



Integrated Assessment of Trade Liberalization and Trade-Related Policies

A Country Study on the Cotton Sector in China



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NOTE

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EXECUTIVE SUMMARY

In China, the specific policy studied is that of import liberalization rather than export expansion. The study examines the impact of tariff-rate quotas (TRQs) on the production and import of selected agricultural products. The environmental, social and economic effects are largely imputed through changes in production and consumption structures. The methodology used is the JAPA model with partial equilibrium and econometric sub-models, which seek to examine the effects of some trade policy variables. This is the only *ex ante* study in this series, i.e. it forecasts the potential effects of the TRQs on Chinese exports and imports on the basis of current consumption patterns and current utilization of resources.

The study examines the impact of TRQ offers under the Compilation of the Legal Instruments on China's Accession to the World Trade Organization. As this is a theoretical projection, two assumptions have been made. First of all, it is assumed that the trade concessions given by China will have to be extended on a most favoured nation (MFN) basis to all the member countries of the WTO, subsequent to China joining the WTO. Second, it is assumed that the entire TRQs will be imported irrespective of whether imports are more or less competitive with domestic products. Subject to these assumptions, the following examples have been chosen for simulation by the JAPA model.

According to the Compilation of the Legal Instruments on China's Accession to the World Trade Organization the TRQs for year 2002 are:

Wheat 8.468 million metric tons
Corn 5.85 million metric tons
Cotton 818,500 metric tons.

Assuming that the entire TRQs are imported, this increase in imports will result in a decreased cultivation of some crops. Wheat, corn and cotton imports are likely to bring significant shifts in overall crop production structures. According to the optimal solution of the JAPA model, compared with the baseline projection, the total cultivated land area will decrease by 1.11 per cent, or about 92,624 hectares.

Reduced cultivation is expected to bring about positive effects on the environment because of the reduction in the application of chemical fertilizers and pesticides. The reduction of pesticide application was evaluated at 0.10 million RMB, and the reduction of chemical fertilizer application was evaluated at 1.11 million RMB. This did not include, however, the reduced application that may result from effects other than reduced cultivation, for example the decreased prices of agricultural products may encourage decreased fertilizer application per hectare.

The study also imputes negative economic and social effects to the decrease in cultivated land. If cultivated land were to be abandoned, it could be used for non-agricultural purposes, such as city extension, industry and building. The average shadow price of the cultivated land estimated by the partial equilibrium model is 155 RMB per hectare which

works out to a total value of 14.36 million RMB for the abandoned land. The study assumes that this is a social opportunity cost rather than an environmental cost. The higher rental value of urban land, which would accrue as an economic benefit is not included in these calculations. This is justified by the study on the grounds that it used a partial equilibrium model which focuses exclusively on the agricultural sector and does not examine other interlinkages with either urban expansion or related industries such as the textiles sector.

After China joins the WTO, both opportunity and challenge will confront the agricultural sector. While theoretically China could increase agricultural imports (TRQs) in the initial period, this may have economic, social and environmental effects. According to the study, the overall production of cotton will go down because of imports, however, it is likely that textile production and export will go up. This would thus result in increased export revenues, which has not been taken into account when calculating the economic benefits arising from trade liberalization. At the same time, it must also be recognized that textile production can be pollution intensive, and has high water consumption demands.

The study shows that in a cost-benefit analysis (CBA) framework, the negative economic and social effects will be higher than the positive effects. This perception is based on the assumption that China's imports of agricultural products are not likely to be balanced by Chinese exports of agricultural products, as product quality standards in international markets may be too high for China to meet.

As the most important problems identified by China were the negative economic effects of its accession to the WTO, the solutions also were economic in nature. An important priority for China is to improve the competitiveness of its cotton sector. For this it proposes to introduce "green box policies", improve its cotton breeding programme, encourage the formation of cooperatives, and various other measures.

Maintaining a balance between supply and demand, and avoiding fluctuations was also considered an important part of the proposed strategy. This balance includes regional balance and varietal balance. Suggestions include adjusting the scale and distribution of cotton production, promoting the production of cotton to order, improving the cotton wholesale market, and establishing an agricultural consulting system.

On environmental policies, the study strongly recommends conducting assessments, especially general equilibrium (GE) assessments. However, even if data for a comprehensive GE analysis may be difficult to obtain, it is necessary to examine some of the interlinkages with other related sectors, especially livestock and textiles, which would benefit respectively from reduced prices of grain feed and cotton. The study also recommends using integrated pest management techniques, bio-pesticides made from traditional Chinese herbs, banning the production, marketing and application of all highly toxic, high residue pesticides, levying an environmental pollution tax, strengthening the administration of genetically modified cotton production, and promoting the production of organic cotton. As this is an *ex ante* analysis it would be interesting to monitor the actual developments in these sectors as WTO accession commitments are implemented, to compare actual effects with *ex ante* assessments. Pilot implementation of some of these policies can also be carried out in the meantime.

ABBREVIATIONS AND ACRONYMS

AERI	Agricultural Economics Research Institute
AIA	Advanced Informed Agreement
ATC	Agreement on Textiles and Clothing
AMS	Aggregate Measure of Support
CAAS	Chinese Academy of Agricultural Science
CAPA	Chinese Agricultural Policy Analysis Model
CBA	cost-benefit analysis
CGE	Computable General Equilibrium Model
DPL	Delta and Pine Land Company
DTIE	Division of Technology, Industry and Economics
ETU	Economics and Trade Unit
GATT	General Agreement on Tariffs and Trade
GDP	gross domestic product
GMO	genetically modified organism
IFOAM	International Federation of Organic Agricultural Movements
IPM	Integrated Pest Management
JAPA	Jiangsu Agricultural Policy Analysis model
LA/AIDS	Linear Approximation/Almost Ideal Demand System
LMO	living modified organism
MFA	Multifibre Arrangement
MOFTEC	Ministry of Foreign Trade and Economic Cooperation
NGO	non-governmental organization
NTBs	non-tariff barriers
NTMs	non-tariff measures
PE	converted quantity
RMB	Chinese currency
PNTR	Permanent Normal Trade Relations
SEI-B	Stockholm Environment Institute–Boston
SEPA	State Environmental Protection Administration
SMC	Supply and Marketing Cooperatives
SOEs	State Owned Enterprises
SPS	Agreement on Sanitary and Phytosanitary Measures
TRQ	tariff-rate quota
UNEP	United Nations Environment Programme
URAA	Uruguay Round Agreement on Agriculture
WTO	World Trade Organization

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United Nations Environment Programme

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

UNEP, which is headquartered in Nairobi, marked its first 25 years of service in 1997. During this time, in partnership with a global array of collaborating organizations, UNEP has achieved major advances in the development of international environmental policy and law, environmental monitoring and assessment, and our understanding of the science of global change. This work has, and continues to support, successful development and implementation of the world's major environmental conventions. In parallel, UNEP administers several multilateral environmental agreements including the Vienna Convention's Montreal Protocol on Substances that Deplete the Ozone Layer, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (SBC), the Convention on Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (Rotterdam Convention, PIC) and most recently, the Cartagena Protocol on Biosafety to the Convention on Biological Diversity as well as the Stockholm Convention on Persistent Organic Pollutants (POPs).

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FOREWORD

The People's Republic of China joined the WTO at the end of 2001, and this is expected to bring enormous influence to the country. On the one hand, it will promote China's economic reform and improve China's foreign trade environment, on the other hand it requires China to open its markets and carry out trade liberalization. Agriculture is a foundation of the Chinese economy, providing food and industrial raw materials, and is supported by a rural population of 0.8 billion. Therefore the trade liberalization of agricultural products will have huge impacts on Chinese agriculture.

Economic development and trade have close linkages with the environment. When trade liberalization creates economic gain, it may also bring environmental degradation, social impacts and loss of public support for trade liberalization policies. Therefore environmental considerations need to be taken into account in the development of trade liberalization policies.

Agricultural inputs have become an important source of environmental pollution in China, but this has not yet aroused sufficient attention. It is necessary to make an integrated assessment of agricultural pollution, on the basis of which the Government can draw up a scientific policy to stimulate economic growth and development.

After China's accession to the WTO, both opportunity and challenge will exist. The opportunity for agricultural exports holds future potential to adjust agricultural production structures and develop "green agriculture", but the present challenge lies in the huge agricultural imports which may shock China's agricultural sector, and bring enormous social, economic and environmental impacts.

This country study project aims to apply the Jiangsu Agricultural Policy Analysis model (JAPA) to make a scenario analysis of the impacts of agricultural trade liberalization—especially with respect to tariff-rate quota (TRQ) imports. Additionally it will make an integrated assessment of the social, economic and environmental impacts of trade liberalization, and provide policy recommendations for the transition to sustainable development in the Chinese cotton sector, in order to mitigate the negative social and environmental consequences.

1. INTRODUCTION

Cotton is one of the most important cash crops in China. About 300 million people are involved in cotton production. Cotton is a pillar agricultural commodity in many regions and benefits a large rural population. Cotton is also an important raw material for the textile industry; the cotton textile industry is the biggest sector in China with over 10 million workers, and textiles and garments are the most important export commodities. China's accession to the WTO brings favourable opportunities to the textile industry, although it may have a huge impact on cotton production.

1.1 China's cotton production

China is the largest cotton producing country in the world. Out of 31 provinces in mainland China, 24 provinces produce cotton. Since 1949 great progress has been achieved in cotton production.

1.1.1 Cotton acreage

China's total cotton acreage in the 1950s was around 5.5 million hectares. From the early 1960s to the early 1980s, the total cotton acreage fell to below 5 million hectares. It rose sharply in 1982 by over 12 per cent from the 1981 level. Thereafter the acreage increased until it reached over 6.9 million hectares in 1984. It then fell to 4.3 million hectares in 1986 before it again rose to over 6.8 million hectares in 1992.

The last five years have seen a continuous decline in China's cotton acreage. A sharp fall of 12.91 per cent occurred in 1996, from 5.4 million hectares in 1995 to 4.7 million hectares. In 1999 the cotton acreage declined by 15 per cent, down to only 3.7 million hectares.

1.1.2 Cotton yield

China's cotton yield has shown a sharply rising trend from 1949 to 1999. Before 1966, it was below the world's average, since 1966 it has been well above it. The early 1980s saw China's greatest leap in its cotton yields. During this period, new high-yield cotton varieties were developed and adopted. The high-yield varieties and improved field management jointly contributed to a significant improvement in cotton yields, which doubled over the 1978-1984 period, increasing from 0.45 to 0.9 metric tons per hectare. Afterwards, the yield fluctuated in the range of 0.66-0.89 metric tons per hectare. After 1997 China achieved enormous success in raising cotton yields to 1.02 metric tons per hectare.

1.1.3 Cotton output

China's cotton output increased rapidly since the founding of the People's Republic of China. In 1949 China's output was 444 thousand metric tons. It rose more than tenfold

to reach 4.5 million metric tons in 1998. The average annual growth rate in cotton output was 4.84 per cent, which is 1.94 percentage points higher than the world's average of 2.9 per cent for this period. Since 1982, China's cotton output has ranked first in the world, accounting for more than 20 per cent of the world's total production. This output growth, however, has not always been smooth. Sharp ups and downs reflect the complex relationship between natural conditions, state policies and the general economic environment.

During the period 1950-1960, cotton output rose sharply as China emerged from the shadow of civil war, and especially after the cotton industry was brought under the orbit of state planning, and state contract purchasing was made part of China's cotton policy in the early part of the decade. The year 1958 saw the peak of cotton output for the decade, reaching a record of 1.96 million metric tons. In the following three years, 1960-1962, China's cotton production was devastated by a combination of bad planning and nationwide natural calamity. The three largest cotton producing provinces, Hebei, Shandong and Henan, were the most severely affected areas. Cotton output fell from 1.7 million metric tons in 1959 to 0.75 million metric tons in 1962. Subsequent recovery, however, was rapid. Cotton output increased by 60 per cent in 1963. A new record was reached in 1967 at 2.35 million metric tons. From 1966 to 1978, a ten-year long stagnation followed. The turning point came in 1978, the start of rural economic reform. The establishment of the family production responsibility system and the adoption of various favourable pricing and incentive policies boosted cotton production.¹

From 1978 to 1984, China's cotton output increased steadily, and reached a historic high of 6.26 million metric tons in 1984. Afterwards cotton output fluctuated between 4.1-5.7 million metric tons. Finally cotton output dropped to 3.8 million metric tons in 1999.

1.1.4 Main cotton producing areas

Broadly speaking, China has three major cotton growing regions; the Xinjiang Autonomous Region, the Yangtse River Basin Region (which includes principally Jiangsu and Hubei), and the Huang-Huai Region (principally Hebei, Henan, and Shandong). Among these three regions, the Huang-Huai Region has been the largest producer of cotton.

The Huang-Huai Region: The three major cotton growing provinces, Hebei, Shandong and Henan, once accounted for 50 per cent of China's total cotton output. In 1996, the ratio of cotton sown to total cultivated land area in these provinces was 21 per cent, 26.5 per cent, and 32.7 per cent respectively, and the number of cotton growing counties in these three provinces totalled 136, 124, and 99 respectively. Cotton has been a very important sector in the economies of these provinces. However, cotton production in this region has fluctuated widely over the past ten years, with output, acreage and also yield declining in most of the marketing years. There were two important factors that made production declines in this region more pronounced than in other regions.

Firstly, since 1992, cotton growth in areas along the Yellow River has suffered from the *bollworm* and other cotton diseases. In Hebei for example, from 1991 to 1992, its cotton output decreased by 52 per cent as a result of bollworm attacks, and in 1993 cotton output

¹ Policies include increases in procurement price and rewards of fertilizers and grain on the basis of cotton sale to the state.

was further reduced by 47 per cent from the 1992 level due to a bollworm calamity compounded by severe *verticillium* wilt and drought.

Secondly, the central Government adopted a “withdrawing cotton fields and return them to grain” policy, which aimed to fulfil a high grain output target set for the year 2000. Grain is the major alternative crop in cotton growing areas. According to the state plan, the target grain output level for 2000 was 500 billion kilograms, and the target cotton output was 5 million metric tons. However, with limited arable land, it proved to be very unlikely that these two targets could be achieved simultaneously. As a result, the Government decided to sacrifice cotton output for grain. The policy was implemented in Hebei, Shandong, and Henan provinces. As planned, in these three provinces, the area under cotton cultivation was to be reduced by 1.33 million hectares by 2000 which, measured in terms of output, equals 1 million metric tons.

The Yangtse River Basin Region: The Yangtse River Basin Region is the second largest cotton producing area in China. With cotton acreage of 2 million hectares, it accounts for close to 30 per cent of China’s cotton production. The annual average cotton output in this area is around 1.5 million metric tons. Generally speaking, cotton production in this area is more efficient and the cotton produced is of better quality. The middle and lower reaches of the Yangtse River, especially Jiangsu, Zhejiang and Shanghai, constitute the most prosperous economic zone in China at present, and industrialization here has taken place at a very fast pace. As a result, opportunity costs of cotton production are much higher in this area than in other areas. Land that was traditionally sown with cotton has been increasingly out bid by rural industries and other agricultural sectors, and therefore the acreage has been gradually shrinking. The cotton sector has to increasingly depend on multiple cropping for its output growth. The prevalent multiple cropping indexes are 3 in this area.

The Xinjiang Region: With an average annual cotton acreage of 1 million hectares, it has become increasingly important as a result of its great potential in cotton production. Average cotton yield in Xinjiang is as high as 1,176 kilograms per hectare, and the annual cotton output is set to approach 1.5 million metric tons. In 1998, Xinjiang accounted for over 30 per cent of China’s cotton output and its share in national output is still set to rise.

Compared to other regions, Xinjiang has several advantages in cotton production. It has favourable natural conditions, less incidence of bollworm attacks, good irrigation systems and low labour opportunity cost. Adequate light supply, high temperatures, stable water resources and abundant land are unrivalled conditions that Xinjiang is endowed with. A satisfactory range of cotton varieties has made Xinjiang a cotton base that cannot be replaced. It is the only area that has the capability to produce the sea-island cotton and the long-staple cotton. Furthermore, Xinjiang has a very long history of cotton production. As a result, technology has been well developed and farming mechanization as well as market-oriented technology service systems are beginning to take shape. According to 1994 statistics, 85 per cent of Xinjiang’s total area under cotton is ploughed mechanically, and 78 per cent of it is sowed mechanically (Mao, 1998). Considering the comparative advantage Xinjiang has in growing cotton, the central Government decided to shift China’s cotton-milling capacity to Xinjiang, accompanied by a whole set of favourable policies. This has brought new opportunities to Xinjiang’s cotton industry.

1.1.5 China's position in world cotton markets

Cotton is grown or used in virtually every country in the world. The largest producers, consumers, and exporters are China, the United States, the former Soviet Union, India, and Pakistan. These countries have accounted for 77 per cent of world production, 62 per cent of consumption, and 66 per cent of exports in recent years. Other important exporting countries include Turkey, Australia, Paraguay, Argentina, and the French-speaking countries of West Africa. These countries export virtually all their production. The European Union (EU), the Russian Federation, Japan, Taiwan, South Korea, Hong Kong, and the countries of Eastern Europe traditionally have been the largest cotton importers.

TABLE 1.1

Cotton output in main cotton producing countries (in 0 000 metric tons)

Year	China	U.S.	India	Pakistan	Uzbekistan	Turkey	Australia
1990	451.0	338.0	199.0	164.0	165.4	65.0	31.0
1991	567.5	383.5	167.3	219.3	149.8	53.9	41.0
1992	450.8	353.1	198.2	200.7	154.0	57.4	46.9
1993	373.9	370.3	221.0	219.9	189.4	52.5	37.3
1994	434.1	423.5	226.4	158.4	130.6	59.0	32.9
1995	476.8	46.8	226.4	169.8	130.6	76.2	31.6
1996	420.0	375.0	238.0	187.0	131.0	76.0	63.1
1997	460.0	401.0	272.0	176.0	106.0	76.0	58.0
1998	450.0	300.0	272.0	156.0	97.0	80.0	67.0
Average	453.8	332.4	224.5	183.5	139.3	66.2	45.4

Source: IISD/WWF 1997:8-9; Banuri, 1998.

China accounts for more than 20 per cent of world production and nearly 20 per cent of world consumption. Any development in China will have a significant impact on the world cotton markets. In 1997, China imported 783 thousand metric tons of cotton, which was about 13.6 per cent of the world's total imports, but in 1999 it became a net exporter of 330 thousand metric tons. While the increase in China's exports was not extraordinarily large by historical standards, and its decrease in imports was not its largest ever, on a net basis, the impact of these two changes was extraordinary, see Table 1.2.

Before 1993 the domestic price of China's cotton was very low, about 32.91 US cents/pound. In 1994 the Government increased the cotton purchase price by 47 per cent, and again in 1995 by 29 per cent, which caused an enormous increase in the price of domestic cotton, going up to 76.79 US cents/pound. After 1997 the world cotton prices began to decrease, which made the government-issued cotton purchase price higher than the world price. Since 1999, the Chinese Government decided to free the cotton price, and domestic cotton prices dropped to 42.02 US cents/pound; the price fluctuated around 54.72-63.47 US cents/pound in 2000. This means that Chinese cotton has lost its competitive advantage in price. After China opens its cotton markets, high quality and low priced foreign cotton could be imported, which may influence Chinese cotton production.

TABLE 1.2
Cotton prices, imports and exports in China

Year	China cotton price	World cotton price	Cotton import ton	Cotton export ton	Cotton net export ton
	US cents/pound	US cents/pound			
1990	32.91	82.87	559484	183354	-376130
1991	32.91	62.90	351782	293604	-58178
1992	32.91	57.74	296402	260158	-36244
1993	36.20	70.69	17994	163862	145868
1994	59.67	91.35	525829	125092	-400737
1995	76.79	85.55	760568	21759	-738809
1996	76.79	78.58	683974	4527	-679447
1997	76.79	72.17	782976	1480	-781496
1998	71.31	58.23	209418	45115	-164303
1999	42.02	47.62	36900	367000	330100

Sources: (1) Cotton prices: «China's new and improved cotton market», Hunter Colby, et al., 2000.
(2) Cotton imports and exports: Chinese Statistics Yearbook, 1990-2000.

Production costs is one of the key factors in competing in the international cotton market. According to the survey of the International Cotton Advisory Committee (ICAC, 1998), China still has a comparative advantage in the cost of production. The average cotton production cost was US\$ 1110.1 per hectare, which was lower than in the USA, Australia, and Israel, but was higher than in Pakistan and India. Among the different items of the costs in China, the physical costs were high, but the labour costs were relatively low. Detailed information can be found in Table 1.3.

1.2 China's textile industry

Beginning with the establishment of the first cotton mill in 1890, China's textile industry has a history of over 100 years. Since 1949, the textile industry has obtained great achievements. A large group of enterprises with modern textile equipment, and a large number of technicians and industrial workers form the foundation on which the rapid development of the Chinese textile industry is based. In the mid 1980s, the textile industries throughout the world began to move to developing countries. Taking advantage of this opportunity, China's textile enterprises expanded their exports and brought along the development of the industry. After over 50 years of development, China's cotton yarn output increased by 19 fold, reaching 5.42 million metric tons in 1998. The textile industry holds a very important position in China. Before the 1980s, the gross value of this industry accounted for more than 15 per cent of the country's total GDP. In the 1990s, the textile industry underwent restructuring, and in 1998 the gross value added of industrial output of the textile industry was 171.6 billion RMB, which covered 8.84 per cent of the country's total GDP, see Table 1.4.

TABLE 1.3
Cotton production costs in main cotton producing countries

Country	Total cost	In which					Net cost of ginned cotton per kg	Ginned cotton yield (kg/ha)
		Seeds	Fertilizer	Pesticide	Irrigation	Land rent		
China	1110.1	37.5~ 41.7	95.1~ 386.5	40.1~ 142.9	45~ 148.2		0.89	1144.1
USA	1285.3	41.4	114.9	126.0	15.0	118.1	1.50	662.0
Australia	2196.9	28.8	81.9~ 244.9	234.1~ 548.3			1.45	1353.3
Israel	3170.7	75.7	121.6	270.3~ 297.3	433.0	15.4~ 85.7	1.53	1740.5
Pakistan	581.8	11.1~ 14.2	67.1~ 65.6	97~ 107.1	20.5~ 49	56.2~ 112.3	0.68	524.5
India	811.2	11.9~ 35.7	38.1~ 86.9	108.9~ 164.9	26.2~ 54.8	35.7~ 71.4	1.22	420.8

Sources: (1) International Cotton Advisory Committee, 1998.

(2) «Study on WTO and technique improvement in cotton production», working paper, Mao, 2000

1.2.1 Textiles and clothing as a main foreign trade earner

China is traditionally a textile exporter; while basically satisfying the domestic demand for clothing, a considerable proportion of textile production is exported. Textile exports have accounted for a very large share of total export revenues since the early 1950s. As of 1990, the amount of foreign exchange earned from the export of textiles and clothing reached US\$ 12.5 billion, accounting for 20.1 per cent of China's total export earnings. In 1997, the amount of foreign exchange earned from the export of textiles and clothing reached US\$ 45.6 billion, accounting for 24.93 per cent of the country's total export earnings. The textile export earnings was US\$ 42.9 billion in 1998, a decrease of 6 per cent compared with 1997; its share in total export revenue fell to 23.34 per cent. This fall in textile exports was largely attributed to the Asian financial crisis, see Table 1.4.

The world ranking of China as a textiles and clothing exporter has moved steadily up over the past 20 years, rising from tenth place in 1980 to number one position in 1995. According to WTO figures,² the value of China's textiles and clothing exports accounted for 4.6 per cent of the world total in 1980 and 12 per cent in 1995. It reached 13.7 per cent of the world total in 1997. In terms of volume, China has been the world's top exporter of textiles and clothing since 1997.

China's textiles and clothing export destinations are undergoing a diversifying process. In 1992, textiles and clothing exports destined for Hong Kong, Japan, the EU and the US represented 82 per cent of the total textiles and clothing exported. However, in 1998, the percentage decreased to 76 per cent. Hong Kong was the largest importer of China's textile and clothing products and Japan was the second largest, followed by the US and the EU.

² World Trade Organization, «Agreement on Textiles and Clothing.»

TABLE 1.4

Chinese textiles production and export

Year	Yarn output	Textiles value added	Share in GDP	Textiles export earnings	Share in total export
	10,000 ton	billion RMB	%	billion US\$	%
1990	462.60	–	–	12.5	20.10
1994	489.50	169.8	11.55	35.5	29.24
1995	542.20	149.4	9.67	38.0	25.52
1997	561.90	183.6	9.25	45.6	24.93
1998	542.00	171.6	8.84	42.9	23.34

Sources: (1) Yarn output: *The achievements and prospects of China's cotton textile industry*, Zhu Lanfen, 2000.

(2) Chinese Textile Industry Statistics, 1990-2000.

1.2.2 Ownership structure of the textile industry

The majority of the textiles and clothing suppliers are State Owned Enterprises (SOEs). Foreign-funded enterprises are gaining an increasingly larger share of the export market, representing 32 per cent of the total in 1998. Collective enterprises and private enterprises domestically owned account for only 3.9 per cent and 0.1 per cent of the total respectively. However, as China's market-oriented reform is further carried out, the market shares of the non-state enterprises will continue to grow.

1.2.3 Comparative advantage of China's textile industry

China's comparative advantage in textiles and clothing production is based on its large labour force. According to an estimate by the World Bank,³ China's working population was 723 million in 1995, which was 29 per cent of the global total, and half the working population of low-income countries. Compared to other large textiles and clothing exporters of the world, the labour cost is very low in China. China is lower than all the other countries for its labour costs of textile production and ranked the second lowest in labour costs of apparel production. However, the difference between textiles and clothing production is that textiles is more technology-intensive compared to apparel and therefore the comparative labour advantage of China is partly offset by its disadvantage in technology.⁴

1.3 Cotton and textiles production in Jiangsu province

Jiangsu province is in south-eastern China. It is located at 30°-35° N and 116°-122° E. It borders with Shanghai city in the south-east, Zhejiang province in the south, Anhui province in the west and Shandong province in the north. It borders with the Pacific Ocean in the east. Jiangsu has good communications and convenient transportation linkages with other regions of China.

³ World Bank Policy and Research Bulletin, Volume 11, Number 2, April-June 2000.

⁴ Handbook of Textile Quota Management and Usage.

Although Jiangsu is not one of the largest provinces in China, it plays an important role in the country. The province covers 102.6 thousand km², which is only 1.1 per cent of China's total territory, but contains about 4.7 per cent of the cultivated land of China. It contributes more than 8 per cent of the country's total GDP.

Jiangsu is one of the top 10 cotton producing provinces in China. In 1998 it produced 10.26 per cent of total Chinese cotton; it is also the biggest cotton consumption province, consuming 16.13 per cent of total Chinese cotton. Jiangsu is the number one textiles industry base in China. In 1998 it produced 928.7 thousand metric tons of cotton yarn, 3.172 billion metres of cloth, 1.41 million metric tons of chemical fibre and 0.811 billion suits of garments; the total output value of textiles in Jiangsu was 148.16 billion RMB, which is 21.64 per cent of the total Chinese textile output. The textile export revenue was 6.18 billion RMB, 11 per cent of the total Chinese textile export revenue.

2. IMPACT OF CHINA'S ACCESSION TO THE WTO

China was one of the 23 original signatories to the General Agreement on Tariffs and Trade (GATT) in 1948. After China's revolution in 1949, the Government in Taiwan announced that China would leave the GATT system. Although the Government in Beijing never recognized this withdrawal decision, nearly 40 years later in 1986, China notified the GATT of its wish to resume its status as a GATT Contracting Party. A working party to examine China's status was established in March 1987 and met for the first time in October 1987. At that time, China's Deputy Minister for International Economic Relations and Trade, Mr. Shen Juren, said China's reform programme, which began in the early 1980s, was having a profound effect on the country's economy.

Like many of the countries now applying for World Trade Organization (WTO) membership, China is in the process of implementing economic reforms and transforming its economy to one that is more market-based. China's accession process to the WTO is guided by a working party whose membership consists of all interested WTO member governments. Initially, the Working Party on China's status was established under GATT in 1987 and concerned only China's trade regime for goods. In 1995, it was converted to a WTO Working Party and its scope was broadened to include trade in services, new rules on non-tariff measures and rules for intellectual property rights.

A substantial part of China's accession process involved bilateral negotiations between China and WTO members. These are usually conducted privately, either at the WTO in Geneva or in capital cities. Other meetings concern either informal or formal sessions of the Working Party. While several areas of China's trade policies, i.e. schedules of market access commitments in goods and specific commitments in services, have been and will continue to be the focus of bilateral and multilateral negotiations, it is the responsibility of the Working Party to maintain an overview of how the negotiations are progressing and to ensure that all aspects of China's trade policies are addressed.

2.1 Impact of China's accession to the WTO in general

China, like all other countries, can best manage its growing economic relations with the world on the basis of rights and obligations agreed by consensus and reflected in enforceable rules and disciplines. The benefits of China's accession to WTO include:

Promotion of China's economic reform. In order to gain the accession to WTO, China has speeded the steps towards opening up its markets. Chinese market accession, including industrial and agricultural products, telecommunications, insurance, banking, professional services, travel and tourism, will be opened up not only to foreign companies, but also to Chinese non-state entities. China has to give up its monopoly policy step by step. The law and regulation system will be improved, the market-oriented economic system will be established.

Improvement of Chinese foreign trade environment. After accession to the WTO, China can enjoy multilateral Permanent Normal Trade Relations (PNTR) with the 130 members of WTO. This could be favourable for increasing China's export capacity.

This is the only way to resist bilateral pressures or threats of unilateral actions. It is also the only way to sustain and promote domestic economic reform, knowing that China's efforts in this direction are being matched by its trading partners, members of the WTO who share the same obligations under the WTO Agreements.

*Joining the WTO means assuming binding obligations in respect of import policies—*obligations which will necessitate an adjustment in China's trade policies and, in most cases, economic restructuring. But, in turn, China will benefit from all the advantages that have been negotiated among the 130 members of the WTO. It will be entitled to export its products and services to the markets of other WTO members at the rates of duty and levels of commitment negotiated in the Uruguay Round—this includes tariff bindings benefiting nearly 100 per cent of China's exports of industrial products to developed countries, with almost one-half of these products being subject to duty-free treatment. These tremendous market accession opportunities will be underpinned and reinforced by the two cardinal principles of most-favoured-nation and non-discrimination.

Equally important, China will have recourse to a multilateral forum for discussing trade problems with its WTO partners and, if necessary, to a binding dispute settlement procedure if its rights are impaired. This greater level of security will benefit China immensely—encouraging even greater business confidence, and attracting even greater levels of investment.

There is another major reason for China's participation in the multilateral system. Only inside the system can China take part in writing the trade rules for the 21st century. This will be an unprecedented set of rights and obligations negotiated internationally by consensus.

2.2 Impact of China's accession to the WTO on agriculture

Until the Uruguay Round, agriculture received special treatment under the GATT trade rules through loopholes, exceptions, and exemptions from most of the disciplines applying to manufactured goods. As a result, the GATT allowed countries to use measures disallowed for other sectors (e.g., export subsidies), and enabled countries to maintain a multitude of non-tariff barriers that restricted trade in agricultural products. Participants in the Uruguay Round continued the GATT's special treatment of agricultural trade by agreeing to separate disciplines on agriculture in the Agreement on Agriculture (URAA), but initiated a process aimed at reducing or limiting the exemptions and bringing agriculture more fully under GATT disciplines.

Under the Agreement, countries agreed to substantially reduce agricultural support and protection by establishing disciplines in the areas of market access, domestic support, and export subsidies. Under market access, countries agreed to open markets by prohibiting non-tariff barriers (including quantitative import restrictions, variable import levies, discre-

tionary import licensing, and voluntary export restraints), converting existing non-tariff barriers to tariffs, and reducing tariff rates. URAA signatory countries also agreed to reduce expenditures on export subsidies and reduce the quantity of agricultural products exported with subsidies, and prohibit the introduction of new export subsidies for agricultural products. Domestic support reductions were realized through commitments to reduce an aggregate measure of support (AMS), a numerical measure for the value of most trade-distorting domestic policies. The agreement is implemented over a 6-year period, 1995-2000.

The provisions and commitments defined by the Agreement on Agriculture include a number of important elements. These can be roughly divided into the following four areas: market access, domestic support, exports subsidy, sanitary and phytosanitary measures (SPS). The agricultural market access commitments include measures to address the following problems: trading rights, tariff reductions, 'tariffication' and quotas.

2.2.1 Tariffication

Tariffication, or the replacement of non-tariff barriers (NTBs) by tariffs, is an important part of agriculture's inclusion within the framework of GATT, in that it brings agricultural trade policy into line with the GATT principle of transparency, and potentially eliminates some of the distortionary effects that NTBs have on trade. It requires countries to convert their existing NTBs into tariff equivalents. These tariff equivalents are established for the base period and are entered in the Country Schedules as the base rate of tariff.

China has committed to eliminate non-tariff barriers on agricultural imports upon its accession to the WTO and to implement a series of tariff cuts between 2000 and 2004. In addition, China has committed to follow WTO standards in eliminating all quantitative restrictions. In particularly sensitive sectors, China will adopt tariff-rate quotas (TRQs) for wheat, rice, corn, cotton, soybean oil and other products, with gradually increasing quota levels, mostly over the same period.

For goods subject to a TRQ, a specified quantity of import (i.e., a quota) may enter at a low tariff rate, and additional imports are assessed a higher tariff. The negotiated TRQs are not "minimum purchase" commitments, i.e., they do not require China to actually import at the full TRQ amount. Rather, by cutting tariffs, they provide the opportunity for trade to the extent that domestic demand exceeds supply.

Accession to the WTO is expected to expand China's imports of farm products, particularly for major agricultural commodities which have TRQs. An important element in China's increased imports will be the growing shares of TRQ imports reserved for private traders. The system of TRQs will expand market opportunities for major agricultural commodities. The quantities of these commodities allowed in at the low "within-quota" tariff rate will increase annually from 2000 through 2004 (except soybean oil which will be fully liberalized with nothing but a bound duty by 2005).

2.2.2 Tariff reductions

China will reduce tariffs immediately on accession to the WTO which, when fully phased-in will result in tariff levels comparable with or better than those of many developed country trading partners.

TABLE 2.1
Tariff quotas of agricultural products

<i>Products</i>	<i>Year</i>	<i>TRQ</i>	<i>Rate</i>	<i>STE share</i>
Wheat	Initial	7,884,000 mt	1%	90%
	2002	8,468,000 mt	1%	90%
	2003	9,052,000 mt	1%	90%
	2004	9,636,000 mt	1%	90%
Corn	Initial	5,175,000 mt	1%	
	2002	5,850,000 mt	1%	68%
	2003	6,525,000 mt	1%	64%
	2004	7,200,000 mt	1%	60%
Rice (short and medium grain)	Initial	1,662,500 mt	1%	50%
	2002	1,995,000 mt	1%	50%
	2003	2,327,500 mt	1%	50%
	2004	2,660,000 mt	1%	50%
Rice (long grain)	Initial	1,662,500 mt	1%	50%
	2002	1,995,000 mt	1%	50%
	2003	2,327,500 mt	1%	50%
	2004	2,660,000 mt	1%	50%
Soybean oil	Initial	2,118,000 mt	9%	
	2002	2,518,000 mt	9%	34%
	2003	2,818,000 mt	9%	26%
	2004	3,118,000 mt	9%	18%
	2005	3,587,100 mt	9%	10%
Palm oil	Initial	2,100,000 mt	9%	
	2002	2,400,000 mt	9%	34%
	2003	2,600,000 mt	9%	26%
	2004	2,700,000 mt	9%	18%
	2005	3,168,000 mt	9%	10%
Rape-seed oil	Initial	739,200 mt	9%	
	2002	878,900 mt	9%	34%
	2003	1,018,600 mt	9%	26%
	2004	1,126,600 mt	9%	18%
	2005	1,243,000 mt	9%	10%
Sugar	Initial	1,680,000 mt	20%	70%
	2002	1,764,000 mt	20%	70%
	2003	1,852,000 mt	20%	70%
	2004	1,945,000 mt	15%	70%
Wool	Initial	253,250 mt	1%	
	2002	264,500 mt	1%	
	2003	275,750 mt	1%	
	2004	287,000 mt	1%	
Cotton	Initial	780,750 mt	1%	33%
	2002	818,500 mt	1%	33%
	2003	856,250 mt	1%	33%
	2004	894,000 mt	1%	33%

Source: Selected from Compilation of the Legal Instruments on China's Accession to the World Trade Organization, MOFTEC.

China will reduce its overall average tariffs for agricultural products from an average of 22 to 17 per cent. All tariff cuts will be implemented by 2004, when all other WTO members will have implemented their Uruguay Round tariff cuts. All agricultural tariffs will be bound (cannot be increased). For certain agricultural exports such as animal products, fruits and dairy products, the average tariff will fall from 31 to 14 per cent.

TABLE 2.2
Tariffs of some agricultural products

<i>Description</i>	<i>Bound rate at date</i>		<i>Implementation</i>
	<i>of accession</i>	<i>Final bound rate</i>	
Wheat and maslin	74	65	2004
Rye	0-3		
Barley	3		
Maize (corn) seed, other	32-74	20-65	2004
Rice	74	65	2004
Grain sorghum	2.6	2	2004
Soya beans	3		
Groundnuts	15		
Sunflower seeds	15		
Flours and meals of soya beans	9		
Soya-bean oil	63.3	9	2006
Rapeseed oil	63.3	9	2006
Wool	38		
Cotton	61.6	40	2004
Flax	6		
Peas, beans	13		
Vegetables (potatoes, peas, beans, spinach, sweet-corn, garlic stems, garlic seedlings)	11.8-13	10.0-13	2004
Coconuts, brazil nuts and cashew nuts	13-26	10.0-20	2004
Bananas	19	10	2004
Dates, figs, pineapples, avocados, guavas, mangoes and mangosteens, fresh or dried	15.0-30	12.0-30	2004
Oranges, chiao-kan	28.4-28.8	11.0-12	2004
Grapes	28-29.2	10.0-13	2004
Apples, pears and quinces fresh	22-22.8	10.0-12	2004
Strawberries, kiwifruit, lychee	27.1-39	14.0-30	2004-2010
Coffee	15	8	2004
Meat of bovine animals, fresh or chilled	31.8-35	12.0-20	2004
Meat of swine, fresh, chilled or frozen	16.8-20	12.0-20	2004
Butter and other fats and oils derived from milk; dairy spreads	36.7	10	2005
Cheese and curd	34.8-36	12	2004
Margarine	36	30	2004
Cane or beet sugar	71.6	50	2004

Source: Selected from Compilation of the Legal Instruments on China's Accession to the World Trade Organization, MOFTEC.

2.2.3 Domestic support

In order to limit the trade distortions caused by domestic agricultural support policies, the Agreement on Agriculture introduces commitments intended to curb these policies. These commitments require countries to quantify all domestic support deemed by the Agreement to have a distortionary effect on trade, i.e., the creation of what is known as the Aggregate Measure of Support (AMS), and then progressively reduce these support measures. The AMS calculation includes all domestic support policies that are considered to have a significant effect on the volume of production, both at the product level, and at the level of the agricultural sector as a whole. Market price support, except that which is achieved through border controls alone, is a major component of the AMS calculation.

The AMS is calculated by first deriving the levels of support for each commodity, plus a similar calculation for non commodity-specific support. Each of these is then summed to provide the aggregate measure. Apart from those policies which are included in the calculation, there are also a large number which are excluded. Whether or not these have, in reality, a significant effect on production is, in some cases, open to interpretation. Policies are categorized as follows:

'Amber box' policies

Those policies which do have a substantial impact on the patterns and flow of trade, and therefore are included in the AMS calculation, are classified in what is called the 'amber box'; these policies are to be disciplined by requiring limitations or gradual reductions in related support levels.

'Green box' policies

Policies that are not deemed to have a major effect on production and trade are placed in the 'green box'. Green box policies include a variety of direct payment schemes that subsidize farmers' incomes in a manner that is deemed not to influence production decisions. They also include assistance provided through:

- producer retirement programmes;
- resource (e.g. land) retirement programmes;
- environmental protection programmes;
- regional assistance programmes;
- certain types of investment aid;
- general services that provide for example;
 - research, training and extension;
 - marketing information;
 - certain types of rural infrastructure.

'Blue box' policies

Policies that fall into neither of these categories, but are somewhere in between, are known as 'blue box' policies; these are also exempted from the AMS calculation. Most of the exemptions to AMS commitments are policies placed in the 'green box' but some

additional polices also gain exemption as a result of the accord reached at Blair House. These are the so-called 'blue-box' polices. The most notable of these are the compensatory payments and land set-aside programme of the EU's Common Agricultural Policy, and the United States' deficiency payments scheme. Such direct payments under production-limiting programmes are exempted from AMS reduction if:

- such payments are based on fixed area and yields; or
- such payments are made on 85 per cent or less of the base level of production; or
- livestock payments are made on a fixed number of head.

'De minimis' exemptions

AMS calculations are carried out for each commodity and for non product-specific support. The 'de minimis' exemption allows any support for a particular commodity (or non product-specific support) to be excluded from the total AMS calculation if that support is not greater than a given threshold level. China agreed to a 'de minimis' exemption of 8.5 per cent, and an additional exemption is contained in the provisions of the Agreement, in the following circumstances:

- Where the value of total domestic support for a particular commodity is not greater than 8.5 per cent of the total value of production of that product, then that support need not be included in the calculation of the total AMS, which means that it will not have to be reduced.
- The same arrangement applies for non product-specific support. That is, provided that its value does not exceed 8.5 per cent of the value of total agricultural production, then, it too may be excluded from the AMS commitments.

2.2.4 Export subsidy

The subsidized export of agricultural surpluses has been a major source of international trade disputes, and the distortions that it has created on world markets, in terms of price and general market instability have been substantial. It is partly for this reason that the agreement reached on export subsidies is seen by many to be the most important element of the URAA and is likely to have the most immediate and direct impact on world markets. Export subsidies, measured in terms of both the volume of subsidized exports, and in terms of the budgetary expenditure on subsidies, have been capped at base period levels. China has committed to remove export subsidies for farm products.

2.2.5 Agreement on Sanitary and Phytosanitary Measures (SPS)

The Uruguay Round's SPS Agreement imposed disciplines on the use of measures to protect human, animal, and plant life and health from foreign pests, diseases, and contaminants. Three years into its implementation, the Agreement can be credited with increasing the transparency of countries' SPS regulations and providing improved means for settling SPS-related trade disputes. In addition, the SPS Agreement established rules to prevent countries from using arbitrary and unjustifiable health and environmental regulations as disguised barriers to trade. China agrees that sanitary and phytosanitary disputes should be settled scientifically.

2.3 Impact of China's accession to the WTO on textiles

Under the Uruguay Round Agreement, the developed country import quotas for textiles and clothing, created through the Multifibre Arrangement (MFA), are scheduled for elimination by 2005 for all WTO members (although the US would have recourse to two new product-specific safeguards to protect against any surge of imports). Without WTO membership, China would continue to face bilaterally negotiated quotas in its major export markets.

WTO membership will have important consequences for the position of China in the world market. If China were excluded from the WTO, its textile products would be discriminated against in the US and EU markets. China's textiles industry, especially its synthetic fibre production, has been subject to both tariff and non-tariff barriers imposed by the West all these years. Unlike other developing country exporters, China was excluded from the Uruguay Round Agreement on Textiles and Clothing (ATC). This means that China has not benefited from acceleration in quota growth, and the progressive movement of textiles and clothing products under GATT rules provided for under this Agreement. Under the latest available version of the Agreement, China's textiles and clothing quotas on the day before China joins the WTO will become the base to which the ATC rules. China will benefit from the integration of textiles and clothing products that has occurred since 1994, and from accelerating the growth rate applying to China's quotas. This process paves the way for expansion of China's exports of textiles and clothing, with all existing quotas to be phased out by 2005, and any special textiles safeguards introduced under the Agreement phased out by 2008. This aspect of the Agreement is the only important case where China will benefit in terms of improved market access—all of the other benefits will arise from China's own reform commitments. China's textiles exports have accounted for a very large share of total export revenues since the early 1950s. The growth rate of textiles exports is much higher than the total export growth rate. The revenue from textile exports was US\$ 42.9 billion in 1998, the export revenue from textiles accounted for around 25 per cent of the total during 1978-1998.

The textiles and clothing sectors will benefit greatly from the liberalization of the textile trade after China joins the WTO. In particular, following the removal of quotas, exports can be further increased. Upon accession, certain Chinese textiles and clothing exports will benefit immediately from the liberalization process. These include 24 categories of products destined for the US, such as baby clothing (except diapers), down feather products, certain footwear, handkerchiefs, hosiery and carpets; and eight categories destined for the EU, such as handkerchiefs, combed wool, narrow fabrics, clothing accessories, swimwear and tents. According to the ATC, during 2002-2004 Chinese textiles exports will be limited by quota, but the quota may increase by 2.54 per cent each year, which means Chinese textiles exports may increase by US\$ 0.3 billion each year. After 2005 the textiles exports quota will be removed, so that Chinese textile exports may increase up to US\$ 11 billion.

2.4 Impact of China's accession to the WTO on agricultural environment

After its accession to the WTO, China should find its position in the global agricultural market, and adjust its agricultural production structure according to the comparative advantage. Although China possesses comparative advantages in some agricultural

products, the low quality (especially environmental quality) of the commodities could limit export competitiveness. Many countries have increased their sanitary and phytosanitary standards and inspection measures are becoming stricter, which constitutes a method of Technical Barriers to Trade (TBT). If China wants to export agricultural products in an international market, it must urgently improve the qualities of the products and bring Chinese standards in line with international standards.

The environment could be a serious problem to China's sustainable agricultural development, therefore environmental considerations should be taken into account in agricultural policy formulation. Promotion of "green agriculture" could be the ideal solution for China to maximize the benefits of trade liberalization and achieve sustainable agricultural development. The main environmental problems in cotton production are as follows.

2.4.1 Pesticide pollution

The term pesticide covers herbicides, fungicides, and insecticides. Insecticides are the pesticides most commonly used in cotton production. The environmental impacts of applied pesticides in cotton production can be divided into three major categories, the consequences to human health; on wildlife; and on water, soil and air contamination.

According to Schuman (1993), human health effects due to overexposure to pesticides are divided into six major categories: acute toxicity, which damages organ systems or metabolism; delayed toxicity, which causes renal, hepatic, haematologic, or neurologic effects; chronic cumulative toxicity, which includes carcinogenic effects; reproductive effects, which result in sterility and birth defects; hypersensitivity, which possibly causes cardiovascular anaphylactic shock and psychological or psychiatric conditioning, which is difficult to diagnose (Shaw et al., 1997).

Pesticides enter into the human body in several ways: through the skin (dermal), by swallowing (oral) and by breathing (inhalation). Cotton growers are the most direct victims of pesticide use. Lack of awareness and a lack of safety measures can cause farmers to be easily poisoned when exposed to pesticides. Workers may be exposed to residual pesticides in ginning and spinning mills. People who drink water that is contaminated by pesticides are either poisoned immediately or suffer from long-term harmful effects of the pesticides. Additionally, pesticides can also affect human health indirectly by contaminating food for human consumption or accumulating in the food chain (Shaw et al., 1997). Various ginning by-products often find their way untreated into the feed of dairy and beef cattle, the spray drift of pesticides are "swallowed" by wildlife and livestock, and cotton seed oil is a major edible oil in some regions, notably in some parts of Shandong province.

The damaging effects that agrochemicals have on wildlife and domestic animals can be either direct, such as acute toxic poisoning through eating pesticide-covered seeds and animals or indirect, such as the loss of habitat caused by the use of herbicides (Shaw et al., 1997). Some of the insecticides and herbicides can be long-lived in the soil. There may be an insidious loss of vital soil organisms which play important roles in decay, nitrogen fixation, the sulphur cycles and are of significance in their symbiotic relationship with crops (e.g. mycorrhizal fungi, soil arthropods). It is likely that the microclimate of the fields is altered, which leads to serious soil degradation (Barrow, 1991).

Pesticides can enter surface water sources through run-off. Valorized pesticides may also pollute the air and dissolve in precipitation. These chemicals are likely to build up in

cotton sediments and will eventually be concentrated in living organisms through the food chain (Wagner, 1994).

Pesticides also find ways into groundwater through leaching and draining. The degree of groundwater contamination is largely determined by soil characteristics and the location of the field (Shaw et al., 1997).

2.4.2 Chemical fertilizer pollution

Fertilizers are used to replenish the nutrients that the crop takes up from the soil or to insert lacking nutrient types in the soil (Harry de Vries, 1995). The main environmental impacts of fertilizer application arise when it is not properly used, or when (climatic) conditions are not as predicted. The composition of applied fertilizers may not always coincide with the extracted nutrients. This means that some nutrients are still depleted while others are overcompensated. This may lead to soil degradation (Harry de Vries, 1995). In some regions of China, *urea* is over used to such an extent that it has caused major imbalances between nitrogen (N) and phosphorous (P), with the highest ratio of N and P being 1:0.8 - 1.0 (Zhang Jusong, 2000). The direct consequence of this is high input accompanied by low yield. Fertilizers contribute to soil degradation in several other ways. Examples are: soil acidification caused by super phosphate fertilizers; accumulation of phosphates and heavy metals in soils; and soil firmness induced by over-application of chemical fertilizers. Soil degradation means the loss of fertility and therefore encourages increasingly larger inputs of fertilizers, thus leading to a fertilizer dependency cycle.

Additionally, problems occur when climatic conditions (especially rainfall, but the same effect occurs with over-irrigation) differ from expected values. When rainfall is short, the crop might be harmed more than it gains from fertilizer application. When rainfall is more abundant than expected, some of the applied fertilizer may leak away from topsoil to lower (and for the crop unreachable) layers, or drained with rainwater into rivers and lakes. In the latter case, the fertilizer can pose a risk to water resources (Harry de Vries, 1995). Too much fertilizer in rivers and lakes is one of the main characteristics of water pollution.

One of the well-known causes of groundwater contamination is the massive use of fertilizers containing nitrogen. Nitrogenous fertilizers, phosphate fertilizers and ammonium-rich fertilizers can be converted in the soil by nitrosomonas bacteria to nitrate compounds. These fertilizers, if not entirely absorbed by the crop, will cause serious problems. Some of the nitrates leach out to contaminate water bodies and may also be converted by soil micro-organisms into nitrogenous gases which escape to add to the "greenhouse effect". Nitrates, composed of one atom of nitrogen and three atoms of oxygen (NO_3), pose health risks to infants when found in drinking water. Although nitrate itself is not usually considered harmful to human health, the immature digestive systems of infants changes nitrate to nitrite (NO_2), which can cause a disease called *methaemoglobinaemia* (McCasland et al., 1997). Haemoglobin of babies with methaemoglobinaemia will be converted to methaemoglobin, which cannot carry oxygen. In severe cases, the infants may have digestive or respiratory problems and anoxia (McCasland et al., 1997). Additionally, nitrous oxide emissions from the use of nitrogen fertilizer affects air quality.

Another problem environmentalists have with fertilizers is that agricultural run-off can be disastrous to water ecosystems. If an overabundance of nutrients is located within a water source, eutrophication can set in. The water's oxygen content is used up by microbial organisms and fish die off. Since fertilizers are highly necessary, improvements in its

application are needed to reduce collateral ecological damage. The damage caused by agrochemical run-off can be reduced by implementing proper irrigation scheduling, paying close attention to weather forecasts and using strip crops to minimize the amount of fertilizers and pesticides washed away into water bodies by rainfall (Shaw et al., 1997).

2.4.3 Plastic film pollution

The application of plastic film is very popular in China. The plastic films mentioned here refer to polythene film which is as thick as 0.008 mm and is used to cover the cotton nursery surface (and therefore in China is called ground surface film). It is mainly used to raise ground temperature and retain moisture for cotton growth (Mao, 1998). After germination, holes are made for the cotton plants to grow through.

Plastic film was first introduced in the 1970s and it is already applied to 50 per cent of China's cotton acreage during recent years. It is most extensively used in Xinjiang, where it represents 40 per cent of the total cost of cotton production (labour costs not included). It has been proven that this newly popularized technology is very effective for its designed purpose. However, plastic film fragments that remain in the soil may stay for as long as 100 years without being degraded by microbes. If the plastic film fragments are not removed, they may hamper cotton root growth and cause decrease in yields.

2.4.4 Irrigation problems

Cotton is a high-volume water user. Therefore, water is a very important input in cotton cultivation. Irrigation waters make it possible to grow cotton in some regions that otherwise would not be suitable. They help to increase cotton yields and ensure a regular harvest and they are very effective in shortening cotton's ripening periods (Roche, 1994). However, unchecked water use compounded by some of the inefficient irrigation practices, makes the cotton production system in most of the cotton producing regions largely unsustainable. Water resources are, obviously, not inexhaustible. The intensive water use makes a huge dent in this limited water base, as well as various other side effects it has caused, mostly in conjunction with other production practices.

The large volume of water used and the low rate of utilization shows that water is often regarded as an everlasting resource. New irrigation practices have enabled farmers to draw water from deep underground aquifers, as well as from surface water stored in dams and levees. Water shortages are typically viewed as a supply problem rather than as a demand issue (Shaw et al., 1997). However, irrigation waters, either pumped from aquifers or diverted from surface sources, can cause environmental damage and threatens to undermine future production.

Over-irrigation and lack of drainage causes leakage and run-off of agrochemicals, which have disastrous impacts on the environment. Irrigation run-off from surrounding cotton fields has created wastelands, and birds living in the surrounding areas are experiencing birth defects in record numbers. The toxic run-offs and leakages into groundwater and surface water are harmful to humans and wildlife, and wipe out natural biological systems available to the farmers.

Excessive pumping of groundwater for cotton growing is common in many regions. Often, the speed of pumping is much faster than that of natural replenishment. As ground-

water is drawn out of the aquifers, porous and permeable soils that once harboured water are prone to compression and sinkage, which may well destroy the aquifers. Serious subsidence problems and intrusion of salt water may also arise as a consequence of excessive groundwater mining (Shaw et al., 1997).

Another important consequence that surface water irrigation has is soil salinization. In general, irrigation and the subsequent evaporation of water leaves salt residue on the soil. If the salt content is high, plants have more difficulty sucking up water. They wilt and are more vulnerable to pests. If the soils are shallow and the water table is near the root zone of crops, even water of relatively low salt content will cause soil salinity. A good way to slow the salting of soils is to irrigate at night to reduce evaporation. Drip watering is also beneficial and uses less water. The problem with drip irrigation systems is they are more expensive to construct. A good drainage system also lessens the salinization problem. However, the disposal of saline irrigation water into rivers, lakes and the sea poses formidable environmental problems. In addition to high salt concentrations, it contains arsenic, boron and mercury (Shaw et al., 1997). The agrochemical contamination of water can be reduced using many of the practices discussed in relevant sections. Other mediation methods include low-volume irrigation, the restoration of wildlife habitats or the use of agroforestry to minimize the impacts of salinity and high water tables. However, in the long run, some regions may have to stop the production of cotton.

2.4.5 Transgenic cotton production

In China, insects, especially the cotton bollworm, cause a 10-15 per cent output loss in an average year and they have been unusually rampant in the last few years. Most of the breeds of cotton are not insect-resistant. Breeding new varieties that are resistant to insects through genetic engineering, is a potentially important way of raising cotton yield without using pesticides. The most commonly used methods include modifying plant characteristics (e.g. the shape and size of leaves which form the source of nutrients for insects), the speed of ripening (thus limiting the exposure time to insects during the vulnerable stages), and the introduction of insect-repellent genes into the plant (Banuri, 1998). The most commonly used genes to build cotton resistance to pests are those for the Bt (*bacillus thuringiensis*) toxin.

During 1995 and 1996 the Cotton Research Institute of the Chinese Academy of Agricultural Science (CAAS) cooperated with the American Delta and Pine Land Company (DPL) in experiments with the cotton bollworm. Since January 1997, some varieties of the American DPL series, such as 33B, 99B, 32B were approved by Hebei and Anhui province. Besides the American DPL series there are some varieties of Bt-resistant transgenic cotton, such as the Zhongmian series (ZM29, 30, 32, 38) and the Guokang series (GK-12, JM-26, SGK321, etc.) which were independently developed by the Cotton Research Centre and the Biotechnology Research Institute of the CAAS (Du Min, 2001).

The properties of the transgenic cotton include the ability to achieve high yield with low cost, enhancing production profits and providing benefits to farmers. Most importantly it can reduce the need for applied pesticides and in this respect the transgenic cotton in China shows the following characteristics:

- Resistance varies according to time and space. The insecticidal activity of the insect-resistant cotton is mainly effective for the bollworm in its first and second generations, while for the third and fourth generations the activity decreases

obviously. In the same period the insecticidal activity of cotton bud is lower than leaf. Therefore the Bt-resistant transgenic cotton shows a better performance in the Huang-Huai region which is seriously hit by second and third generation bollworm, while the resistance is weaker in the Yangtse River region which is more seriously hit by third and fourth generation bollworm.

- The existence of decreasing resistance. When selecting bollworm larvae indoors by generations, the resistance grades of the insect-resistant cotton degraded from “highly resistant” to “resistant” to “moderately resistant” (Zhang Yongjun, et al., 2000).
- The single-resistance property of the present insect-resistant cotton. It is only effective in killing *lepidoptera*, thus pesticides are still needed to kill other insect pests during the growth period of the insect-resistant cotton (Du Min, 2001).

However, a number of risks are associated with biotechnology and can be divided into two parts: technology-inherent risks and technology-transcending risks. Technology-inherent risks are those associated with threats to human health and the environment:

- Genetic modification may change the toxicity, allergenicity or nutritional value of food, and alter antibiotic resistance. This could be harmful to human and animal life or health.
- The transfer of inserted genetic material to other domesticated or native populations, generally known as *gene flow*, through pollination, mixed matings, dispersal or microbial transfer.

Technology-transcending risks emanate from the political, social and environmental context in which a technology is used e.g., increasing the poverty gap within and between societies, loss of biodiversity, negative impact on the ecosystems - the impact of new biological elements in ecosystems may take years or decades to be understood:

- Genetically modified plants may transfer genetic material and associated traits to conventional varieties, developing more aggressive weeds, threatening ecosystems, and harming biological diversity. Biodiversity may also be lost as a result of the displacement of conventional cultivars by a small number of genetically modified cultivars.
- Unintended effects on the dynamics of populations in the receiving environment as a result of impacts on non-target species, which may occur directly by predation or competition, or indirectly by changes in land use or farming practices.
- Unintended effects on biogeochemistry, especially through impacts on soil microbial populations that regulate the flow of nitrogen, phosphorus and other essential elements (FAO, 2001).

3. BACKGROUND TO THE PROJECT

3.1 Relevance of the cotton sector to the national economy

China is one of the largest cotton producing and consuming countries in the world and the cotton sector occupies an important position in China's national economy. The total cotton output was 3.8 million metric tons in 1999 with the sown area of 3.7 million hectares. The number of farmers, either directly or indirectly involved in cotton production, has been around 300 million in recent years, and the annual income the farmers earn from cotton production has been around 30 billion RMB in an average year (Mao, 1998). Cotton has become one of the backbone crops of the cotton producing areas and one of the main sources of their fiscal revenue (Wang and Wei, 1997).

The cotton sector has close linkages to the textiles and clothing sectors. The textiles industry holds a very important position in China. Before the 1980s, the gross value of industrial output of this industry accounted for more than 15 per cent of the country's total GDP (the State Textile Industry Bureau of China, 2000).

As China joins the WTO, and therefore becomes subject to the Agreement on Agriculture and Agreement on Textiles and Clothing, the Chinese economy in general and the cotton sector in particular will be faced with significant adjustments. Under the bilateral agreement reached with the US in November 1999 for example, upon accession to WTO, China will significantly relax the import quota on US cotton and, in turn, the US will gradually relax its quota restrictions on China's cotton and other textiles and clothing products. In 1992, China accounted for nearly one fourth of total global cotton production (ICAC, 1993c: 6-7), and continues to rank as the world's single largest producer. The cotton and cotton products industry is the single most significant sector in terms of value added as well as employment, in the Chinese economy. Finally, this sector has also long been the subject of multilateral trade negotiations, and is a prominent feature in the current negotiations over trade and the environment. It is an area where the market and non-market environmental measures introduced by industrialized countries will affect the prospects for stability and sustainability in the South.

While the cotton sector (including the production and marketing of cotton) and the textiles and clothing sectors are closely linked, this project will be concerned with the cotton sector only. It will study the institutions and policies governing cotton production and marketing in China, the slow progress towards a market system (the sector remains one of the most controlled sectors in China), the distribution of gains, and the environmental impact of current cotton production methods. The information to be collected through this project will equip policy-makers to begin the reconfiguration of policies to maximize the benefits and avoid major dislocations from global trade agreements.

Cotton production has also had severe environmental impacts on the local ecosystems and, ultimately, on the local population. One of the principal goals of this project is to study and measure such environmental impacts, and to find technologically feasible

and economically rational ways to reduce such impacts to socially acceptable limits, for example by using “greener” technologies and methods of cultivation.

3.2 Project objectives and outputs

3.2.1 Project objectives

This project aims to make an integrated assessment of the economic, social and environmental impacts of China’s accession to the WTO, with a focus on the cotton sector; to provide policy recommendations for a transition to sustainable development of the cotton sector in view of China's entry into the WTO; and to strengthen China's negotiating capacity in subsequent rounds of trade talks relating to cotton. Specific objectives are to:

- Enhance the country’s understanding of the implications of WTO membership, promote cotton-trade liberalization in China in a sustainable manner, and enhance its negotiating capacity in future rounds of trade talks.
- Assess the environmental as well as social and economic impacts of China’s potential trade liberalization in cotton.
- Use a sector specific methodology to assess these impacts. The established Jiangsu Agricultural Policy Analysis model (JAPA) will be used to assess the impacts of trade liberalization on cotton production, and to identify optimal resource allocation adjustments after trade liberalization.
- Formulate a policy package to correct the identified negative impacts of liberalized trade, and to maximize the positive ones. Both economic and regulatory instruments will be considered.
- Perform a cost-benefit analysis for implementing this policy package.
- Contribute to establishing a long-term policy development process in China’s cotton sector, to address future trade-related environmental and social impacts of the sector’s activity.
- Contribute to enhancing coordination between related national entities and to increasing national expertise in using integrated assessment tools to identify and quantify both negative and positive environmental, social and economic impacts of trade liberalization.
- Enhance and support national capacity in international trade policy-making and research.

3.2.2 Project outputs

This project will provide the following outputs:

- An inception report, outlining the focus of the study, the methodologies to be used and the availability of data.
- A work-plan outlining the activities to be undertaken during the 18-month study with a schedule for all project activities with a listing of project milestones.

- Reports on the proceedings of all national workshops and planning meetings undertaken as part of the study.
- Country and sector specific methodologies for integrated assessments of trade liberalization in the cotton sector.
- An assessment of the impact of different trade liberalization policies and multilateral trade rules on the cotton sector, and a proposal for clear and practical policy options to reduce negative environmental and social impacts.
- A draft country study report for peer review.
- Information on consultations with government representatives on possibilities for implementation.
- Publication of the peer-reviewed country study, including a recommended policy package designed for implementation in the cotton sector.
- Analysis and evaluation of the recommended policy package and its implementation.
- An action plan for implementation.
- A final brief report providing an assessment and evaluation of the outcome of the project.

3.3 Project approach and process

3.3.1 UNEP

The United Nations Environment Programme organized and provided financial support for the project. UNEP gave technical input and manuals, held project review meetings and invited experts and consultants to make comments and suggestions for the project. Mr. Abaza, Chief of the Economics and Trade Unit (ETU) came to China to participate in our stakeholders' meeting in July, 2000.

3.3.2 National institution

The National Institution responsible for this project is the Agricultural Economics Research Institute (AERI) of Nanjing Agricultural University. The project leader is Professor Shudong Zhou. The local institution has:

- Assembled a multidisciplinary team to carry out the study and the project (May, 2000).
- Reviewed the comprehensive global and national literature and methodologies and existing policies, particularly economic reform and trade policies. They include analysis of data sources and the impact of trade liberalization policy for the cotton sector. The output was an Inception Report (May/June, 2000).
- Convened a national stakeholders' workshop to launch the project. The workshop defined the project's objectives, approach, process, partners, and resulted in a detailed work programme. The output was a National Stakeholders' Workshop Report (July, 2000).

- Established a National Steering Committee to guide the study with local input (July, 2000).
- Undertaken a detailed field study that included mainly:
 - an analysis of the effects of trade liberalization policies on the sector
 - an assessment of the positive and negative environmental, social and economic impacts of trade liberalization on the cotton sector (including a cost-benefit analysis to provide to the extent possible the costs and benefits associated with trade liberalization)
 - a package of recommended measures and policies to promote the sustainable production of cotton in China

The output was a first draft of the country study on Environmental Effects of Trade Liberalization in China's Cotton Sector (June/October, 2000).

- Submitted the study to UNEP to be presented and reviewed at an international experts' workshop (November, 2000).
- Prepared the final country study incorporating comments of the international group of experts and submitted to UNEP for review and comments (February, 2001).
- Presented the country study at the UNEP/BMU Ministry Meeting on Environment, Sustainable Development and Trade held in Berlin, Germany (March, 2001).
- Convened a national stakeholder meeting to implement the project (August, 2001).

3.3.3 Stakeholders' approach—project steering committee

A National Steering Committee has been established to guide the project. The Steering Committee is composed of members of the Ministry of Agriculture, the Ministry of Foreign Trade and Economic Cooperation, the State Environmental Protection Administration, the Chinese Textiles Association, Beijing University, the International Economics and Trade University, the Chinese Academy of Agricultural Sciences, the Jiangsu Agriculture and Forestry Department, the Jiangsu Environmental Protection Administration, Nanjing Agricultural University, the Jiangsu Tongyu Fabric Group Company, and the Delegate of Cotton Farmers etc.

3.4 National institution, team members and UNEP

3.4.1 National institution

Nanjing Agricultural University was formerly part of the Nanjing University and Jinling University, and has more than 85 years of history. The Agricultural Economics Research Institute (AERI) of Nanjing Agricultural University was established in December 1986 with the approval of the Ministry of Agriculture. AERI consists of six research groups undertaking research in various areas. It has 66 faculty members—17 professors and 27

associate professors. Senior faculty has won international and domestic recognition in their fields of study, while the middle-career and young scholars have achieved great success with their solid theoretical training and standards of rigor in pursuing academic work. AERI has many young talents who are full of initiative and vigour and have a strong commitment to applicability and excellence in research.

AERI has carried out many research projects financed by local and national governments and international foundations. Recent projects include: the Supply and Demand for Animal Products in Big and Medium Cities, financed by the local government of Jiangsu Province; A Comparative Study between the Chinese and Foreign Agricultural Economies, also financed by the local government of Jiangsu Province; Agricultural Sustainable Development of Red and Yellow Soil Region in South China, financed by the Science Committee of China; Exploitation of Seabeach in Jiangsu Province and its Sustainable Development, financed by the Winrock Foundation of the US; Optimization of Grain Reserve Systems in China, financed by the Natural Science Foundation of China, and so on. In total, 162 research projects have been completed by AERI since 1979. Eighty-eight books and more than 700 journal articles have been published based on them.

3.4.2 Team members

Relevant experience and previous relevant work of the project leader

Shudong Zhou, Ph.D., Professor and deputy director of the Agricultural Economic Research Institute (AERI) of Nanjing Agricultural University. Professor Zhou has 15 years of research experience in agricultural economics. He studied at the University of Oxford, England during 1988-1989, and studied at the University of Giessen, Germany during 1995-1999. He got his Ph.D. degree with the dissertation "Regional Model for Agricultural Policy Analysis in Jiangsu, China". The model combined econometrics methods and a partial equilibrium model; it can be used for baseline projection, for agriculture policy evaluation and for policy simulation. This model includes 48 important agricultural products such as cotton, rice, wheat, rapeseed. Much research on the impact of China's accession to WTO has been undertaken using this model. His recent research also includes assessing the effects of China's WTO accession on Chinese agricultural policy and strategy.

Relevant experience and previous work of the collaborating partner

Minquan Liu, Ph.D., Providence Professor of Economics at the Hopkins-Nanjing Centre of the University of Nanjing. Dr. Liu's work has concentrated on the economics of development and reform in China and East Asia. Recent publications and work have focused on China's agricultural sector, financial reform and foreign direct investment. He has completed collaborative projects on China's agriculture funded by the Department for International Development, UK, and another on EU foreign direct investment in the province of Guangdong, China.

Relevant experience and previous relevant work of the international consultant

Tariq Banuri, Ph.D., Senior Research Director at SEI-B, whose work focuses on sustainable development policy, with special emphasis on the impact of such global trends as trade liberalization and the changing nature of governance. He is a leading member of two of the largest professional networks in the area of conservation and sustainable development: the Inter-governmental Panel on Climate Change (IPCC), in which he is a

Convening Lead Author; and the IUCN-the World Conservation Union, where he is the elected chair of the Commission on Environmental, Economic, and Social Policy (CEESP).

3.4.3 UNEP as project organizer and supporter

This project is organized and financially supported by the Economics and Trade Branch (ETB), Division of Technology, Industry and Economics (DTIE), United Nations Environment Programme (UNEP).

Responsible officer at UNEP:

Hussein Abaza

Chief, Economics and Trade Branch

Division of Technology, Industry and Economics

United Nations Environment Programme.

4. DEVELOPMENT OF IN-COUNTRY METHODOLOGY

4.1 Overview of methodology selection

In order to assess the social, economic and environmental impacts of trade liberalization on China's cotton sector, the research is carried out step by step.

First, the possible impacts of trade liberalization on cotton production in China after joining the WTO will be studied. Specifically, a suitably adapted version of our existing JAPA model (Jiangsu Agricultural Policy Analysis) will be used to make a baseline projection on the situation in 2002, which will provide a comparative basis; then a scenario analysis on the impact of agricultural imports increase will be made with the JAPA model.

Second, the model scenario analysis results of agricultural imports increase will then be used to assess the social, economic and environmental impacts of trade liberalization. For this, the relationship between the level of cotton production and the use of inputs such as chemical fertilizers and pesticides under existing methods of production will be estimated.

Third, an integrated assessment is applied in the study. For this purpose it is necessary to make an economic valuation of the social and environmental impacts.

Fourth, a cost-benefit analysis is conducted to assess the social, economic and environmental impacts of trade liberalization.

Fifth, based on the above cost-benefit analysis and scopes of implementation, a specific policy package will be recommended.

4.2 Methodology

4.2.1 The methodological approach of the JAPA Model

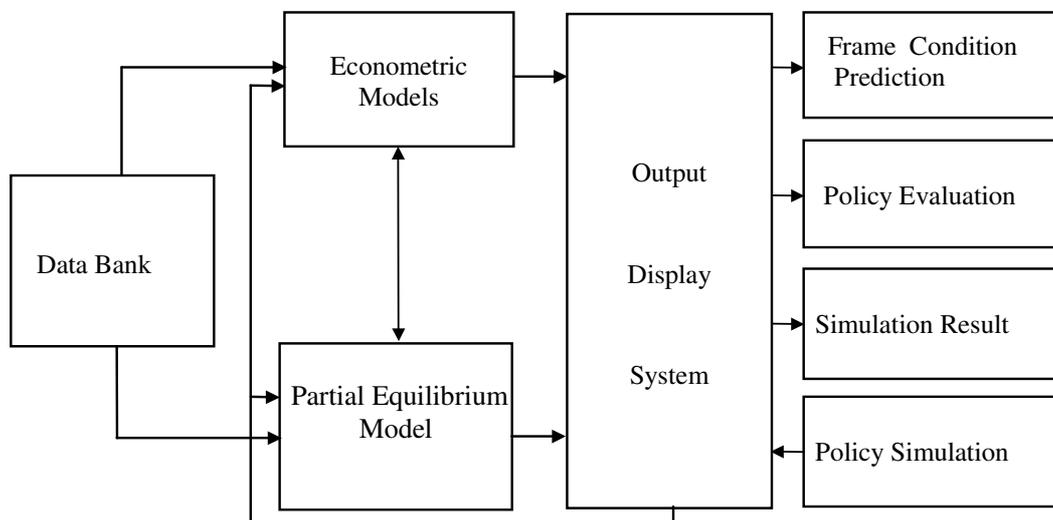
The econometric model and programming models are widely used for economic forecasting and for policy simulation. The JAPA model is a combination model consisting of different sub-models. It includes a data bank, a series of econometric models, a partial equilibrium model and an interactive display system. This display system allows the user to operate the model and to control the sub-models with ease because it can transfer information to sub-models within the JAPA Model. The model structure is described in Figure 4.1. (For further details see Zhou, 1999).

Econometric model

In the first sub-model, a Linear Approximation/Almost Ideal Demand System (LA/AIDS) is established to estimate the human consumption level of various commodities and

FIGURE 4.1

Structure of the JAPA model



Source: Zhou, Shudong, 1999.

the price elasticity of major consumer goods, This LA/AIDS model and other regression models also provide many coefficients for the partial equilibrium model.

The LA/AIDS model is usually specified as:

$$W_i = \alpha_i + \sum \gamma_{ij} \ln P_j + \beta_i \ln \left(\frac{X}{P} \right) \quad (4.1)$$

with the theoretical restrictions imposed

$$\sum \alpha_i = 1, \quad \sum \beta_i = 0, \quad \sum \gamma_{ij} = 0 \text{ (homogeneity)}, \quad \gamma_{ij} = \gamma_{ji} \text{ (symmetry)}$$

The model uses Stone's index, it is specified as:

$$\ln P = \sum W_k \ln P_k \quad (4.2)$$

where

- W_k : share of total expenditure allocated to good k
- P_k : price of good k
- P : price index
- C : expenditure level

A two-stage budgeting model is used to estimate expenditure share for Food 1 (crop products), Food 2 (animal products), clothing, daily household goods and others in the first stage; and afterwards to estimate the expenditure share within the Food 1 group for wheat, rice, vegetables, fruits, tea, rapeseed and other crop products; and the expenditure share within the Food 2 group for pork, beef, poultry, egg, fish and other animal products in the second stage.

This LA/AIDS model will enter the partial equilibrium model to define the human consumption behaviour. The price elasticity is widely used to show supply or demand responsiveness to price change. The price demand elasticity is used to show how the peoples' consumption level responds to price changes. Normally the price demand elasticity is negative, implying that if the price of a commodity increases, the consumer decreases their consumption level of this commodity.

The price demand elasticity E is specified as:

$$-\delta_{ij} + \frac{\gamma_{ij}}{W_i} - \frac{\beta_i}{W_i} \left[W_j + \sum_k W_k \ln P_k (E_{kj} + \delta_{kj}) \right] \quad (4.3)$$

where

$E_{ij} = \delta_{ij}$ is Kronecker delta ($\delta_{ij} = 1$ when $i = j$; $\delta_{ij} = 0$ when $i \neq j$).

where

(4.3

δ_{ij} is Kronecker delta ($\delta_{ij} = 1$ when $i = j$; $\delta_{ij} = 0$ when $i \neq j$).

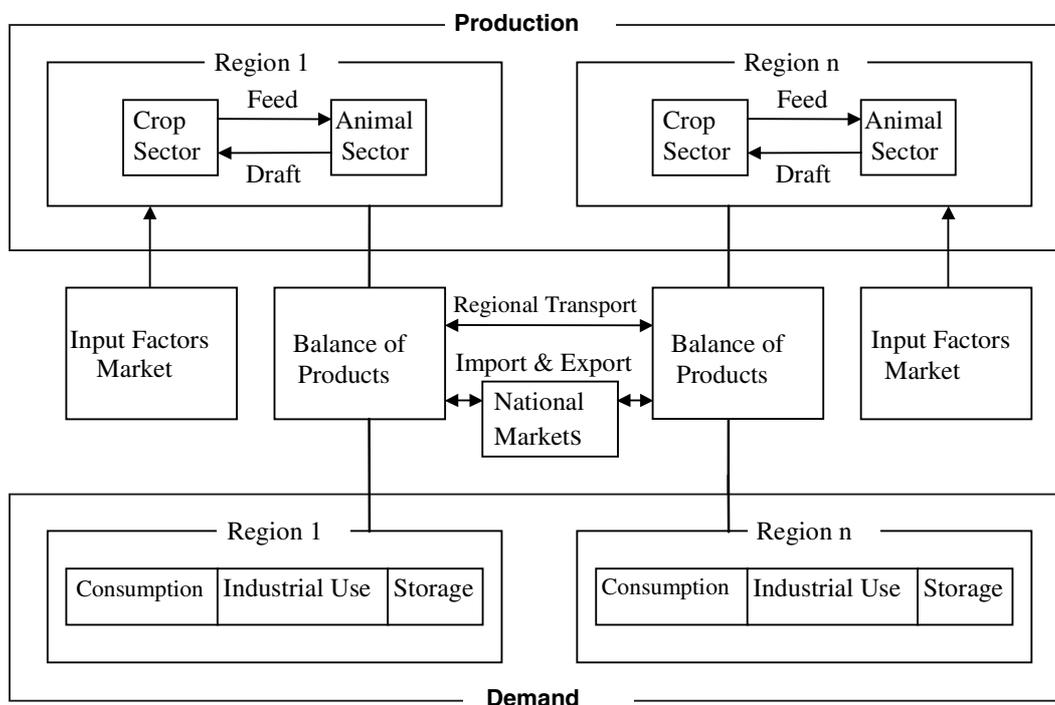
Partial equilibrium model

The second sub-model is a partial equilibrium model. The objective function of this model is maximizing producer surplus and consumer surplus. The model includes the crop sector and the animal sector for five regions in Jiangsu province. It considers all input items and output products on the supply side, and human consumption, industrial demand, feed, storage, loss, regional transport, international import and export on the demand side. Figure 4.2 shows the structure of the partial equilibrium model. The characteristics of the partial equilibrium model are:

- multi-cropping system, JAPA model including 41 cropping and animal activities, 31 agricultural products;
- interregional transport as endogenous variable;
- international trade as exogenous variable;
- non-linear labour cost;
- calibration for non-linear cost for risk, disturbance and etc.;
- calibration for non-linear cost for regional transport.

Because this model is relatively complex, an interactive display system has been established which makes it easier to go through the tables and change policy variables and then make simulations. This display system can transfer information from one program to another program and it can also control the partial equilibrium model. After the partial equilibrium model has run the simulation, the simulation results will be sent back to the display system.

FIGURE 4.2

Structure of the partial equilibrium model

Source: Zhou, Shudong, 1999.

The objective function of the partial equilibrium model is maximizing producer surplus and consumer surplus. The Samuelsonian objective function has two components: the total area under the demand function and the area under the supply function. The first component enters the objective function with a positive sign and the second with a negative sign so that their algebraic sum is the sum of producer and consumer surpluses (see Figure 4.3).

On the assumption of a competitive market without export and import, according to Figure 4.3, at the equilibrium solution $e(P, Q)$, the value of the objective function can be expressed as follows:

$$\text{Obj} = \text{CS} + \text{PS} \quad (4.4)$$

where

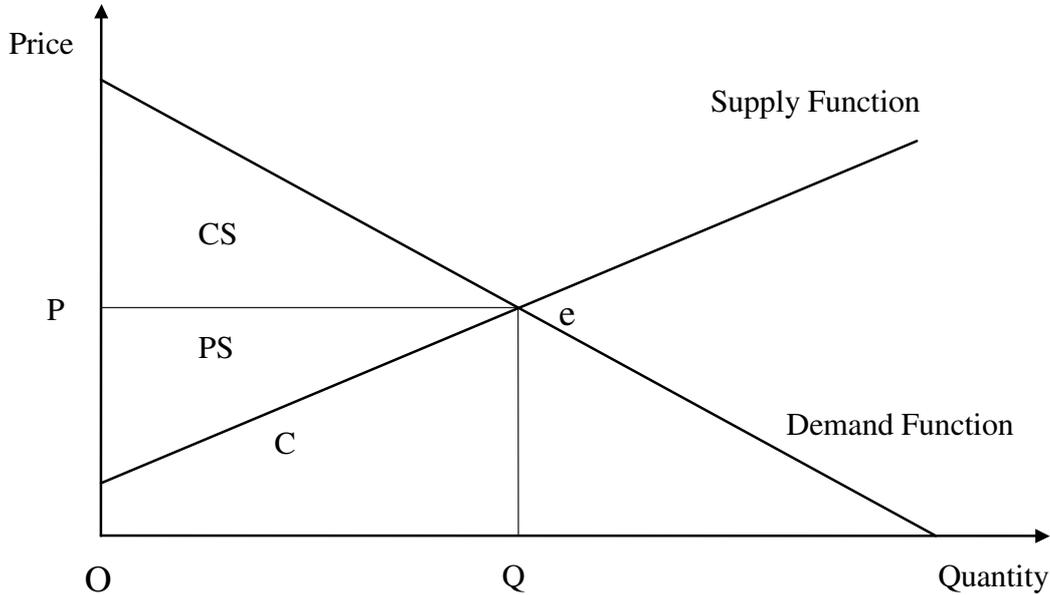
CS: consumer surplus

PS: producer surplus

Consumer surplus can be described as the difference between willingness to pay and actual payment. Producer surplus can be described as the difference between actual payment and variable costs.

FIGURE 4.3

Geometry of the objective function in a competitive market



Source: Modified representation from HAZELL and NORTON, 1986.

The area between demand curve and supply curve is the sum of producer and consumer surplus. Therefore the objective function of the partial equilibrium model is expressed as follows:

$$\text{Obj} = \text{Area under demand curve} - \text{Physical input costs} - \text{Transport costs} - \text{Labour costs} \\ - \text{Non-linear costs for risk} - \text{Non-linear costs for regional transport}$$

This leads to the following mathematical formulation:

$$\text{Obj} = \sum_{r,O} [\alpha \cdot XDC + 0.5 \beta \cdot (XDC)^2] \quad \text{----[Area under demand curve] (4.5)}$$

$$- \sum_{r,aa} (\text{INANPR} \cdot \text{INANQU}) \cdot X_{aa} \quad \text{----[Animal physical cost] (4.6)}$$

$$- \sum_{r,ac} (\text{INCRPR} \cdot \text{INCRQU}) \cdot X_{ac} \quad \text{----[Crop physical cost] (4.7)}$$

$$- f_a \cdot \sum_{r,OA} (d \cdot XTC) \quad \text{----[Animal transport cost] (4.8)}$$

$$- f_c \cdot \sum_{r,OC} (d \cdot XTC) \quad \text{----[Crop transport cost] (4.9)}$$

$$- \sum_r \text{clab} \cdot \text{lab}^2 \quad \text{----[Non-linear labor cost] (4.10)}$$

$$- \sum_{r,a} 0.5 X' \cdot \text{diag}(\text{nlcoc}) \cdot X \quad \text{----[Non-linear cost for risk] (4.11)}$$

$$- \sum_{r,O} 0.5 \delta' \cdot \text{diag}(\text{nlcot}) \cdot \delta \quad \text{----[Non-linear cost for transport] (4.12)}$$

where

XDC	: total demand
INANPR	: input price of animal production
INANQU	: input quantity of animal production
INCRPR	: input price of crop production
INCRQU	: input quantity of crop production
X	: activity level
Fa	: transport fee for animal products
Fc	: transport fee for crop products
D	: distance between regions
XTC	: regional transport quantity
Wage	: wage rate
Clab	: coefficient of labour function
Lab	: labour use
Nlcoc	: non-linear coefficient for risk
Nlcot	: non-linear coefficient for transport
Delta	: derivation from observed net transport stream

Besides the objective function, there are many constraints that should be considered in the partial equilibrium model. The following constraints are included in the model:

- Acreage constraint for irrigated land
- Acreage constraint for dry land
- Labour force constraint
- Quota constraint
- Market balance constraint for products
- Feed balance constraint
- Calorie balance constraint
- Draft balance constraint.

4.2.2 Baseline projection

In order to provide a fair comparison basis for the scenario analysis on the impact of trade liberalization, it is necessary to make a baseline projection. The baseline projection takes the following assumptions for the future:

- Simulation year 2002;
- People's income level increases at the increase rate of 1999, the LA/AIDS model will estimate people's average consumption levels of agricultural commodities, the industrial demand, storage and other demand are assumed at the same levels of 1999;
- Population increases according to the growth rates of 1999 in the 5 regions, multiplies the average consumption levels to get the total human demand for agricultural commodities, plus industrial demand, storage and other demand to get the total demand;

- Cultivated land decreases as the trend of 1999 in the 5 regions; so agricultural production is under the constraints of the cultivated land of each region.
- The average production yields for each region in 1999 are used for the simulation, which means the yield increase in the future caused by technical improvement is not considered in the simulation;
- Natural disasters are not considered.

After simulation, the JAPA model provides the following results as listed in Table 4.1.

TABLE 4.1

Projected sown area and output in Jiangsu province

	<i>Sown area 1000 ha</i>	<i>Output Metric ton</i>
Wheat	2,107.46	8,885,820
Barley	203.91	929,247
Rice	2,365.03	17,875,760
Corn	485.07	2,342,998
Soybean	244.40	520,319
Rapeseed	528.14	908,609
Cotton	635.62	594,423
Fruit	193.80	1,423,805

Source: Model projection results.

These and also other simulation results will be used as the baseline projection.

4.2.3 Scenario analysis: policy simulation

This model scenario analysis tries to find what kind of impacts large agricultural imports could bring to China. According to the Compilation of the Legal Instruments on China's Accession to the World Trade Organization, China will adopt tariff-rate quotas (TRQs), i.e. a system in which imports up to the quota level are charged a minimal tariff, and imports above that level a high tariff. Three examples are chosen for simulation:

- Wheat – According to the Compilation of the Legal Instruments on China's Accession to the World Trade Organization, the TRQ of wheat for year 2002 should be 8.468 million metric tons.
- Corn – According to the Compilation of the Legal Instruments on China's Accession to the World Trade Organization, the TRQ of corn for year 2002 should be 5.85 million metric tons.
- Cotton – According to the Compilation of the Legal Instruments on China's Accession to the World Trade Organization, the TRQ of cotton for year 2002 should be 818,500 metric tons.

The reason for selecting the import of three products for scenario analysis is based on the following consideration. The JAPA model is an equilibrium model—all resources are movable. If only cotton is imported into the Chinese market, the resources (land, labour etc.) can move to the production of wheat, corn and other products, which means the import of one product would not bring a huge impact on Chinese agriculture. Wheat, corn and cotton are three important products which have no competitive advantage in China. When large imports of all three agricultural products enter the Chinese domestic market at same time, it could bring enormous impacts to Chinese agricultural production, the agricultural resources surplus may happen and prices of agricultural products may decrease.

The scenario analysis tries to find if the import TRQs for the above three commodities can fully enter Chinese markets, and what could be the consequences. For the simulation year, it is assumed that at the end of 2001 China will join the WTO, therefore the simulation assumption is the import TRQs of wheat—8.468 million metric tons, corn—5.85 million metric tons and cotton—818,500 metric tons in 2002.

Actually the JAPA model is designed only for Jiangsu province, so it is necessary to divide the total TRQs into the different provinces in China. Jiangsu province gets its shares of TRQs according to its production share, because the simulation tries to find the impacts on agricultural production. Therefore the scenario assumptions for the simulation of import TRQ shares of Jiangsu and the other assumptions are:

- Wheat – 632,083 metric tons;
- Corn – 97,861 metric tons;
- Cotton – 57,589 metric tons;
- The industrial demand for cotton increases by 3 per cent;
- China has not made great progress in agricultural export.

Other external conditions assumptions remain unchanged as the baseline projection. The simulation results will be discussed in the next chapter.

4.2.4 Cost-benefit analysis and economic valuation

The most widely practiced analytical technique for project appraisal is cost-benefit analysis, commonly known by its acronym CBA. The cost-benefit analysis is an attempt to put the concepts of sustainability into practice, using a common indicator in the development of the project's decision making. The main difficulty lies in putting a monetary value on social and environmental costs for which no market prices generally exist. Some form of shadow pricing for both marketed and non-marketed commodities becomes necessary. This section discusses the methodology of economic valuation of social and environmental impacts.

Economic valuation of social impacts

The model scenario analysis results show a decrease in agricultural employment. The reduction in agricultural employment is expressed in terms of agricultural labour working days. The current wage rate in the agricultural labour force per working day can be consid-

ered as the opportunity cost, therefore the decrease of agricultural employment can be evaluated as the total opportunity cost of the agricultural employment reduction in working days.

The model scenario analysis results also show a decrease in utilization rates of cultivated land—valuable land lies waste. The average shadow price of the cultivated land estimated by the partial equilibrium model can be considered as the land rent. The model baseline projection shows the average shadow price of all agricultural cultivated land is 155 RMB per hectare. Therefore this shadow price of the unused cultivated land is the opportunity cost of cultivated land which lies waste. Other social impacts such as social instability cannot be evaluated here.

Economic valuation of environmental impacts

It is relatively difficult to make an economic valuation of environmental impacts, because the consequences of some environmental problems are very hard to estimate.

1. Pesticide pollution

Cotton is one of the crops most susceptible to insect damage, and the production of cotton consumes 25 per cent of all insecticides used in the world (Patagonia, INC, 1996, cited in Shaw et al., 1997).

Among the three cotton producing regions in China, Xinjiang has the least amount of insect problems and therefore uses less pesticides input for cotton production. The Huang-Huai region and Yangtse River regions, however, are frequently troubled by insect infestations. On average, insecticides costs per hectare in these two regions are 13.4 per cent higher than that in the US (Mao, 2000).

Insects that cause the most problems are the cotton bollworms. In some parts of China, the second and even third generations of cotton bollworms often occur. Cotton bollworms have detrimental effects on cotton yield. Since 1992, cotton production in areas along the Yellow River has been suffering from cotton bollworm infestations. In Hebei for example, from 1991 to 1992, its cotton output decreased by 52 per cent as a result of bollworm attacks and in 1993 cotton output was further reduced by 47 per cent from the 1992 level due to a bollworm calamity compounded by severe verticillium wilt and drought (Yu et al., 1996).

When faced with serious insect problems, it is very hard to persuade farmers not to use insecticides if alternative solutions are not readily available. What makes it even harder for the farmers to reduce insecticide use is the relative profitability of cotton compared to other crops, and a sudden outbreak of disease or insect infestation may cause enormous damage to yield. Farmers thus feel compelled to apply large doses of insecticide to reduce the risks of immediate loss. Sometimes this eagerness to protect the yield may lead to over-use of insecticides—insecticides are sprayed more frequently and in higher concentrations than necessary. The excessive use serves only to poison the environment instead of the insects. According to estimates, the utilization rate of pesticides is only about 30 per cent, the remaining 70 per cent of the pesticide remains in the soil, or is drained with rainwater into rivers and lakes. According to our survey, the average pesticide input quantity is about 1,500 grams per hectare in cotton production; so only 450 grams of pesticide is actually effective, the remaining 1,050 grams will pollute the environment.

The environmental pollution is converted in the following way:

$$PE_i = \frac{QG}{D_i} \quad (4.13)$$

where

- PE_i : converted quantity
 Q : quantity of waste in grams
 C_i : concentration of pollution object
 D_i : conversion rate

According to the standard issued by the Environmental Protection Administration, the conversion rate D_i for pesticides is 50. The average concentration of pesticide is assumed as 20 per cent.

It is also important to assign economic value to the converted pollution quantity. Because it is difficult to estimate the direct and indirect damage pollution has on human health, on wildlife, on water, soil and air, an effective way is to find the shadow price for treating the environmental pollution. For the shadow price we use the official standard for pollution made by the Chinese State Environmental Protection Administration—1.4 RMB per PE (converted quantity).

According to the equation (4.13) the converted quantity (PE) of pesticides is 4.2 per hectare; multiply by 1.4 to get the shadow price to treat environmental pollution, the cost is 5.88 RMB per hectare in cotton production. This can be considered as the cost of the environmental pollution for the cost-benefit analysis.

The applied quantity of pesticide varies according to the crops; the converted quantities and the shadow prices of pesticide pollution of main crop production per hectare are calculated and listed in table 4.2.

TABLE 4.2

Converted quantities and shadow prices of pesticide pollution per hectare

	<i>Converted quantity</i>	<i>Shadow price</i>
Wheat	0.8	1.13
Barley	0.5	0.73
Rice	1.9	2.62
Corn	0.4	0.50
Soybean	0.4	0.59
Rapeseed	0.5	0.65
Cotton	4.2	5.88
Fruit	11.8	16.48

Source: Author's calculation.

2. Chemical fertilizer pollution

The main environmental impacts of fertilizer application arise when it is not properly used, or when (climatic) conditions are not as predicted. In China, fertilizers used for cotton accounts for 50 per cent of all physical inputs for the country as a whole (Mao, 1999). According to estimates, the utilization rate of chemical fertilizer is about 35 per cent, the other 65 per cent remains in the soil, or is drained with rainwater into rivers and lakes. A research project on agricultural pollution carried out by the Nanjing Soil Research Institute of China's Science Academy⁵ showed that the levels of fertilizers draining into rivers and lakes varied according to the soil type, method of fertilizer application, time of fertilizer application and amount of rainfall. An experiment in 1988 showed that on dry cotton-production land the fertilizer draining into rivers and lakes is 8.7 kilograms per hectare (calculated in pure nitrogen), about 2.6 per cent of the applied chemical fertilizer. The current survey calculated (according to an average chemical fertilizer input quantity of 365.4 kilograms per hectare), that in each cotton growth season, 9.5 kilograms of chemical fertilizers per hectare (calculated in pure nitrogen) are drained with rainwater into rivers and lakes. This level is harmful to humans and fish.

Although 65 per cent of the applied chemical fertilizers cannot be used for current crop growth, they may be useful for growth in the next season. Additionally, the soil degradation caused can be solved by the application of organic manure or compound fertilizers to adjust the balance of nitrogen (N), phosphorous (P), potassium (K) and other elements. Therefore we focus the measurement of chemical fertilizer pollution on the chemicals that are drained into rivers and lakes. According to the above mentioned study, about 6.9 per cent of applied chemical fertilizers in paddy fields drains into rivers and lakes. The percentage of applied chemical fertilizers drained into rivers and lakes is assumed as 2.6 per cent for dry-land crops (as in cotton production).

The applied quantity of chemical fertilizer varies in other crops as well. Here we convert all kinds of chemical fertilizer to pure nitrogen. According to the standard issued by the Environmental Protection Administration, the conversion rate D_i of pure nitrogen is 800. With the equation (4.13), the converted quantities and the shadow prices of chemical fertilizer in main-crop production per hectare are calculated and listed in table 4.3.

TABLE 4.3

Converted quantities and shadow prices of chemical fertilizer pollution per hectare

	<i>Converted quantity</i>	<i>Shadow price</i>
Wheat	11.89	16.65
Rice	39.55	55.37
Corn	11.22	15.71
Soybean	2.51	3.51
Rapeseed	10.71	14.99
Cotton	12.98	18.17
Fruit	19.91	27.88

Source: Author's calculation.

⁵ Nanjing Soil Research Institute. "Agricultural pollution and the control countermeasure", project report, 1990.

3. Plastic film pollution

Plastic film is widely used in cotton production. After harvesting, a large quantity of broken film will remain in the fields, and may hamper crop growth in the next season. This problem becomes very serious where mechanized farming is carried out. In Xinjiang the problem of remaining film in cotton fields is called “white pollution”, and is their biggest environment problem. According to a survey by the Agriculture Department of Xinjiang in 1999, the remaining film in the cotton fields has amounted to 52.8 kilograms per hectare on average (Mao, 2000), which causes about 15 million RMB in direct economic loss in cotton production each year. On average about 60 per cent of the cotton field is covered by plastic film. Calculating according to a rate of 20-30 per cent of remaining broken film, the average quantity of remaining broken film in the cotton fields is 15 kilograms per hectare, and within 3 years it can reach 45 kilograms—about 360 thousand broken pieces. The broken films can remain for 100 years without degrading, and can bring enormous damage to agricultural production. When the amount of remaining broken film reaches 37-45 kilograms per hectare, it can reduce wheat yields by 7 per cent, vegetable yields by 10 per cent or cotton yields by 10-15 per cent. The average estimated value is about 818.3 RMB per hectare for three years of accumulated remaining broken film. Therefore the average valuation of “white pollution” is estimated at about 272.8 RMB per hectare per year.

In other provinces where farm mechanization is not carried out in cotton production, the problem of remaining film is not so serious, because farmers can find the film and remove it during ploughing. Therefore the impact of broken films is not considered in the cost-benefit analysis in Jiangsu province.

4. Irrigation problems

Cotton is a high-volume water user. Therefore, water is a very important input in cotton cultivation. In China, the annual water use for cotton amounts to 1,500-9,000 m³ per hectare (Mao, 1998). China’s cotton producing regions are mostly arid and semi-arid regions and cotton production in these regions has been a major contributor to severe water shortages. In south Xinjiang, water diversion for cotton irrigation is drying up the lower reaches of the rivers in its domain.

To make the large volume of water use even more unsustainable are the inefficient irrigation practices. In China’s cotton producing regions, the utilization ratio of irrigation waters is only 30-40 per cent, which is 20-30 per cent lower than those of industrialized cotton producing countries. According to research conducted by the Agriculture Department of Xinjiang, cotton yield has a clear relationship with irrigation; when irrigation water is below 6000-8250 m³ per hectare, the un-ginned cotton yield will be below 2250 kilograms per hectare; when irrigation water reaches 8250-9000 m³ per hectare, the un-ginned cotton yield can reach 2250-3375 kilograms per hectare; when irrigation water is above 9000 m³ per hectare, the un-ginned cotton yield can reach 3375-4125 kilograms per hectare (Mao, 2000).

South-east China is a wet or semi-wet region, where rainfall is abundant, so irrigation is not a problem for agricultural production. The irrigation fees (energy and labour costs for irrigation) are included in the production costs, but the irrigated water is not evaluated in the cost-benefit analysis in Jiangsu province, because farmers do not to pay the irrigation water charge.

5. INTEGRATED ASSESSMENT OF TRADE LIBERALIZATION

After China joins the WTO, both opportunity and challenge will confront the agricultural sector. The opportunities for agricultural exports could hold potential for the future, but for now the challenge concerns large-scale agricultural imports. The situation for the cotton sector is that China will import large quantities of cotton, promote textile industry development and increase the export of textiles and clothing.

Therefore the current challenge is that trade liberalization will cause large-scale agricultural imports mainly in wheat, corn, cotton and soybean oil etc. This country study mainly focuses on the cotton sector, but only one product import alone (cotton) will not bring huge impacts on China's agriculture, because farmers can produce more corn, wheat, soybean and rapeseed. But many agricultural commodities imported together into China's domestic market could bring enormous impacts. As specified in the Compilation of the Legal Instruments on China's Accession to the World Trade Organization, China will adopt tariff-rate quotas for bulk commodities. For technical reasons the TRQ imports of the three bulk agricultural commodities (wheat, corn and cotton) are chosen for the integrated assessment of trade liberalization.

The JAPA model will be used to simulate the consequences of agricultural imports based on the assumptions in the baseline projection (4.2.2) and the scenario analysis assumptions (4.2.3). Comparing scenario analysis results with the baseline projection, the impacts of large-scale imports of the three commodities can be assessed. On this basis the social, economic and environmental impacts will be analysed.

The integrated assessment aims to assess the consequences of the first two years of China's accession to the WTO, when large agricultural imports enter the Chinese market, with the assumption that China has not made obvious progress in agricultural exports because of technical limitations and 'green barriers'. The model scenario analysis showed the following results.

5.1 Economic impacts

In Chapter 4, the methodology of the JAPA model and scenario analysis is discussed. The model scenario analysis results indicate that the large imports of wheat, corn and cotton will bring enormous economic impact

1) Helps to solve the shortage of two commodities

The baseline projection shows that in 2002 Jiangsu will have shortages in cotton and corn, but not in wheat. Therefore the import of cotton and corn will help Jiangsu to solve the shortages.

2) *Sown area and output decrease*

The wheat, corn and cotton imports will bring great pressure on agricultural production, therefore the production structure should be adjusted to adapt to the change. According to the optimal solution of the partial equilibrium model, compared with the baseline projection, the sown area of wheat could decrease by 4.91 per cent, that of corn by 2.48 per cent and that of cotton by 3.82 per cent, and as a result of structural adjustments, the sown areas of other crops could increase; for example the sown area of rice could increase by 0.24 per cent and soybean by 0.86 per cent (see Table 5.1). But this sown area expansion will be limited by the levels of consumption. In any case the total sown area will decrease by 1.11 per cent, about 92,624 hectares.

TABLE 5.1

Simulated sown area, output and price changes

	<i>Sown area change</i> %	<i>Output change</i> Metric ton	<i>Price change</i> %
Wheat	-4.91	-436,294	-3.89
Barley	0.81	7,527	-1.06
Rice	0.24	42,902	-0.52
Corn	-2.48	-58,106	-0.57
Soybean	0.86	4,475	-1.01
Rapeseed	1.80	16,355	-2.99
Cotton	-3.82	-22,707	-2.84
Fruit	2.47	35,168	-1.23

Source: Model simulation results.

The production structure adjustments will also cause output change. Table 5.1 shows that the wheat output could decrease by 436,294 metric tons, corn by 58,106 metric tons and cotton by 22,707 metric tons; at the same time rice output will increase by 42,902 metric tons, soybean by 4,475 metric tons, rapeseed by 16,355 metric tons and fruit by 35,168 metric tons.

3) *Price decreases of agricultural products*

The wheat, corn and cotton imports will cause price decreases, not only the prices of the three commodities, but also the prices of all other crop commodities, because the production structure adjustment increases the sown area and output of other crop production. The model scenario analysis results in Table 5.1 show that the price of wheat will decrease by 3.89 per cent, corn by 0.57 per cent, cotton by 2.84 per cent, rice by 0.52 per cent, soybean by 1.01 per cent, rapeseed by 2.99 per cent and fruit by 1.23 per cent, comparing with the baseline projection.

The price decrease of agricultural commodities is favourable to consumers, and is also favourable to animal production because some main products and by-products are used as feed, but it is unfavourable to producers of agricultural commodities.

4) *Producer surplus and farmers' income decrease*

The wheat, corn and cotton imports will cause farmers to reduce the production of the three products, and at same time increase the production of other products to a small extent. Although it could bring positive income effect accruing from increased production of rice, soybean, rapeseed, fruit and barley, in general after agricultural production structure adjustment, the producer surplus for crop products will decrease by 3.2 per cent. Owing to the price decrease alone, farmers' income from crop production will decrease by 921.75 million RMB.

5.2 Social impacts

Besides the above economic impacts, large-scale imports of wheat, corn and cotton will also bring enormous social impacts.

1) *Promote agricultural production structure adjustment*

The trade liberalization should promote agricultural production structure adjustments according to the comparative advantage. China needs to find its position in the global marketplace, and reallocate resources to the products which have comparative advantage.

2) *Utilization rate of cultivated land decrease; valuable land lies waste*

Jiangsu province in south-eastern China, carries out a multi-cropping system of production, so there may be two or three harvests in one field. There are many combinations of cropping patterns, so sown area and cultivated land usage are differentiated. Planting-packages for multi-cropping systems are used in the JAPA model. After agricultural production structure adjustments according to the imports increase, the model scenario analysis results indicated that valuable cultivated land cannot be sufficiently used, and about 92,624 hectares will lie waste.

3) *Reduction in the self-sufficiency rates of agricultural commodities*

Owing to the three commodity imports, after production structure adjustments, the self-sufficiency rate of the three agricultural commodities will decrease, i.e., the self-sufficiency rate of wheat decreases from 144 to 137 per cent, that of corn decreases from 40 to 38 per cent, and cotton from 91 to 87 per cent, while the self-sufficiency rate of rice increases from 124 to 125 per cent, that of soybean from 35 to 36 per cent, rapeseed from 81 to 82 per cent and fruit from 159 to 160 per cent.

4) *Agricultural employment decrease*

The model scenario analysis results also show that after agricultural production structure adjustments, owing to the decrease of agricultural production, agricultural employment decreases by 16.55 million working days—farmers do not have enough work to do. Unemployment in the agricultural sector will increase.

5) *Poverty and social instability*

Poverty is still a big problem in China. About 60 million rural residents are still below the poverty line; they are mostly located in less developed areas, where agricultural production constitutes their main source of income. Decrease in farmers' incomes could worsen the poverty in rural areas. The decrease in farmers' incomes and the increase in unemployment could be factors for social instability. Additionally, if large numbers of farmers move to urban areas to find jobs, it could also worsen unemployment in urban areas.

5.3 Environmental impacts

The model scenario analysis results show that large-scale imports of wheat, corn and cotton may have environmental impacts.

1) *Reduction in the application of chemical fertilizers and pesticides*

The wheat, corn and cotton imports will necessitate agricultural production structure adjustments; according to the optimal solution of the partial equilibrium model, the sown area of crop products will decrease. This could result in a decrease in the application of chemical fertilizers and pesticides. The reduction may include two parts: firstly, the production structure change causes the sown area decrease, which will reduce the inputs that include chemical fertilizers, pesticides, water etc. The model scenario analysis shows that the usage of chemical fertilizers will decrease by 1.01 per cent and pesticides by 1.39 per cent, comparing with the baseline projection. Secondly, owing to the decrease in prices of agricultural products, farmers could reduce the quantities of applied chemical fertilizers and pesticides. For example, as the cotton purchase price decreased from 12,350 RMB in 1998 to 7,660 RMB per metric ton in 1999, farmers reduced the applied quantities of chemical fertilizer by 6.42 per cent and pesticide by 29.82 per cent (the change in pesticides application was also related to the disease and pest conditions).

2) *Cultivated land may be lost*

Cultivated land is a very important resource for agricultural revival. China is a 'cultivated-land-scarce' country; cultivated land per capita is 0.11 hectares. In Jiangsu province the cultivated land is even less, only 0.07 hectares per capita and 0.185 hectares per agricultural labour force in 1999. The average rate of decrease in cultivated land was 0.3 per cent for the last 15 years, meaning that China has lost on average 282 thousand hectares of valuable cultivated land each year. In such circumstances, the waste of cultivated land could be a very serious problem for the sustainability of agricultural development.

After agricultural production structure adjustments owing to the imports increase, the model scenario analysis results indicated that the valuable cultivated land cannot be sufficiently used—about 92,624 hectares of cultivated land will lie waste, which will impair sustainability of China's agricultural production.

If cultivated land lies waste, this cultivated land may be used for non-agricultural purposes, such as city extension, industry and building, which will further reduce sustainability of agricultural production. In north-western China, if the cultivated land is not used and irrigated it may simply turn to wasteland. The decrease of cultivated land has been a serious phenomenon in China.

6. EVALUATION OF TRADE LIBERALIZATION

Based on the JAPA model, the scenario analysis results and the integrated assessment above, the impacts of trade liberalization will be valued in order to make the cost-benefit analysis.

6.1 Economic impacts

The model scenario analysis results show that agricultural imports can help China to solve the shortages of agricultural commodities. Jiangsu will meet its shortages in corn and cotton in 2002, therefore bringing positive impacts. This is valued as a benefit of about 871.56 million RMB.

To adapt to agricultural importing, the agricultural production structures should be adjusted. The sown areas and outputs of some agricultural products will decrease and farmers will face losses. For example, after production structure adjustments, the output of wheat will decrease by 436,294 metric tons, valued at 521.37 million RMB; that of corn decreases by 58,106 metric tons, valued at 71.12 million RMB; that of cotton decreases by 22,707 metric tons, valued at 296.42 million RMB. On the other hand, the output of rice increases by 42,902 metric tons, valued at 51.56 million RMB; that of soybean increases by 4,475 metric tons, valued at 12.67 million RMB; that of rapeseed increases by 16,355 metric tons, valued at 48.13 million RMB; that of fruit increases by 35,168 metric tons, valued at 26.77 million RMB. The aggregated impact of the outputs change for all agricultural products is valued at 703.62 million RMB.

The large agricultural imports will cause price decreases in all agricultural commodities. Table 5.1 shows that the price of wheat will decrease by 3.89 per cent, the price of rice by 0.52 per cent, corn by 0.57 per cent, soybean by 1.01 per cent, rapeseed by 2.99 per cent, cotton by 2.84 per cent and fruit by 1.23 per cent. The price decreases are negative impacts on the producers of agricultural products, but they are positive impacts to consumers. The impact of aggregated price decrease is valued as 921.75 million RMB.

The above two impacts constitute for the most part a decrease in farmers' income. Another factor affecting farmers' income could be the decrease of agricultural employment which will be discussed under social impacts.

After accession to the WTO, China will reduce the tariff to 1 per cent within TRQs, so government tariff income will decrease. The tariff decrease for the three commodities within TRQs is valued at 1,018.55 million RMB.

China will have to pay foreign currency to import agricultural commodities, and the cost for importing the three commodities is valued at 1,626.90 million RMB. This should be netted for current expenditures on the three agricultural products, roughly 703.62 million RMB. Therefore the net outlay on imports would be 923.28 million RMB.

6.2 Social impacts

The model scenario analysis results also indicate that agricultural imports could bring social impacts. As a side effect of the decrease in area sown, the agricultural employment will decrease by 16.55 million working days. Calculated according to the current agricultural labour force wage rate, the opportunity cost of the increased unemployment is 148.95 million RMB.

After agricultural production structure adjustments, the utilization rate of cultivated land will decrease and about 92,624 hectares cultivated land will lie waste, which will impair sustainability in China's agricultural production. The average shadow price of the cultivated land estimated by the partial equilibrium model is 155 RMB per hectare. Therefore the opportunity cost of cultivated land that lies waste is 14.36 million RMB.

Trade liberalization could promote agricultural production structure adjustments according to comparative advantage, but the impact is not possible to evaluate at this time.

6.3 Environmental impacts

Agricultural commodity imports could reduce the area sown for crops, so it also reduces the quantities of chemical fertilizers and pesticides applied. Table 5.1 shows the simulated change of sown area for crop products, and Table 4.2 shows the shadow prices of pesticide pollution per hectare for each crop products, Table 4.3 shows the shadow prices of chemical fertilizer pollution per hectare, and these can be used to estimate the impact on the environment.

If we consider the reduced application of chemical fertilizers and pesticides caused by a decrease in sown area, the reduction of pesticide application can be valued at 0.10 million RMB, and the reduction of chemical fertilizer application can be valued at 1.11 million RMB.

Owing to irrigation, soil degradation is not a problem in Jiangsu province, and the plastic film pollution is not serious here because mechanized farming is not carried out in cotton production. These factors are therefore not considered in the CBA.

6.4 Net impacts (benefits/costs)

Cost-benefit analysis (CBA) is a framework that allows the monetized costs and benefits of a project or policy to be compared, using the various valuation tools, and is a useful way of converting all the information relevant to the assessment of a proposed action into a comparable and easily understood form. The CBA can be undertaken *ex ante* or *ex post*, which could help policy makers to understand the net benefits of a project or policy. In this section the CBA will be applied to assess the impacts of the import TRQs of the three agricultural commodities. Because it is very difficult to assign economic value to some indirect social and environmental impacts, the CBA only includes impacts which can be valued. The results of the CBA is listed in Table 6.1.

TABLE 6.1

Cost-benefit analysis of the impacts in the agricultural sector in Jiangsu

	million RMB
Costs of the import TRQs of the three agricultural commodities	
Agricultural output value changes	703.62
Prices of agricultural products decrease (for producer)	921.75
Agricultural employment decrease	148.95
Tariff loss	1,018.55
Cultivated land lies waste	14.36
Payment for the import	923.28
Total costs:	3,730.51
Benefits of the import TRQs of the three agricultural commodities	
Solve the shortage of the two commodities (corn and cotton)	871.56
Prices of agricultural products decrease (for consumer)	921.75
Reduction of pesticide application	0.10
Reduction of chemical fertilizer application	1.11
Total benefits:	2,427.20
Net cost:	1,303.31

Source: Author's calculation according to simulation results.

Table 6.1 shows that after the import of the three agricultural commodities (TRQ), the agricultural production structure change could cause agricultural output value to decrease by 703.62 million RMB; the price decrease will reduce farmers' income by 921.75 million RMB; the agricultural employment will decrease by 16.55 million working days, the opportunity cost is valued as 148.95 million RMB; after China decreases the tariff rate to 1 per cent, the tariff loss for the TRQ import of the three commodities is about 1,018.55 million RMB; the opportunity cost of the cultivated land which lies waste is valued as 14.36 million RMB, and the payment for the import of the three commodities is about 923.28 million RMB. Therefore the total cost is 3,730.51 million RMB in Jiangsu province.

On the other hand, the imports can solve the shortages of corn and cotton in Jiangsu (Jiangsu does not have a wheat shortage), so the benefit for this is valued at 871.56 million RMB; and the price decrease of agricultural commodities is a positive impact to consumers, so it brings 921.75 million RMB in benefit to consumers. Additionally, the agricultural imports can reduce the use of pesticides and chemical fertilizers, reducing environmental pollution. The benefits are about 0.10 million RMB and 1.11 million RMB respectively, therefore the total benefit is 2427.20 million RMB in Jiangsu. Because in Jiangsu irrigation water is abundant, there are no water quotas used, therefore the irrigation factor is not evaluated here.

Comparing total costs and total benefits in Jiangsu, assessment of the net cost of importing the three commodities is 1,303.31 million RMB. However, this estimated net cost applies only to the agricultural sector in Jiangsu, the benefits to city extension, industry and building, to textile industrial production and export are not included, which will be estimated by each sector. For example, if Jiangsu can increase textiles exports by 5 per cent, the export revenue could increase by US\$ 230.45 million, roughly 1,843.6 million RMB.

7. PROPOSED POLICY PACKAGES

The scenario analysis results show that trade liberalization policies do not always bring benefits and that the economic benefits accruing from trade liberalization are not equal among sectors and countries. At same time, trade liberalization may bring social and environmental impacts, such as unemployment, poverty and environmental pollution. Based on the above analysis, this chapter aims to propose policy recommendations to mitigate the negative and enhance the positive impacts, provide a strategy for sustainable development in cotton production, and submit suggestions for establishing a market-oriented cotton marketing system.

7.1 Main impacts identified

7.1.1 Impact of China's accession to the WTO on the cotton sector

According to the schedule of the Compilation of the Legal Instruments on China's Accession to the World Trade Organization, China will permit imports of 818,500 metric tons of cotton at a duty of 1 per cent in 2002. This volume will grow to 894 thousand metric tons by 2004. Imports above these levels will face a higher duty of 61.6 per cent, which will be reduced to 40 per cent by the year 2004. China made specific commitments to administer these TRQs so as to maximize the potential that they will be filled; specifically, if TRQs are not utilized they will be redistributed to other end users who have an interest in importing. Moreover, 33 per cent of the TRQ will be reserved for importation through state trading enterprises and 67 per cent will be reserved for non-state trading entities. Finally, if a TRQ share that was reserved to be imported by a state trader is not contracted for by October for any given year, it will be reallocated to non-state trading entities.

The TRQ for cotton is enormous in relation to China's cotton consumption. According to statistics, the cotton consumption level of the textile industry was 3.8 million metric tons in 1999. If China imports 818,500-894 thousand metric tons of cotton annually, the cotton import could take a share of 21-23 per cent of China's total cotton production. This will have a huge impact on Chinese cotton production, especially in the Xinjiang region. After its accession to the WTO, China will give up export subsidies, losing its export advantage in the world market.

7.1.2 The positive impacts identified

China's textile exports to developed countries will be greater after accession to the WTO, trade liberalization should boost Chinese textiles and clothing exports, which will bring a high demand for cotton. The agricultural imports could solve the shortage problems of some agricultural commodities; it also promotes agricultural production structure adjustments according to comparative advantage. On the environment, the cotton imports could

reduce the acreage of planted cotton, and thus reduce the quantities of chemical fertilizers and pesticides applied.

7.1.3 The negative impacts identified

China's accession to the WTO may increase uncertainty for Chinese textiles and clothing exports. The Agreement on Sanitary and Phytosanitary Measures (SPS) could be used by some countries to hinder imports, which could cause enormous fluctuation in the production and price of textiles.

As the cotton sector is closely linked to the textiles industry, any fluctuation in the production and price of textiles may cause uncertainty for cotton production and price. The cotton import increase (TRQ) could bring enormous shock to domestic cotton production and marketing. The sown areas and output of cotton will decrease; the price of cotton in the domestic market will decrease; agricultural employment will decrease and these will reduce the benefits to cotton farmers. The decrease in farmers' incomes could worsen the poverty in rural areas and may cause problems of social instability.

If China cannot make great progress in agricultural exports, the large-scale imports could cause social and environmental difficulties: the utilization rate of cultivated land will decrease; the self-sufficiency rate of cotton production will decrease; valuable cultivated land could lie waste or be occupied for non-agricultural purposes such as city extension, industry and building, which may impair the sustainability of China's agricultural production.

7.2 Proposed policy recommendations to mitigate the negative and enhance the positive impacts

7.2.1 Increasing the competitive advantage of Chinese cotton

After China joins the WTO, both opportunity and challenge will confront the agricultural sector. China's domestic markets will become a part of the global market. As China imports some products, it should adjust its production structures and develop a long-term strategy for agricultural exports. Therefore it is important to increase the competitive advantage of cotton.

1) Supporting agriculture with 'Green box' policies

The agricultural basis in China is weak, and agricultural input is very low compared to other countries. Agricultural production has a low resistance to natural disasters such as drought, flooding, typhoons and plagues of pest or disease. For example, the main cotton producing regions are located in the dry or semi-dry areas to the north of the Yangtse River and water shortage is a restrictive factor for the sustainable development of cotton production. It is important to use 'Green box' policies to build water conservation projects and improve irrigation systems to protect the agricultural environment, to improve rural infrastructure, to establish marketing information services and to invest in research, training and extension in agriculture. (Recommendation to Ministry of Agriculture (MOA)).

2) *Promoting new cotton varieties*

For long time now, Chinese cotton variety breeding has aimed at increasing yields without paying much attention to improvement in quality. After China's accession to the WTO, Chinese agricultural products will face not only the competition of prices, but also competition in variety and quality. Local governments will need to invest more to promote technological innovation in order to increase the product quality.

The prevalent varieties of Chinese cotton have an average length of 29-31mm and an average fineness of 5500-6500 m per gram, which is well above world average. There is a big demand for the long-staple variety, the medium long-staple variety, the variety with a fibre strength of 23-28 gf/tex, micronaire 3.7-4.2, and varieties which are resistant to blight, cotton wilt and pest. (Recommendation to MOA, research institutes.)

3) *Promoting the production of special-purpose cotton*

Because textile industries are required to produce high-quality products, they impose increasing demands for special-purpose cotton, such as long-staple cotton, medium long-staple cotton, colour cotton and organic cotton. Owing to climatic conditions, Xinjiang has an advantage in producing long-staple cotton and organic cotton. The Huang-Huai region and Yangtse River regions may try to produce medium long-staple cotton and colour cotton. (Recommendation to MOA, farmers.)

4) *Adjusting regional distribution*

Mainland China has 31 provinces, out of which 24 provinces produce cotton. Some provinces have a strong comparative advantage, while others do not. So production capacities and future demand should be analysed and regional cotton distribution should be adjusted in order to shift production to regions that have a comparative advantage. There are 10 top cotton producing provinces which can be considered as the cotton production zone. Local government should invest capital in the construction of farmland and also in developing new varieties through technological extension to stabilize cotton production. (Recommendation to MOA, local governments.)

5) *Establishing cotton-production cooperatives (sector association)*

China is a 'cultivated-land-scarce' country—cultivated land per capita is 0.11 hectares. In Jiangsu province the cultivated land is even less, only 0.07 hectares per capita and 0.185 hectares per agricultural labour force in 1999. This small amount of cultivated land is normally divided into separate plots, a situation that results in low land productivity and also low labour productivity. The low levels of production cannot suit the big markets—it is not possible to increase production efficiency over small scattered plots. This also restricts demands for agricultural inputs and hinders the application of new technology, which is not favourable to improving the quality of agricultural products.

Establishing cotton production cooperatives is a possible solution. The cooperative is organized by farmers on the principle of voluntary participation. It is an economic corporate organization and can assume a legal status. The cooperative will have the ability to purchase good quality cotton seed, cultivate one variety in one region in order to ensure quality, and demand high prices for high quality products. Additionally, it can increase

agricultural inputs, introduce new varieties and benefit from technological innovations. Finally it can negotiate production orders with end users in order to stabilize production and ensure farmers' income. The establishment of cotton production cooperatives can be top down and bottom up at the same time.

The cotton production cooperatives should formulate a system that has three levels: the lowest level (town and village level) of the cooperatives will be responsible for farm production and management; the middle level (prefectural and county level) of the cooperatives will be responsible for communication with scientific research and extension institutions for new variety introduction or technology innovations, and will negotiate production orders with cotton end users; the highest level (national and provincial level) of the cooperatives will be responsible for designing cotton production strategy, researching the global cotton supply and demand situation with the support of research institutions, and deciding on production structure adjustments. (Recommendation to MOA, local governments and farmers.)

7.2.2 Maintaining a balance between supply and demand

The ultimate objective in government intervention in cotton production is to maintain a basic balance between supply and demand and avoid fluctuations. This balance includes regional balance and variety balance. Although Xinjiang province has the advantage in cotton production, China cannot move all its cotton production to Xinjiang—the limitations of cotton production in Xinjiang lie in irrigation water supplies, uncertainty of natural disasters, transport capacity and regional cotton processing capacity. Creating regional balance means that cotton production quantities should be decided according to the regional processing capacity, transport capacity and cost, natural resources limitations, and it should try to minimize the risks of natural disasters.

Different textile industries require different grades and varieties of cotton. Some textile industries need long-staple cotton to produce high-quality textiles, some need short-staple cotton to produce jeans, some need organic cotton and others require colour cotton. Given the need for variety, China should not only pursue the supply and demand balance of aggregate cotton quantity, but should also balance the availability of the main grades and varieties of cotton.

1) Analysing the impacts of China's accession to the WTO and deciding on cotton production scale and distribution

After China's accession to the WTO, the supply and demand situation of agricultural products could change, therefore the production structure and resource allocation should be adjusted. The production structure adjustment is not simply a matter of changing the ratio of grain products to cash crops, but deciding on the production quantities of products according to the comparative advantage. There are many constraints in agricultural production, such as resource limitations, potential demand, import and export possibilities. The complement and supplement relationship among products is very complex, which could be solved by applying the Computable General Equilibrium model (CGE). The next target is to establish a Chinese Agricultural Policy Analysis model (CAPA) to provide a quantitative basis for the agricultural structure adjustment of each province. This model considers each province as one region, the regional trade is considered as an endogenous variable, the foreign trade (import and export) is considered as an exogenous variable. Under the multi-

channel constraints, the model will find the optimal production levels for each major agricultural commodity for each province. (Recommendation to MOA.)

2) *Completing the multi-channel cotton marketing system and promoting lateral cooperation among different cotton marketing entities*

After the old cotton-marketing monopoly is abolished, chaos in the cotton markets can be expected. The “cotton war” in 1999 was characterized by different cotton marketing entities redividing shares in the cotton market. China is in the process of establishing a new, open cotton marketing system. It will be important to coordinate relationships between the different entities in order to avoid vicious competition.

In the current situation, the different cotton marketing entities have their advantages and disadvantages, and it is necessary to promote lateral cooperation amongst them. For example, the textile mills could cooperate with the cotton gin factories of the Supply and Marketing Cooperatives (SMC) in purchasing and processing the cotton; the textile mills could provide a purchase fund and the cotton gin factories of the SMC purchase and process the cotton, both of them benefiting from this cooperation. (Recommendation to SMC.)

3) *Promoting the production of cotton to order*

One approach for balancing the production of cotton grades and varieties is to promote the production of cotton to order. The textile industries and cotton production cooperatives (or farmers) can contract cotton production and purchasing. The contract should indicate the purchase quantity, variety, grade and price; the purchase price will be decided according to the price in the wholesale market at the harvest season (for example 5 per cent higher than the price of the National Cotton Exchange). The textile industries will pay earnest money to the cotton production cooperative, both parties to the contract should take legal responsibility. This method will ensure that the textile industries can be supplied with the qualified cotton when they have special requirements for quality and variety, while at the same time it can stabilize cotton production. (Recommendation to MOA, textile factories and farmers.)

4) *Improvement of the cotton wholesale market*

A National Cotton Exchange was established in April, 2000 in Beijing. It has 122 seats, 77 belong to SMCs, 35 to textile industry entities and 10 seats are allocated to cotton import and export companies. Although the Exchange has established 20 stations through its frame of networks, it is only allowed to make deals in Beijing Central Station, in other stations it is only possible to observe the auction information.

There are still improvements to be made to the National Cotton Exchange; the Exchange only sells old cotton (cotton stocks and reserves) and Xinjiang cotton at auction, a very large quantity of ‘new cotton’ is excluded. Therefore the Exchange does not provide a ‘price signal’ for new cotton, so it is urgent to include new cotton at the National Cotton Exchange auctions.

There are only 122 seats in the National Cotton Exchange, which is too few for all the cotton marketing dealers in the whole of China. The future target of the Exchange should

be that every cotton marketing dealer with a license is entitled to a seat in the Exchange, and any kind of cotton can be traded in any network station of the Exchange.

Besides the National Cotton Exchange, China needs ‘on the spot’ cotton transaction markets in the main cotton producing regions. For a long time, the Chinese Government did not allow on the spot cotton transaction markets, in order to ensure SMC monopoly. After the monopoly marketing system is removed, it will be necessary to establish on the spot cotton transaction markets in the main cotton production regions. (Recommendation to SMCs.)

5) *Establishing a textile exporter association*

After China’s accession to the WTO, many enterprises could have licenses to export textiles and clothing, and it would be advisable to establish a textile exporter association in order to avoid vicious competition and to guarantee product quality. China’s textile industry should change strategy from producing low-price products to producing medium-price/medium-quality products and even high quality products (such as organic cotton or colour cotton products). (Recommendation to Ministry of Foreign Trade and Economic Cooperation (MOFTEC), textile companies.)

6) *Establishing an agricultural consulting system*

After the economic reform, the production plans made by the Government in the agricultural sector were abolished. Farmers can now make their own production decisions, but they may be confused by different information. The most important information farmers need to know is—what crop and how much should be produced in order to sell at good price?

An agricultural consulting system can engage in the collection and analysis of marketing information, providing a service to farmers to guide their agricultural production. As a semi-government organization the agricultural consulting system works as an intermediary between the Government, the industrial processing enterprises of agricultural products, wholesale markets and cooperatives and farmers. After China’s accession to the WTO, China will have to adjust the structures of agricultural production, and the consulting system can work with government policy makers, marketing research institutions, wholesale markets, agricultural cooperatives and farmers to realize the agricultural production structure adjustments. (Recommendation to MOA.)

7.2.3 Stimulate sustainable development in the cotton sector

Sustainable production is defined as “production that meets the needs of the present and does not hamper the ability of future generations to satisfy their needs.” A ‘weak’ interpretation of the sustainability criterion is that there should be no irreversible effects caused by pollution or depletion of natural resources. A ‘strong’ interpretation would be that current production is undertaken in such manner that even reversible negative environmental impacts are avoided or neutralized. An operational interpretation of the latter is offered by Kox and Stellinga (1992:17-19). They propose an agricultural production system that can be considered sustainable if seven ecological constraints are met:

- the nutrient status of the soil is left intact (or is restored);

- pollution emission (by fuel gases, agrochemicals) is absent or neutralized in the agricultural sector itself;
- on balance, no encroachment into natural landscapes, such as wetlands, natural forests, and mountainous regions, takes place. Agricultural expansion in one area may be compensated for by establishing by new reservations (wild areas) where wild animals can reproduce and live undisturbed;
- no contribution is made to endangering biodiversity;
- no contribution is made to depletion of fossil energy resources or other non-reproducible (mineral) stocks;
- no land erosion takes place due to agricultural activity;
- the resilience of the local ecosystem is left intact.

Although the Government also has to consider other policy objectives concerning income, equality, technology, financial constraints and the priorities under such constraints, the above objectives should be a part of policy-making instead of only the definition of sustainable agriculture, or there will never be a concrete judgment as to whether a certain production method is sustainable or not (Harry de Vries, 1995). Taking the environment seriously is a necessary but not sufficient step towards environmental policy. To provide coherence, the policy requires clear objectives and targets that derive from them. It also requires an appropriate set of instruments and a set of institutions capable of implementing it (Dieter Helm, 1996).

China is a big country and large quantities of chemical fertilizers, pesticides, plastic film and irrigation water are used in agricultural production. For example, in recent years, more than 1.6 million metric tons of chemical fertilizers, 6.7 thousand metric tons of pesticides, 40 thousand metric tons of plastic film and 368 million m³ of irrigation water are applied for cotton production annually in China, which must have enormous influence on the environment.

Different regions have different natural conditions and different degrees of dependency on unsustainable production methods. Therefore, in transition to developing sustainable cotton production, there should be alternatives to choose from.

1) Carrying out an integrated assessment on environmental impacts

When a country tries to accelerate economic growth through trade liberalization, it should also consider the possible negative impacts on the environment as a side effect. It is necessary to enhance any integrated assessment of environmental impacts with the methodological approach suggested by UNEP, to increase government and public awareness on environmental issues, and to address the relationship between economic development and environmental protection. AERI and the State Environmental Protection Agency (SEPA) can organize training workshops on the integrated assessment of environmental impacts of trade liberalization. (Recommendation to SEPA.)

2) Decreasing the application of chemical fertilizers

One of the environmental problems with cotton production is that the utilization rate of chemical fertilizer is very low (about 35 per cent), and a large proportion of the product

is wasted and causes environmental pollution. China should therefore support research and extension into using chemical fertilizers more efficiently. If the utilization rates of chemical fertilizer can be increased to 45-50 per cent, the quantities of chemical fertilizers that are applied could be reduced.

Even though all fertilizers have adverse effects on the environment, natural manures are prone to cause less problems than chemical fertilizers. Crop rotation can also reduce the risk of mineral depletion—different crops use and replenish different minerals thus reducing the need to apply fertilizers. Plant residues can remain in the fields after harvesting so that the minerals within the crop stalks decompose back into the soil, lessening the pressure to apply chemical fertilizers. (Recommendation to SEPA and MOA.)

3) *Establishment of a pest and disease prevention service*

The utilization rate of pesticides in China is also very low (about 30 per cent). There are several reasons for this; firstly, farmers cannot find the right time to kill the pests in their early stages, so after the pest plague has become very serious, they have to use large quantities of pesticides to control the situation; secondly, farmers like to use over the recommended dose to be sure that the pests are killed immediately; thirdly, when farmers do not apply pesticides at the same time, pests can move from one plot to another to avoid exposure; fourthly, farmers like to buy low priced pesticides, which tend to be highly toxic, high residue and harmful to environment.

In order to increase the efficiency of pesticide application, a pest and disease prevention service should be established. The service will have contracts with farmers and production cooperatives to provide a service to control plant diseases and eliminate pests. The advantage of the service is that it will be able to predict plant diseases and plagues of pest and use appropriate pesticides to eliminate them efficiently, while at the same time minimizing the environmental pollution.

The local government may provide a starting fund for the establishment of the pest and disease prevention service; banks may provide low-interest rate loans; the pest and disease prevention service can buy pesticides directly from the factories at lower (wholesale) prices; charges of the pest and disease prevention service should be settled at a level comparable to the farmers' current costs. An experiment in Jiangsu showed that this method could decrease the applied quantity of pesticide by 50 per cent. (Recommendation to SEPA and MOA.)

4) *Integrated pest management*

Integrated pest management (IPM) consists of the careful integration of a number of available pest control techniques that discourages pest population development and keeps the use of pesticides and other interventions to levels that are economically justifiable and safe for human health and the environment. IPM emphasizes the growth of a healthy crop with the least disruption to agro-ecosystems, thereby encouraging natural pest control mechanisms. It seeks to reduce pest populations to economically manageable levels through a combination of biological control (use of pest-resistant varieties), culture control (e.g., crop rotation, inter-cropping), physical control (hand picking of pests), and less toxic chemical controls (use of *pheromones*). However, it does allow the use of chemical pesticides, even synthetic and toxic ones, only when there is a real need (Banuri, 1998).

A few countries in Asia, including China, have adopted national IPM policies, with the help of national and international agencies. Although these policies were targeted at rice production initially, their effects have subsequently spread to other crop sectors. Presently, a 12 million euros (€) project to enable small-scale cotton farmers in Asia to cut their insecticide use by half and increase their production is to be implemented by the FAO.⁶

The European Union-funded project will train 90,000 small cotton producers in integrated pest management. Six Asian countries are participating in the project; China, India, Pakistan, Bangladesh, the Philippines and Vietnam. The EU/FAO project provides for 3,800 Farmers' Field Schools. The schools use the participatory learning approach to educate farmers in IPM techniques, as has been done by Indonesia. Farmers will learn more about cotton agronomy, cotton agro-ecosystems and alternative pest control techniques. They will be trained in how to physically remove and destroy pests, build up beneficial predators, and rotate and diversify crops. The aim is to keep a balance between pests and their natural enemies and to keep the spraying of expensive and potentially damaging and dangerous insecticides to an absolute minimum. The project will also promote farm-oriented local research. Pilot projects in China, financed by the Asian Development Bank, have shown that cotton farmers have reduced their use of pesticides and increased yields at the same time (FAO, 1999). The Chinese Government should also provide financial support to extend Integrated Pest Management. (Recommendation to SEPA and MOA.)

5) *Partial alternatives to pesticide*

Partial alternatives to the use of pesticides exist that lead to more sustainable cotton production. Partial alternatives include biological pest control, microbial pest control, control through sex pheromones, physical removal of pests and cultivation of genetically modified cotton. The first two are based on the idea that every organism on earth has natural enemies; biological control emphasizes the importance of parasites and predators as natural enemies and microbial control usually involves a spray containing a bacterium or a fungus or a *baculovirus*. *Pheromones* are the substances the female insects secrete to attract males for mating. It is possible to trap part of the pest population through imitating these pheromones by making a synthetic substance with the same effect (Harry de Vries, 1995). (Recommendation to SEPA and MOA.)

6) *Strengthening administration of genetically modified cotton production*

The acreage of transgenic cotton in China has been increasing fast. In 1998 the acreage was no more than 100,000 hectares, whereas in 2000 it increased to almost 1 million hectares. The proportion of transgenic cotton out of the total cotton growing area has increased from 2.2 per cent in 1998 to 28 per cent in 2000. Three series are dominant in China, accounting for more than 80 per cent of the total transgenic cotton grown (Du Min, 2001).

China has issued administration regulations for agricultural GMO (genetically modified organism) products in commercial production, processing, marketing, import and export. In the initial period of GMO production, a series of practical administration regulations are essential for its stable development. The principle is that administration

⁶ FAO homepage, "Asian farmers learn integrated pest management", <http://www.fao.org/News/1999/990604_e.htm>

regulations should consider not only the benefit to producers, but also the benefits and rights of consumers, as well as the environmental impacts.

- Prudently make extension of currently approved GM cotton varieties.
- Only after approval from the GMO administration body, can farmers produce the currently approved GM cotton varieties, with isolated zones to prevent hybridizing with non-GM cotton varieties.
- Carry out an identity preservation (IP) system for GMO products.
- It is important to apply an identity preservation (IP) system for GMO products. The storage, processing, transportation, and marketing of GMO products should be separated from non-GMO products, even though this could increase the cost by 6 - 17 per cent; these are the best measurements to be taken to prevent genes proliferation and pollution.
- Carry out labelling for GMO products.
- The GMO labelling should indicate which gene has been modified in the product (such as Bt), which makes it possible to identify the specific product when some transferred genes prove unsafe. Consumers have the right to information on GMO products and to make informed choices and decisions.
- Promise not to export GMO products.

China should promise not to export GMO products, as this strategy could increase the competitive advantage of exporting non-GMO products.

- Apply the Advanced Informed Agreement procedure (AIA) for the import of GMO products.

The purpose of the Advanced Informed Agreement procedure (AIA) is to ensure that recipient countries have both the opportunity and the capacity to assess risks that may be associated with a living modified organism (LMO) before agreeing to its import. (Recommendation to MOA and SEPA.)

7) *Ban the production, marketing and application of all highly toxic, high residue pesticides*

Many highly toxic, high residue pesticides have been banned by developed countries, but they are still being used in China - farmers can still buy them and use them in agricultural production. It is important to ban the production, marketing and application of all highly toxic, high-residue pesticides through legislation. The Government should offer subsidies to the factories that produce pesticides to compensate for the revenue decrease owing to the ban, and encourage them to produce high efficiency, low toxicity, low residue pesticides. (Recommendation to SEPA and MOA.)

8) *Levy an environmental pollution tax*

The agricultural 'area-source' pollution is more difficult to control than the industrial 'point-source' pollution. The low prices are the main reason that farmers like to apply low-

efficiency chemical fertilizers and high toxicity, high residue pesticides; on the other hand over-high prices will hinder farmers from applying the high-efficiency chemical fertilizers (such as compound fertilizers) and low toxicity and low residue pesticides. It is possible to use an environmental pollution tax to give farmers an economic incentive to reduce the applied quantity of chemical fertilizers and pesticides. The tax will increase the price of low-efficiency chemical fertilizers and high toxicity, high residue pesticides, and the revenue can be used to subsidize farmers in purchasing more environmentally sound fertilizers and pesticides. (Recommendation to SEPA and Tax Bureau.)

9) *Promoting the research and development of bio-pesticides using Chinese herbal medicine*

Chinese herbal medicine is a great treasure, and it can also contribute to the production of pesticides that are friendly to the environment. The Chinese Government should provide financial support to research into producing low-toxicity, low residue herbal pesticides that can be degraded in the eco-environment. This would benefit not only the farmers, but also the consumers of agricultural commodities as an environmentally friendly industrial sector with a bright future. (Recommendation to SEPA, MOA, research institutes and the private sector.)

10) *Increasing irrigation efficiency*

In the north-western area of China it is very important to increase the utilization rate of irrigation water, from a current 30 per cent to a more efficient 70 per cent (Mao, 1999). This calls for technological, institutional and policy changes. Drought-resistant varieties need to be bred to reduce water requirements, and irrigation systems that reduce percolation and leakage should be developed. The various kinds of irrigation practices such as drip irrigation, furrow irrigation, sub irrigation, sprinkler irrigation and irrigation at night to reduce water evaporation should be experimented with in order to discover the best methods in different regions. Research on optimal irrigation scheduling and irrigation volume should be encouraged and flood irrigation that is typical in many regions must be stopped as soon as possible.

The study proposes organizing an Irrigation Water Saving Project in north-western regions. New laws governing the use of water should be established, and the enforcement of such laws should be strengthened. Policies concerning subsidies on irrigation and water use must be reformed in most cotton producing regions. In some regions, irrigation water quotas could be established, where quota price and above-quota prices of irrigation water could be decided in order to increase irrigation efficiency. (Recommendation to SEPA, MOA and farmers.)

11) *Promoting the production of organic cotton*

Local governments should encourage the introduction of environmentally friendly cultivation practices. Organic cotton is the most sustainable alternative to conventional production and it comes close to this goal (Harry de Vries, 1995). Organic farmers use biologically-based rather than chemically dependent growing systems to raise crops. Organic cotton is produced without synthetic insecticides, fertilizers and defoliators, as well as other inputs prohibited by the certifying organization. Worldwide organizations exist which are entitled to control the production (both product and process) and certify the

product as organic. (Harry de Vries, 1995). Until very recently, fields must be free of synthetically derived chemicals for three years to achieve organic certification. The International Federation of Organic Agricultural Movements (IFOAM) regulations were changed in late 1994 to a one year transition period where levels of chemical inputs are lower.

Organic cotton farming is a high yielding and environmentally preserving method of farming. However, transition to organic farming is not an easy task. Much effort has to be made to facilitate the transition and address the aftermath. Due to variations in natural conditions, in-depth research needs to be conducted to find out if local conditions are conducive to organic farming and if so, what specific combinations should be chosen for organic farming. In some areas (for example, regions that have high pest occurrence and lack of pest predators), it may be impossible to grow organic cotton and in other regions costs may be prohibitively high. Technical aspects such as the variety of pest and their predators and the right time to release those predators, have to be studied. Coaching and extension to farmers is also needed in order for them to learn the ways of organic farming. Yield may decline sharply during the first couple of years after transition, and achieving premium prices may prove elusive when cotton quality fails to please the market.

“Farmers who have changed to organic production have encountered higher costs and/or lower yields. This is compensated for by higher prices on the market for organic textiles. However, this is a relatively small market and thus the possibilities of this form of compensation remains limited (mainly because it remains a voluntary decision of consumers to buy these products against higher price).”

Harry de Vries, 1995.

Xinjiang has very good natural conditions for the development of organic cotton farming, and the local government can play a very important role in promoting organic production.

China has started building a base for encouraging the production of organic cotton in some regions, on a very small scale. In some other regions, however, organic cotton farming is unheard of. For the Chinese Government and cotton growers, organic farming is a new challenge after years of dependency on chemicals for higher cotton yields. At present, organic farming is still conducted as pilot projects. However, further developments can be expected from China's organically grown cotton. Since organic cotton farming is a highly labour-intensive process, it will be to China's advantage to promote organic cotton farming given its abundant labour resource and low labour costs, which is a bright way forward for sustainable agricultural production. (Recommendation to SEPA, MOA, the private sector and farmers.)

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