will become the world's largest exporter within five years. Half of these exports will be produced by foreign companies or joint ventures with foreign companies. However, China's import of final products has grown rapidly in recent years as a result of the expanding domestic market; consequently, its surplus on the current account of its balance of payments is decreasing. Also net FDI inflow has played an important role in the development of the Chinese economy. These investments have contributed to the growth of exports. The importation of inputs as well as FDI may enhance productivity growth in China by technological spillovers. These spillovers occur when China receives productivity benefits from technologies developed by others.

Because of these developments, the composition of China's output changed from the production of importables to the production of exportables and non-tradables. In other words, China has taken advantage of its low labor costs. In 1977, before the reforms, China's two-way trade accounted for a mere 0.6 percent of the world total, while in 2002 this figure was 5 percent. China's share in world trade is expected to grow to 6 percent in 2003 and to 7 percent in 2004 (CPB, 2003). The contribution of Chinese trade to the nation's GDP increased from less than 10 percent to more than 40 percent between 1977 and 2002. Participation in the international trading system has become vital for China maintain its economic growth.

As a consequence of economic growth, the domestic market is gradually growing and this holds in particular for products and services with high-income elasticities. However, trade barriers to final consumption goods are in general still very high in China. The growing domestic market may increase the interest of foreign companies in FDI.

Furthermore, China's accession to the WTO has made the country a more reliable trading partner. This applies particularly to its most important trading partner, the USA. Before its accession, China needed the US Congress to renew each year its status as most favored nation. The accession of China has diminished the risk premium for export-oriented production in China.

What does all this mean for foreign agribusiness companies? First of all, China is interested in importing inputs for the supply chain for agricultural products. This applies not only to goods but also to management skills and knowledge that can be used in the local situation. This means that new technologies have to be suited or adopted to the local circumstances, namely land scarcity, a limited availability of capital and an institutional system that differs from that in developed countries. The inputs that are particularly important are those for labor-intensive agricultural products. This is for two related reasons. Although the rural regions are undergoing a process of restructuring, there is a huge surplus of labor in rural areas and, in general, wage costs are relatively low in China compared to those in developed neighboring countries such as Japan, South Korea, etc. China is therefore interested in importing inputs to boost the production of labor-intensive agricultural export products as far as these inputs are not available in China. Important in this respect are not only inputs for the agricultural production process itself, but also all the inputs in the supply chain that are necessary to meet the requirements of the import markets in developed countries.

Secondly, the importation of China's labor-intensive intermediate agricultural products is of particular interest to foreign agribusiness companies. Thirdly, incomes in China are rising and particularly in the big cities in the eastern part of the country – which have the highest incomes - a clear change in consumption patterns and distribution systems is occurring. This offers increasing opportunities for foreign agribusiness companies to supply Chinese consumers with new products.

Thus, China offers opportunities also for Dutch agribusiness companies. The Netherlands is specialized in the production of labor-intensive products, and supplies markets in the developed countries of Western Europe. Land for agricultural production is scarce in the Netherlands, just as it is in China. However, there are also big differences. For example, labor and land productivity in Dutch agriculture are much higher than they are in Chinese agriculture as a result of the Netherlands' use of more capital- and more knowledge-intensive production systems. The similarities in combination with the differences can make Dutch agribusiness companies an interesting partner particularly for importing inputs into China and for developing the supply chain for agricultural products in China. In addition, China's growing domestic market offers opportunities for Dutch companies to export to China technology-intensive products with a high value added per kg of product.

8.3 Sino-Dutch trade

A distinction should be made between export to and import from China. Both the export of agricultural products and food to China and the import of these products from China can be of importance for the Dutch agribusiness sector. This is particularly the case when these products are intermediate products for the Dutch agribusiness sector or when they compete with Dutch products. Both export to and import from China are dealt with in this chapter.

8.3.1 Trade in general

China's major trade partners include Japan, South Korea, the USA, and Hong Kong. The Netherlands ranks as China's 27th most important importing partner, with a value of USD 1.2 billion in 2000. Compared to the small position of the Dutch trade in China, China is much more important for the Netherlands: it ranks number seven among the Netherlands' importing partners, following Germany, the USA, the UK, Belgium, France, and Japan. During the last decade, Dutch imports from China have increased sharply, reaching USD 6.6 billion in 2000. China has a great trade surplus with the Netherlands. On the list of China's export destinations, the Netherlands ranks number nine. However, some of China's exports to the Netherlands are re-exported from the Netherlands to other countries.

Figure 8.1 shows the Dutch share in China's total imports during the last decade. The percentage of China's imports from the Netherlands is both insignificant (less than 1%) and declining. As Figure 8.2 shows, the Dutch share in all of China's importing categories is negligible, except for the categories beverages & tobacco (a modest 7.8%) and food & live animals (1.4%). Dutch beer accounts for 99 percent of the export value in the beverage & tobacco category.

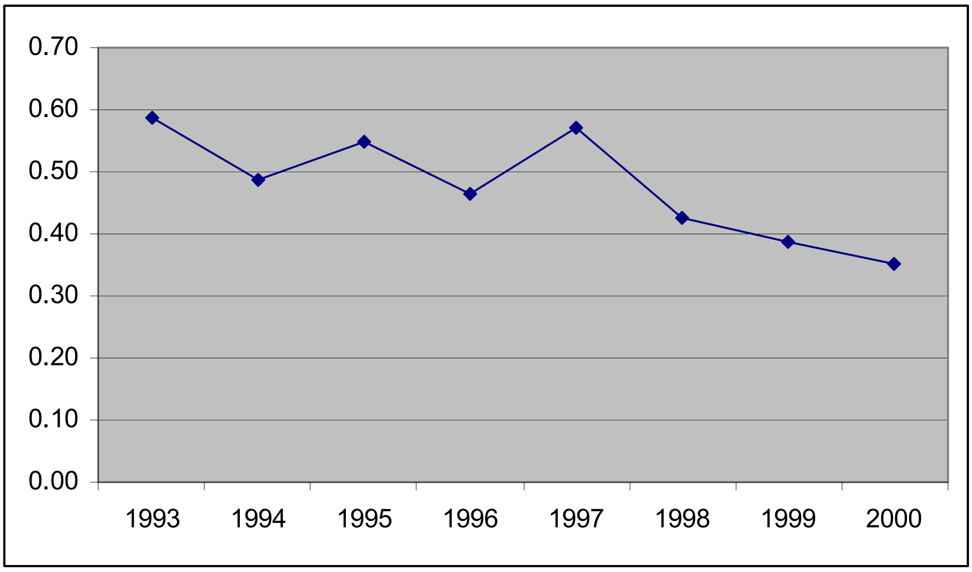


Figure 8.1 Share of China's total imports from the Netherlands (%)

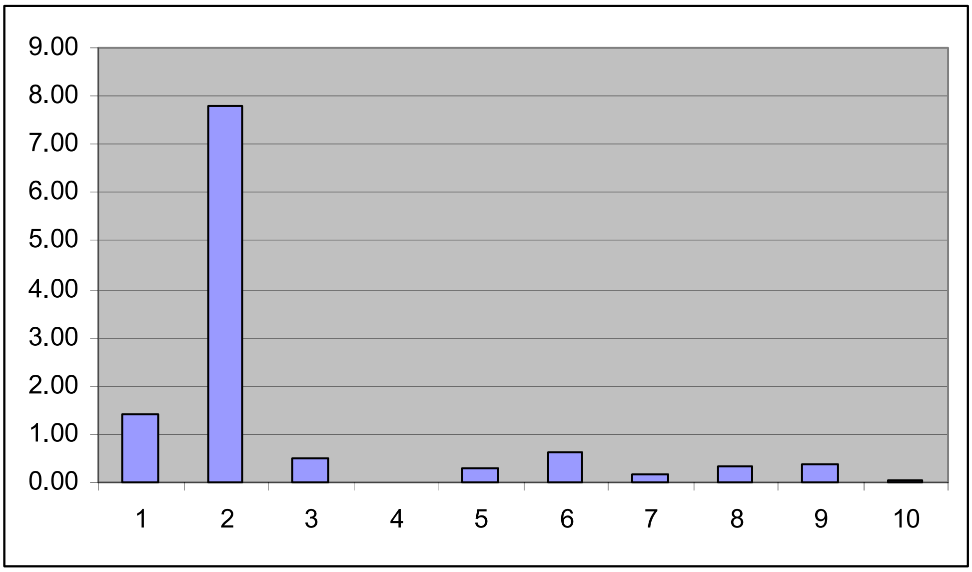


Figure 8.2 The Dutch share in China's import categories in 2000 (%)
1: food & live animals; 2: beverages & tobacco; 3: crude materials & inedibles;
4: fuels, lubricants, etc.; 5: animal, vegetable oils, fats, & wax; 6: chemicals & related products; 7: manufactured goods; 8: machines & transport equipment; 9: misc. manufactured articles; 10: other goods

The major categories of Chinese imports from the Netherlands in terms of value are machines & transport equipment, chemicals & related products, and crude materials & inedibles (see Figure 8.3). In 2000, Chinese imports of Dutch machines & transport equipment amounted to USD 416 million. The leading subcategories include electric machines, special industrial machinery, and general machines. Machinery for agriculture and the agrofood industry also belongs to this category. The second largest category is chemicals & related products (mainly organic chemicals, plastics, and other chemical materials), as well as fertilizers & pesticides. Imports of crude materials & inedibles from the Netherlands have increased in recent years. This category ranks third; the leading subcategory is metalliferous ore & scrap.

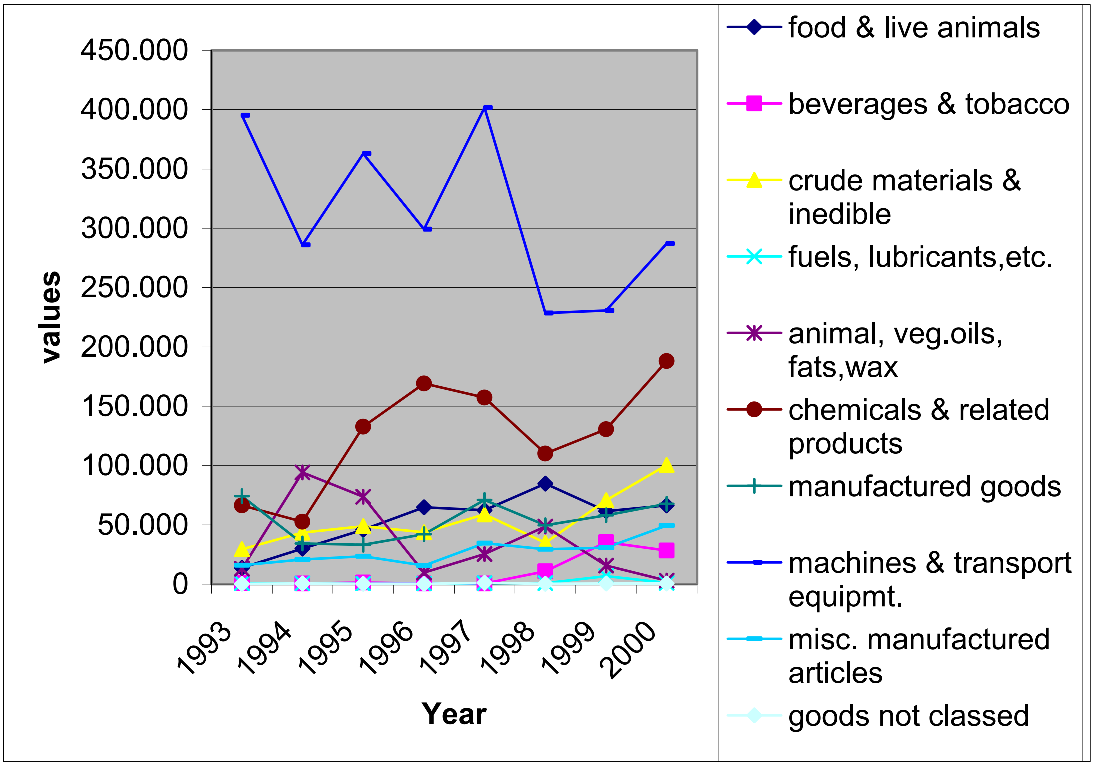


Figure 8.3 Total Chinese import value from the Netherlands by category, 1993-2000 (USD millions)

The major categories of Dutch imports from China include machines & transport equipment and manufactured articles & goods. Half of the Dutch import value from China (USD 3 billion) comes from the machines & transport equipment category, of which the import value of office machines and automatic data processing equipment reached USD 2 billion in 2000, making it one of the largest categories. The importation of manufactured articles & goods mainly comprises metal products, mineral products, textile articles, fabric, wooden products, clothing, and baby toys.

8.3.2 Trade in agricultural products and food

In 2000, the value of China's agricultural exports to the rest of the world exceeded USD 15 billion. The largest category was fish products, followed by vegetables & fruits, and meat & crude animals. The value of China's agricultural exports to the Netherlands was USD

371 million, representing 2.4 percent of China's total agricultural exports. This share is relatively high for the product categories oilseed (14%) and crude animal materials (7%). In the same year (2000), the total value of agricultural products imported into China amounted to USD 12.6 billion. The top four categories that China imported were oilseed, cork & wood, fish products, and animal feedstuff.

As shown in Table 8.1, the Dutch share in China's total imports of agricultural products was 1.55 percent. The beverages category was the major one, accounting for 32 percent of China's total imports. As stated earlier, the excellent achievement in the beverage category derives from the beer export (Heineken). Other interesting categories include crude animal & vegetable materials, meat products, and dairy products. Within the crude vegetable materials category, the important subcategories were bulbs, live plants, and seeds for sowing. Within the meat product category, 99 percent of China's imports from the Netherlands were meat offal. The same applies to dairy products, though 100 percent of China's imports from the Netherlands are milk and cream products (i.e. no other dairy products such as butter and cheese products).

Table 8.1 China's imports of agricultural products in total and from the Netherlands by category (USD million)

Category	1993	1997	2000	NL 2000	NL % in 2000
101a All agricultural products	3,975.7	8,813.3	12,698.8	196.4	1.55
00 - Live animals	18.7	41.0	52.3	1.2	2.38
01 - Meat, meat preparations	70.0	157.1	651.0	35.0	5.37
02 - Dairy products, bird eggs	51.3	65.6	216.5	10.8	5.01
03 - Fish, crustaceans, molluscs	367.1	544.6	1,210.3	7.2	0.60
04 - Cereals, cereal preparations	1,026.9	934.1	613.3	0.4	0.06
05 - Vegetables and fruit	97.7	335.2	524.4	0.5	0.09
06 - Sugar,sugar preparations,honey	134.0	251.1	178.1	2.2	1.26
07 - Coffee,tea,cocoa,spices	55.0	82.3	94.8	1.7	1.80
08 - Animal feedstuff	307.4	1,791.0	907.9	9.1	1.00
09 - Misc. edible products, etc.	78.1	102.2	309.8	6.7	2.18
11 - Beverages	45.1	65.8	159.8	51.3	32.09
12 - Tobacco,tobacco manufact.	200.3	254.4	204.4	0.1	0.04
21 - Hides,skins,furskins,raw	189.4	405.0	637.8	17.1	2.68
22 - Oilseeds,oleaginus fruit	28.8	873.8	2,943.6	0.1	0.00
24 - Cork and wood	634.0	959.8	2,658.5	8.7	0.33
29 - Crude animal, veg. materials	170.4	266.1	360.0	23.2	6.45
41 - Animal oils and fats	36.3	89.4	143.8	0.9	0.63
42 - Fixed veg. fats and oils	456.6	1,572.4	754.8	19.5	2.59
43 - Animal and veg.fats and oils	8.7	22.4	77.7	0.5	0.70

8.3.3 Future development

Tables 8.2 and 8.3 show the projection of annual import/export growth rate for various commodities as generated by the GTAP model (see Chapter 5). As an exact correspondence between the classification of the SITC and the GTAP database is not possible. We made a crude approximation match (see Figure 8.4). One of the problems is that the SITC categories used in Table 8.1 include both primary and processed products, while the GTAP data as used in Tables 8.2 and 8.3 have a separate category for processed food.

Figure 8.4

Classification used in Table 8.1 (UNCTAD)	Classification used in Tables 8.2 & 8.3 (GTAP)
04	1, 2, and 3 for rice, wheat, coarse grains
22+42	4 for oilseeds
06	5 for sugar
26	6 for plant fibers
05+09+29+08	7 for horticulture
00+01+21+41+43	8 and 9 for cattle and pork and poultry
02	10 for milk
03	11 for fish
07+09+11+12	12 for processed food

Note about UNCTAD category:
08 contains both horticulture and processed food
09 contains other animal products, oilseeds and processed food
24 cork and wood are in the broader GTAP extraction category

We assume that the Dutch share in the Chinese import as indicated in Table 8.1 will not change in the near future. What trade opportunities are there then for Dutch agribusiness companies?

The Chinese import of agricultural products consists to a large extent of products that do not play an important role in Dutch agriculture or Dutch exports, as indicated in Table 8.2. This holds particularly for cereals, oilseeds, sugar, and plant fibers. These products accounted for more than two-thirds of Chinese agricultural imports in 2001. Generally speaking, these product sectors will not offer significant business opportunities for the Dutch agribusiness given the sector's negligible import share in the Chinese total, although the import growth in some of these sectors is expected to be high. Although relatively lower growth rates are expected for pork, poultry, and fish these categories could offer export opportunities as the Chinese import values are already high. In other words, an important growth in terms of volume is foreseen for these categories. For the other sectors, both horticulture and cattle show a high import growth. However, for cattle the import value in 2001 was still low, although the Dutch companies seem to be doing better in this sector. The most important business opportunities for the Dutch agribusiness seem to lie in horticulture. Of the four categories which include horticultural products (i.e. categories 05, 08, 09, 29), category 29 (crude vegetable materials) is the most important. In 2000, China imported more than 12 million crude vegetable items, of which 9 million were bulbs or live plants. Other significant imports from the Netherlands were cut flowers, oilseed residue, and potatoes.

Table 8.2 Projection annual growth rate of China's imports

Commodity	Import value in 2001	2001-2005	2005-2010	Opportunities for Dutch export a)
1 Rice	117	8	10	+
2 Wheat	187	5	8	+
3 Coarse grains	773	9	11	+
4 Oilseeds	2953	7	5	+
5 Sugar	450	8	7	+
6 Plant fibers	913	12	16	+
7 Horticulture	109	14	16	+++++
8 Cattle and meat	21	36	26	++++
9 Pork, poultry, etc.	452	9	8	++
10 Milk	72	8	8	+++
11 Fish	348	4	4	+++
12 Processed food	1585	11	7	Hard to conclude

a) based on the value of Chinese imports from the Netherlands and import growth, + = limited and +++++ = sizeable opportunities; (+) = not or limited export products of the Netherlands.
Source: based on Chapter 5.

Not only China's imports but also its exports will grow in 2001-2003 (see Table 8.3). However, the increase in Chinese exports will be smaller than the expected growth of world exports (see Chapter 5). As a consequence, the share of China in the world export of agricultural products will decrease somewhat. This is partly to do with the growth of China's domestic market. This development can be seen as favorable for the Netherlands. Table 8.3 shows that two commodities have a big export potential in China, namely horticulture and processed food, both of which already enjoy a high export value and will continue to enjoy a higher export growth rate in the future. This development will increase the competition on the world horticultural market, in which the Dutch are leading.

Table 8.3 Projection annual growth rate of exports

Commodity	Export value in 2001	2001-2005	2005-2010
1 Rice	324	-1	-1
2 Wheat	6	-7	-6
3 Coarse grains	562	-13	-6
4 Oilseeds	66	-2	-2
5 Sugar	50	-1	0
6 Plant fibers	47	-10	-7
7 Horticulture	2240	4	3
8 Cattle and meat	50	1	1
9 Pork, poultry, etc.	924	1	5
10 Milk	58	1	2
11 Fish	808	4	5
12 Processed food	17282	4	5

Source: based on Chapter 5

Table 8.4 Projection commodity import in China and the Dutch Share (USD millions)

Commodity	Total China 2005	Total China 2010	Dutch share in China (%)*	Imports from NL in 2005	Imports from NL in 2010
1 Cereals	1421	2064	0.06	85	120
4 Oilseeds	3732	4393	0.01	40	45
5 Sugar	598	717	1.26	750	900
7 Horticulture	170	264	6.45	1,100	1,700
8 Cattle	51	71	2.38	120	170
9 Pork, poultry, etc.	618	781	4.03	2,490	3,150
10 Milk	95	123	5.01	480	620
11 Fish	399	468	0.6	240	280

* In 2000 for several commodities (e.g. horticulture and cattle) is used their dominant share within their categories, while for others (e.g. pork & poultry) is used their weighted share.

Based on the GTAP forecast results for China's import value in 2005 and 2010 and on the share of China's imports from the Netherlands, we calculated China's estimated import value from the Netherlands in 2005 and 2010 for several commodities as indicated in Table 8.4. Pork & poultry products turn out to be the largest Dutch export category to China. The export value will amount to over USD 2.5 billion in 2005 and to 3 billion in 2010. The leading products in these export categories from the Netherlands to China are pig meat and meat offal, which reached USD 35 million in 2000. These products are followed by hides and skins. The second largest trade opportunity for the Dutch is horticulture. Its import value from the Netherlands will exceed USD 1 billion in 2005 and reach USD 1.7 billion by 2010. Although processed food is not mentioned in Table 8.4, it can be expected that for some processed foods the prospects for Dutch exports are favorable, particularly for those goods where the Netherlands has a competitive advantage and the price per kg is high.

8.4 Foreign Direct Investments

8.4.1 Introduction

In addition to trade opportunities, direct investment opportunities comprise an important category of business opportunities. In this section the focus is on FDI in China. We first discuss FDI in the worldwide context, and then in the context of China. Finally, we discuss Dutch FDI in China. There are relationships between trade and FDI, particularly when a choice can be made between trade and FDI. These relationships and the large variety of motives of companies for FDI are discussed in 8.4.3.4 and 8.4.5.2. On the basis of the available data and this more theoretical part, the opportunities for the Dutch agribusiness sector for FDI in China are discussed in 8.4.5.3.

8.4.2 Overview of FDI inflow worldwide

FDI worldwide grew sharply in the second half of the 1990s, and reached a record high of USD 1.4 trillion in 2000. FDI consists partly of new investments and partly of acquisitions. Developed countries were the dominant recipients, accounting for more than USD 1 trillion, while only 240 billion went to developing countries. The high amount of FDI in the developed countries was mainly a result of major mergers and acquisitions across developed economies in 2000. In other words, new investments played only a limited role.

The global inflow of FDI declined sharply in 2001 (Figure 8.5). However, the slump in 2001 was concentrated in developed economies, where FDI inflows shrank by 59 percent, compared to 14 percent in developing economies. Of the total inflow of USD 735 billion FDI in 2001, 503 billion went to developed economies, 205 billion went to developing economies, and the remaining 27 billion went to the transition economies of Central and Eastern Europe. The 49 least developed countries (LDCs) remain marginal recipients, with only 0.5 percent of the global total (Table 8.5). The decline of FDI to developing countries was limited to a small number of host countries, such as Argentina, Brazil, and Hong Kong.

Although its inflow more than halved, the US remained the largest FDI recipient in 2001, followed by the UK and France. Figure 8.6 lists the world's top 10 FDI inflow economies. China (excluding Hong Kong) ranks sixth on this list; it regained its position as the largest FDI recipient of the developing countries. Including Hong Kong, China ranks second on the list for 2001. In 2002, China's FDI reached the level of USD 53 billion (CPB, 2003).

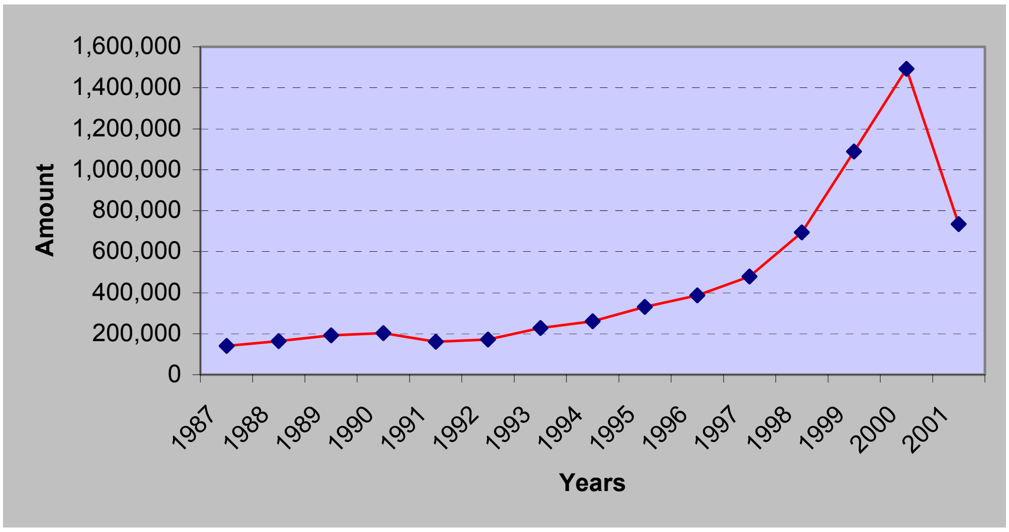


Figure 8.5 FDI inflows in the world, 1987-2001 (USD billions)
Source: UNCTAD database.

Table 8.5 World distribution of FDI inflows, selected years (USD millions)

YEAR / COUNTRY/GROUP	1970	1975	1980	1985	1990	1995	2000	2001
TOTAL WORLD	12,586	26,580	54,945	57,596	202,782	330,516	1,491,934	735,146
Developed countries	9,477	16,971	46,530	42,693	164,575	203,311	1,227,476	503,144
Western Europe	5,207	10,160	21,427	16,762	96,803	118,265	832,067	336,210
European Union	5,127	9,879	21,317	15,879	90,213	114,439	808,519	322,954
Other Western Europe	80	281	111	883	6,591	3,827	23,549	13,256
North America	3,083	5,947	22,725	21,862	56,004	68,027	367,529	151,900
Other developed countries	1,187	864	2,377	4,069	11,767	17,019	27,880	15,034
Developing countries	3,109	9,609	8,380	14,873	37,567	112,537	237,894	204,801
Africa	747	790	380	2,407	2,483	5,743	8,694	17,165
Latin America and the Caribean	1,438	4,295	7,485	7,278	10,282	30,866	95,405	85,373
Asia and the Pacific	924	4,525	516	5,187	24,803	75,928	133,795	102,264
Asia	787	4,501	396	5,110	24,251	75,217	133,707	102,066
West Asia	168	2,610	-3,162	740	2,141	3	688	4,133
Central Asia	-	-	-	-	4	1,484	1,895	3,569
South, East and Southeast Asia	620	1,891	3,558	4,371	22,106	73,729	131,123	94,365
The Pacific	136	23	119	77	552	711	88	198
Central and Eastern Europe	-	-	35	30	639	14,668	26,563	27,200

Source: UNCTAD.

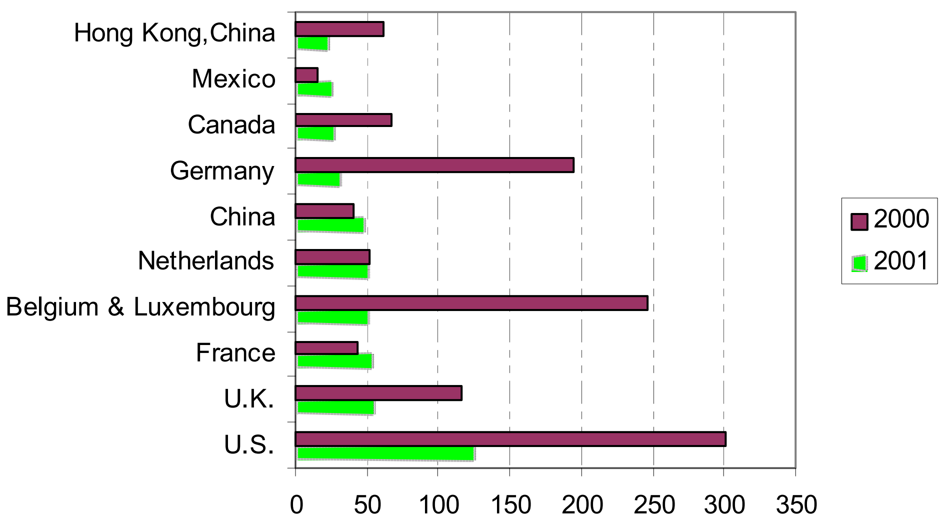


Figure 8.6 World FDI inflows, top 10 economies, 2000 and 2001 (USD billions)
Source: UNCTAD database.

8.4.3 FDI in China

8.4.3.1 Development of FDI in China

Since the birth of the first joint venture in China in 1980, FDI has contributed significantly to China's push toward a market-oriented economy. In 1979-2000, China received FDI amounting to USD 346.6 billion, accounting for 5.5 percent of the world FDI inward stock. China is by far the largest FDI recipient among the developing countries. Based on the size of China's FDI inflow, its development can be roughly separated into three stages (Figure 8.7).

- Early stage (1979-1991). As China started to open its doors to the outside world in the late 1970s, the government first established four Special Economic Zones (SEZs)[1] along the south coast in order to attract FDI. However, by 1983 the total amount of realized FDI was only USD 1.8 billion. Subsequently, the Chinese government designated another 14 coastal cities[2] and two development zones[3]. These 'open door' regions provided preferential tax policies to attract foreign capital and to promote exports. Just as the FDI inflow was starting to take off, the Tiananmen massacre in 1989 led to FDI activities reaching a record low.
- Rapid growth stage (1992-1998). In 1992, China adopted a new policy advocated by Deng Xiaoping that emphasized China's commitment to a stronger market-oriented economic reform. The Chinese government issued a series of new regulations and opened up the whole of China to foreign capital and technology. The impact was impressive: FDI growth rates were over 100 percent in 1992 and 1993. In 1998, FDI inflow reached its peak level of USD 45 billion.
- Stable stage (since 1999). Chinese FDI inflow slowed down in 1999, partly as a result of the Asian financial crisis of the late 1990s and partly as a result of the slowdown of the world economy. In recent years, the FDI inflow into China has stabilized at around USD 40-45 billion. During the global economic slowdown in 2001, China remained one of the most favored FDI destinations. According to China's Ministry of Foreign Technical and Economic Cooperation (MOFTEC), Chinese inward FDI continuously performed well, also in 2002. In January through November 2002, the contracted FDI reached USD 76 billion, and the actually used FDI reached 48 billion, up by 14 percent compared to 2001. This positive development of FDI was supported by the accession of China to the WTO, as trade liberalization lowers production costs and the price of capital goods (Elena Ianchovichina et al., 2003). In 2003 the increase may slow down because of the impact of SARS on investment decisions.

[1] Shenzhen, Zhuhai, Shantou, and Xiamen.
[2] Dalian, Qinhuangdao, Tianjin, Yantai, Qingdao, Lianyungang, Nantong, Shanghai, Ningbo, Wenzhou, Zhanjiang, and Beihai.
[3] Hainan SEZ and the Pudong New Area in Shanghai.

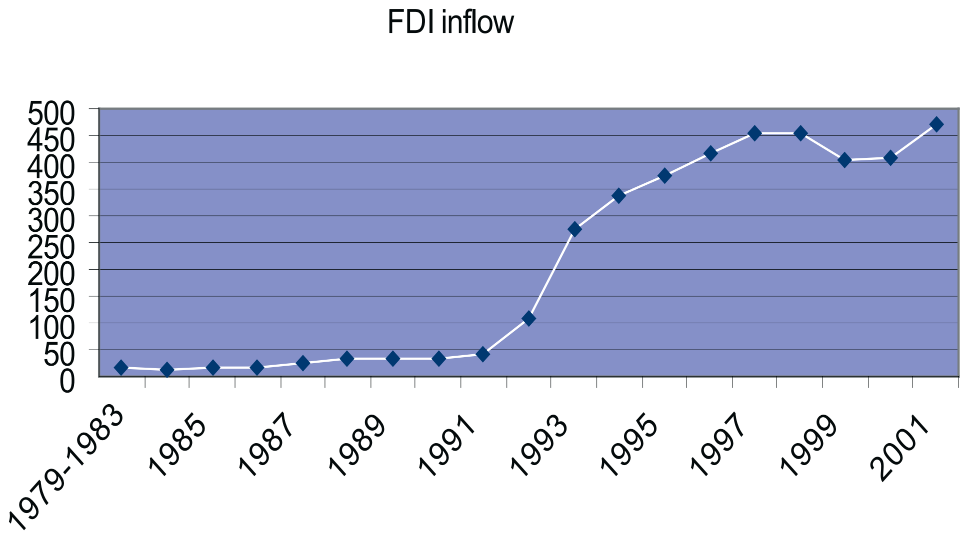


Figure 8.7 Chinese annual FDI utilization 1979-2001 (USD 100 millions)
Source: China Statistical Yearbooks 1999, 2000, 2001 and 2002.

8.4.3.2 Geographic distribution of FDI in China

Appendix 8.1 presents several years of FDI distribution pattern across the country. As a consequence of central government policy, the provinces which have SEZs received far more FDI than their inland counterparts (Table 8.6 and Figure 8.8). More than 80 percent of FDI went to the SEZs. Just one of these Zones - Guangdong Province - absorbed almost 30 percent of China's FDI, while 14 percent went to Jiangsu Province. The dominant position of Guangdong in FDI is connected with its relations with neighboring Hong Kong.

Almost all FDI studies related to China have noted this uneven geographic distribution. Broadman and Sun (1997) regressed provincial FDI stock data on its GDP, labor cost, human capital, infrastructure, and geographic location, and found that the most significant factors affecting FDI destination are market size of host provinces, infrastructure development, quality of labor, and geographic location (coastal areas).

In the late 1990s, the Chinese government launched its 'GO WEST' policy campaign. Since then, a large amount of government investment has been poured into building infrastructure in the western regions, in order to attract more FDI. An advantage of these regions is that labor costs are lower than they are in the coastal regions.

Table 8.6 Geographic distribution of FDI in China by province (in %)

Guangdong	29
Fuijan	9
Jiangsu	14
Shanghai	8
Shandong	6
Liaoning	5
Hainan	2
Tianjin	4
Zhejiang	3
Guangxi	2
Hebei	2
Beijing	4
Hubei	2
Hunan	2
Rest	9

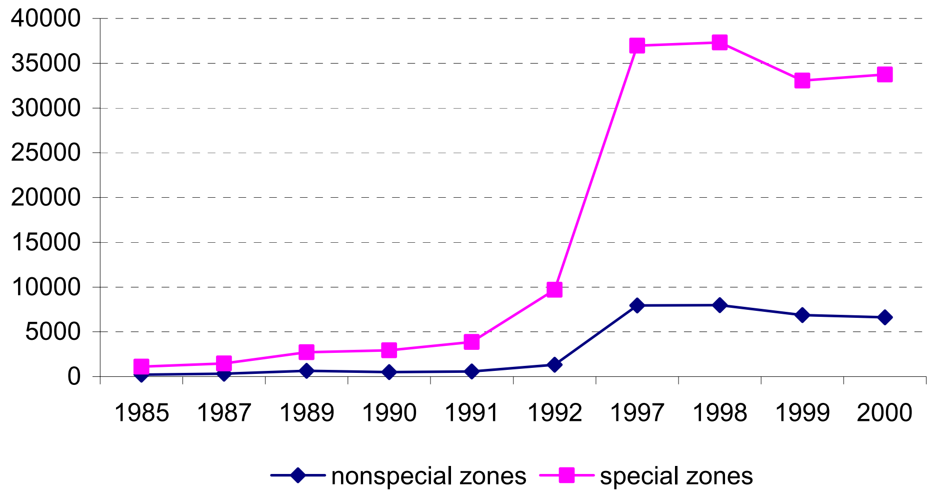


Figure 8.8 Chinese FDI utilization among SEZs and other zones (USD millions)
Source: Calculated by authors based on various SSBs.

8.4.3.3 Sector distribution of FDI in China

Not only China's FDI geographic distribution but also the distribution across sectors is skewed (Table 8.7). Compared with Asia and with the world as a whole, the share of FDI in China's primary sector, and particularly in agriculture, is extremely low. Less than 2 percent of Chinese FDI goes to agriculture, while the figure for Asia in 1993 was around 12 percent.

FDI in China is concentrated in the secondary sector, especially in the manufacturing sector and to a lesser extent in the energy sector. More than 60 percent of FDI is in the manufacturing sector. Especially in this sector FDI increases productivity and exporting foreign companies profit from low labor costs in China. Unfortunately, data about the food industry are not available. The proportion of FDI in the tertiary sector in China is comparable to other parts of the world. However, there are significant differences in internal structure. Real estate investment in China contributes to a considerable amount of FDI in the tertiary sector. In the top year 1993, as much as 39 percent of total FDI inflow in China went to real estate management. Although this figure then dropped, it remains higher compared to the rest of the world. Other areas where FDI could grow further is trade distribution and financial services. In these sectors, China could learn from the experiences of other Asian countries.

8.4.3.4 Concluding remarks

Earlier we said that there can be a relation between FDI and trade: FDI can be a substitute for trade, and trade can complement FDI. Liu et al. (2001) examined on the economy level the causal relations between trade and FDI for China and nineteen home countries/regions (including the Netherlands) in the period 1984-1998, and came up with three main findings, namely that there is a one-way complementary causal link:

- between the growth of China's imports and the growth of the inward FDI stock from the home country/region;
- between the growth in the inward FDI stock in China and the growth of China's export to the home country/region; and
- between the growth of China's exports and the growth in its imports.

Most FDI in China goes into manufacturing and can be considered as efficiency-seeking and only to a lesser extent as marketing-seeking. This has to do with the large differences in resource endowments. FDI in China is a package of skills (technological, management, marketing) and financial capital. An important attraction factor for FDI is the relatively cheap labor in China. In this respect we should also mention China's FDI policy, which encourages foreign invested firms to export their products. On the basis of these exports, more foreign exchange is earned to finance imports to ensure the supply of key materials and embodied technology.

A further growth in Chinese imports and exports of labor-intensive products is simulated in section 8.4, and it might be expected that this will go hand in hand with a further growth in FDI. However, one has to keep in mind that the relations that existed in the period 1984-1998 might change. A further increase in income will change domestic markets, and give a positive impulse to market-seeking FDI.

Table 8.7 China's FDI inflow by sector (%).

Sector	China						Asia	World
	1984	1988	1993	1998	2000	2001	1993	1993
Primary	**40.9**	**12.3**	**1.1**	**2.64**	**3.1**	**3.6**	**33.4**	**22.1**
Farming, forestry, animal husbandry, and fishery	1.7	2.7		1.4	1.7	1.9	11.8	5
- Mining & quarrying	32.9			1.3	1.4	1.7	21.4	17
Secondary	**26.9**	**47.6**	**45.9**	**63.1**	**68.9**	**70.8**	**46.1**	**42.4**
- Manufacturing				56.3	63.5	66		
- Electric power, gas, and water production & supply				6.8	5.5	4.8		
Tertiary	**32.1**	**40.1**	**53**	**34.3**	**27.9**	**25.6**	**28.6**	**38.2**
- Construction			3.5	4.5	2.2	1.7	2.5	3.4
- Transport, storage, and post & telecommunications			1.3	3.6	2.5	1.9	1.5	4.4
Wholesale & retail trade, and catering services			4.1	2.6	2.1	2.5	6.1	11.1
Real estate management	15.4	28.3	39.3	14.1	11.4	11	1.9	4.8
- Social services				6.5	5.4	5.5		
- Health care, sports, and social welfare				0.2	0.3	0.3		
- Education, culture & arts, and radio, film & television				0.2	0.1	0.1		
- Other sectors (finance)			4.8	2.5	3.9	2.4	(9.6)	(14.5)

Source: Broadman & Sun, 1997; data for 1998, 2000 and 2001 are from SSB.

8.4.4 FDI from the Netherlands

8.4.4.1 Development of Dutch FDI in China

In 2000, the stocks of Dutch FDI in the world was EUR 323,640 million. Of this, 40 percent went to the US - the largest recipient - followed by Belgium, the UK, and Germany. At EUR 1,375 million, the Dutch investment stock in China was less than 1 percent. The development of Dutch FDI was more or less similar to that of total FDI in China. Table 8.8 and Figure 8.9 show that Dutch investment in China in the 1980s got off to a slow start, but a big expansion followed in the late 1990s. It reached a peak in 2000, with a total amount of USD 789 million, which is less than 2 percent of total FDI in China. The differences between contracted and actually used investment indicate that many projects are still in progress. Recently, some Dutch companies postponed decisions to invest in China because of the SARS epidemic (Konijn & Wiemers, 2003).

Table 8.8 Dutch investment in China (USD 10,000)

Year	Number of projects	Actually used	Contracted
1982	1	0	7
1983			
1984	2	0	188
1985	4	13	266
1986	4	249	29
1987	0	21	0
1988	5	2062	15,314
1989	10	1773	1772
1990	6	1598	2160
1991	14	667	1687
1992	37	2841	4116
1993	109	8400	15,169
1994	95	11,105	36,582
1995	105	11,411	60,232
1996	77	12,511	88,921
1997	80	41,380	56,718
1998	97	71,882	56,268
1999	76	54,168	67,581
2000	102	78,948	341,412
2001	114	77,611	97,397

Source: MOFTEC, 2002.

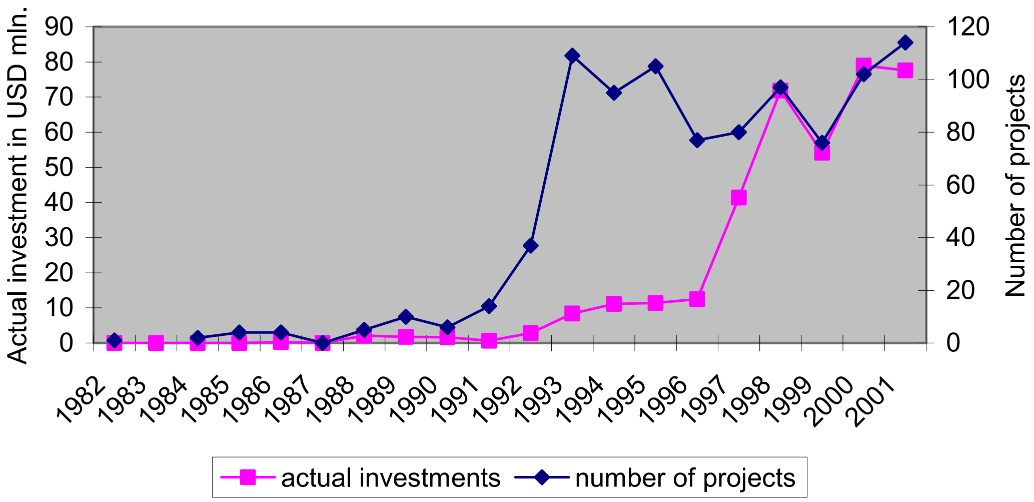


Figure 8.9 Dutch direct investment in China (1982-2001)

8.4.4.2 Geographic distribution of Dutch FDI in China

China's Ministry of Foreign Trade and Economic Cooperation (MOFTEC) started collecting FDI data for each country at the geographic and the sector level in 2000. We can therefore analyze only the data from the last three years. Some 70 percent of all Dutch investments in the last three years went to the SEZs as presented in bold in Appendix 8.2. Jiangsu province is the location with the highest value of actually used FDI (it absorbed 25 percent of the total amount), followed by Shanghai and Guangdong. However, Guangdong is the province with by far the highest amount of contracted FDI. The number of contracts was the highest in Shanghai, with a share of almost 25 percent. Noticeably, the Dutch also invested a considerable amount in China Natural Gas Co.

Generally speaking, there are no remarkable differences in preference in the regional distribution of Dutch FDI compared with total FDI in China (Table 8.9). The most favored FDI destinations for the Dutch are the coastal SEZs, just as they are for total FDI.

Table 8.9 Dutch FDI preferences in China, actually used (percent)

Geographic Distribution	Dutch	Total FDI
Jiangsu	0,26	0,14
Shanghai	0,15	0,08
Guangdong	0,14	0,29
Liaoning	0,11	0,06
Beijing	0,07	0,04
Hubei	0,06	0,02
Hunan	0,05	0,02
Zhejiang	0,04	0,03
Tianjin	0,03	0,04
Shandong	0,02	0,06
China Natural Gas Co.	0,02	

Source: calculated by authors based on SSB.

8.4.4.3 Sector distribution of Dutch FDI in China

Table 8.10 (sector distribution of Dutch FDI in China) shows that two-thirds of Dutch FDI went to manufacturing, which is comparable to the total FDI data at the national level. This may be a result of the heavy investments made by Philips in China. The Dutch investors have only a modest investment in real estate management (4%) and are not as heavily involved in this sector as other foreign investors are. As a country with a strong agricultural capacity, the Dutch investment in Chinese agriculture is very low, accounting for only 4.5 percent of its total. This share is only slightly more than the share of agriculture in total FDI. The data for the food industry as such are not available; they belong to the manufacturing sector.

Table 8.10 Sector distribution of Dutch FDI in China (Jan. 2000-Oct. 2002; USD 10,000)

Sector	Number of projects	Contract value	Used Value
National total	323	206,762	158,672
Farming, forestry, animal husbandry and fishery	19	6177	7187
Mining and quarrying	1	175	278
Manufacturing	171	133,770	103,403
Electric power, gas, water production & supply	2	3475	9840
Construction	2	1096	1115
Transportation, storage, postal & telecommunications services	13	5931	1490
Wholesale & retail trade, and catering services	34	8894	9198
Finance and insurance	0	107	0
Real estate management	18	21,578	6908
Social services	46	5759	1964
Health care, sports and social welfare	2	6	5
Education, culture & arts, and radio, film & television	3	600	290
Other sectors	12	19,014	16,330

Source: MOFTEC, 2002.

8.4.5 FDI opportunities for Dutch agribusiness companies

8.4.5.1 Introduction

FDI cannot be seen apart from trade. FDI usually comes within the scope of companies when trade is less attractive or impossible. In the following subsection we elaborate the reasons for FDI. In the last subsection we discuss the FDI opportunities for Dutch agribusiness companies on the basis of the results presented in 8.4 and against the background of the discussion in the following subsection.

8.4.5.2 Relations between trade and FDI

There are a number of reasons why Dutch companies choose direct investment as a strategy for internationalization (Bijman & van Berkum, 2001). The first is that it is not possible to export the products from the Netherlands at a reasonable price, because of high transport costs, high import tariffs, etc. The second reason is that a further growth of production in the Netherlands may be difficult or even impossible because of, for example, the limited availability of raw materials etc. A third reason is that it may be difficult to realize production or marketing by contract. Particularly the efficient exploitation of company-specific intangible assets (such as knowledge, reputation and management) is difficult to realize by contracts.

All three reasons are to some extent valid for agricultural FDI in China. The physical distance between the Netherlands and China is very large and transport costs are high. Therefore, trade to China will be limited to high value added products. Import regulations as a motive for FDI are becoming less important because of trade liberalization in China within the framework of the WTO. However, there is still a difference in import restrictions between the import of inputs and that of final products for the Chinese consumer market, the latter being more restricted. On the other hand, the Chinese government is becoming more critical when considering granting privileges to foreign companies. The second reason given above holds for a large number of agricultural and food products in the Netherlands, as production is already extremely high and a further increase is limited by European and national policies. Possibly the third reason given may play a less important role as far as agricultural FDI in China is concerned, as a lack of knowledge and management know-how can be relatively easily be filled by consultants and temporary contract workers.

BOX

Dutch companies in China: some examples

Financial services

Rodamco Asia invests in China and other Asian countries. It owns 60 percent of an apartment block in Beijing and 100 percent of an apartment block in Shanghai. The company plans to make more investments in Chinese real estate.

Fortis and ING are two other financial services companies active in China. Both companies have a license to cooperate with a local party. For example, in 2003 ING started a joint venture with the Beijing Capital Group, called the ING Capital Life Insurance Company Limited. This company operates in Dalian, where it is the first foreign-invested insurance provider. Fortis also has limited activities in the field of asset management.

Consumer market

Heineken has been cooperating for over 70 years with its regional partner, Fraser & Neavem. The size of the Chinese activities is limited; however, Heineken has plans to expand its activities in China. (Big Heineken export of beer to China in statistics)

Unilever. China's share in the total turnover of Unilever is about 2 percent. Unilever aims to double its turnover in China in the period 1999-2004. To achieve this target, it has a strategic research laboratory in Shanghai and has implemented a restructuring to ease further investments.

Ahold. Not all the activities of Dutch companies in China have been successful. In 1996, Ahold opened a number of TOPS supermarkets in Shanghai. However, the results were disappointing and Ahold decided to sell its investments and withdraw from China.

Industry and services

Draka has a strong position in the glass fiber cable market as a result of its 37.5 percent share in the company YOFC – the market leader in China. However, selling prices are under pressure because of increasing imports.

IHC Caland supplies dredgers to Chinese state dredging companies. In the future, IHC Caland will be able to profit from the gradually opening of the Chinese dredging market.

Agribusiness companies

Friesland Dairy Foods has had a dairy factory in Tianjin for a number of years now. During some years, the results have been disappointing.

AVEBE has started a joint venture with a company in Yunnan to produce starch potatoes and to process them into starch products.

Rijk Zwaan – a seed company – has an outlet in Shandong Province. It also has a research station in Qingdao (Shandong Province) and a demonstration station in Shouguang (Shandong Province).

Nutreco – whose main activities are in the production of feed (premixes, specialties), aquaculture, and the processing of meat – has a production facility in China.

Numico – a company specialized in, among other things, the production of food for babies and for those with specific dietary needs – has a production facility in China.

Van Melle – which specializes in confectionary – has a production unit in China for the production of local brands.

China has to compete for FDI with other countries. China is disadvantaged not only because it is a far-away country but also because of important differences in language, culture, and political system. Generally speaking, much time has to be invested and patience is needed to be successful. Only a few Dutch agribusiness companies have a long tradition of doing business in China and have thus thoroughly experienced these differences. This may explain the limited Dutch FDI in China.

However, these differences will become less important in the future because more and more people are speaking English and have studied abroad; increasing cultural exchanges are improving mutual understanding; and the political system is becoming increasingly market oriented and transparent for foreign companies. Moreover, an increasing number of Dutch agribusiness companies are building up experiences in doing business with China and are learning from the experiences of other companies.

On the other hand, China has some advantages over other countries in competing for FDI: its markets are growing rapidly as a result of urbanization, economic growth, and population growth, and labor costs are lower than they are in developed countries, and it is expected that these costs will remain low in the medium term because of the huge surplus of labor in China.

On the basis of the results of section 8.4 and against the background of the discussion above, the following is an elaboration of the opportunities for Dutch FDI in the Chinese agribusiness sector.

8.4.5.3 FDI opportunities for Dutch agribusiness companies

Horticulture is an important growth sector in China both for the internal market and for export. The sector is interesting for China as it is labor intensive and labor costs are low. The export of horticultural products is directed mainly to neighboring markets, such as Japan, Hong Kong, and South Korea. These are high-income markets with high labor costs, and they demand high quality products.

Generally speaking, the transport costs are too high for many – if not most – horticultural, vegetable, and floricultural products from the Netherlands. In addition, it is expected that a number of current Dutch export products in this sector will not be competitive in the medium term as a result of the development of the horticultural sector in this part of the world. However, the Netherlands has developed much knowledge of and has extensive management experience in producing and marketing horticultural products. From this perspective, the Netherlands could play a growing role in the development of the horticultural sector in China. This applies particularly to the segment of the market that requires high quality products. One of the major handicaps is the lack of protection of breeders' rights. FDI in this sector could also increase export opportunities; for example, the export from the Netherlands of seed for horticultural products and equipment for horticultural production.

In the international statistics, potatoes are in the vegetable category. It is worthwhile to mention this product separately, however. In a relatively short period, the demand for processed potatoes in the fast-food market has grown considerably. However, the required quality of potatoes is not available. Although the Netherlands is specialized in the production of the required quality of potatoes, transport costs are too high to make export possible. The production and processing of potatoes in China could be a challenge for Dutch potato processors. The production of processed potatoes should be based on Dutch inputs of raw material in order to obtain the required quality. However, this means that the current problems with the import of Dutch seed potatoes will have to be solved.

A second sector for which FDI could be interesting for Dutch companies is the dairy sector. This is not so much because of export growth (as it is for horticultural products) as because of the growth of domestic demand. The development of this sector is in its infancy. The average consumption of dairy products in China is still low, although there has been a take-off in consumption in such rapidly developing cities as Beijing and Shanghai. This consumption consists to a large extent of perishable products, such as fresh milk and yogurt. Therefore these kinds of products do not present export opportunities for the Netherlands: they must be produced close to the market.

There is a well-developed dairy sector in Netherlands, as well as in, for example, France, New Zealand, and the USA. Although increased production by the dairy sector in the Netherlands is possible only to a limited extent, the sector could use its extensive experience to cooperate in the development of the Chinese dairy sector. A handicap in this respect, however, is that the Dutch dairy sector is dominated by farmers' cooperatives, whose interests differ from those of private companies. Such cooperatives are interested primarily in adding value to the milk produced by their members.

The production of dairy products comprises the production and the processing of milk – and the Netherlands can contribute to the development of both in China. In addition, FDI could stimulate the export from the Netherlands of basic materials and equipment.

8.5 Conclusion and discussion

The driving forces of economic growth in China are investment (both FDI and domestic), domestic demand, and export. The development in the income per capita is to a large extent determined by technical change, which leads to an increase in total factor productivity. Investments play an important role in this respect. Although China has attracted substantial FDI in the last few decades, its FDI inflow accounts for only around 3 percent of its GDP. However, it may deliver an important contribution to the growth of productivity. More than 60 percent of FDI is in the manufacturing sector. FDI has been pouring into the coastal regions, although recent policy is shifting towards the western part of China in order to exploit its rich resources and to stimulate domestic demand there.

Dutch FDI in China began in the 1980s, but got off to a very slow start. It really took off in 1992 after the opening up policy was formally adopted nationwide. The Dutch FDI stock accounts for less than 1 percent of China's total FDI. Also Dutch FDI is strongly skewed toward manufacturing, which absorbed two-thirds of the total. In terms of regional preference, Jiangsu is the first choice of Dutch companies, followed by Shanghai.

The Netherlands is one of the world's largest trading countries. However, this study shows that the Dutch trade position in China is limited. This is only partly to do with the great physical distance between the two countries. An important role is played by the differences in culture, and these differences make transaction costs high when doing business with China. This is why the role of small and medium-sized companies in trade and FDI is limited and why the multinationals are more active in the Chinese market. China, on the other hand, has made more use of – or has more – trade opportunities than the Dutch and has generated a huge trade surplus. This also holds for the agricultural sector, where the Dutch have only a limited share in China's agricultural import.

Sino-Dutch trade has certain strong characteristics. The Dutch export special industrial machinery to China, and import office machines and automatic data processing equipment from China. As far as agricultural trade concerned, trade is virtually one-way: edible offal and flower bulbs are the major Dutch export categories to China, while China exports only a very limited amount of agricultural products to the Netherlands.

The question whether Dutch agricultural FDI stimulates or substitutes the trade with China remains unanswered. More detailed information on the Dutch FDI destination areas is needed in order to answer this question. Important reasons for Dutch companies to make FDI are the impossibility of exporting to China at a reasonable price, the limited availability of raw materials for production in the Netherlands, and difficulties in realizing production in China by contract. What is certain, however, is that the export of Dutch agricultural products and Dutch FDI in the Chinese agribusiness sector are limited. The reasons for this may be that other markets are more attractive and/or that it is difficult to do business in China. Finally, the Netherlands is primarily a trading nation, which may explain the limited FDI by the Dutch.

China's economy grew by 8 percent in 2002, and many experts predict that this strong growth will continue and that China will remain one of the world's hottest investment destinations. In fact, in 2002 China replaced the USA as the world's no.1 FDI recipient. The Economist Intelligence Unit forecasts that China's annual FDI inflow will be over USD 60 billion in 2003-2007, putting it into the second position (*The Economist*, April 10, 2003). In the future, Dutch companies considering investing in China should pay attention to the Chinese government's policy changes, as the focus is being switched from the east to the west of the country. Much of the northwestern part of China is rich in agricultural and natural resources, and remains untapped.

In terms of sector preferences for FDI, the Dutch agribusiness could play a much more important role in floriculture, animal husbandry, transportation, storage logistics, etc. The Dutch agribusiness companies are currently involved in these sectors to various degrees, but are focused mainly on trade relations. A long-term commitment from both sides is needed to foster a direct investment relationship.

9. Concluding remarks

Food security: central goal of China's agricultural policy

Food security has been a central goal of China's agricultural policy. Since the early 1980s, domestic reforms aimed at boosting agricultural growth and farm income have covered nearly every aspect of the economy, starting from land reform 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 China's economy. China has been able not only to increase its ability to feed its growing population with the limited available natural resources, but has also become an important food and agricultural exporter. Per capita availability of food and household food security have improved significantly. Increased domestic production is almost solely responsible for the increased per capita food availability.

China's experience demonstrates the importance of institutional change, technological development, price and market liberalization, rural economic development and macro-economic policies in improving agricultural productivity, farmer income, and food security in a nation with limited land and other natural resources. Technology has been the main engine of China's agricultural economy growth. Institutional arrangement and government food policies also play an important role in China's food production and making food available for the whole of China's society. Rural enterprise development and off-farm employment play a substantial role in China's economy and farmer's income. Broad participation in strong rural economic growth has brought about a tremendous reduction in absolute poverty.

External reforms in general have paralleled domestic reforms. During nearly 20 years of reform, China's foreign trade regime has gradually changed from a highly centralized, planned and import-substitution regime into a more decentralized, market-oriented and export-promotion regime. Reform and trade liberalization in China's external sector has proceeded gradually. In the initial stage, reformers only implemented measures that provided incentives to selected sets of corporations and institutions. Because the experience gained from the reform grew and the objectives of trade could be achieved through alternative settings of institutions and policies, trade liberalization has been implemented smoothly since the late 1980s. However, in the late 1990s, China also used various means to protect some of its crops, such as maize and cotton.

The impact on agriculture, however, is only part of the story. Reforms have also affect the access of households to non-farm employment and the wage they earn for being in the off farm market. In general, China has gained a lot from market liberalization. Increasing exports of manufacturing goods have been produced in factories that hire a lot of rural labor. These factories have also had spillover effects that have helped make domestic factories more productive and have increased the demand for labor. In a country like China, increasing the demand for off- farm labor is probably the most important factor in improving the economy.

China's future agriculture is a subject of growing concern. On the one hand, rapid industrialization and urbanization will lead to competition for agricultural resource uses. The impacts of trade liberalization on China's domestic agricultural sector- that engages hundreds of millions of small farmers- are the other growing concern of the policy makers. Rapid economic growth has continued unevenly across regions and among income groups. The income gap among regions and between the rural and urban has not been narrowed.

Limited options for increasing food and agricultural supplies has made the challenge of meeting China's food security target more formidable. Fiscal constraints may preclude leaders from implementing some of the planned policies. The constraints imposed on leaders by resource scarcity and political-economic realities have increased the need to understand the scope for food supply expansion from one of the most important sources- namely investments in agricultural technology- and to understand the scope of income growth from non-farming activities, namely rural enterprise. The nation needs to keep promoting policies that facilitate investment and that allow rural households to move to these jobs without constraints.

Quality of data needs improvement for model simulations

For the purpose of this study, two models are used and adapted GTAP (Global Trade Analysis Project) and CAPSiM (Chinese Agricultural Policy Simulation Model). The quality of the outcomes of the models depends to a large extent on the quality of the data used. Particularly China's livestock supply and demand statistics are not consistent with even the most basic criteria: supply equals demand and the implied derived demand for feed equals the supply of feed. For this reason a number of data sources were used to create new supply and demand series. As a result demand is corrected upward in the data and supply was corrected downward. A decomposition analysis shows that the single largest source of the discrepancy was the adjustment to supply and the adjustment to demand to account for the out-of-home consumption.

If the adjusted data sets are correct, there are implications for the validity of past statistics and the accuracy of alternative forecasts. We have shown how differences in livestock statistical series can create such great discrepancies in predicted feed grain imports that some analysts believe China will export feed grain for the next 5 years or more, while others predict that the nation may have to import over 80 mtt. Meat trade would be subject to similar differences in forecasts. Beyond supply, demand and trade, gross domestic product (GDP) figures could be significantly influenced. Since livestock makes up 30 percent of agricultural GDP (AGDP), and the growth rate of livestock was overstated by 37 percent, the reported growth rate of AGDP (which according to CNSB was 4 percent annually between 1987 and 1999) would have to be lowered by 1 percentage point to 3 percent annually. GDP growth would have to be lowered by 0.11 percent.

As China develops, and forecasts point to continued future growth, there will be a continuing and rising demand for higher quality data. Clearly, some of the data sets - the livestock data, in particular - are so poor that without adjustments it is impossible to have a firm base for investment and policy planning. Especially in an economy that is changing so fast and will continue to do so in the future, the challenge to improve data collection is now more important than ever.

Uncertainties in China's food demand and policies to boost China's food supply

China is highly acclaimed for its ability to feed its growing population with the extremely limited natural resources. Over the last four decades, per capita availability of food, household food security, and nutrition all have improved significantly. Increased domestic production is almost solely responsible for increased per capita food availability and significantly contributes to poverty alleviation and farmers' income.

Determining factors in the CAPSiM-projection of future food consumption are: population growth, income growth per capita, urbanization and growing importance of consumer markets in the rural area. The most uncertain of these factors is income growth. Alternative income growth scenarios result in significant changes in China's food demand and trade for almost all commodities except for grain. Higher income growth will boost meat demand, which will be offset by lower meat export. However, grain supply and demand balances will keep nearly stable at about 90% in 2020, so the impact of income growth on food security will be minimal.

On the food supply side China's experience demonstrates the importance of technological development, institutional change, price and market liberalization, rural economic development and other conducive policies in improving agricultural productivity, farmer's income, and food security in a nation with limited land and other natural resources. Among other factors, technology and irrigation have been major driving forces of productivity growth and the engine of China's agricultural economy development.

Limited options for increasing food supplies has made the challenge of meeting China's food security target even more formidable. Decollectivization and fiscal reform have already been tapped for most of their gains. Fiscal constraints may preclude leaders from implementing some of the planned policies. The nation's budget crises, above all, bind the hands of officials even if investments in agricultural research promise high returns. Chronic budget shortfalls and looming trade agreements also effectively shut off the option of using East Asian -style price policies to maintain production levels.

The constraints imposed on leaders by resource scarcity and political-economic realities increase the need to understand the scope for supply expansion from the most important sources of past supply growth, investments in agricultural technology and irrigation. Improved technology and irrigation have been by far the largest drivers of agricultural production growth, and as such are major sources of increased food availability in China. Our analysis shows that extra investments in agricultural research and irrigation will boost production and will increase self-sufficiency rates in particular for non-grain products. A third factor effecting production is erosion and salinization of land. Slowing down the rate at which arable land is declining due to erosion and salinization will have an important positive impact on production growth, which consequently results in higher self-sufficiency rates. The analyses and results with CAPSiM presented in this section establish a basis for China's leaders and policy makers to confidently invest in the nation's agricultural research system, in irrigation and in the reduction of erosion and salinization of land.

Based on the results of this study and on experience in the rest of the world, if China wants its agriculture to continue to supply sufficient food for the country's growing population with its rising income and under trade liberalization, it must increase its investments in agricultural research, irrigation and reduction of the growth of eroded or salinized land. The current agricultural research investment intensity (0.44%) is low. However, a limiting factor for increasing investments in irrigation is the scarcity of water in particular in Northern China and the growing competition for water for industrial and urban consumption.

Future of China's food economy: limited increase of strategic food import

Food security is a central goal in China's agricultural policies. Projections with GTAP for the period 2001-2020 indicate that this goal can be realized to a large extent and that impacts on global trade will be limited. During this period the self-sufficiency for grains will not decline below the policy target of a self-sufficiency rate of 95. This is thanks to an important increase in China's agricultural production. However, also Chinese international trade in agricultural products will grow considerably. Part of this development can be attributed to the China's accession to the WTO and the phasing out of the Multi-Fiber Agreement (MFA). Nevertheless, the impact of accession to the WTO is limited because many policy changes directed towards more international trade took already place during the reform period in the run-up to China's accession. Both, China's accession and the phasing out of the MFA, will allow China to exploit more fully its comparative advantage.

The accession of China to the WTO will have a negative production impact in such land-intensive sectors as coarse grains, oilseeds, sugar and cotton. Positive production impacts by increasing exports are to be expected in food processing, horticulture, fish and such labor-intensive industries as the textile industry. Positive impacts in agriculture are to a large extent due to the assumed better compliance with SPS standards in the medium term. This underlines how important it is for China to strive to further comply with these standards.

China's accession to the WTO will lead to a high relative increase in imports, especially of cattle, cotton (for the rapidly growing textile industry), coarse grains and processed food. The import growth of dairy is relatively moderate. The production impact of these imports is limited, as in most sectors imports are until now relatively small. Exceptions are the land-intensive sectors mentioned above; as stated, for these products accession to the WTO will have a clear negative effect on production growth. These results show that China can realize efficiency gains by expanding sectors where it has a comparative advantage.

The phasing out of the MFA has a positive impact on the labor-intensive textile/cotton complex: exports of textile will show strong growth and the production of textile and cotton will increase. This will have limited negative production effects on some land-intensive products as the production of cotton becomes more competitive.

In the longer term, self-sufficiency in almost all agricultural products, including China's strategic agricultural products, will decline. China's imports will grow, but its share in world markets will in the longer term remain below ten percent or exceed this limit to only a small extent (coarse grains and oilseeds). However, an exception will be cotton with an increasing world market share to almost 30 percent. For non-agricultural products China's share in world import market for oil products will grow considerably. On the longer term the share for oil products will be more than 20 percent. For most agricultural export products, China's share in world exports will be less than 10 percent. The only exception is fish and, temporarily, processed food. For the labor-intensive industries, and particularly for the textile industry, the position is different: China's share in world exports for textile will grow to over 40 percent.

China's role in world trade will increase further in the course of time, as a result of high income growth rates and the country's accession to the WTO. However, for most agricultural products, China's world market share is less than 10%. In other words it can be concluded from this analysis that China will to a large extent be able to feed its population, also in the longer term. At the same time, China will exploit its comparative advantages, resulting in changes in composition of production without having serious consequences for the development of world markets for agricultural products. The only exceptions to this are cotton, textile and vegetable oil.

Evaluation of Doha Development Round proposals: important gains for China

The static gains from global liberalization in the Doha round as formulated in the proposals of the USA, the EU and the CAIRNS group may amount to about 0.3% of world GDP. This estimate made with GTAP does not take into account such dynamic effects as capital accumulation and technology spillovers. Relative to their GDP, low income countries (LDCs) are the greatest beneficiaries of improved market access and reduced domestic support to agriculture in OECD countries. For some poor African and Asian countries the income gains can be as high as 1.5 - 2 percent of their GDP. However, the realization of these potential gains for LDCs depends very much on an active participation of LDCs in the liberalization effort.

Under the proposals studied here, the main beneficiaries from agricultural liberalization will be exporting countries, especially in the USA and CAIRNS proposals, because they go further in improving market access than do the EU proposal. As far as the effects of domestic reforms in OECD countries are concerned, the simulations show that the world market effects are not very great and are not always positive for everyone. Especially LDC food importers may see rising world food prices.

China can clearly gain from the Doha round. It is estimated to capture 8% of global income gains while its share in world GDP is around 3%. However, its interests in agriculture seem to be covered by proposals already made by other players. Therefore, China might very well want to free-ride on proposals of others, rather than develop an own position in the negotiations on the 'classic' agricultural agenda. This may be quite different in the areas of food quality and food safety, where China clearly has an active interest in SPS and TBT issues. Modeling of food-safety-related impediments to trade is clearly an area of future research.

The largest gains for China will not to be found in the agricultural dossier, but in improved markets access for labor-intensive manufacturing. As far as the textile industry and the food industry are concerned, this will increase the demand for agricultural products like cotton and for raw materials for the food processing industry. Expanding labor-intensive industries, also fostered by new export opportunities, may be part of a rural development strategy that includes labor absorption into industries outside primary agriculture.

Biotechnology in rice and cotton: substantial gains of GM rice adoption
China is developing the largest public plant biotechnology capacity outside of North America. Adoption of Bt cotton has been proceeding at a rapid pace in recent years. The largest part of the potential productivity gains from Bt cotton will be realized already by 2005. In contrast, GM rice is not yet available to farmers on a commercial basis, and our estimates indicate that large productivity gains are yet to be realized between 2005 and 2010.

The economic gains from the adoption of GMOs are substantial. In the most optimistic scenario made with GTAP- where China commercializes both Bt cotton and GM rice- the welfare gains amount to an additional annual income of about USD 5 billion (about USD 3.50 per person) in 2010. If actual adoption rates are lower, there will still be an income gain of 3 billion USD in 2010. The gains from GM rice adoption will be considerably larger than the Bt cotton gains.

The patterns of global trade in both the textiles and garment sector and the rice sector will not be affected very much. The Chinese biotechnology research strategy has concentrated on crops that are of great importance to rural livelihoods, and not on those that are important in terms of export earnings. Rice exports from China represent only a small share in international rice trade. There will be an immediate impact on the export revenues of major cotton exporters. The cost savings and yield increases from Bt cotton will translate into lower production cost for the Chinese textiles and garments industry, but these cost reductions will not be so large that other garments producers will be affected very much.

Our results indicate that trade restrictions will not significantly lower the gains from biotechnology research in China. A trade ban on GM rice (food crop) would have only a minor effect since the portion of rice exported is very small. The effects of unilateral labeling of soybean imports would be larger and have clear distributional impacts. If China wants to label GM products, this would increase the domestic price of soybeans, and therefore benefits Chinese soybean farmers. However, domestic labeling also increase the price of domestic GM rice, and this would affect rice consumers.

Our findings suggest that it would be economically advantageous for China to continue the promotion of its GM biotechnology, including commercializing its GM food crops. The economy-wide benefits associated with more productive crops far outweigh R&D expenditures. Our findings also suggest that most gains occur inside China, and can be achieved despite the biotech-unfriendly polices adopted by some industrialized countries.

Trade and FDI: limited role of the Netherlands
China has attracted substantial foreign direct investments (FDI) in recent decades, and in 2002 it became the world's most important FDI recipient. More than 60% of FDI is in the manufacturing sector. FDI has been pouring into the coastal regions although recent policy is shifting to the western part of China to exploit its rich resources and stimulate domestic demand there.

Dutch FDI in China began in the 1980s, but it took off in 1992 after the opening up policy was formally adopted nation-wide. The Dutch FDI stock accounts for less than 1% of China's total FDI. Also Dutch FDI is strongly skewed toward manufacturing, which absorbed two-third of the total. In terms of regional preference, Jiangsu is the Netherlands' first choice, followed by neighboring Shanghai.

The Dutch trade position in China is limited. This also holds for the agricultural sector: the Netherlands has only a limited share in China's agricultural imports. China, on the other hand, has generated a huge trade surplus with the Netherlands. As far as agricultural trade concerns flower bulbs and edible offal are the major Dutch export categories to China, while China's exports of agricultural products to the Netherlands are very limited.

It can be concluded that both the export of Dutch agricultural products and Dutch FDI in the Chinese agribusiness are limited. This has only partly to do with the great distance between the two countries. An important role is played by the differences in culture, which make transaction costs high when doing business with China. This explains why the role of small and medium-sized companies in trade and FDI is limited and why multinational companies are more active in the Chinese market.

It is expected that China's strong economic growth will continue and that China will remain one of the most favored investment destinations. In order to better utilize the economic opportunities, Dutch investors need to pay much attention to the policy changes of the Chinese government, which is shifting its focus from the east to the west. A large part of northwest China is rich in agricultural and natural resources, and remains untapped.

FDI and export opportunities for the Dutch agribusiness exist in horticulture, intensive livestock products and -to much lesser extent- dairy products. Dutch companies are currently involved in these sectors to different degree, but mostly focusing on trade relations.

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Appendices Tables

Appendices tables Chapter 3

Appendix 3.1 Classification of commodities and data sources GTAP and CAPSiM

GTAP	Code	CAPSiM
1 Rice	0113: Rice, not husked 0114: Husked rice 2316: Rice, semi- or wholly milled	Milled rice = 0114+2316
2 Wheat	0111: Wheat and meslin	Wheat < 0111
3 Cgrains	0112: Maize (corn) 0115: Barley 0116: Rye, oats 0119: Other cereals	Maize = 0112 Other coarse grains > 0115 + 0116 + 0119
4 Oilseeds	014: Oil seeds and oleaginous fruit 2163: Soya-bean, ground-nut, olive, sunflower-seed, safflower, cotton-seed rape, colza and mustard oil, crude 2164: Palm, coconut, palm kernel, babassu and linseed oil, crude 2165: Soya-bean, ground-nut, olive, sunflower-seed, safflower, cotton-seed, rape, colza and mustard oil and their fractions, refined but not chemically modified; other oils obtained solely from olives and sesame oil, and their fractions, whether or not refined, but not chemically modified 2166: Maize (corn) oil and its fractions, not chemically modified 2167: Palm, coconut, palm kernel, babassu and linseed oil and their fractions, refined but not chemically modified; castor, tung and jojoba oil and fixed vegetable fats and oils (except maize oil) and their fractions n.e.c., whether or not refined, but not chemically modified 2168: Margarine and similar preparations 2169: Animal or vegetable fats and oils and their fractions, partly or wholly hydrogenated, inter-esterified, re-esterified or elaidinised, whether or not refined, but not further prepared 217: Cotton linters 218: Oil-cake and other solid residues resulting from the extraction of vegetable fats or oils; flours and meals of oil seeds or oleaginous fruits, except those of mustard; vegetable waxes, except triglycerides; degras; residues resulting from the treatment of fatty substances or animal or vegetable waxes 218	Oil crop + Soybean = 014 Oil = 2163 + 2164 + 2165 + 2166 + 2167
5 Sugar	018: Plants used for sugar manufacturing 235: Sugar	Sugar crop = 018 Sugar = 235
6 Pfb	0192: Raw vegetable materials used in textiles	Cotton < 0192

7 OthCrop	012: Vegetables 013: Fruit and nuts 015: Live plants; cut flowers and flower buds; flower seeds and fruit seeds; vegetable seeds 016: Beverage and spice crops 017: Unmanufactured tobacco 0191: Cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form of pellets; swedes, mangolds, fodder roots, hay, lucerne (alfalfa), clover, sainfoin, forage kale, lupines, vetches and similar forage products, whether or not in the form of pellets 0193: Plants and parts of plants used primarily in perfumery, in pharmacy, or for insecticidal, fungicidal or similar purposes 0194: Sugar beet seed and seeds of forage plants 0199: Other raw vegetable materials	Vegetable + potato + sweet potato ≈ 012
8 Ctl	0211: Bovine cattle, sheep and goats, horses, asses, mules, and hinnies, live 0299: Bovine semen 21111: Meat of bovine animal, fresh or chilled 21112: Meat of bovine animals, frozen 21115: Meat of sheep, fresh or chilled 21116: Meat of sheep, frozen 21117: Meat of goats, fresh, chilled or frozen 21118: Meat of horses, asses, mules or hinnies, fresh, chilled or frozen 21119: Edible offal of bovine animals, swine, sheep, goats, horses, asses, mules or hinnies, fresh, chilled or frozen 2161: Fats of bovine animals, sheep, goats, pigs and poultry, raw or rendered; wool grease	Beef = 21111 + 21112 Mutton = 21115 + 21116 + 21117
9 Oap	0212: Swine, poultry and other animal, live 0292: Eggs, in shell, fresh, preserved or cooked 0293: Natural honey 0294: Snails, live, fresh, chilled, frozen, dried, salted or in brine, except sea snails; frogs' legs, fresh, chilled or frozen 0295: Edible products of animal origin n.e.c. 0297: Hides, skins and furskins, raw 0298: Insect waxes and spermaceti, whether or not refined or colored 21113: Meat of swine, fresh or chilled 21114: Meat of swine, frozen 2112: Meat and edible offal, fresh, chilled or frozen, n.e.c. 2113: Preserves and preparations of meat, meat offal or blood 2114: Flours, meals and pellets of meat or meat offal, inedible; greaves 2162: Animal oils and fats, crude and refined, except fats of bovine animals, sheep, goats, pigs and poultry	Eggs = 0292 Pork = 21113 + 21114 Poultry < 0212
10 Milk	0291: Raw milk 22: Dairy products	Milk = 0291
11 Fish	015: Hunting, trapping and game propagation including related service activities 05: Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing	Fish ≈ 015 + 05

Appendix 3.2 Commodity values for China (1997) in CAPSiM and GTAP

GTAP		CAPSiM		Exchange Rate: 8.2898		
	VOM (M US$)		Quantity (1000 Ton)	Producer Free Market Price (Yuan/Ton)	Value (M US$)	%Diff
1 Rice	60397	Milled rice	140515	2286	38748	-35.84
2 Wheat	11275	Wheat	123289	1661	24703	119.10
3 Cgrains	12864				18200	41.48
		Maize	104309	1209	15213	
		Other coarse	19184	1291	2988	
4 Oilseeds	19268				13880	-27.97
		Soybean	14732	3410	6060	
		Edible Oil	7767	8346	7820	
5 Sugar	1623	Sugar	7026	3950	3348	106.27
6 Pfb	7092	Cotton	4603	13939	7740	9.13
7 OthCrop	83426				73654	-11.71
		Sweet Potato	20474	1168	2885	
		Potato	11442	1502	2073	
		Vegetable	239579	2377	68696	
All Crops	***195945***				***180273***	***-8.00***
8 Ctl	7937				8169	2.93
		Beef	2834	15092	5159	
		Mutton	1428	17472	3010	
9 Oap	86346				68815	-20.30
		Eggs	10421	7137	8972	
		Pork	26594	15953	51178	
		Poultry	5929	12115	8665	
10 Milk	2839	Milk	6811	3254	2674	-5.83
11 Fish	22944	Fish	25625	7498	23177	1.02
All livestock	***120066***				***102835***	***-14.35***
Total	**316011**				**283108**	**-10.41**

Note: VOM, Value of Output at Market prices.

Appendix 3.3 Import value (CIF) for China (1997) in CAPSiM and GTAP

GTAP		CAPSiM				%Diff
	VIWS		Quantities	Price	Value	
1 Rice	152	Milled rice	330	424	140	-8.05
2 Wheat	371	Wheat	1860	198	368	-0.73
3 Cgrains	386				383	-0.85
		maize	2	146	0	
		other coarse grains	1922	199	382	
4 Oilseeds	3959				2543	-35.76
		Soybean	5638	303	1709	
		Edible oil	1525	547	834	
5 Sugar	259	Sugar	280	293	82	-68.29
6 Pfb	1391	Cotton	750	1774	1331	-4.32
7 OthCrop	997				31	-96.88
		Sweet Potato	4	764	3	
		Potato	19	330	6	
		Vegetable	53	411	22	
8 Ctl	323				261	-19.29
		Beef	87	2483	216	
		Mutton	25	1787	45	
9 Oap	2064				372	-81.97
		Eggs	1	928	1	
		Pork	10	1658	17	
		Poultry	216	1642	355	
10 Milk	263	Milk	251	277	69	-73.59
11 Fish	104	Fish	151	3478	525	404.91

Note: VIWS, Value of Imports at World prices by Source.

Appendix 3.4 Export value (FOB) for China (1997) in CAPSiM and GTAP

GTAP		CAPSiM	CAPSiM			%Diff
	VXWD		Quantities	Price	Value	
1 Rice	404	Milled rice	940	281	265	-34.51
2 Wheat	18	Wheat	898	198	178	887.94
3 Cgrains	933				911	-2.32
		maize	6620	130	859	
		other coarse grains	316	166	52	
4 Oilseeds	834				251	-69.89
		Soybean	190	386	73	
		Edible oil	267	666	178	
5 Sugar	144	Sugar	380	349	133	-7.78
6 Pfb	4	Cotton	1	2320	2	-42.00
7 OthCrop	2520				2462	-2.29
		Sweet Potato	22	595	13	
		Potato	14	144	2	
		Vegetable	2765	885	2447	
8 Ctl	129				175	35.45
		Beef	106	1627	172	
		Mutton	1	2243	2	
9 Oap	2703				1278	-52.73
		Eggs	46	552	25	
		Pork	275	1883	518	
		Poultry	388	1893	734	
10 Milk	52	Milk	148	410	61	16.72
11 Fish	598	Fish	720	2622	1888	215.67

Note: VXWD, Value of exports at World prices by Destination.

Appendix 3.5 Aggregate Demand (Consumption) of Pork and Poultry Based on HIES and Trade Data

Year	(1) Population (million)	(2)	(3) Per Capita Pork Consumption (kg)	(4)	(5) Per Capita Poultry Consumption (kg)	(6)	(7) Net Exports (mmt)	(8)	(9) Aggregate Consumption Based on HIES and Trade (mmt) [c]	(10)
	Urban	Rural	Urban [b]	Rural	Urban [b]	Rural	Pork	Poultry	Pork	Poultry
1980	191.4	795.7	16.38	6.49	1.58	0.66	0.15	0.08	10.47	0.88
1981	203.3	798.6	16.92	7.43	1.60	0.71	0.17	0.17	11.84	1.02
1982	206.6	801.6	17.46	8.36	1.74	0.78	0.31	0.31	13.23	1.25
1983	218.9	804.4	18.00	9.30	1.98	0.82	0.30	0.30	14.63	1.35
1984	231.5	807.1	17.10	10.62	2.22	0.94	0.30	0.30	16.07	1.52
1985	250.9	807.6	17.16	10.32	2.49	1.03	0.32	0.32	16.73	1.77
1986	263.7	811.4	17.55	11.79	2.66	1.14	0.32	0.32	18.76	1.95
1987	276.7	816.3	17.95	10.98	2.83	1.15	0.31	0.31	18.40	2.03
1988	286.6	823.7	17.54	10.05	3.33	1.25	0.29	0.29	17.56	2.27
1989	295.4	831.6	17.53	10.28	3.65	1.28	0.31	0.31	18.13	2.45
1990	296.5	837.2	18.46	10.54	4.30	1.26	0.35	0.35	18.91	2.68
1991	305.4	852.8	18.86	11.19	4.40	1.34	0.33	0.33	20.20	2.82
1992	323.7	848.0	17.70	10.88	5.08	1.49	0.27	0.27	19.69	3.18
1993	333.5	851.7	17.40	10.96	5.20	1.62	0.30	0.30	19.95	3.41
1994	343.0	855.5	17.37	10.23	5.43	1.63	0.39	0.39	19.49	3.64
1995	351.7	859.5	17.24	10.58	5.79	1.83	0.34	0.34	20.03	3.95
1996	359.5	864.4	17.55	11.85	6.41	1.93	0.31	0.31	21.81	4.28
1997	369.9	866.4	15.34	11.46	7.03	2.36	0.27	0.27	20.54	4.92
1998	379.4	868.7	15.88	11.89	7.22	2.33	0.26	0.26	21.50	5.02
1999	388.9	870.2	16.91	11.68	7.81	2.48	0.21	0.38	21.94	5.58

Sources: Population comes from Yearbooks (CNSB, 1981 to 2000); meat consumption comes from HIES--rural and urban (see Table 3.5); exports come from Yearbooks.

[a] Per capita consumption is measured in retail weight and aggregate consumption is measured in carcass weight. Retail weight figures (the original units for consumption data) are converted to carcass weight (the original units for production data) by using standard conversion coefficients (0.77 for pork; 1.0 for poultry) from Fuller et al. (2000).

[b] Before 1985, the urban survey did not cover county-level towns, the residents of which we believe had lower consumption levels than their counterparts in the larger cities. Therefore, when we multiply the per capita pork (poultry) consumption in column 3 (5) by the urban population (column 1), we adjust the figures for 1980 to 1984 downward (by an amount equivalent to 33 percent lower per capita consumption for 66 to 70 percent of urban population (which is our estimate of the proportion of the population that lives in county-level towns).

[c] (9)=(1)*(3)+(2)*(4)+(7) and (10)=(1)*(5)+(2)*(6)+(8).

Appendix 3.6 Adjusted Aggregate Pork and Poultry Demand (Consumption) - Adjusted for the Omission of Out-Of-Home Consumption

Year	(1) Aggregate Consumption Based on HIES and Trade (mmt)	(2)	(3) Population (million)	(4)	(5) Per Capita Omission of Pork *Out-Of-Home* Consumption (kg)	(6)	(7) Per Capita Omission of Poultry *Out-Of-Home* Consumption (kg)	(8)	(9) Adjusted Aggregate Demand-- for Omission of O*ut-Of-Home* Consumption (mmt)	(10)
	Pork [a]	Poultry [b]	Urban	Rural	Urban [c]	Rural [d]	Urban [e]	Rural [f]	Pork [g]	Poultry [h]
1980	10.47	0.88	191.4	795.7	0.10	0.03	0.02	0.02	10.52	0.88
1981	11.84	1.02	203.3	798.6	0.15	0.04	0.03	0.02	11.92	1.06
1982	13.23	1.25	206.6	801.6	0.20	0.06	0.04	0.03	13.34	1.31
1983	14.63	1.35	218.9	804.4	0.28	0.08	0.06	0.04	14.79	1.42
1984	16.07	1.52	231.5	807.1	0.36	0.10	0.08	0.06	16.29	1.60
1985	16.73	1.77	250.9	807.6	0.45	0.13	0.09	0.07	17.02	1.86
1986	18.76	1.95	263.7	811.4	0.55	0.15	0.11	0.08	19.11	2.05
1987	18.40	2.03	276.7	816.3	0.70	0.19	0.14	0.10	18.86	2.16
1988	17.56	2.27	286.6	823.7	0.86	0.22	0.18	0.12	18.14	2.42
1989	18.13	2.45	295.4	831.6	0.98	0.25	0.20	0.14	18.80	2.62
1990	18.91	2.68	296.5	837.2	1.00	0.25	0.21	0.14	19.59	2.85
1991	20.20	2.82	305.4	852.8	1.05	0.27	0.22	0.15	20.95	3.01
1992	19.69	3.18	323.7	848.0	1.64	0.30	0.34	0.17	20.76	3.43
1993	19.95	3.41	333.5	851.7	2.14	0.36	0.44	0.20	21.34	3.73
1994	19.49	3.64	343.0	855.5	2.80	0.55	0.58	0.30	21.44	4.11
1995	20.03	3.95	351.7	859.5	3.75	0.74	0.78	0.41	22.71	4.59
1996	21.81	4.28	359.5	864.4	4.35	1.02	0.90	0.56	25.15	5.11
1997	20.54	4.92	369.9	866.4	4.75	1.15	0.99	0.63	24.31	5.85
1998	21.50	5.02	379.4	868.7	5.30	1.38	1.10	0.76	25.90	6.12
1999	21.94	5.58	388.9	870.2	5.83	1.45	1.21	0.80	26.83	6.76

[a] The figures in column 1 come from Appendix 3.5, column 9; [b] The figures in column 2 come from Appendix 3.5, column 10; [c] The figures in column 5 come from Appendix 3.7, column 4; [d] The figures in column 6 come from Appendix 3.7, column 10; [e] The figures in column 7 come from Appendix 3.7, column 6; [f] The figures in column 8 come from Appendix 3.7, column 12; [g] (9)=(1)+(3)*(5)+(4)*(6) and [h] (10)=(2)+(3)*(7)+(4)*(8).

Appendix 3.7 *Estimates of Per Capita Out-of-Home Pork and Poultry Consumption in Urban and Rural China, 1980 to 1999.*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Urban Per Capita Consumption, Out-of-home						Rural Per Capita Consumption, Out-of-home					
	Consumption, out-of-home		Pork (kg)		Poultry (kg)		Consumption, out-of-home		Pork (kg)		Poultry (kg)	
Year	Total Food Expenditure [a]	Index of out-of-home consumption [b]	CCAP Survey [c]	Estimated Over Time [d]	CCAP Survey [c]	Estimated Over Time [d]	Total Food Expenditure [a]	Estimated Index on the 1998 Base [b]	CCAP Survey [c]	Estimated Over Time [d]	CCAP Survey [c]	Estimated Over Time [d]
1980	*4.47*	0.02	-	0.10	-	0.02	*0.93*	0.02	-	0.03	-	0.02
1981	*6.22*	0.03	-	0.15	-	0.03	*1.32*	0.03	-	0.04	-	0.02
1982	*8.62*	0.04	-	0.20	-	0.04	*1.89*	0.04	-	0.06	-	0.03
1983	*12.08*	0.05	-	0.28	-	0.06	2.70	0.06	-	0.08	-	0.04
1984	*15.55*	0.07	-	0.36	-	0.08	3.52	0.08	-	0.10	-	0.06
1985	*19.08*	0.08	-	0.45	-	0.09	4.52	0.10	-	0.13	-	0.07
1986	*23.69*	0.10	-	0.55	-	0.11	5.17	0.11	-	0.15	-	0.08
1987	*29.89*	0.13	-	0.70	-	0.14	6.31	0.14	-	0.19	-	0.10
1988	*36.70*	0.16	-	0.86	-	0.18	7.49	0.16	-	0.22	-	0.12
1989	*42.07*	0.19	-	0.98	-	0.20	8.39	0.18	-	0.25	-	0.14
1990	*42.87*	0.19	-	1.00	-	0.21	8.29	0.18	-	0.25	-	0.14
1991	*44.96*	0.20	-	1.05	-	0.22	9.20	0.20	-	0.27	-	0.15
1992	70.27	0.31	-	1.64	-	0.34	10.16	0.22	-	0.30	-	0.17
1993	91.77	0.40	-	2.14	-	0.44	12.04	0.26	-	0.36	-	0.20
1994	119.88	0.53	-	2.80	-	0.58	18.51	0.40	-	0.55	-	0.30
1995	160.66	0.71	-	3.75	-	0.78	24.88	0.54	-	0.74	-	0.41
1996	186.21	0.82	-	4.35	-	0.90	34.15	0.74	-	1.02	-	0.56
1997	203.44	0.90	-	4.75	-	0.99	38.62	0.83	-	1.15	-	0.63
1998	227.01	1.00	5.3	5.30	1.10	1.10	46.41	1.00	1.38	1.38	0.76	0.76
1999	249.59	1.10	-	5.83	-	1.21	48.73	1.05	-	1.45	-	0.80

[a] Figures come from HIES--urban and rural (see Table 3.5). Since there was no information about out-of-home consumption in urban areas before 1991, these figures had to be estimated. To do so, we calculated the average ratio of urban out-of-home consumption to rural out-of-home consumption for 1992 to 1999. This ratio was approximately 2. Since we have information on rural out-of-home consumption between 1982 and 1991, we estimate urban out-of-home consumption for this period by multiplying the rural figures by 2. The rural and urban out-of-home consumption figures for 1980 to 1982 are projected backward from figures in later years.

[b] Index of total out-of-home food expenditures calculated from column 1 or 7 using 1998 as a fixed base.

[c] Figures come from CCAP Survey (described in Table 3.5). Statistics also shown in Table 3.6.

[d] (4)=(2)*5.3 (from column 3), (6)=(2)*1.1 (from column 5), (10)=(8)*1.38 (from column 9) and (12)=(8)*0.76 (from column 11).

Appendix 3.8 Adjusted Aggregate Pork and Poultry Demand--Adjusted to Account for Omission of Consumption Due to Increased Migration in Rural China, 1980 to 1999

Year	(1) Population [a] (million) Urban	(2) Rural in home	(3) Migrant	(4) Per Capita Consumption, in-home [b] (kg) Pork Urban	(5) Rural	(6) Migrant	(7) Poultry Urban	(8) Rural	(9) Migrant	(10) Per Capita Consumption, out-of-home [c] (kg) Pork Urban	(11) Rural	(12) Migrant	(13) Poultry Urban	(14) Rural	(15) Migrant	(16) Adjusted Aggregate Demand--Adjusted for Omission of Migrant Consumption (mmt) Pork [d]	(17) Poultry [e]
1980	191.4	779.4	16.2	16.38	6.49	11.44	1.58	0.66	1.12	0.10	0.03	0.07	0.02	0.02	0.02	10.63	0.88
1981	203.3	779.6	19.0	16.92	7.43	12.18	1.60	0.71	1.16	0.15	0.04	0.10	0.03	0.02	0.03	12.04	1.07
1982	206.6	781.0	20.6	17.46	8.36	12.91	1.74	0.78	1.26	0.20	0.06	0.13	0.04	0.03	0.04	13.46	1.32
1983	218.9	782.4	22.0	18.00	9.30	13.65	1.98	0.82	1.40	0.28	0.08	0.18	0.06	0.04	0.05	14.91	1.43
1984	231.5	782.5	24.6	17.10	10.62	13.86	2.22	0.94	1.58	0.36	0.10	0.23	0.08	0.06	0.07	16.39	1.62
1985	250.9	781.5	26.0	17.16	10.32	13.74	2.49	1.03	1.76	0.45	0.13	0.29	0.09	0.07	0.08	17.14	1.88
1986	263.7	781.7	29.7	17.55	11.79	14.67	2.66	1.14	1.90	0.55	0.15	0.35	0.11	0.08	0.10	19.23	2.07
1987	276.7	783.9	32.4	17.95	10.98	14.47	2.83	1.15	1.99	0.70	0.19	0.45	0.14	0.10	0.12	19.01	2.19
1988	286.6	790.1	33.5	17.54	10.05	13.80	3.33	1.25	2.29	0.86	0.22	0.54	0.18	0.12	0.15	18.30	2.46
1989	295.4	795.6	36.0	17.53	10.28	13.91	3.65	1.28	2.47	0.98	0.25	0.62	0.20	0.14	0.17	18.97	2.67
1990	296.5	798.3	38.8	18.46	10.54	14.50	4.30	1.26	2.78	1.00	0.25	0.63	0.21	0.14	0.18	19.79	2.91
1991	305.4	806.4	46.4	18.86	11.19	15.03	4.40	1.34	2.87	1.05	0.27	0.66	0.22	0.15	0.19	21.18	3.08
1992	323.7	797.6	50.4	17.70	10.88	14.29	5.08	1.49	3.29	1.64	0.30	0.97	0.34	0.17	0.26	20.98	3.52
1993	333.5	794.2	57.5	17.40	10.96	14.18	5.20	1.62	3.41	2.14	0.36	1.25	0.44	0.20	0.32	21.58	3.84
1994	343.0	792.2	63.3	17.37	10.23	13.80	5.43	1.63	3.53	2.80	0.55	1.68	0.58	0.30	0.44	21.74	4.23
1995	351.7	787.1	72.3	17.24	10.58	13.91	5.79	1.83	3.81	3.75	0.74	2.25	0.78	0.41	0.60	23.02	4.73
1996	359.5	786.8	77.6	17.55	11.85	14.70	6.41	1.93	4.17	4.35	1.02	2.69	0.90	0.56	0.73	25.43	5.28
1997	369.9	780.7	85.6	15.34	11.46	13.40	7.03	2.36	4.70	4.75	1.15	2.95	0.99	0.63	0.81	24.53	6.05
1998	379.4	774.7	93.9	15.88	11.89	13.89	7.22	2.33	4.78	5.30	1.38	3.34	1.10	0.76	0.93	26.15	6.35
1999	388.9	760.5	109.7	16.91	11.68	14.30	7.81	2.48	5.15	5.83	1.45	3.64	1.21	0.80	1.01	27.21	7.05

[a] Rural in-home population includes those who live and work in rural China. The migrant population includes those rural residents who live and work in urban China. Migrant population comes from Rozelle et al (1998) and is adjusted here by multiplying by 1.2 to account for the family members of migrants who live in urban areas. Rural in-home population equals Yearbook's total rural population (in Appendix 3.7, column 2) minus migrant population in column 5.

[b] Urban and rural per capita consumption comes from Appendix 3.5, column 3 and 4 for pork and column 5 and 6 for poultry. Per capita migrant consumption is assumed to be the average of per capita urban and rural consumption.

[c] Per capita out-of-home consumption comes from Appendix 3.6, columns 5 and 6 for pork and columns 7 and 8 for poultry.

[d] Pork aggregate consumption, (10)={(1)*[(4)+(10)]+(2)*[(5)+(11)]+(3)*[(6)+(12)]}*1.2987/1000 plus trade in Appendix 3.5, column 7. The figure 1.2987 is the meat-carcass conversion factor.

[e] Poultry aggregate consumption, (11)= {(1)*[(7)+(13)]+(2)*[(8)+(14)]+(3)*[(9)+(15)]}/1000 plus trade in Appendix 3.5, column 8.

Appendix 3.9 Adjusted Aggregate Pork and Poultry Demand (Consumption)—Adjusted for the Omission of In-Home Consumption for Urban and Rural China, 1980 to 1999.

Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	Adjusted Aggregate Demand (mmt) [a]		Population (million) [b]			Per Capita Omission of Pork *In-home* consumption (kg) [c]			Per Capita Omission of Poultry In-home consumption (kg) [d]			Adjusted Demand-- for Omission of *In-Home* Consumption (mmt) [e]	
	Pork	Poultry	Urban	Rural in home	Migrant	Urban	Rural	Migrant	Urban	Rural	Migrant	Pork	Poultry
1980	10.63	0.88	191.40	779.40	16.20	0.00	0.00	0.00	0.00	0.00	0.00	10.63	0.88
1981	12.04	1.07	203.30	779.60	19.00	0.00	0.00	0.00	0.00	0.00	0.00	12.04	1.07
1982	13.46	1.32	206.60	781.00	20.60	0.00	0.00	0.00	0.00	0.00	0.00	13.46	1.32
1983	14.91	1.43	218.90	782.40	22.00	0.00	0.00	0.00	0.00	0.00	0.00	14.91	1.43
1984	16.39	1.62	231.50	782.50	24.60	0.00	0.00	0.00	0.00	0.00	0.00	16.39	1.62
1985	17.14	1.88	250.90	781.50	26.00	0.00	0.00	0.00	0.00	0.00	0.00	17.14	1.88
1986	19.23	2.07	263.70	781.70	29.70	0.00	0.00	0.00	0.00	0.00	0.00	19.23	2.07
1987	19.01	2.19	276.70	783.90	32.40	0.00	0.00	0.00	0.00	0.00	0.00	19.01	2.19
1988	18.30	2.46	286.60	790.10	33.50	0.30	0.05	0.18	0.06	0.03	0.04	18.47	2.50
1989	18.97	2.67	295.40	795.60	36.00	0.61	0.10	0.35	0.12	0.05	0.09	19.31	2.75
1990	19.79	2.91	296.50	798.30	38.80	0.91	0.14	0.53	0.19	0.08	0.13	20.31	3.03
1991	21.18	3.08	305.40	806.40	46.40	1.21	0.19	0.70	0.25	0.10	0.17	21.90	3.25
1992	20.98	3.52	323.70	797.60	50.40	1.51	0.24	0.88	0.31	0.13	0.22	21.92	3.73
1993	21.58	3.84	333.50	794.20	57.50	1.82	0.29	1.05	0.37	0.15	0.26	22.75	4.09
1994	21.74	4.23	343.00	792.20	63.30	2.12	0.34	1.23	0.44	0.18	0.31	23.13	4.54
1995	23.02	4.73	351.70	787.10	72.30	2.42	0.39	1.40	0.50	0.20	0.35	24.65	5.09
1996	25.43	5.28	359.50	786.80	77.60	2.72	0.43	1.58	0.56	0.23	0.39	27.31	5.69
1997	24.53	6.05	369.90	780.70	85.60	3.03	0.48	1.75	0.62	0.25	0.44	26.67	6.51
1998	26.15	6.35	379.40	774.70	93.90	3.33	0.53	1.93	0.68	0.28	0.48	28.56	6.86
1999	27.21	7.05	388.90	760.50	109.70	3.63	0.58	2.11	0.75	0.30	0.52	29.91	7.63

[a] The figures come from Appendix 3.8, columns 16 and 17.
[b] Source of population numbers are explained in Appendix 3.8, footnote a.
[c] The figures in columns 6 and 7 come from Appendix 3.11, columns 3 and 6; the figures in column 8 are the averages of columns 6 and 7.
[d] The figures in columns 9 and 10 come from Appendix 3.10, column 9 and 12; the figures in column 11 are the averages of columns 9 and 10.
[e] (12)=(1)+(3)*(6)+(4)*(7)+(5)*(8) and (13)=(2)+(3)*(9)+(4)*(10)+(5)*(11).

Appendix 3.10 Calculations Showing Basis for Adjustments for the Omission of In-Home Consumption Made to Per Capita Pork and Poultry Demand (Consumption) Statistical Series in China, 1980 to 1999 [a]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Urban Pork Consumption (kg)			Rural Pork Consumption (kg)			Urban Poultry Consumption (kg)			Rural Poultry Consumption (kg)		
Year	In-home from CCAP survey [b]	Annual increase in omitted demand [c]	Amount that HIES under reports due to the omission [d]	In-home from CCAP survey	Annual increase in omitted demand	Amount that HIES under reports due to the omission	In-home from CCAP survey	Annual increase in omitted demand	Amount that HIES under reports due to the omission	In-home from CCAP survey	Annual increase in omitted demand	Amount that HIES under reports due to the omission
1980	-	-	0.00	-	-	0.00	-	-	0.00	-	-	0.00
1981	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00
1982	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00
1983	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00
1984	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00
1985	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00
1986	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00
1987	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00	-	0.00	0.00
1988	-	0.30	0.30	-	0.05	0.05	-	0.06	0.06	-	0.03	0.03
1989	-	0.30	0.61	-	0.05	0.10	-	0.06	0.12	-	0.03	0.05

Appendix 3.10 *Calculations Showing Basis for Adjustments for the Omission of In-Home Consumption Made to Per Capita Pork and Poultry Demand (Consumption) Statistical Series in China, 1980 to 1999* [a] *(continuation)*

1990	-	0.30	0.91	-	0.05	0.14	-	0.06	0.19	-	0.03	0.08
1991	-	0.30	1.21	-	0.05	0.19	-	0.06	0.25	-	0.03	0.10
1992	-	0.30	1.51	-	0.05	0.24	-	0.06	0.31	-	0.03	0.13
1993	-	0.30	1.82	-	0.05	0.29	-	0.06	0.37	-	0.03	0.15
1994	-	0.30	2.12	-	0.05	0.34	-	0.06	0.44	-	0.03	0.18
1995	-	0.30	2.42	-	0.05	0.39	-	0.06	0.50	-	0.03	0.20
1996	-	0.30	2.72	-	0.05	0.43	-	0.06	0.56	-	0.03	0.23
1997	-	0.30	3.03	-	0.05	0.48	-	0.06	0.62	-	0.03	0.25
1998	19.21	0.30	3.33	12.42	0.05	0.53	7.91	0.06	0.68	2.61	0.03	0.28
1999	-	0.30	3.63	-	0.05	0.58	-	0.06	0.75	-	0.03	0.30

[a] Adjustments are made to the demand data after adjustments are made for omissions due to out-of-home demand and migration. Conceptually, these adjustments in part make up for omissions due to factors such as meat demand that was not recorded due to the meat being part of processed foods. Empirically, adjustments are made by comparing in-home demand from the HIES data with in-home demand from our own CCAP survey (see Table 3.6). It is assumed that such omissions were not present in 1987 and that the rise in omissions occurred at a linear rate.

[b] Figures in column 1, 4, 7 and 10 come from 1998 CCAP Survey (see Table 3.6). To get rid of sample selection bias, we multiply CCAP Survey in-home meat consumption by the ratio of national HIES estimate to weighted average of HIES estimates of the four provinces from which the CCAP Survey sample households were chosen.

[c] This is calculated by taking the total amount by which in-home demand is underreported by HIES in 1998 (from column 3), subtracting the amount by which demand is assumed to be underreported in 1987 (that is 0) and dividing by 11, the number of years between 1987 and 1998. Likewise, we have created columns 5, 8 and 11.

[d] The figure in 1998 is the difference between in-home demand from the CCAP survey (column 1) and the demand reported in the HIES survey (Appendix 3.5, column 3, row for 1998). The rest of the figures are calculated by starting at 1998 and working backwards towards 1987. Each year's figure is just the next year's figure minus 0.30 (column 2), the "average annual increase in omitted in-home demand." Likewise, we have created columns 6, 9 and 12.

Appendix 3.11 Reconciling China's Eggs Production (Supply) and Consumption (Demand) Statistics Series, 1980 to 1999

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
						Various Supply/demand Ratios (to Assess the Consistency of Data Series Adjustments)			
Year	Aggregate Demand Based on HIES and Trade Data (mmt) [a]	Adjusted Demand— for omission of *out-of-home* and *migrant* consumption (mmt) [b]	Adjusted Demand- - for omission of *in-home* consumption (mmt) [c]	Reported Aggregate Egg Supply from Yearbook (mmt)	Adjusted Aggregate Egg Supply— for over reporting (mmt)	(4)/(1)	(4)/(2)	(5)/(2)	(5)/(3)
1980	2.13	2.18	2.18	2.57	2.57	1.20	1.18	1.18	1.18
1981	2.24	2.29	2.47	2.69	2.69	1.20	1.17	1.17	1.09
1982	2.31	2.38	2.74	2.81	2.81	1.22	1.18	1.18	1.03
1983	2.69	2.78	3.34	3.32	3.32	1.23	1.19	1.19	1.00
1984	3.15	3.26	4.01	4.32	4.32	1.37	1.32	1.32	1.08
1985	3.57	3.70	4.65	5.35	5.35	1.50	1.45	1.45	1.15
1986	3.63	3.77	4.95	5.55	5.55	1.53	1.47	1.47	1.12
1987	4.05	4.23	5.62	5.90	**6.14** [d]	1.46	1.40	1.45	1.09
1988	4.38	4.59	6.22	6.96	6.55	1.59	1.51	1.43	1.05
1989	4.60	4.84	6.70	7.20	6.92	1.57	1.49	1.43	1.03
1990	4.78	5.03	7.11	7.95	7.40	1.66	1.58	1.47	1.04

Appendix 3.11 Reconciling China's Eggs Production (Supply) and Consumption (Demand) Statistics Series, 1980 to 1999 (continuation)

Year	(1) Aggregate Demand Based on HIES and Trade Data (mmt) [a]	(2) Adjusted Demand for omission of out-of-home and migrant consumption (mmt) [b]	(3) Adjusted Demand-- for omission of in-home consumption (mmt) [c]	(4) Reported Aggregate Egg Supply from Yearbook (mmt)	(5) Adjusted Aggregate Egg Supply-for over reporting (mmt)	(6) Various Supply/demand Ratios (to Assess the Consistency of Data Series Adjustments)	(7)	(8)	(9)
1991	5.10	5.39	7.74	9.22	7.99	1.81	1.71	1.48	1.03
1992	5.51	5.88	8.48	10.20	8.71	1.85	1.73	1.48	1.03
1993	5.44	5.87	8.73	11.80	9.27	2.17	2.01	1.58	1.06
1994	5.94	6.52	9.64	14.79	9.79	2.49	2.27	1.50	1.02
1995	6.22	6.97	10.36	16.77	10.59	2.69	2.41	1.52	1.02
1996	6.40	7.29	10.95	19.65	**11.35** [d]	3.07	2.70	1.56	1.04
1997	7.34	8.32	12.27	18.97	12.25	2.58	2.28	1.47	1.00
1998	7.71	8.87	13.10	20.21	13.31	2.62	2.28	1.50	1.02
1999	8.02	9.32	13.84	21.35	14.26	2.66	2.29	1.53	1.03
Growth [e]	6.08	7.01	8.02	11.43	7.36	5.05	4.14	0.31	-0.64

[a] Figures in column 1 are the same as Table 3.3, column 7, the calculation that is shown in Appendix 3.12, column 8.
[b] Adjustments to create the figures in column 1 are shown in Appendix 3.12, column 10, adjustments that include the omission of out of home consumption of urban and rural residents and the omission of consumption by rural migrant labors and their families.
[c] Adjustments to create the figures in column 3 are shown in Appendix 3.12, column 11, adjustments that include the omissions of out-of-home, migrant and in-home consumption.
[d] The bold figures are the three-year averages of Yearbook production data from 1986 to 88 and the meat production generated from 1997 Ag Census.
[e] An annual growth rates between 1987 and 1998, where 1987 and 1998 are three-year averages centered on 1987 and 1998.

Appendix 3.12 Adjustments to Egg Consumption to Account for the Omissions of Out-Of-Home, Increased Rural Migrant and In-Home Consumption

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Population (million)			Per Capita Egg Consumption (kg)			Net Exports (mmt)	Aggregate Demand Based on the HIES and Trade (mmt) [a]	Aggregate Consumption after Each Adjustment to the Omission of Which Consumption		
Year	Urban	Rural in home	Migrant	Urban	Rural	Migrant			Out-Of-Home (mmt) [b]	Migrant (mmt) [c]	In-Home (mmt) [d]
1980	191.4	779.4	16.2	5.68	1.40	3.54	0.06	2.13	2.14	2.18	2.18
1981	203.3	779.6	19.0	5.74	1.41	3.58	0.07	2.24	2.25	2.29	2.47
1982	206.6	781.0	20.6	5.88	1.43	3.66	0.07	2.31	2.33	2.38	2.74
1983	218.9	782.4	22.0	6.90	1.57	4.24	0.07	2.69	2.73	2.78	3.34
1984	231.5	782.5	24.6	7.62	1.84	4.73	0.07	3.15	3.19	3.26	4.01
1985	250.9	781.5	26.0	7.35	2.05	4.70	0.07	3.57	3.63	3.70	4.65
1986	263.7	781.7	29.7	7.08	2.08	4.58	0.07	3.63	3.70	3.77	4.95
1987	276.7	783.9	32.4	7.72	2.25	4.99	0.07	4.05	4.14	4.23	5.62
1988	286.6	790.1	33.5	8.50	2.28	5.39	0.06	4.38	4.49	4.59	6.22
1989	295.4	795.6	36.0	8.65	2.41	5.53	0.04	4.60	4.73	4.84	6.70
1990	296.5	798.3	38.8	8.85	2.53	5.69	0.04	4.78	4.91	5.03	7.11
1991	305.4	806.4	46.4	8.96	2.73	5.85	0.04	5.10	5.24	5.39	7.74
1992	323.7	797.6	50.4	9.45	2.85	6.15	0.03	5.51	5.71	5.88	8.48
1993	333.5	794.2	57.5	8.86	2.88	5.87	0.03	5.44	5.69	5.87	8.73
1994	343.0	792.2	63.3	9.68	3.03	6.36	0.03	5.94	6.30	6.52	9.64
1995	351.7	787.1	72.3	9.74	3.22	6.48	0.03	6.22	6.71	6.97	10.36
1996	359.5	786.8	77.6	9.64	3.35	6.50	0.04	6.40	7.02	7.29	10.95
1997	369.9	780.7	85.6	10.13	4.08	7.11	0.06	7.34	8.03	8.32	12.27
1998	379.4	774.7	93.9	10.76	4.11	7.44	0.05	7.71	8.52	8.87	13.10
1999	388.9	760.5	109.7	10.92	4.28	7.60	0.05	8.02	8.91	9.32	13.84

Note: Per capita consumption in column 4 and 5 come HIES--urban and rural (see Table 3.4); trade data come from CNSB's statistical yearbooks; Source of population numbers are explained in Appendix 3.8, footnote a.

[a] Figures are the same as Table 3.3 column 7 and (8)=[(1)*(4)+[(2)+(3)*(5)]]/1000+(7).

[b] (9)= (8) plus the figures in column 1 multiplying consumption (in Appendix 3.13, column 3), plus the sum of population (in columns 2 and 3) multiplying the consumption (in Appendix 3.14, column 6).

[c] (10)=(1)*(4)+(2)*(5)+(3)*(6) plus population in column 1 multiplying consumption (in Appendix 3.13, column 3), plus population in column 2 multiplying consumption (in Appendix 3.13, column 6), plus population in column 3 multiplying the average of consumption (in Appendix 3.13, columns 3 and 6).

[d] (11)=(10) plus column 1 multiplying consumption (in Appendix 3.13, column 9), plus column 2 multiplying consumption (in Appendix 3.13, column 12), and plus column 3 multiplying the average of consumption (in Appendix 3.13, columns 9 and 12).

Appendix 3.13 Calculations Showing Basis for Adjustments for the Omission of In-Home Consumption Made to Per Capita Egg Demand (Consumption) Statistical Series in China, 1980 to 1999

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Adjustments to Consumption Due to Failure to Include out of home consumption						Adjustments to Consumption Due to Per Capita Omission of In-Home Consumption					
	Urban			Rural			Urban			Rural		
Year	Index of out of home food expenditure [a]	Out-of-Home from CCAP Survey [b]	Estimated omission over time (kg) [c]	Index of Out of Home food expenditure [a]	Out-of-Home from CCAP Survey (kg) [b]	Estimated omission over time (kg) [c]	In home from CCAP survey [e]	Annual increase in omission (kg) [f]	Amount that HIES under-reports due to the omission [g]	In-home from CCAP Survey [e]	Annual increase in omission (kg) [f]	Amount that HIES under-reports due to the omission (kg) [g]
1980	0.02	-	0.02	0.02	-	0.01	-	-	0.00	-	-	0.00
1981	0.03	-	0.03	0.03	-	0.01	-	0.24	0.24	-	0.16	0.16
1982	0.04	-	0.05	0.04	-	0.02	-	0.24	0.47	-	0.16	0.33
1983	0.05	-	0.06	0.06	-	0.02	-	0.24	0.71	-	0.16	0.49
1984	0.07	-	0.08	0.08	-	0.03	-	0.24	0.95	-	0.16	0.65
1985	0.08	-	0.10	0.10	-	0.04	-	0.24	1.19	-	0.16	0.81
1986	0.10	-	0.13	0.11	-	0.05	-	0.24	1.42	-	0.16	0.98
1987	0.13	-	0.16	0.14	-	0.06	-	0.24	1.66	-	0.16	1.14
1988	0.16	-	0.19	0.16	-	0.07	-	0.24	1.90	-	0.16	1.30
1989	0.19	-	0.22	0.18	-	0.07	-	0.24	2.14	-	0.16	1.47

Appendix 3.13 Calculations Showing Basis for Adjustments for the Omission of In-Home Consumption Made to Per Capita Egg Demand (Consumption) Statistical Series in China, 1980 to 1999 (continuation)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Adjustments to Consumption Due to Failure to Include out of home consumption						Adjustments to Consumption Due to Per Capita Omission of In-Home Consumption					
	Urban			Rural			Urban			Rural		
Year	Index of out of home food expenditure [a]	Out-of-Home from CCAP Survey [b]	Estimated omission over time (kg) [c]	Index of Out of Home food expenditure [a]	Out-of-Home from CCAP Survey (kg) [b]	Estimated omission over time (kg) [c]	In home from CCAP survey [e]	Annual increase in omission (kg) [f]	Amount that HIES under-reports due to the omission [g]	In-home from CCAP Survey [e]	Annual increase in omission (kg) [f]	Amount that HIES under-reports due to the omission (kg) [g]
1990	0.19	-	0.23	0.18	-	0.07	-	0.24	2.37	-	0.16	1.63
1991	0.20	-	0.24	0.20	-	0.08	-	0.24	2.61	-	0.16	1.79
1992	0.31	-	0.37	0.22	-	0.09	-	0.24	2.85	-	0.16	1.95
1993	0.40	-	0.49	0.26	-	0.11	-	0.24	3.08	-	0.16	2.12
1994	0.53	-	0.63	0.40	-	0.16	-	0.24	3.32	-	0.16	2.28
1995	0.71	-	0.85	0.54	-	0.22	-	0.24	3.56	-	0.16	2.44
1996	0.82	-	0.98	0.74	-	0.30	-	0.24	3.80	-	0.16	2.60
1997	0.90	-	1.08	0.83	-	0.34	-	0.24	4.03	-	0.16	2.77
1998	1.00	1.20	1.20	1.00	0.41	0.41	15.03	0.24	4.27	7.04	0.16	2.93
1999	1.10	-	1.32	1.05	-	0.43	-	0.24	4.51	-	0.16	3.09

[a] Figures are the same as in Appendix 3.7, columns 2 and 8. For detail see Appendix 3.7, footnote b.
[b] Figures in column 2 and 5 come from CCAP Survey shown in Table 3.6.
[c] (3)=(1)*1.20 (in column 2), (6)=(4)*0.41 (in column 5.
[d] See Appendix 3.10, footnote a for detail. In the case of egg, as supply series has been significantly more than demand series since 1980, we adjust egg consumption series for the omission of in-home consumption from 1980.
[e] Figures come from CCAP Survey (see Table 3.6). For detail, reference to Appendix 3.10, footnote b.
[f]. For Detail, reference to Appendix 3.11, footnote c
[g] Figures in 1998 are the difference between in-home demand from the CCAP survey in column 7 and the demand reported in the HIES survey (in Appendix 3.10, column 1 row for 1998. The rest of the figures are calculated by starting at 1998 and working backwards towards 1980. Each year's figure is just the next year's figure minus 0.24 in column 8, the "average annual increase in omitted demand." Likewise, we create column 12.

Appendix 3.14 Reconciling China's Beef Production (Supply) and Consumption (Demand) Statistics Series

Year	(1) Aggregate Demand Based on HIES and Trade (mmt) [a]	(2) Adjusted Demand- for Omission of Out-Of-Home Consumption (mmt) [b]	(3) Adjusted Demand-for Omission of Migrant Consumption (mmt) [c]	(4) Reported Aggregate Beef Supply from Yearbook (mmt)	(5) Adjusted Aggregate Beef Supply- for overreporting (mmt)	(6) Various Supply/Demand Ratios (to Assess the Consistency of Data Series Adjustments)	(7)	(8)	(9)
						(4)/(1)	(4)/(2)	(5)/(2)	(5)/(3)
1980	0.28	0.28	0.28	0.27	0.27	0.97	0.95	0.95	0.95
1981	0.30	0.31	0.31	0.25	0.25	0.82	0.80	0.80	0.80
1982	0.37	0.38	0.38	0.27	0.27	0.72	0.70	0.70	0.70
1983	0.41	0.43	0.43	0.32	0.32	0.77	0.74	0.74	0.74
1984	0.53	0.56	0.56	0.37	0.37	0.70	0.67	0.67	0.67
1985	0.66	0.70	0.70	0.47	0.47	0.71	0.67	0.67	0.67
1986	0.74	0.79	0.79	0.59	0.59	0.79	0.75	0.75	0.75
1987	0.87	0.93	0.93	0.79	**0.78** [d]	0.91	0.85	0.85	0.84
1988	0.98	1.05	1.05	0.96	0.98	0.98	0.91	0.91	0.93
1989	1.07	1.16	1.19	1.07	1.15	1.00	0.92	0.90	0.96
1990	1.19	1.28	1.32	1.26	1.33	1.06	0.98	0.95	1.01
1991	1.33	1.43	1.48	1.54	1.47	1.16	1.08	1.04	1.00
1992	1.39	1.54	1.61	1.80	1.62	1.30	1.17	1.12	1.01
1993	1.46	1.66	1.74	2.34	1.58	1.60	1.40	1.34	0.91
1994	1.41	1.69	1.77	3.27	1.68	2.32	1.94	1.85	0.95
1995	1.44	1.83	1.93	4.15	1.89	2.88	2.28	2.16	0.98
1996	1.52	1.98	2.10	3.56	**2.22** [d]	3.35	1.80	2.36	1.06
1997	1.82	2.34	2.49	4.41	2.39	2.42	1.88	1.77	0.96
1998	1.76	2.37	2.51	4.80	2.68	2.73	2.03	1.91	1.07
1999	1.86	2.54	2.72	5.05	2.84	2.71	1.99	1.86	1.04
Growth [e]	7.00	9.13	9.76	17.86	11.69	10.25	8.09	7.47	1.84

Note: Production data from Yearbook and the same as in Table 3.3, column 11.

[a] The figures in column 1 are the same as in Table 3.3, column 10. They are equal to the sum of population numbers (in Appendix 3.5, columns 1 and 2) multiplying the per capita consumption numbers (in Appendix 3.17, columns 6 and 7).

[b] The figures in column 2 come from Appendix 3.17, column 11.

[c] The figures in column 3 come from Appendix 3.17, column 13.

[d] The bold figures are the three-year averages of Yearbook production data from 1986 to 88 and the meat production generated from 1997 Ag Census.

[e] An annual growth rates between 1987 and 1998, where 1987 and 1998 are three-year averages centered on 1987 and 1998.

Appendix 3.15 Reconciling China's Mutton Production (Supply) and Consumption (Demand) Statistics Series

Year	(1) Aggregate Demand Based on the HIES And Trade (mmt) [a]	(2) Adjusted Demand- for Omission of *Out-Of-Home* Consumption (mmt) [b]	(3) Adjusted Demand- for Omission of *Mi-grant* Consumption (mmt) [c]	(4) Reported Aggregate Mutton Supply from Yearbook (mmt)	(5) Adjusted Aggregate Mutton Supply- for over reporting (mmt)	(6) Various Supply/Demand Ratios (to Assess the Consistency of Data Series Adjustments)	(7)	(8)	(9)
						(4)/(1)	(4)/(2)	(5)/(2)	(5)/(3)
1980	0.42	0.43	0.43	0.45	0.45	1.05	1.04	1.04	1.04
1981	0.46	0.47	0.47	0.48	0.48	1.03	1.02	1.02	1.02
1982	0.50	0.51	0.51	0.52	0.52	1.04	1.02	1.02	1.02
1983	0.52	0.54	0.54	0.55	0.55	1.04	1.02	1.02	1.02
1984	0.57	0.59	0.59	0.59	0.59	1.03	1.00	1.00	1.00
1985	0.63	0.66	0.66	0.59	0.59	0.93	0.90	0.90	0.90
1986	0.66	0.69	0.69	0.62	0.66	0.94	0.90	0.90	0.95
1987	0.69	0.73	0.73	0.72	**0.71** [d]	1.04	0.99	0.99	0.98
1988	0.71	0.76	0.76	0.80	0.81	1.13	1.06	1.06	1.07
1989	0.77	0.83	0.85	0.96	0.87	1.25	1.16	1.13	1.02
1990	0.85	0.91	0.94	1.07	0.97	1.26	1.18	1.14	1.04
1991	0.92	0.98	1.01	1.18	0.95	1.29	1.21	1.17	0.94
1992	0.90	0.98	1.01	1.25	1.00	1.39	1.27	1.23	0.98
1993	0.90	1.01	1.04	1.38	1.04	1.53	1.36	1.32	1.00
1994	0.94	1.09	1.13	1.61	1.22	1.72	1.47	1.42	1.08
1995	0.96	1.18	1.22	2.02	1.26	2.09	1.71	1.65	1.04
1996	1.08	1.35	1.39	1.81	**1.40** [d]	1.67	1.34	1.72	1.00
1997	1.23	1.53	1.58	2.10	1.61	1.71	1.37	1.33	1.02
1998	1.23	1.59	1.63	2.35	1.63	1.90	1.47	1.44	1.00
1999	1.19	1.58	1.60	2.51	1.65	2.12	1.59	1.57	1.03
Growth [e]	5.31	7.23	7.45	11.30	7.58	5.72	3.82	3.61	0.14

Note: Production data in column 4 from Yearbook and the same as in Table 3.3 column 14.

[a] The figures in column 1 are the same as in Table 3.3, column 13. They are equal to the sum of population numbers in (Appendix 3.6, columns 1 and 2) multiplying per capita mutton consumption numbers (Appendix 3.17, columns 1 and 2).

[b] The figures in column 2 come from Appendix 3.17, column 12.

[c] The figures in column 3 come from Appendix 3.17, column 14.

[d] The bold figures are the three-year averages of Yearbook production data from 1986 to 88 and the meat production generated from 1997 Ag Census.

[e] An annual growth rates between 1987 and 1998, where 1987 and 1999 are three-year averages centered on 1987 and 1998.

Appendix 3.16 Calculations showing basis for adjustments made to per capita beef and mutton consumption data due to the omission of out-of-home consumption

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Urban Per Capita Out-of-Home Consumption (kg)					Rural Per Capita Out-of-Home Consumption (kg)				
		Beef		Mutton			Beef		Mutton	
Year	Index of Out of Home Food Expenditure [a]	CCAP Survey [b]	Estimated over time [c]	CCAP Survey [b]	Estimated Over Time [c]	Index of Out of Home Food Expenditure [a]	CCAP Survey [b]	Estimated Over time [d]	CCAP Survey [b]	Estimated over Time [d]
1980	0.02	-	0.02	-	0.01	0.02	-	0.00	-	0.00
1981	0.03	-	0.03	-	0.01	0.03	-	0.00	-	0.01
1982	0.04	-	0.04	-	0.02	0.04	-	0.00	-	0.01
1983	0.05	-	0.05	-	0.02	0.06	-	0.01	-	0.01
1984	0.07	-	0.07	-	0.03	0.08	-	0.01	-	0.01
1985	0.08	-	0.08	-	0.04	0.10	-	0.01	-	0.02
1986	0.10	-	0.10	-	0.05	0.11	-	0.01	-	0.02
1987	0.13	-	0.13	-	0.06	0.14	-	0.01	-	0.02
1988	0.16	-	0.16	-	0.07	0.16	-	0.02	-	0.03
1989	0.19	-	0.19	-	0.08	0.18	-	0.02	-	0.03
1990	0.19	-	0.19	-	0.08	0.18	-	0.02	-	0.03
1991	0.20	-	0.20	-	0.09	0.20	-	0.02	-	0.04
1992	0.31	-	0.31	-	0.14	0.22	-	0.02	-	0.04
1993	0.40	-	0.40	-	0.18	0.26	-	0.03	-	0.05
1994	0.53	-	0.53	-	0.24	0.40	-	0.04	-	0.07
1995	0.71	-	0.71	-	0.32	0.54	-	0.05	-	0.10
1996	0.82	-	0.82	-	0.37	0.74	-	0.07	-	0.13
1997	0.90	-	0.90	-	0.40	0.83	-	0.08	-	0.15
1998	1.00	1.00	1.00	0.45	0.45	1.00	0.10	0.10	0.18	0.18
1999	1.10	-	1.10	-	0.49	1.05	-	0.11	-	0.19

[a] Come from Appendix 3.7, columns 2 and 8.
[b] Figures come from CCAP Survey shown in Table 3.6.
[c] (3)=(1)*1.00 (in column 2) and (5)=(1)*0.45 (in column 4)
[d] (8)=(6)*0.10 (in column 7) and (10)=(6)*0.18 (in column 9).

Appendix 3.17 Adjustments to Basic HIES Beef and Mutton Data to Account for Effect of Increased Migrant and Consumption While out of the home

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Per Capita Beef Consumption (kg)				Beef Net Exports (mmt) [c]	Per Capita Mutton Consumption (kg)				Mutton Net Exports (mmt) [c]	Aggregate Consumption after Adjustment-I for Omission of Out *Of Home* Consumption (mmt) [d]		Aggregate Consumption after Adjustment-II for Omission of Migrant Consumption (mmt) [e]	
Year	Based on HIES [a]		Out of Home [b]			Based on HIES [a]		Out of Home [b]						
	Urban	Rural	Urban	Rural		Urban	Rural	Urban	Rural		Beef	Mutton	Beef	Mutton
1980	*0.48*	*0.16*	0.02	0.00	0.00	*1.10*	*0.25*	0.01	0.00	0.00	0.28	0.43	0.28	0.43
1981	*0.52*	*0.17*	0.03	0.00	0.01	*1.16*	*0.26*	0.01	0.01	0.00	0.31	0.47	0.31	0.47
1982	*0.56*	*0.21*	0.04	0.00	0.01	*1.26*	*0.27*	0.02	0.01	0.00	0.38	0.51	0.38	0.51
1983	*0.62*	*0.22*	0.05	0.01	0.02	*1.24*	*0.28*	0.02	0.01	0.00	0.43	0.54	0.43	0.54
1984	*0.88*	*0.27*	0.07	0.01	0.01	*1.37*	*0.28*	0.03	0.01	0.00	0.56	0.59	0.56	0.59
1985	*1.01*	*0.29*	0.08	0.01	0.03	*1.38*	*0.28*	0.04	0.02	0.01	0.70	0.66	*0.70*	*0.66*
1986	*1.15*	*0.31*	0.10	0.01	0.03	*1.38*	*0.29*	0.05	0.02	0.01	0.79	0.69	*0.79*	*0.69*
1987	*1.28*	*0.35*	0.13	0.01	0.03	*1.39*	*0.29*	0.06	0.02	0.01	0.93	0.73	*0.93*	*0.73*
1988	*1.42*	*0.37*	0.16	0.02	0.05	*1.39*	*0.29*	0.07	0.03	0.01	1.05	0.76	*1.05*	*0.76*
1989	*1.56*	*0.39*	0.19	0.02	0.06	1.40	*0.33*	0.08	0.03	0.01	1.16	0.83	1.19	0.85
1990	*1.69*	*0.40*	0.19	0.02	0.10	*1.59*	*0.35*	0.08	0.03	0.01	1.28	0.91	1.32	0.94

Appendix 3.17 Adjustments to Basic HIES Beef and Mutton Data to Account for Effect of Increased Migrant and Consumption While out of the home (continuation)

Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Per Capita Beef Consumption (kg)				Beef Net Exports (mmt) [c]	Per Capita Mutton Consumption (kg)				Mutton Net Exports (mmt) [c]	Aggregate Consumption after Adjustment-I for Omission of O*ut Of Home* Consumption (mmt) [d]		Aggregate Consumption after Adjustment-II for Omission of Migrant Consumption (mmt) [e]	
	Based on HIES [a]		Out of Home [b]			Based on HIES [a]		Out of Home [b]						
	Urban	Rural	Urban	Rural		Urban	Rural	Urban	Rural		Beef	Mutton	Beef	Mutton
1991	*1.83*	*0.42*	0.20	0.02	0.13	*1.51*	*0.42*	0.09	0.04	0.01	1.43	0.98	1.48	1.01
1992	2.10	*0.44*	0.31	0.02	0.02	*1.40*	*0.41*	0.14	0.04	0.01	1.54	0.98	1.61	1.01
1993	2.08	0.46	0.40	0.03	0.05	1.28	0.45	0.18	0.05	0.01	1.66	1.01	1.74	1.04
1994	1.93	0.44	0.53	0.04	0.06	1.28	0.46	0.24	0.07	0.02	1.69	1.09	1.77	1.13
1995	1.97	0.46	0.71	0.05	0.03	1.29	0.47	0.32	0.10	0.02	1.83	1.18	1.93	1.22
1996	2.01	0.47	0.82	0.07	0.05	1.29	0.58	0.37	0.13	0.02	1.98	1.35	2.10	1.39
1997	2.37	0.56	0.90	0.08	0.05	1.33	0.70	0.40	0.15	0.02	2.34	1.53	2.49	1.58
1998	2.10	0.59	1.00	0.10	0.06	1.24	0.72	0.45	0.18	0.03	2.37	1.59	2.51	1.63
1999	2.21	0.62	1.10	0.11	0.05	0.89	0.80	0.49	0.19	0.04	2.54	1.58	2.72	1.60

[a] Figures come from HIES--urban and rural (see Table 3.5), the italics are estimated based on the ratios of beef to mutton production.
[b] Come from Appendix 3.16, columns 3, 5, 8 and 11.
[c] Come from statistical yearbooks.
[d] (11)=(5) + [(1)+(3)] multiplying the population (in Appendix 3.5, column 1), plus [(2)+(4)] multiplying the population (in Appendix 3.5, column 2) and then divided by 0.74 (in Table 3.2); (12) = (10) + [(6)+(8)] multiplying the population (in Appendix 3.5, column 1), plus [(7)+(9)] multiplying the population (in Appendix 3.5, column 2), and then divided by 0.89 (in Table 3.2).
[e] (13)=(5) + [(1)+(3)] multiplying the population (in Appendix 3.12, column 1), plus [(2)+(4)] multiplying the population (in Appendix 3.12, column 2), plus [(1)+(2)+(3)+(4)]/2 multiplying the population (in Appendix 3.12, column 3) and then divided by 0.74 (in Table 3.3); (14)=(10) + [(6)+(8)] multiplying the population (in Appendix 3.12, column 1), plus [(7)+(9)] multiplying the population (in Appendix 3.12, column 2), plus [(6)+(7)+(8)+(9)]/2 multiplying the population (in Appendix 3.12, column 3) and then divided by 0.89 (in Table 3.3).

Appendices Chapter 5

Appendix 5.1 Regional and sector aggregations

	Description	Original GTAP v5 sector
Regional aggregation		
China	Mainland, China	Mainland, China
Hong Kong	Hong Kong, China	Hong Kong, China
Taiwan	Taiwan, China	Taiwan, China
JapKor	Japan and Korea	Japan, Korea
SEA	South East Asia	Indonesia, Vietnam, Malaysia, Philippines, Thailand, Singapore
OthAsia	Other Asia	Bangladesh, India, Sri Lanka, rest of south Asia
AusNzl	Australia and New Zealand	Australia, New Zealand
NAFTA	North American free trade area	Canada, United States, Mexico
SAM	South and Central America	Central America, Caribbean, Colombia, Peru, Venezuela, rest of Andean Pact, Argentina, Brazil, Chile, Uruguay, rest of South America
EU15	European Union	Austria, Belgium, Denmark, Finland, France, Germany, United Kingdom, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden
CEEC	Central European Associates	Hungary, Pollen, rest of CEEC
ROW	Rest of World	Switzerland, rest of Efta, Turkey, rest of Middle East, Morocco, rest of North Africa , Malawi, Mozambique, Tanzania, Zambia, Zimbabwe, Other Southern Africa, Uganda, rest of Sub-Saharan Africa, Former Soviet Union, Botswana, rest of Sacu, rest of world
Sector aggregation		
Rice	Rice, paddy and processed	Paddy rice, processed rice
Wheat	Wheat	Wheat
Cgrains	Coarse grains	Cereals grains nec
Oilseeds	Oilseeds and vegetable oils	Oilseeds, vegetable oils and fats
Sugar	Sugar raw and processed	Sugar cane, sugar beet, Sugar
Pfb	Plant based fibers	Plant based fibers
Othcrop	Horticulture and other crops	Vegetables fruit nuts, crops-nec
Ctl	Cattle and red meat	Cattle, sheep, goats, horses and their meats
Oap	Pig & poultry- white meat, wool	Animal products nec, wool, silk-worm cocoons, meat products nec
Milk	Raw milk and dairy products	Raw milk, dairy products
Fish	Fish	Fish
Ofood	Food products nec	Food products nec, beverages & tobacco products
Extract	Natural resources and extract	Forestry, coal, oil, gas, minerals nec
Texlea	Textiles and leather	Textiles, wearing apparel, leather products
Labintman	Labour intensive Manfact	Wood and paper products, publishing, metal products, motor vehicles and parts, transport equipment nec
Capintman	Capital intensive manufact	Petroleum, coal products, chemical rubber plastic prods, mineral products nec, ferrous metals, metals nec, electronic equipment, machinery and equipment nec, manufactures nec
Svces	Services and activities NES	Electricity, gas manufacture, distribution, water, construction, trade, transport nec, sea transport, air transport, communication, financial services nec, insurance, business services nec, recreation and other, pub-admin/defence/health/educat, dwellings

Appendix 5.2 Value of income elasticities in 2010 in China

	Adjusted	Standard GTAP
Rice	0.1	0.4
Wheat	0.1	0.4
Coarse grains	0.3	0.4
Oilseeds	0.4	0.9
Sugar	0.6	0.9
Cotton	0.6	0.9
Other crops	0.6	0.9
Cattle	0.6	1.1
Other animal products	0.4	1.1
Milk	0.8	0.8
Fish	0.9	0.9
Other food	0.9	0.9
Extract	1.2	1.2
Textiles- leather	1	1
Labor intensive Manufacturing	1.2	1.1
Capital intensive Manufacturing	1.2	1.3
Services	1.3	1.1

Appendix 5.3 Import protection 2001-05

	Import tariff ad valorem	VAT import	VAT domestic	other, e.g. STE rent	TARGET: import tariff equivalent
	(1)	(2)	(3)	(4)	(5=1+2-3+4)
1 Rice	1	13	10	0	4
2 Wheat	1	13	10	0	4
3 Cgrains	1	13	10	0	4
4 Oilseeds	3	13	10	3	9
5 Sugar	20	17	10	0	27
6 Pfb	1	15	13	0	3
7 OthCrop	6	15	10	0	11
8 Ctl	12	15	13	0	14
9 Oap	12	15	13	0	14
10 Milk	11	17	10	0	18
11 Fish	12	13	10	0	15
12 Ofood	15	15	13	0	17
13 Extract	0.6	15	15	p.m	0.6
14 TexLea	11.5	15	15	0	11.5
15 LabintMan	9.45	15	15	0	9.4
16 CapIntMan	6.05	15	15	0	6.1
17 Svces	9.25	15	15	0	9.3

Appendix 5.4 TRQs China

	TRQ	In-quota tariff (%)				Out-quota tariff (%)				
	1=yes	2002	2003	2004	2005	2002	2003	2004	2005	(*)
Rice	1	1	1	1	1	74	71	65	65	
Wheat	1	1	1	1	1	71	68	65	65	
Coarse grains	1	1	1	1	1	71	68	65	65	
Maize	1	1	1	1	1	71	68	65	65	
Other course grain	0	3	3	3	3					
Oilseeds	1/0					n.a.	n.a.	n.a.	n.a.	
Soybean	0	3	3	3	3	n.a.	n.a.	n.a.	n.a.	
Rapeseed	0	3	3	3	3	n.a.	n.a.	n.a.	n.a.	
Edible oil	1	9	9	9	9	75	71.7	68.3	64.9	(**)
Sugar	1	20	20	20	20	90	72	50	50	
Plant fibres	1	1	1	1	1					
Cotton	1	1	1	1	1	54.4	47.2	40	40	
Wool	1	1	1	1	1	38	38	38	38	
						mmt		TRQ (mmt)		TRQ annual growth rate (2000-2004/5)
Rice						3.76	4.54	5.32	6.33	19
Wheat						8.45	9.05	9.64	10.41	8
Coarse grains						5.7	6.45	7.2	8.14	13
Maize						5.7	6.45	7.2	8.14	13
Other course grain										
Oilseeds										
Soybean										
Rapeseed										
Edible oil						5.69	6.54	6.81	7.27	(**) 15
Sugar						1.68	1.82	1.95	2.11	8
Plant fibres										
Cotton						0.82	0.86	0.89	0.93	5
Wool						0.34	0.36	0.37	0.39	5

(*) 2005 rates and trq volumes are estimates based on extrapolation of annual growth rates, except for edible oil, (**) OUT in 2006, Source: WTO China accession documents

Appendices Chapter 8

Appendix 8.1 Actually used foreign direct investment in selected years by region ($ million)

Pro Region	1985	1990	1999	2000	Subtotal	Percentage
Guangdong	651	1582	11658	11281	56535	0.29
Fujian	119	349	4024	3432	18631	0.09
Jiangsu	33	134	6078	6426	26632	0.14
Shanghai	108	174	2837	3160	15380	0.08
Shandong	36	186	2259	2971	11595	0.06
Liaoning	25	257	1062	2044	8879	0.05
Hainan		103	484	431	3166	0.02
Tianjin	56	37	1764	1166	8053	0.04
Zhejiang	27	49	1233	1613	6164	0.03
Guangxi	31	36	635	525	3295	0.02
Hebei	8	44	1042	679	4527	0.02
Beijing	89	279	1975	1684	8809	0.04
Shaanxi	16	47	242	288	1769	0.01
Hubei	8	32	915	944	3967	0.02
Sichuan	29	24	341	437	1681	0.01
Hailongjiang	4	28	318	301	2077	0.01
Hunan	27	14	654	678	3292	0.02
Henan	8	11	521	564	2564	0.01
Jilin	5	18	301	337	1596	0.01
Jiangxi	10	8	321	227	1642	0.01
Anhui	3	14	261	318	1386	0.01
Guizhou	10	11	41	25	228	0.00
Shanxi	0.5	3	391	225	1203	0.01
Yunnan	2	7	154	128	650	0.00
Xinjiang	11	5	24	19	125	0.00
Inner Mongolia	2	11	65	106	363	0.00
Gansu	0.6	1	41	62	191	0.00
Qinghai			5	0	7	0.00
Ningxia			51	17	94	0.00
Tibet			0	0	0	0.00
Chongqing			239	244	1301	0.01
Ministries			384	382	1301	0.01
National Total	1317	3436	40319	40715	197103	1.00
Of which:						
Special Zones	1094	2951	33074.49	33727.47	162857	0.826254

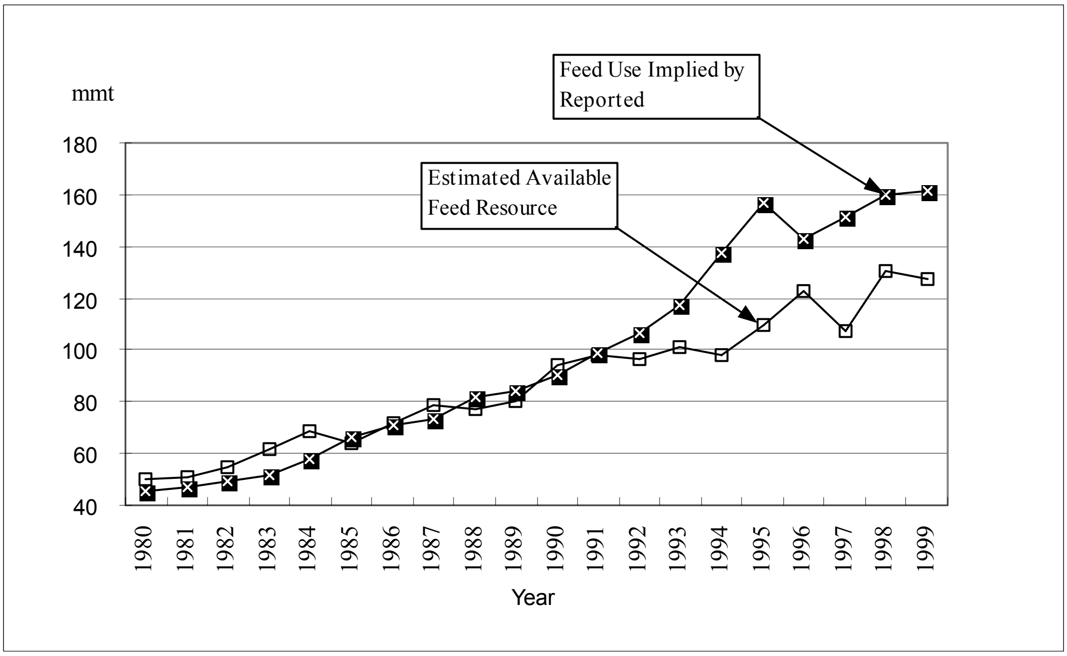
Subtotal: including years of 1985, 1987, 1989, 1990, 1991, 1992, 1997, 1998, 1999 and 2000

Appendix 8.2 Geographic Distribution of Dutch FDI in China (01. 2000 until 10. 2002, 10, 000 US$)

Region	Project numbers	Contracted FDI	Actual Used
Total	313	479876	209799
Beijing	31	6193	14846
Tianjin	10	10301	**6402**
Hebei	7	1206	**1447**
Liaoning	17	19418	23125
of which: Dalian	5	140	**9261**
Jinli	1	10	0
Heilongjiamg	1	6	1883
Shanghai	77	53384	**32085**
Jiangsu	30	46663	**54362**
Zhejiang	47	7936	**8568**
of which: Ningbo	16	3353	2941
Anhui	3	251	512
Fujian	6	745	**1854**
of which: Xiamen	3	714	1854
Jiangxi	2	109	165
Shandong	20	2646	3200
of which: Qingdao	10	1485	**1425**
Henan	1	301	413
Hubei	4	2609	12451
Hunan	7	33749	10708
Guangdong	28	289993	**29739**
of which: Shenzhen	8	-711	6572
Guangxi	2	488	**395**
Hainan	1	0	**18**
Chongqing	0	-102	778
Sichuan	7	2575	647
Guizhou	1	8	8
Yunan	5	919	630
Shaanxi	2	350	300
Gansu	1	62	11
Qinghai	1	5	5
Xinjiang	1	51	58
China Nature Gas Co.			5189

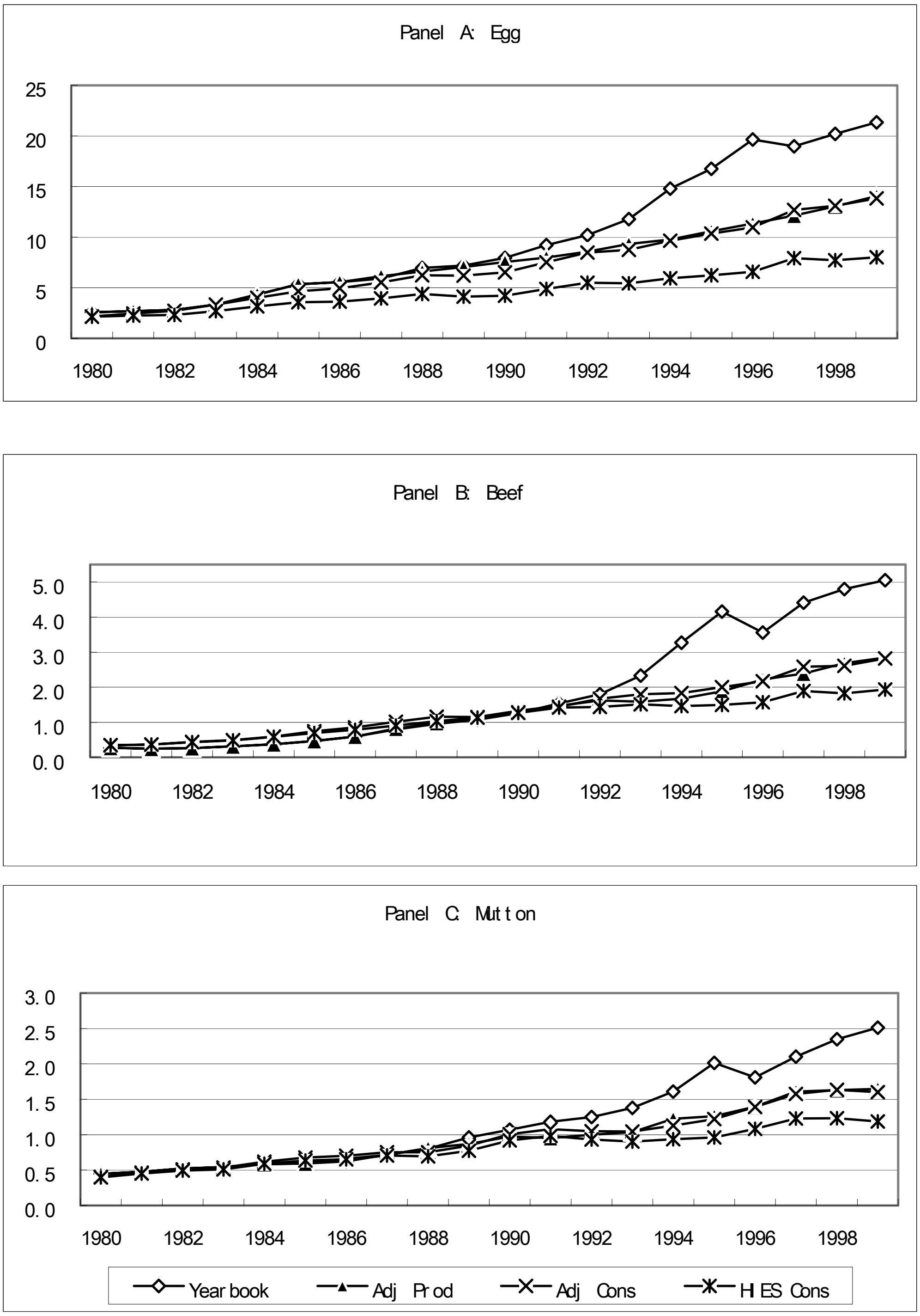
Appendices Figures

Chapter 3



Appendix figure 3.1 *The Divergence of Feed Grain Production and Feed Grain Consumption in China, 1980-99.*

Estimated Available Feed Resource mainly includes corn, wheat bran, sweet potato, rice and other coarse grains. *Feed Use Implied by Reported Production* is estimated using livestock production statistics reported in the CNSB's Yearbooks and standard feed-meat conversion coefficients. See text for details.



Appendix Figure 3.2 *Comparison of Production and Consumption of Eggs, Beef and Mutton Before and After Adjustments (mmt), 1980-99*