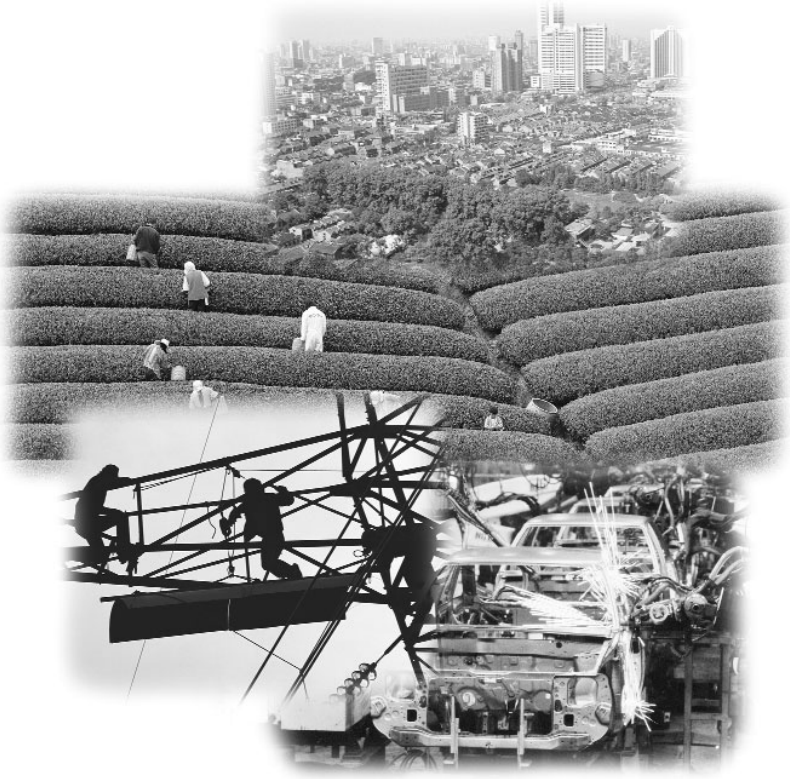
AN ENVIRONMENTAL IMPACT ASSESSMENT OF CHINA'S WTO ACCESSION

An analysis of six sectors



A Report by the Task Force on WTO and Environment
China Council for International Cooperation
on Environment and Development
October 2004

iisd International Institute for Sustainable Development / Institut international du développement durable

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China Council for International Cooperation on Environment and Development

The China Council for International Cooperation on Environment and Development (CCICED), a high level non-governmental advisory body, was established by the State Council of China in 1992. Its stated purpose is "to further strengthen cooperation and exchange between China and the international community in the field of environment and development."

The Council, which meets annually, is composed of 49 Chinese and international members. The members on the Chinese side are of Ministerial or Vice Ministerial rank together with several eminent Chinese experts. The international members are of comparable stature. Members participate as experts in their personal capacities, at the invitation of the Chinese Government. They have been chosen for their expert knowledge and experience and come from different fields of expertise: environment, economics, science, technology, energy policy, agriculture, industry, business, finance and education. The Chinese members come from ministries, agencies and educational institutions directly concerned with the central issues of economic development and the environment.

Expert working groups/task forces have been established by the Council, each jointly chaired and staffed by Chinese and international experts. The working groups/task forces analyze important problems that China faces in the above areas, propose strategies based on international experience and China's needs, conduct demonstration projects and prepare preliminary recommendations for the Council. The Council then decides what recommendations to forward to the Chinese Government. Council members present these recommendations in person to a senior Chinese leader at the conclusion of their deliberations.

Every year since 1993, the CCICED has approved formal recommendations for presentation to the State Council through the Senior Chinese leader whom members meet at the conclusion of their annual session. These recommendations are based largely on the expert reports of the working groups. Because of this unique access to the highest levels of decision-making, these recommendations are given priority attention by the various branches of government. As one senior Chinese leader assured the Council: "The Chinese Government will seriously study the Council's recommendations and will implement them where it is appropriate and relevant to China."

The CCICED has created a unique cooperative mechanism for bringing the best Chinese and international advice directly to the attention of the Chinese Government. It has been one of major contributors to many Chinese environmental achievements during the past years. For more information on CCICED, visit the Council Web sites at: http://www.harbour.sfu.ca/ and http://www.cciced.org/cn/

Task Force on WTO and Environment

The Task Force on WTO and Environment (TFWE) is the successor of the Working Group on Trade and Environment (WGTE) established by the CCICED in 1994. It is a high-level advisory body reporting to the CCICED and carrying out policy-related research leading to practical recommendations for consideration by the Government of China on the development of trade policies and environmental policies that promote sustainable development and trade liberalization. The mandate of the Task Force is to assist China in developing and implementing long-term, comprehensive and integrated trade and environmental policies and measures that support sustainable development, in particular within the context of China as a WTO Member.

In Phase III of the CCICED, the Task Force has more defined objectives, With China's WTO membership, the Task Force aims to help China to enhance its ability to address environment and sustainability issues while it further opens its markets, taking advantage of "green trade" opportunities without sacrificing its environment or natural resources. It also aims to help China to be prepared to address issues related to the environment and sustainable development that may arise in the Doha Round of negotiations.

Task Force on WTO and Environment

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Preface

China's accession to the World Trade Organization (WTO) has been an event of exceptional importance. Its impact on China's economy has been remarkable but the environmental consequences have also been undeniable. It has created opportunities and challenges for improved environmental management, all of which require determined action on the part of the Chinese authorities.

Certain environmental consequences are the result of growth. In many instances the need for careful management of these consequences is well known. Growing industries are dynamic and engaged in processes of innovation, so often opportunities exist to find solutions that protect the environment without impacting growth. The textile sector is a good example.

Trade liberalization not only promotes increased production; it also creates consumer surpluses associated with falling prices or increased quality. Again there are important environmental measures that can be taken to ensure that the consumer surplus also serves environmental needs. These are particularly pronounced in the automobile sector, where prices are currently falling, creating a one-time opportunity to accelerate the introduction of emission standards.

Part of the process of structural change associated with trade liberalization is that certain economic sectors or activities will be reduced because their products can be imported at lower cost or higher quality. Such sectors are less likely to be innovative and do not benefit from the new resources associated with growth. Yet these sectors may still present specific environmental problems that require the attention of policy-makers; these are among the most challenging aspects of the trade and environment debate. Examples may be found in agriculture, which is resource-intensive rather than labour-intensive.

Our report reflects all of these opportunities and challenges. It represents what is probably the most comprehensive assessment undertaken by any country of the environmental consequences of a single trade agreement. It is part of the result of 18 months of intensive work by a large group of researchers and the responsible officials of the State Environmental

Protection Agency and the Ministry of Commerce. As co-chairs, we wish to extend the sincere thanks of the Task Force on WTO and Environment to all those who have contributed to this work. We also wish to thank the Swiss State Secretariat for Economic Affairs for its support of the Task Force and of the research that was necessary to understand the environmental impacts of China's WTO accession and to prepare our report to the China Council for International Cooperation on Environment and Development (CCICED).

Ruqiu Ye and David Runnalls
Co-Chairs
Task Force on WTO and Environment
CCICED

Overview

Overview

1. Background

China's accession to the WTO has been the most important recent development in trade policy—for China and for the WTO as a whole. The impact on China's economy has been profound. While it is not possible to precisely measure the contribution of WTO accession to the continued growth and transformation of China's economy, this event has come to symbolize the determination of China's leadership to pursue its economic course into the future.

Because of the numerous commitments undertaken in the accession process, the consequences of WTO accession have been felt throughout China's economy. They have probably been stronger and more widespread than those experienced by any country following the conclusion of trade negotiations, including the impact of the Uruguay Round. Moreover, the impacts have been fairly predictable whereas trade agreements typically involve a degree of ambiguity that renders the prediction of economic outcomes much more difficult in practice than is suggested by trade theory.

The environmental impacts of China's WTO accession have also been profound.

They have been particularly pronounced in six sectors: agriculture, forestry, marine aquaculture, automobiles, energy and textiles. These are among the most important sectors in China's economy and are also significant in environmental terms. In view of their importance, the Task Force on WTO and Environment (TFWE) of the China Council for International Cooperation on Environment and Development has undertaken environmental impact assessments for each of these sectors.

These studies represent the most comprehensive assessment of the environmental consequences of trade liberalization policies undertaken by any country to date.[1]

The environmental impacts of China's WTO accession fall into the three major categories that were first identified by the Organization for Economic Cooperation and Development (OECD): scale effects, composition effects and technology effects.

Scale effects are the result of growth processes in the economy. They are particularly noticeable in the industrial sectors that can expand production rapidly as long as the necessary inputs are available: natural resources, skilled labour and know-how. This expansion must be accompanied by measured, but determined, policies to ensure environmental quality. Moreover, rapidly expanding industries are also involved in large amounts of new investment, a process that creates the possibility of ensuring less environmentally harmful production processes. In most instances, however, this outcome can be assured only through properly crafted public policies.

Composition effects can be observed when liberalization leads to the expansion of some economic activities while others contract. These phenomena can be observed within agriculture and, to some extent, in forestry. The result is structural economic change through which the composition of an economy is transformed. The environmental challenges of expansion are largely comparable to the challenges of growth. It is the challenges of contraction that represent the most important difficulty in addressing environmental issues, since branches of economic activity that are contracting are often characterized by: low rates of economic returns for those who remain in the activity; low rates of investment; limited innovation; and slow rates of recruitment of new employees who may also bring new ideas and skills. Yet the environmental problems of contracting economic activities are real, in particular when insufficient measures had been adopted in the past to ensure environmental quality.

Technology effects are largely attributable to the impulses for innovation associated with a more open economy. This may occur through the importation of new technologies from outside the country, in particular through investment, or it may be the result of domestic responses to increased competition owing to liberalization. In all instances, it is important to ensure that as

1 The Doha Ministerial Declaration states in its Preamble: "We strongly reaffirm our commitment to the objective of sustainable development, as stated in the Preamble to the Marrakesh Agreement. We are convinced that the aims of upholding and safeguarding an open and non-discriminatory multilateral trading system, and acting for the protection of the environment and the promotion of sustainable development can and must be mutually supportive. We take note of the efforts by Members to conduct national environmental assessments of trade policies on a voluntary basis."

technological innovation occurs it also takes into account the environmental dimension. In general, newer technologies should always be less environmentally harmful than older ones, although this is not invariably the case.

It is clear that WTO accession has brought significant new challenges for environmental management in China. But it also brings opportunities that need to be grasped through appropriate policy responses.

2. Agriculture

Changes in agricultural production are largely attributable to WTO accession since the Uruguay Round Agreement on Agriculture has not produced significant change. Changes in agriculture are very sensitive socially and environmentally and, consequently, of overriding concern from the perspective of sustainable development.

Since WTO accession, China's agriculture trade has continued to grow. In the first half of 2004, the country exported US$10.62 billion of farm produce, an increase of 10.7 per cent over the same period last year. However, its imports of agricultural products soared unexpectedly by 62.5 per cent compared to the same time in 2003. This is the first time ever that China's agriculture trade has had a deficit (US$3.73 billion). Particularly, in wheat trade, China was still a net exporter of wheat in the first half of last year, but its imports exceeded its exports by the end of June.

Compared to other countries, China has a shortage of farmland and water for its agricultural production. China, with 22 per cent of the world's population, has only seven per cent of world farmland and one quarter of the world average water resources per capita. In international markets, obviously China's comparative advantage is in labour and its disadvantages are in land, water and other natural resources. Hence, after accession to the WTO, China's land- and water-intensive agriculture products, such as wheat, corn and rice, will shrink gradually; and labour-intensive products, like horticulture products, temperate climate fruits, vegetables and livestock products, will expand. Consequently, non-point source pollution by chemical application for wheat, corn and rice will shift to point source pollution by chemicals used for horticulture, fruits, vegetables, poultry and others. Also after joining the WTO, considering more and more workers will move to manufacturing and service sectors and that there will be increasingly strict international environmental requirement, the total amount of chemicals used will decrease compared with the baseline scenario. Figure 1 shows the amount of chemical used and grain production in recent years.

After joining the WTO, another profound impact is the environmental pressure on farmland. More grains could be imported from other countries while implementing the Grain for Green program.

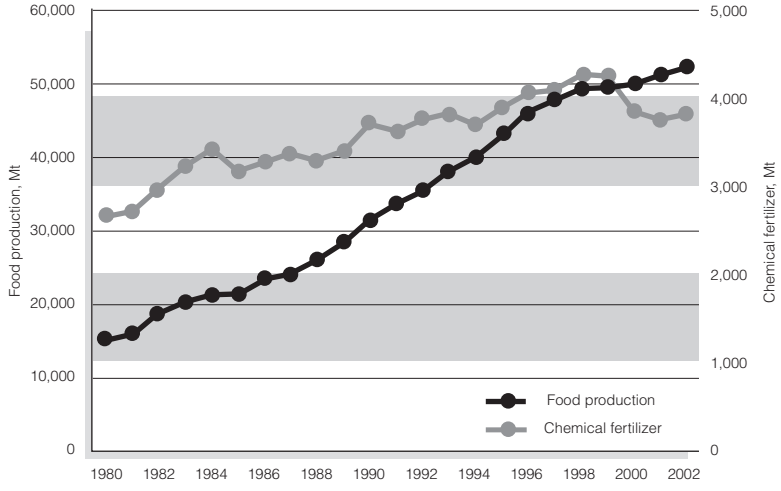

Figure 1. Chemical use and grain production, 1980–2002.

The biggest environmental challenge facing policy-makers with respect to changes that are anticipated in agricultural practices and production, concerns the need to internalize environmental costs. This is a task that most countries find daunting, since farmers, like all producers of commodities, are essentially price-takers and consequently have limited ability to recover from the market additional costs they may incur for environmental protection, in particular if competitors do not face the same costs. Moreover, agriculture is an activity that occurs in the environment and depends on the environment for all of its most important inputs. Traditionally, farmers have not been asked to make payments for these inputs, even when their use caused significant environmental degradation, for example, downstream or through impacts on biodiversity. The introduction of payments for environmental services is resisted by farmers everywhere and is often only possible when issues of scarcity arise.

It is important to recognize that not all measures designed to internalize environmental costs result in increased production costs. For example, the elimination of subsidies for pesticides and fertilizers will reduce over-use, which is often widespread and damages the environment. Elimination of such subsidies can result in improved crops, better environmental conditions and reduced costs. Policy-makers need to focus on opportunities for measures that internalize environmental costs and increase economic efficiency, even though such measures are frequently resisted because they involve changes in established practices, the need to learn new techniques and may be perceived as hiding additional risks that farmers are unwilling to accept.

The introduction of measures for cost internalization that increase production costs can only be achieved over a longer period of time with a consistent policy approach and with appropriate measures to support the necessary changes and to cushion the potential economic impact without negating the environmental benefits. This has generally been the approach favoured by developed countries, where producers have received payments that are increasingly tied to the respect of certain environmental conditions.

The shift in public policy from taxing agriculture to supporting it represents an initial appropriate response to the changes in agriculture that have been triggered by WTO accession.

This policy shift must be accomplished in a manner that is consistent with WTO rules. The "Green Box" under the Agreement on Agriculture provides a significant degree of flexibility in fashioning rural policies that involve a focus on environment and sustainable development by providing support to farmers' incomes, rural communities and the environment.

WTO accession will bring an increase in agricultural trade between China and the rest of the world. China is likely to favour the import of resource-intensive products, such as grains, and the export of labour-intensive products such as vegetables, fruit and poultry. There is already evidence of this process but it creates tensions with established policy priorities, particularly with the longstanding objective of achieving food self-sufficiency. The risks of dependence on international markets are evident and China will move cautiously in this area to ensure stable supplies, to provide buffer stocks and to guarantee a level of domestic production that meets its needs for food security. As a result, China is likely to explore all the options provided by the WTO Agreement on Agriculture and will take a proactive stance on the relevant issues in the ongoing Doha Round negotiations.

There are opportunities for the export of "green food," products that meet international standards for reduced inputs and improved environmental stewardship. The markets for these products currently offer prices that often more than offset any additional cost, in particular when these costs are based on higher inputs of labour, where China enjoys a comparative advantage. The problem is that these markets are particularly difficult to access since few agreed international standards exist. The result is a complex and costly system of accreditation that generally requires a producer-by-producer approach.

The concern for standards that may have the effect of excluding Chinese products from important markets goes well beyond the area of "green food" and organic standards. Both sanitary and phytosanitary standards and technical standards have been of concern to Chinese agricultural producers in recent years. Many of these standards require substantive changes to prod-

ucts and to the ways in which they are produced. They are often difficult to meet by exporters, and questions have been raised concerning their necessity and appropriateness. It is frequently difficult for producers to obtain information about such standards in a timely manner so that rejections that may occur at the border of the importing country can have severe consequences for them. Rejections were typically based on findings of high amounts of pesticide or veterinary drug residue. In addition, accreditation and verification have proven problematic, leaving producers with a difficult choice between expensive foreign inspection and acceptance of their inability to export to certain markets.

3. Forestry

China's changed policies on the replanting of forests and timber extraction, combined with the opening to trade associated with WTO accession, have caused a dramatic shift in the patterns of timber production, trade and use. China is now one of the biggest importers of logs and timber and an exporter of wood products such as furniture. Unless it takes effective measures, China may face a challenge in securing reliable timber supply as well as the reputational risks associated with promoting markets in unsustainably produced or illegally harvested timber.

High domestic economic growth, newly implemented massive forest conservation programs since 1998 and WTO entry together have prompted drastic growth in forest products imports by China (Figure 2).

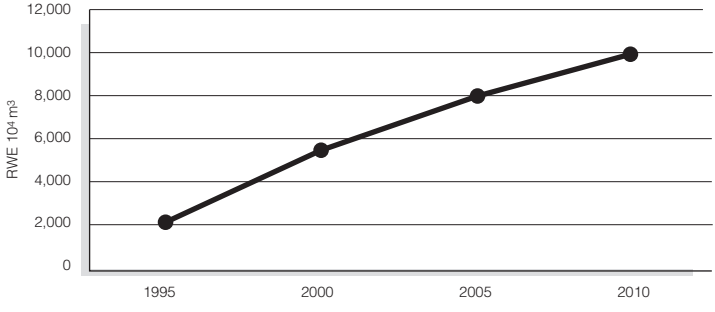

Figure 2. Chinese timber import forecast up to year 2010.

Increased imports of timber have helped China alleviate environmental pressures on forests. Meanwhile, WTO entry helps China to upgrade equipment and technology in the forest industry and raise wood utilization efficiency.

It will also bring increased investments, both public fiscal investment and foreign investment. Increased investment will lead to improved forest management and a better scope for the ecological functions of China's forests.

The overall impact of China's WTO accession on the forest industry will be positive, particularly in combination with vigorous measures for forest protection. Possible negative impacts may be anticipated from increased emissions from the wood processing industry, unless these are effectively controlled, and the risk of alien invasive species introduced by increased trade and growing tourism. These could have a major ecological impact.

Increased forest trade in timber products associated with China's WTO Membership will have global implications as well. The increase in Chinese timber import volume has been dramatic. This has led to concerns about the environmental impacts of China's growing timber import. China's timber import has been mostly from countries or regions that do not practice systematic forest stewardship, such as Indonesia, Myanmar, Cambodia, Papua New Guinea, the Solomon Islands, the Congo basin or the Russian Far East. Exporting timber can generate negative environmental impacts in these countries whose forests are not being well managed. Rapid deforestation has taken place in some of these countries, especially Indonesia, Malaysia and Myanmar.

Not all countries that have increased timber exports to China have, however, experienced a significant reduction in forest resources. Countries such as Russia, Canada, Germany and Cuba have seen little change in their forest resources, while countries such as the United States and New Zealand have actually had an increase. The key is forest management. If a country is pursuing good forestry practice domestically, exporting timber may actually reinforce sustainable forest management and encourage investment in forestry.

There is also the problem of illegal trade in relation to China's timber imports. Illegal timber logging and trade are destructive behaviours that not only damage forests, but also bring serious negative social and economic impacts. The illegal timber trade can result in loss of jobs and the impoverishment of forest-dependent communities.

There is no doubt that China will continue to import timber and other wood products, most likely from its existing major timber trading partners. China may face accusations of exerting excessive pressure on global forest resources, and the reputational risks associated with using unsustainably produced or illegally harvested timber.

Meanwhile, advanced western developed countries are major exporters of processed wood products, and importers of labour-intensive products such

as furniture from China. They have the capacity to assume a greater role in addressing the environmental consequences of the global forest products trade. China and western developed countries should join hands to promote sustainable forest management and to avoid ecological damage in timber supply countries.

The combined changes in domestic forestry policies and timber trade resulting from WTO accession will require close monitoring of forests and forestry policies to ensure that the overall outcomes are desirable. This review should include not only domestic policies and conditions but also import and export policies and forests in other countries that are liable to be impacted.

China levies no tariffs on unprocessed timber, but imposes rising (escalating) tariffs on furniture and other finished goods produced from wood. The impacts of such escalating tariffs, which are used primarily by developed countries, are well known. They shift processing from the country where timber is extracted to the consuming country. In the case of China, the shift is primarily one of processing since China's comparative advantage in the processing stage of the product chain is so pronounced that it can overcome escalating tariffs that may exist in major developed countries.

If China reduces escalating tariffs, it will help improve the ability of timber producing countries to sustainably manage their resources. There is of course no certainty that such a change will enable the producing country to undertake more processing, nor that additional revenue generated by such processing will in fact support better forest management. While most countries from which China obtains timber have labour costs that are comparable to those of China, few are able to achieve the same efficiency gains as China. Moreover, additional revenues will only be made available for sustainable timber production if appropriate policies are in place in those countries to ensure that result. Consequently, these are issues that cannot be addressed unilaterally—by China or by producing countries—but require the development of a shared approach to the issue of sustainable forest management.

At present, there is no institutional structure that can accommodate China's evolving forest management needs in relation to timber trade. As China's relationships with major forest producer countries develop, it will need to identify appropriate institutional venues to address these matters.

China faces similar challenges in the export trade in wood products. This trade is almost entirely composed of processed wood and manufactured products, since China has largely banned the export of domestic timber. The partners in this phase of the product chain are mostly different countries than those that produce raw materials, and the issues and institutions are liable to be different.

There is an opportunity for China to actively cooperate with western developed countries that are the major importers of furniture and processed timber products. The major issues that require consideration concern third party independent certification of timber imports. The primary concern is to ensure that the entire forest product chain is managed in a sustainable manner, reaching from the production of lumber through transport, processing, manufacture, sale, use and disposal. Consequently, the two sides of this activity—the relationship with timber producing countries on the one hand and with countries that consume wood products on the other—are in fact closely related. China will not be able to ensure that its products are produced with sustainably managed timber without developing appropriate relationships with producer countries; and it will not be able to recover any additional costs associated with sustainable management of the wood products chain without maintaining the required relationships with consuming countries.

4. Aquaculture

WTO accession has brought a dramatic expansion in aquaculture exports, which are currently about as large as net agriculture imports. These exports are threatened by product quality issues, in particular as a result of "red tide" that appears to be caused by land-based pollution.

The expansion of aquaculture along China's coast appears to have caught many unaware. The remarkable volume of exports is largely attributable to the general shift towards more labour-intensive products, and the fact that this counterbalances the imports of other foodstuffs should give the Chinese authorities added confidence with regard to food security issues. Yet it is vital to ensure that product quality is maintained, and this is in large measure a matter of protection of the marine environment, the primary production resource.

Major environmental problems of expansion of marine aquaculture include nutrient pollution, chemical pollution (from veterinary products, disinfectants and antiseptics), substrate eutrophication and red tide.

Estimates of the discharge of nitrogen and phosphate show that the total discharge of these two chemicals is likely to keep rising. However, the discharge of N and P may drop steadily with regulatory and technological efforts. The decrease in average level is largely attributed to the improvement of technology, which results in higher feed efficiency and cuts down on solid wastes.

Overall, economic and environmental benefits that China gets from the development of the marine aquaculture sector will outweigh its adverse impacts on the environment, in particular if appropriate policies are put into place.

Regulations and standards for products and production process are gaining importance in regulating international trade of aquatic products. The key factor in expanding China's aquatic exports lies in building up a healthy and ecological farming mode and providing clean, sanitary and safe products. In this sense, the requirements imposed by major importers concerning product quality, safety and sanitary conditions against China's aquatic exports create powerful incentives to adopt needed policies that will result in better products and a better marine environment.

The control of coastal waters is a notoriously difficult task, largely because of jurisdictional complexities combined with challenging environmental dynamics. Land-based pollution is the principal cause of degraded marine environments that impact aquaculture, and aquaculture itself can contribute to local pollution events. The benefits of controlling land-based pollution are numerous, since this also always improves environmental conditions at the source of the pollution. The difficulties that are typically encountered when reducing land-based pollution are related to the fact that the requirements of the marine environment may dictate more aggressive pollution control measures than those implied by efforts to protect the local environment, for example river quality. Pollutants are typically carried away by rivers but they tend to accumulate in coastal waters and wetlands, the very environment in which much aquaculture is practiced. Protection of the marine environment will contribute to making the aquaculture sector more competitive internationally and preserving existing markets.

Meanwhile, the traditional support policies should be changed. Implementing integrated economic policies will promote marine aquaculture development and environmental protection. There is a need to support an optimal breeding structure and a rational development mode, in order to best use all kinds of resources through cyclical re-use of wastes generated within the rearing system. This will minimize waste discharge and achieve satisfactory breeding effects and economic profits, while attaining environmental benefits.

Aquaculture producers frequently have insufficient information concerning market requirements in other countries. This also requires an effective network so as to provide information concerning import requirements and trends of assessment of China's major trading partners, and to keep enterprises informed about relevant developments in the aquaculture sector. Enterprises need technical support concerning new technical requirements that may form barriers to trade and in the formulation of preventive counter measures so as to avoid blindness and losses in trading.

There exists an urgent need for cooperation in the development of relevant international standards for aquaculture products and for the quality of

marine waters that support aquaculture. This is an area in which China could take an active leadership role.

5. Automobiles

The impact of WTO accession on China's automobile market is dramatic and lasting. Reduced prices for automobiles produce a very large consumer surplus, which contributes to increased demand for other goods. From an economic perspective, benefits in this sector as the result of WTO accession are much greater than the costs. Despite the implementation of more stringent emission standards, the explosive increase in the number of cars enhances risks of greatly increased vehicle emissions.

With the growth of the economy and the increase of per capita GDP, consumer purchasing power for automobiles is on the rise. After China's entry into the WTO, reduced tariffs and duties on automobiles and increased foreign direct investment caused the retail prices of cars to drop substantially, further enhancing purchasing power. The production and sale of automobiles in China will rocket for at least a decade to come.

WTO accession also creates powerful incentives to improve production efficiency and to initiate desirable structural changes in the automobile sector, leading to an increase in quality.

The falling price produces a huge consumer surplus. In 2003, the average price cut of cars was 9.06 per cent. If the average price for cars was 150,000 yuan, the price cut would be 13,600 each. The total gain by consumers then was 27 billion. By 2005, further price cuts are expected to take place and the consumer surplus could be as high as over 50 billion yuan.

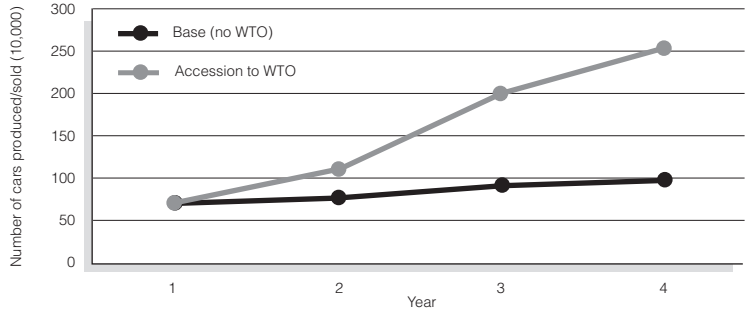

Figure 3. Increase of car numbers (BAU and WTO Scenario).

The WTO scenario analysis shows that CO and NO_x, the major sources of pollution from automobiles in cities, will increase along with the number of

cars. However, emissions of CO are reduced owing to the application of Euro I to all new cars in 2001 and Euro II in 2004. Nevertheless, this environmentally desirable impact was substantially offset by the increase in car numbers (Figure 3). In 2004, the difference in emissions with and without WTO accession was halved as the number of cars sold was 160 per cent higher.

The existence of a consumer surplus, as the result of trade liberalization and foreign direct investment after WTO accession, creates a unique opportunity to protect the environment. It permits China's authorities to reduce emission levels and to increase fuel efficiency standards quickly, thus reducing several key impacts of automobiles on the environment. Consumers will benefit from improved product quality that is associated with most of these measures while not perceiving any increase in costs that may be occasioned by these measures because it is shielded by the overall decrease in prices.

This is, however, a transitional phenomenon. Once automobile prices stabilize at a certain level, government measures that result in costs—particularly environmental measures—will be perceived as price increases and are liable to be resisted, even when they produce secondary benefits such as improved performance or higher quality automobiles.

Motor vehicles registered before WTO accession can cause twice or even up to 10 times the pollution of newer cars. Early phase-out of old vehicles can increase the environmental capacity for more cars without increasing total emissions. The resistance to this policy may be minimal and the environmental benefits can be substantial. For those vehicles that have been phased out, no permission should be given for re-sale and re-use. They should be sent to recycling facilities. Disincentives should be provided to curb the use of luxurious cars with large engines, which require more oil and land.

From a longer-term perspective, the Chinese automobile industry faces a number of major challenges, including land vulnerability (in particular arable land); oil supply; traffic congestion; air pollution; and global environmental concerns. These are liable to be magnified by the rapid growth in the automobile market, and will be even more severe if measures are not taken now while conditions are propitious.

There are a number of challenges China is now facing to reduce future risks. The most obvious is the need to develop the system of mass transit to provide people with viable alternatives to the excessive use of automobiles. While this is an issue that is influenced by numerous considerations, many of which have little bearing on the automobile market and its environmental consequences, it is also the case that the existence of a viable system of public transport is a necessary condition for controlling the manifold impacts associated with automobile use, including the environmental impacts.

Another challenge for China is to participate actively in the search for future automobile technologies. No matter what happens to the supply of fossil fuels and their impact on the environment, the automobile represents a technology that will not disappear unless it is replaced by something that is manifestly superior in key respects, including the degree of independence and individual choice offered by the automobile. At the same time, it is clear that the automobile as it currently exists needs to be not only improved but also replaced in key respects that reduce its unacceptable impacts. The search for the most promising technology to accomplish this goal is now on—and China must determine what its position is with respect to this development.

Finally, it will be necessary to ensure that the financing of the numerous measures that are required to address the impacts of rapid growth of the automobile market is undertaken in a manner that ensures that the polluters—in this instance the users of automobiles—pay. A range of options exist that focus on taxing automobile use or taxing the sources of pollution associated with automobile use. In particular, a levy on luxurious cars with large engines can be imposed to raise financial resources and to reduce the demand for oil and land.

6. Energy

Economic growth associated with trade liberalization has caused rapidly increasing energy demand. If adequate and appropriate policies and counter measures are not put in place, there will be greater pressure on energy supply and environment, which will surely lead to China's increased dependence on imported energy and the consequent responsibilities and concerns. Accession to the WTO itself could be a key factor for higher energy demand because of the possibility of more energy-intensive industry moving to China, which could also be more pressure on environment.

The scenario study shows that energy demand in China in 2020 could range from 2.4 billion tce to 3.4 billion tce depending on technological progress and energy-intensive sectoral development, etc. Such a huge energy demand will exert serious pressure on energy supply. That means even for the lowest energy demand scenario, China would need to import 200 million tonnes of oil, and 100 billion m^3 of natural gas; for the high energy demand scenario, China needs to import nearly 400 million tonnes of oil; 260 billion m^3 of natural gas; and 300 million tonnes of coal (Figures 4 and 5).

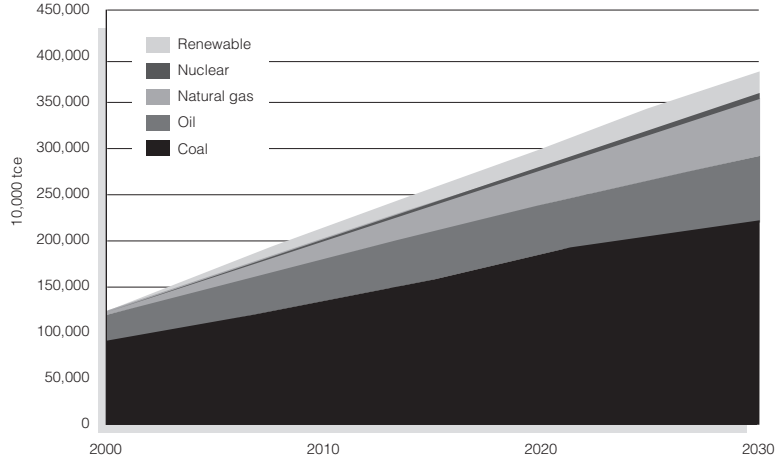

Figure 4. Primary energy demand.

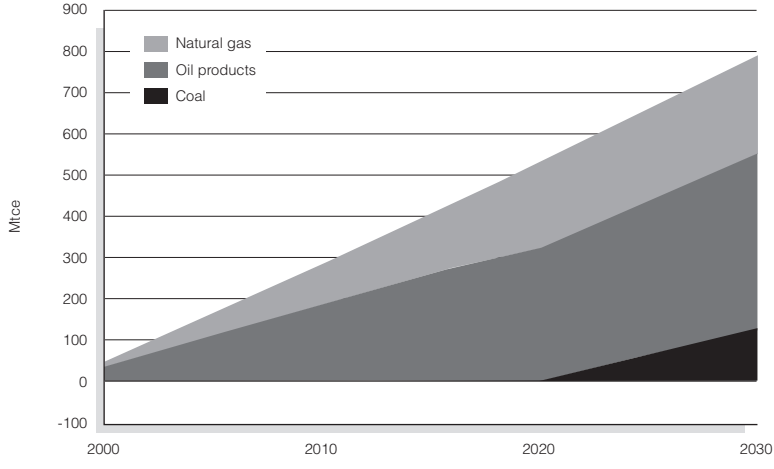

Figure 5. Energy import and export: baseline scenario.

With the income increase in rural households, the energy demand in rural areas will also increase quickly.

Given substantially increased energy production, the environmental impacts could be profound. SO_2 emission will keep increasing before 2010 with the rapid increase of coal use in China. However, China has adopted strong policy to control SO_2, assuming more and more desulfurization technologies

will be used and therefore SO_2 emissions will diverge from fossil fuel use. Because of lack of policy to control NO_x, its emissions will rise substantially. The same trend will apply for total suspended particulates (TSP) emissions.

China's energy utilities must be prepared to operate in an increasingly international market. Although many of these utilities are not themselves exposed to international markets, the scope for arbitrage between energy resources will increase as the energy supply system is increasingly integrated, so that even producers who are entirely domestic in orientation are likely to find that prices for all forms of energy in the Chinese market will be significantly influenced by changes in international prices for key energy sources, including oil, coal and gas.

The impacts of the energy system on the environment and sustainable development are well documented. Even as China's energy markets are increasingly integrated into international markets it has no choice but to establish the foundations of a clean energy system, covering all aspects of energy supply with particular attention to the efficiency of rural energy supply. A wide range of laws, regulations and standards needs to be developed to drive the target of a clean energy system and to make China's energy supply system competitive internationally.

Coal will continue to play a critical role in China's energy system. Consequently, China has a particularly pressing need for clean coal technologies. This generally involves participation in international markets for clean coal technology, a process that would be significantly enhanced if China invests its own resources in this sector and cooperates internationally to diffuse new technologies as widely as possible when they become available.

There will be a significant possibility for China to become a manufacturing centre of energy-intensive and resource-intensive products in the world because of low production costs. This trend should be controlled to prevent China from becoming a provider of raw materials and causing damage to the environment. External costs should be included in production costs to help prevent possible environmental and economic damage.

7. Textiles

Growth in textiles is driven by WTO accession and the anticipated end of the WTO textile agreement in January 2005 in accordance with the results of the Uruguay Round. It is expected that many of the additional raw materials needed by the industry will be imported.

China's WTO accession has brought unprecedented opportunities for the development of the textile industry. The growth of the sector will be even more rapid after 2005 when the quota restriction is completely phased out (Figure 6). Taking the cotton textile sector as an example, there will be an increase in

total output. As output increases, so will wastewater discharge, the main source of pollution in the textile industry (Figure 7). By using 2001, the year China joined the WTO, as the baseline, the forecast shows that the total amount of wastewater discharged from the cotton textile sector will grow by up to 60 per cent by 2005 and by up to 90 per cent by 2010, if the current proportion of discharge remains unchanged. Without WTO, the total amount of wastewater discharged from the cotton textile sector would have increased by 36.05 per cent by 2005, and by 27.38 per cent by 2010.

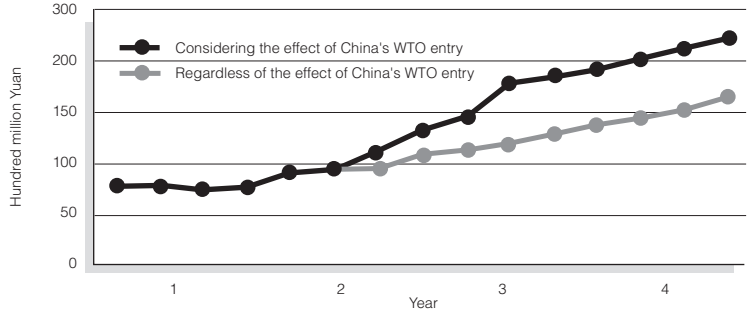

Figure 6. Gross output value of the textile industry after WTO accession (hundred million yuan).

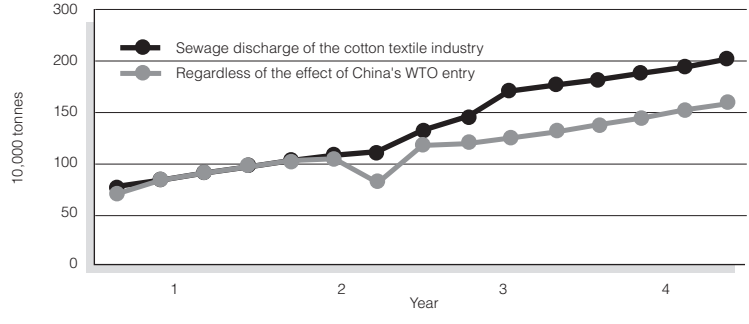

Figure 7. Wastewater discharge of the Chinese cotton textile industry after China's WTO entry (10 thousand tonnes).

Without a dramatic improvement of technology, increased production will inevitably lead to increased consumption of various resources, such as energy, water, cotton, additives and dyes, etc. It is predicted that consumption of energy and water would more than double by 2010.

WTO accession will bring foreign investment and advanced technology into China at an accelerating rate. It will raise the technological level of the industry, increase production efficiency, use fewer resources and reduce pollution. Many policies have some positive environmental impacts; including increased cotton import; tightened review and approval for the establishment of new facilities; technology advancement; reinforced environmental enforcement; promotion of cleaner production; and eco-labelling, etc.

Despite potential positive environmental impacts from the prospective technology effect and composition effect, the production scale of this industry may override the benefits of the above positive impacts.

There will be a notable increase in the number of small enterprises in the cotton textile sector after China's WTO accession due to a low threshold for entry into this sector. If no adequate policies are in place and if no measures are taken, serious environmental problems will arise.

At the same time, a contraction of cotton production is anticipated, since this represents the kind of extensive agricultural activity that does not work to China's comparative advantage, let alone correspond to the continuing concern about food security.

The most important environmental issue in relation to textile manufacturing is wastewater from processing and dyeing. The resulting wastewater is often difficult to treat, requiring a significant investment in facilities and expert operations. The study also assesses China's wastewater treatment capacity in the industry, which indicates that capacity in the sector needs to be doubled in order to meet the wastewater treatment needs of a growing production. Policies must be adopted to ensure that all wastewater from textile production is treated. For larger producers this will entail the operation of wastewater treatment facilities on site, for pre-treatment or for full secondary treatment. Where necessary, small and medium enterprises will need to be linked to shared wastewater treatment facilities.

The approval procedures of the new textile enterprises need to be strengthened in particular by implementing rules regarding environmental impact assessment and three simultaneities (pollution control facilities should be designed, installed and put into operation simultaneously as designing, constructing and operating the main part of the project) must be strictly followed in order to increase the environmental threshold for new enterprises to enter the sector.

China is expected to be the leading producer and exporter of textiles in the world. This position entails opportunities to shape the international debate on the environmental impacts of textile production; it also entails responsibilities that fall upon the country with the largest production. China must

promote technological innovation including energy efficiency, particularly in small and medium enterprises.

The textile sector is particularly sensitive to changes in product standards. WTO notification procedures do not provide adequate or timely information. China must develop its own information system on foreign standards and prepare to participate actively in the development of international standards.

8. Conclusions

After China's WTO accession, most of the sectors considered by the TFWE have already experienced and are likely to further experience rapid growth: textiles, automobiles, energy, labour-intensive agriculture and aquaculture. This growth is attributable to numerous factors, including economic growth, the development of export opportunities and foreign investment in China. Some sectors, in particular the production of resource-intensive agricultural crops and forestry, are expected to contract or at least to witness high levels of imports.

Growing and contracting sectors will experience totally different environmental consequences and will therefore need to be treated differently by the government, monitoring their development and formulating environmental policies and regulations accordingly.

9. Recommendations

Agriculture:

- Take advantage of increased trade opportunities provided by WTO accession, favour the import of resource-intensive products such as grains, which equals the import of indirect environmental benefits; encourage the export of labour-intensive products, such as vegetables, fruits and poultry; and provide support for farmers to switch from resource-intensive agriculture such as wheat growing to labour-intensive agriculture such as animal husbandry and horticulture.
- Adopt measures that internalize environmental costs resulting in increased production costs. For example, eliminate subsidies for pesticides and fertilizers in order to provide incentives to avoid over-use of these chemicals, and introduce payments for environmental services. A first step in this direction would be the establishment of a joint group by relevant departments to review existing agricultural subsidies, to explore possible charges for water, ecological compensation fees, and develop appropriate policies to promote sustainable agriculture.
- Ensure the shift of public policy from taxing agriculture to supporting it is consistent with WTO rules. "Green Box" measures allow Members to

provide support to farmers' incomes, rural development and the environment. China will need to increase support to its agriculture infrastructure, rural development and agriculture-related environmental protection.

- Address the market access difficulty of Chinese agriculture exports by establishing an information mechanism to provide timely information with respect to foreign environmental requirements and test procedures of agricultural products. China needs to strengthen its own standards whenever possible, and reinforce its own inspection and quarantine practices. It should work with its trading partners to strengthen international cooperation and information exchange; participate in international standards setting and invite the consultation of foreign countries in China's standards setting; and seek the creation of systems of equivalency and mutual recognition with important export markets.

Forestry:

- Review China's existing forest policies. This review should include not only domestic policies and conditions, but also import and export policies and forests in other countries that are liable to be impacted.
- China should consider reducing escalating tariffs on furniture and other finished goods produced from wood so as to improve the ability of timber producing countries to sustainably manage their resources.
- Establish a semi-official international coordinating group to provide advice on illegal logging and undocumented exports. This will also create a structure that can support necessary information exchange.
- Actively cooperate with western developed countries that are the major importers of furniture and processed timber products, promoting third party independent certification of timber imports and ensure that the entire forest product chain is managed in a sustainable manner, from the production of lumber through transport, processing, manufacture, sale, use and disposal.

Aquaculture:

- Strengthen protection of the marine environment so as to contribute to making the aquaculture sector more competitive internationally and to preserve existing markets.
- Formulate and implement integrated economic policies that promote marine aquaculture development and environmental protection. Efforts should be made to support an optimal breeding structure and a rational development mode, in order to best use all kinds of resources through cyclical re-use of wastes generated within the rearing system so as to min-

imize waste discharge and to achieve satisfactory breeding effects and economic profits, and at the same time, to attain the best ecological benefits.

- Establish an effective network so as to provide information concerning import requirements and trends of assessment of China's major trading partners, and to keep enterprises informed about relevant developments in the aquaculture sector, and to provide technical support with respect to new technical requirements that may form barriers to trade.
- Actively participate in the development of relevant international standards for aquaculture products and for the quality of marine waters that support aquaculture. This is an area in which China could take an active leadership role.

Automobiles:

- Grasp the opportunity of the temporary consumer surplus: collect environmental resources tax and fuel taxes from car consumers, while providing subsidies to manufacturers who adopt advanced technologies and to the consumers who engage in early replacement of outdated automobiles.
- Accelerate the introduction of more stringent emission standards.
- Speed up the phase-out of old vehicles with no permission for re-sale and re-use.
- Develop a viable system of public transport so as to provide alternatives to the excessive use of automobiles.
- Vigorously develop future automobile technologies.

Energy:

- Establish a response system for the coming large energy demand and import; develop a long-term energy development strategy; and establish a system of energy supply and energy security.
- Energy conservation is essential for China to reduce the demand and to release the pressure for energy supply. Use of large amounts of fossil fuel will cause serious environmental problems. A full range of policies and measures should be developed to abate pollution.
- Technology is the key issue for clean energy and a lower energy demand future. Research and development must be emphasized. International collaboration for technology transfer and diffusion should be encouraged. Clean coal technology development should be pursued by China in cooperation with a few other interested countries.

- External costs should be included in production costs, especially for energy and resource intensive products to avoid possible environmental and economic damage.

Textiles:

- Policies must be adopted to ensure that all wastewater from textile production is treated. Where necessary, small and medium enterprises must be linked to shared wastewater treatment facilities.
- Efforts should be made to strengthen the approval procedures of the new textile enterprises, in particular the rules regarding environmental impact assessment and three simultaneities (pollution control facilities should be designed, installed and put into operation simultaneously as designing, constructing and operating the main part of the project) must be strictly followed in order to increase the environmental threshold for new enterprises to enter into this sector.
- China is expected to be the leading producer and exporter of textiles in the world. It must promote technological innovation including energy efficiency, in particular in small and medium enterprises.
- The textile sector is particularly sensitive to changes in product standards. WTO notification procedures do not provide adequate or timely information. China must develop its own information system on foreign standards and prepare to participate actively in the development of international standards.

Agriculture

Agriculture

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(State Environmental Protection Administration)

1. Introduction

This research analyzes the environmental impacts of agriculture production after China's accession to the WTO. According to our qualitative analysis, we assume that the food self-sufficiency policy, as the core of current agriculture policy, has negative impacts on China's environmental quality and ecosystems because of domestic intensive and extensive production. After China's accession to the WTO, there are several possible directions for China's agriculture policy. One option is to import more grains, which would reduce environmental pressures in China. The research included a quantitative test of the hypothesis that WTO accession would cause fewer environmental impacts. Policy recommendations based on this research, have been given to the Chinese government.

The research is to follow the logic chain illustrated in Figure 1.

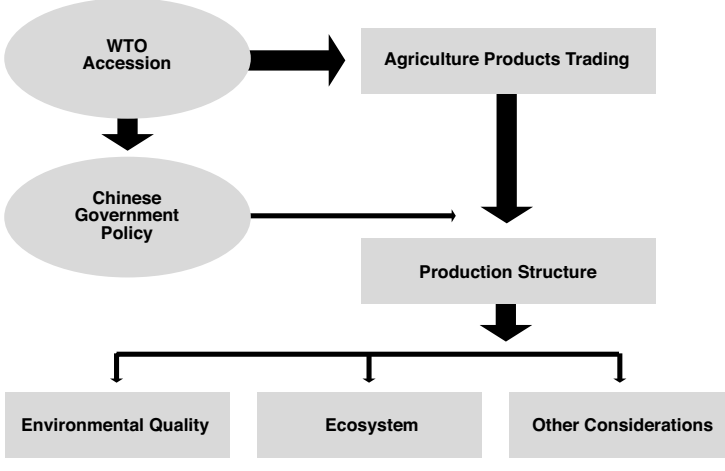


Figure 1. WTO accession and agriculture: the research path.

The research uses a computable general equilibrium (CGE) model developed by the Development Research Centre of State Council to simulate quantitative changes of WTO's impacts.

The research is mainly intended to measure the scale effects and composition effects of agriculture's impacts through CGE model simulation. The technology effects of agriculture's impacts of WTO accession are not considered.

The research includes five parts:

- a review of China's agriculture policy from the viewpoints of environment and trade;
- selection of Qianan county, Hebei province for wheat case study;
- measurement of economic and environmental impacts of agricultural production due to the changes of WTO accession; and
- policy analysis of agriculture trade and environment.

2. Review of China's Agriculture Policy

This section reviews and analyzes China's current agriculture policy from the perspective of environmental management and trade.

2.1 Current China's Agriculture Policy

Within China's current agriculture policy system, there are two key policies: food security and farmers' income. The core of the policy system is to ensure food security, like the grain self-sufficiency policy—95 per cent of grains must be produced domestically, not imported. The others are supporting sub-policies around the core policy, including trade policy, pricing policy, subsidy policy, production policy, etc.

Raising the income level of farmers is only a new policy, compared to the national policy of grain self-production and food self-sufficiency, in place before China's opening up policy issued in 1979. At that time, producing as much as possible was the priority during times of shortage. Food self-sufficiency was deemed necessary for national security and for saving scarce foreign currency for the development of industries. However, some grains still had to be imported to respond to food shortages.

After implementation of Household Responsibility System in early 1980s, China was able to export large amounts of agriculture products. Furthermore, in order to encourage farmers to produce more grains, a pricing policy was implemented. As a consequence, grain prices increased rapidly, which gradually affected China's ability to compete in the world grain market. Only after the reform of the exchange rate of the Chinese yuan in

1994 did China's grain prices drop. However, it lost competitive advantage again due to high increased production cost of grain. Compared to the world market, China's prices normally are: wheat, 10–60 per cent higher; maize, 20–60 per cent higher; and Indica rice, up to 15 per cent high (but Japonica rice up to 15 per cent lower). Due to the rapid increasing production costs of grain, China has been being facing the challenge of importing grain during these years.

Trade policy, as a key sub-policy, is intended to support the goal of food self-sufficiency. On one side, trade policy sets up import quotas to limit grains and others foods imported into China. On another side, trade policy encourages agriculture input materials to be imported to support the production of food within China: chemical fertilizers, pesticides, films used for agricultural purposes, as well as others. China set up very low and even zero tariffs for chemical fertilizers, which has been applied for several decades with no pressure from WTO or GATT. As a result of the tariff policy, China is the leading chemical fertilizer importer in the world.

After the report "Who will feed China?" by Lester Brown in 1994, although there were still some arguments, the food self-sufficiency policy had been clearly set up as a national core policy of agriculture in order to implement food security. Since joining into the WTO, China has had little change in the policy. Earlier this year, a new CPCC document emphasized farmers' incomes and food security. Now food self-sufficiency is the core policy of Chinese agriculture. China's is the world's largest grain producer, producing 22 per cent of the world total on seven per cent of the world's arable land.

2.2 Environmental consequences of current agriculture policy

In order to implement the policy of food self-sufficiency, there are two basic types of implementation: *intensification* (mainly intensive use of chemicals, energy and water) to increase production per capita; and *extensification* (mainly development of marginal land) to expand the amount of cultivable land. Therefore, the intensification and extensification of agriculture have strong impacts on both environmental quality and ecosystems. The areas of impact include water, air, land, food safety and ecological conservation. In rural areas, industrialized agriculture is the major source of environmental pollution and cause of land degradation, compared with the other two sources: rural industry and residential municipal wastes.

Water pollution

To ensure agricultural yields, farmers apply a lot of chemicals. The use of chemical fertilizers has increased year by year. Figure 2 illustrates grain production and chemicals use. China is also the largest importer, producer and consumer of chemical fertilizers in the world. The national average annual

application rate is about 225 kgN-1ha-1. In some coastal regions the average is even greater than 400 kgN-1ha-1.

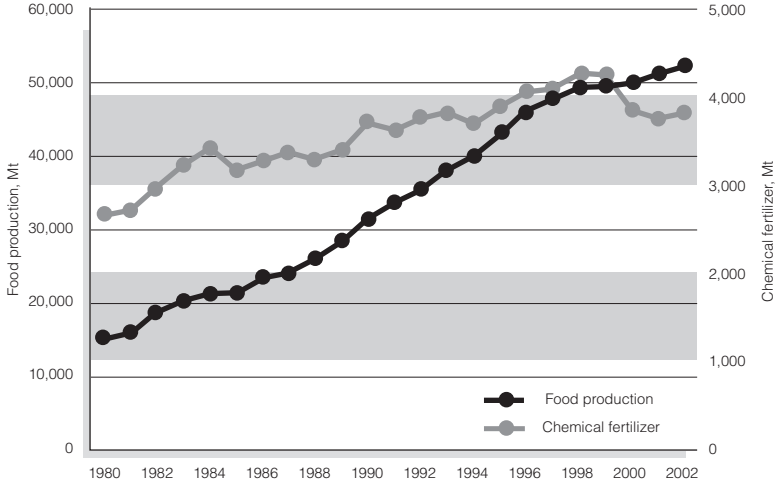


Figure 2. Food production and chemical fertilizer in China, 1980-2002.

However, the utilization rate of fertilizer is very low, only 30–45 per cent for N, 10–25 per cent for P, and 40–50 per cent for K. This causes serious problems of non-point source pollution. Overuse of chemical fertilizers and pesticides is resulting in serious non-point source pollution and eutrophication of water bodies. There are 4,880 lakes in China, covering 83,400 km^2 (0.8 per cent) of the country. According to SEPA's statistical data, each big lake and 75 per cent of total lakes are eutrophicated. For instance, the CAS analytical results indicated that in 1995 the TN and TP loading entering Taihu Lake from non-point sources accounted for 55 per cent and 28 per cent without calculating precipitation.

Additionally, the intensive livestock industry is another point pollution source of water, especially in suburbs or towns around cities. For example, around Shenzhen city there are some chicken farms and pig farms, which emit large volumes of wastewater. In 1995, total livestock excrements were 2.5 billion tonnes; 3.9 times the total annual industrial solid wastes. Only some of the livestock excrement has been treated before being released into water bodies.

Air pollution

In order to implement food security policy in last four decades large areas of grassland and forestland have been cultivated as farmland. Also, grassland

areas have been over-grazed to produce more agriculture and livestock products. One of the negative environmental consequences is sandstorms on grasslands. The frequency and intensity of sandstorms is rising, especially compared to the first half of 20th century. During 1950-1990, the average year had 1.77 sandstorms. However, in 2002 there were up to 12 sand storms. When sandstorms come to cities from grasslands, the air pollution can be very severe.

Another air pollution source is crop straw burning. After harvest, many farmers directly burn straw in the field, resulting in very heavy air pollution. In 2002, for example, the air pollution by straw burning dramatically decreased visibility in Shijiazhuang City. The airport of Shijiazhuang City had to close for 48 hours. Every year, there are about 400 million tonnes of crop straw that need to be managed.

Land degradation

For many years the intensive use of farmland has diminished the quality of the farmland. Soil fertility in most regions is getting low. The farmland with humus soil below 0.6 per cent now takes up 12 per cent of total farmland. Fifty-nine per cent of total arable land lack phosphate and 23 per cent lack potash.

Table 1. Growth rates of major grains sown area and yields in China, 1970–2003.

	1970–78	1978–84	1984–95	1996–00	2001–03
Rice					
Production	2.5	4.5	0.6	0.3	-4.8
Sown area	0.7	-0.6	-0.6	-0.5	-3.8
Yield	1.8	5.1	1.2	0.8	-1.0
Wheat					
Production	7.0	8.3	1.9	-0.4	-4.5
Sown area	1.7	0.0	0.1	-1.4	-5.9
Yield	5.2	8.3	1.8	1.0	1.5
Maize					
Production	7.4	3.7	4.7	-0.1	3.3
Sown area	3.1	-1.6	1.7	0.8	1.4
Yield	4.2	5.4	2.9	-0.9	1.8

Notes: Growth rates are computed using regression method.

Sources: NSBC, 1980-2003 and MOA, 1980-2003.

Due to grassland over-grazing, there are 130 million hectares of degraded grassland in China—a number that is increasing by two million hectares annually.

Extension of farmland to marginal land results in soil erosion. There are 1.8 million square kilometers of water erosion areas in China, taking up 18.6 per

cent of China's total territory. Until the Grain for Green program started, this total continued to increase.

Soil contamination is also a problem. Each day there are about 350,000 kilograms of municipal solid waste produced in rural areas. In 1995, nearly one million tonnes of agriculture plastic films were used, covering 6.5 million hectares of farmland. Some soil contamination is from industrial wastewater irrigation released by township and village enterprises and urban industries.

Food safety

China is also a large producer, importer and consumer of pesticides. Figure 3 illustrates pesticide use in the 1990s. Annual use of pesticide is more than 1.2 million tonnes. The average application rate of pesticide is 12.73 kg/ha over all of China. In 2000, the organic Cl and organic P pesticides amounted to 39.4 per cent and 37.4 per cent of total pesticides used. Most pesticides are applied to vegetable, fruit, rice and wheat crops. So far, about nine million hectares farmland have been polluted by pesticides.

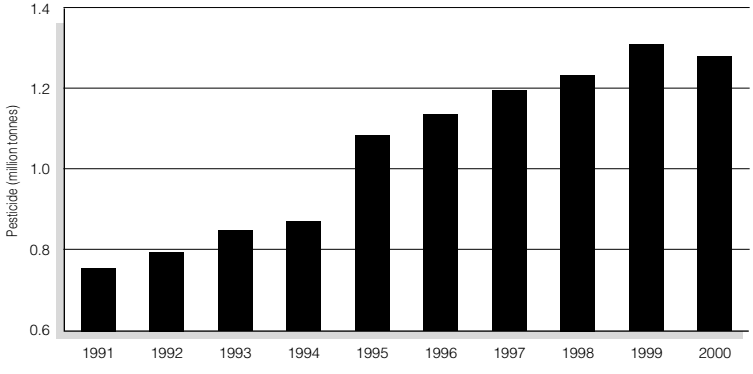


Figure 3. Pesticide use, 1991-2000.

Residual pesticides on agriculture products is a severe problem. Although a mandatory label for non-pollution agriculture products only sets the minimum standard for foods, a high proportion of products could not meet the standards. Green food and organic food represent only a small portion of agricultural products. Agricultural products contaminated with pesticides often result in food poisoning. China's agriculture products also face trade barriers when exporting to other countries. For example, in 2001 EU checked for pesticides on 62 Chinese tea products, up from six.

Although the Pesticide Administration Rule was put into action in 1997, poor management makes it hard to enforce the regulation. At ground level, local environmental protection bureaus have almost no capacity to enforce related rural environmental regulations.

Invasive species and biodiversity loss

Expansion and intensification of agriculture activities result in decreasing habitat, which threatens nature reserves and biodiversity. Of the 640 endangered species identified by CITES, China has 156. Invasive species along with imported products are also increasing, posing strong negative impacts on China's ecosystem. So far, the estimated economic loss due to invasive species is about 57.4 billion RMB yuan.

Further, township and village enterprises, which are normally small and medium size enterprises, are still polluting the rural environment, although the situation has improved over the last decade.

2.3 China's Accession to the WTO and Its Grain Trading Policy

The status and trends of agriculture commodities trading are described in Table 2. China has experienced trade growth in livestock products, fishery products and horticulture products. China has no competitive advantage in grains, oilseeds and sugar.

Table 2. China's net exports of food and feed trade (US$ million), 1980–2002.

Commodities	1980	1985	1990	1995	2000	2001	2002
Live animals and meat	739	728	1,153	1,707	932	1,317	302
Dairy products	66	26	-26	1	-30	-27	-80
Fishery products	367	239	1,268	2,266	2,493	2,912	3,132
Grains, oils and oilseeds	-1,991	241	-1,298	-5,152	-1,496	-3,490	-3,403
Horticulture	970	1,168	2,180	3,663	3,690	4,065	5,564
Sugar	-95	-195	-73	-614	-4	-220	-11
Sum of above foods	56	2,207	3,204	1,873	5,585	4,558	5,504

Source: China's National Statistical Bureau and China's Custom Authority.

Before China's accession to the WTO, the Chinese government clearly stated that to realize food self-sufficiency based on domestic resources is China's basic strategy. Therefore, net importing of grain would be limited to five per cent of domestic consumption. After WTO, according to the commitment, China still would import maximally 15 per cent of domestic consumption and also experience the following changes:

Market access

- Cancellation of Non-tariff Barriers: after the accession to the WTO, China will eliminate the quota, the license and the quanti-

tative limitation and only adopt the single tariff to the import of agricultural products.

- Tariff Reduction: China promised to decrease the tariff of agricultural production to 17 per cent or so in 2004 from 46.4 per cent in 1992 and 46.4 per cent in 1999.
- Quota for Important Agricultural Products: The promised quota is 5.7–8.8 per cent for domestic consumption. The tariff rate within the quota is usually 1–10 per cent and that beyond the quota is 10–80 per cent.

Table 3. Quota of Main Agricultural Products (10,000 tonnes, per cent).

Item	Wheat	Corn	Rice	
			Japonica	Indica
TRQ in 2002	846.8	585	199.5	199.5
TRQ in 2003	905.2	652.5	232.75	232.75
TRQ in 2004	963.6	720	266	266
Tariff within quota (%)	1~10	1~10	1~9	1~9
Tariff beyond quota (%)	74~65	65~74	65~74	65~74
Proportion of state-owned farms (%)	90	60~71	50	50
Percentage in the current yield (%)	8~9	5~6	3~4	

Source: http://www.moftec.gov.cn/table/wto/PARTI_Section1_A.pdf
http://www.moftec.gov.cn/table/wto/PARTI_Section1_B.pdf

- Commitment to give up the use of Special Safeguard Provisions (SSP): the SSP provides that when the import volume of product covering the tariff increased to a trigger level or the import price decreased to a trigger level, the member can adopt

Domestic support

China promised to account for the subsidies to investment and inputs which should be exempt from commitments under Paragraph 2 of Article 6 under the WTO Agreement of Agriculture into the *minimis* permission under Paragraph 4 of same Article as "Amber Box" policy. Moreover, the percentage of *minimis* permission of AMS to domestic agricultural or to special agricultural products will not exceed 8.5 per cent of agricultural production or total production of the special products.

Export subsidy

China promised to eliminate export subsidies to agricultural products which include the price subsidy, the subsidy in kind and the export subsidies to production process, storage and transportation which developing countries could have under the Paragraph 4 of Article 9 under the WTO Agreement of Agriculture.

3. Wheat Case Study: Impacts of Wheat Production in Qianan City, Hebei Province

3.1 Background

Hebei is one of the major wheat producing provinces of China. It has less than 350,000 square kilometers of territory, but more than 70 million people. After WTO, its wheat production would be strongly affected by trading volume and structural changes.

The case study in Qianan city is intended to analyze what has happened to wheat production in Hebei, what will be the alternatives for wheat production and what are the environmental implications of changes in wheat production.

Qianan City is located in the Northern part of Hebei province. Its climate is good for wheat production. It has a total of 120,800 hectares of territory with 50,000 ha of farmland taking up 41.8 per cent of the land. It also had a population of 0.664 million in 2002 with a GDP of 8.99 billion RMB.

Its major industries are building materials, metallurgy, textiles and others. Its major agriculture products are wheat, corn, peanuts, chestnuts, apples, pork, chicken and others.

Figure 4. Map showing the location of Qianan city.

3.2 Changes in Wheat Plantations

The planting areas of wheat in Qianan city have been decreasing; both before and after WTO accession. Table 4 shows the trends in recent years. The reason for the decrease in planting area is that wheat revenues have been decreasing. In 2002, the net revenue was 747 RMB yuan/ha, which is less than the previous year. Thus, farmers are showing less and less interest in planting wheat.

Table 4. Wheat planting areas in Qianan city.

1999–2000	2000–2001	2001–2002	2002–2003
24,300 ha	21,700 ha	19,700 ha	11,500 ha

Alternatives to current wheat production include the following:

1. From low quality wheat to high quality wheat production
2. From wheat to other crops, such as
    - Chestnuts
    - Peanuts
    - Vegetables
    - Apples
    - Watermelon
    - Others
3. From "grain" to "green," wheat farmland shifting to
    - Forestland
    - Grassland
4. From agricultural land to urban and industrial land

The changes in wheat farmland patterns have shown that the market drives the process. Wheat farmlands are shifting to high outputs of production, without policy interventions. Land-intensive production is shifting to labour-intensive production, such as chestnuts, peanuts, vegetable and apples.

3.3 Environmental Impacts of Wheat Production Changes

Based on the calculations for changes in 2003, after shifting from wheat plantation, the environmental impacts are:

- Nitrogen fertilizer will be decreasing 21.6 per cent, i.e., a reduction of 577,000 kilos. The contributions are mainly from peanut plantations and grassland.

- Phosphate fertilizer will be increasing 7.4 per cent, i.e. 62,000 kilos growth, mainly due to watermelon and apple growth.
- Agricultural plastic film will be increasing 401,000 kilos, mainly from greenhouse infrastructure for vegetables and watermelons.
- Economy forestland, such as apples and chestnuts, will increase by 1,080 ha.

The conversion from wheat farmland to ecological forestland and grassland has not been calculated due to the lack of data. Land shifting from farmland to urban construction land and industrial land has not been taken into account yet.

Generally speaking, for ecosystems, the conversion from wheat farmland to other uses has very positive ecological impacts; for water quality it has both positive and negative impacts. The trends of chemical fertilizer's impacts are moving from non-point source pollution to point source pollution, which often happens in greenhouses for vegetable plantation.

4. Economic and Environmental Impacts of China's Accession to the WTO

4.1 CGE Model

The research chose the CGE model to simulate economic and environmental changes resulting from China's accession to the WTO. There are a total of 53 sectors in the model, including agriculture, forestry, textiles, as well as energy and automobile related sectors.

In the model, production activities are described by the Constant Elasticity of Substitution (CES) production function. The demands of people are described by the Extended Linear Expenditure System (ELES). Trade is described by the Constant Elasticity of Transformation (CET) function with the Armington assumption.

In the model, SO_2, NO_x, COD, TSS, and soot are considered as major pollutants. The emission parameters are based on China's Environmental Statistical Yearbook as well as other domestic parameters. Specifically for agriculture chemical fertilizer, pesticide and water consumption are being considered.

The model is a dynamic model with the base year of 1997. Results of 2010 are projected. The assumptions of China's accession to the WTO are described below:

Table 5. Simple description of assumptions of China's accession to the WTO.

Assumptions	Description
E1	Baseline: - Importing quota growing rate is 3% - Textile exporting quota growing rate is 5% - Other tax rates are fixed at the base year
E2	Free trade of agriculture products 1 - TRQ as commitment of China - Other non-TRQ products reductions
E3	Free trade of agriculture products 2 - Based on E2, to reduce grain self-sufficiency rate to 85% in 2010
E4	Industrial products reduction of tariff and quota elimination - During 2000-2008, reduce to 55% based on tariff level of year 2000 - During 2000-2005, import quotas for petrochemical and automobile parts being eliminated
E5	Reduction of MFA - During 2000-2004, exporting quota increasing - in 2005, no textile export quota limitation
E6	Whole picture of China's accession to the WTO - E2 - E4 - E5

4.2 Economic Impacts

The current status of agriculture structure and trends are outlined in Table 6.

Table 6. Structural changes in the agricultural economy, 1970–2002.

	1970	1980	1985	1990	1995	2000	2001	2002
	Agricultural output value share (%)							
Crop	82	76	69	65	58	56	59	55
Livestock	14	18	22	26	30	30	26	31
Fishery	2	2	3	5	8	11	11	11
Forestry	2	4	5	4	3	4	4	4
	Crop sown area shares (%)							
Cereal grains								
— Rice	22.1	23.1	21.9	22.3	20.5	19.2	18.5	18.2
— Wheat	17.4	19.7	20.0	20.7	19.3	17.1	15.8	15.5
— Maize	10.8	13.7	12.1	14.4	15.2	14.8	15.6	15.9
Sub-total	50.3	56.5	54	57.4	55	51.1	49.9	49.6
Soybean	5.5	4.9	5.3	5.1	5.4	6.0	6.1	5.6
Rapeseed	1.0	1.9	3.1	3.7	4.6	4.8	4.6	4.6
Peanut	1.2	1.6	2.3	2.0	2.5	3.1	3.2	3.2
Sugarcrops	0.4	0.6	1.0	1.2	1.3	1.0	1.1	1.2
Cotton	3.4	3.4	3.5	3.8	3.6	2.6	3.1	2.7

	1970	1980	1985	1990	1995	2000	2001	2002
Tobacco	0.2	0.3	0.9	0.9	0.9	0.8	0.8	0.8
Vegetable	2.0	2.2	3.2	4.3	6.3	9.7	10.5	11.2
Others	41.6	34.5	34.3	30.6	31.2	34	35.1	35.8
Total	100	100	100	100	100	100	100	100
	Tea and fruit planted areas (1,000 hectares)							
Tea		1,041	1,077	1,061	1,115	1,089	1,141	1,134
Fruit		1,783	2,736	5,179	8,098	8,932	9,043	9,098

Source: NSBC, China's Statistical Yearbook, various issues; China Rural Statistical Yearbook, various issues.

After China joins the WTO, productivity factors, such as land, labour, capital and natural resources, would be re-allocated globally. The structure of agriculture could change again and a general perception based on our qualitative judgments could be:

- labour-intensive industries such as manufacturing, livestock, horticulture, vegetable planting and handcraft would further expand;
- intelligence/intellect-intensive and knowledge-intensive industries including information, telecommunications, consulting, community services, education and culture, etc. would grow further;
- land-intensive industries, such as grain production, cotton production and traditional nomadic forms of husbandry would decrease;
- capital-intensive industries would largely increase, including banking, security, insurance, brokerage, tourism, real estate, education and culture; and
- pollution-intensive industries will vary from the east to the west of China. Generally speaking, environmental pressure would increase in central and western regions but decrease in eastern regions.

The following table shows the general macro-economic impacts of China's accession to the WTO by 2010.

Table 7. Macro-economic impacts by 2010. (Ratios based on baseline).

	E6	E2	E3	E4	E5
GDP	1.14	0.47	0.55	0.14	0.27
Investments	0.85	0.48	0.50	-0.06	0.15
Exporting	17.37	2.23	2.83	4.21	6.51
Importing	16.99	2.22	2.80	4.10	6.36
Grain self-sufficiency rate	0.89	0.89	0.85	0.97	0.97

Compared with the baseline, China's GDP would increase by 1.14 per cent. Both exporting and importing would dramatically increase by 17.37 per cent and 16.99 per cent respectively. The grain self-sufficiency rate could be kept at 89 per cent.

Specifically the economic impacts on agriculture are simulated below.

Table 8. Economic Impacts on Agriculture by 2010 (Ratios based on baseline).

	E6	E2	E3	E4	E5
Total production					
Rice	-4.5	-4.1	-3.8	0.1	-0.1
Wheat	-9.5	-9.2	-19.5	-0.1	-0.2
Maize	-1.9	-1.6	-1.1	0.1	-0.2
Cotton	-1.2	-7.6	-7.0	0.0	6.8
Other non-grains	-0.2	-0.2	0.2	0.2	-0.2
Forestry	-3.2	-0.9	-0.5	1.1	-2.4
Wool	-0.5	-5.7	-4.3	1.5	3.4
Other livestock products	2.1	1.7	2.1	0.0	0.1
Fishery	1.0	1.0	1.2	0.3	-0.2
Import					
Rice	583.6	523.8	507.4	0.1	0.0
Wheat	144.1	134.5	305.4	-0.1	2.9
Maize	508.4	442.8	428.8	1.2	4.7
Cotton	177.1	89.8	86.6	0.0	0.0
Other non-grains	27.1	3.1	1.7	-2.3	10.0
Forestry	8.8	5.7	4.9	-3.5	4.7
Wool	5.6	4.6	4.4	2.0	-2.5
Other livestock products	1.2	-3.6	-4.5	-1.4	4.1
Fishery	5.3	0.1	-0.4	-1.7	4.0
Export					
Rice	0.8	7.5	10.8	4.4	-7.6
Wheat	0.0	0.0	0.0	0.0	0.0
Maize	2.0	8.8	12.2	4.4	-7.7
Cotton	2.0	2.0	6.1	4.1	-4.1
Other non-grains	2.5	10.1	13.1	4.1	-7.8
Forestry	-4.6	2.9	4.3	4.9	-8.5
Wool	3.0	4.6	8.4	5.7	-4.8
Other livestock products	4.7	11.8	14.5	4.1	-7.8
Fishery	-1.5	6.3	7.8	4.6	-8.6

Compared with the baseline, by 2010 the production of wheat, rice, maize, cotton, forestry, wool and other non-grain products would drop by a certain percentage. Only the production of livestock farming products and fish

farming products would increase. The most significant change is that by 2010 the imported amount of rice, wheat, maize and cotton would dramatically increase several times.

4.3 Environmental Impacts of Agriculture Production After China's Accession to the WTO

Based on economic changes of accession to the WTO, the preliminary results of environmental impacts are simulated by our CGE model as well. Table 9 shows the environmental impacts by WTO accession which are represented by key environmental indicators. Good indicators on ecosystem services have not been found yet.

Table 9. Key environmental indicators changes after WTO accession, by 2010 (Ratios based on baseline).

Environmental indicators	E6	E2	E3	E4	E5
Chemical using amount					
N	-2.9	-3.0	-4.5	0.1	0.1
P_2O_5	-3.6	-3.7	-6.3	0.1	0.1
K_2O	-1.5	-1.6	-1.5	0.2	0.0
Com	-2.9	-3.0	-4.6	0.1	0.1
Pesticide using amount	-3.0	-3.8	-4.2	0.3	1.0
Water consumption	-3.0	-3.1	-4.7	0.1	0.1

From the table shown, compared with the baseline, the use of any chemical—whether nitrogen, phosphate, potash, compound fertilizer or pesticides—or water consumption, would decline by 2.9 per cent, 3.6 per cent, 1.5 per cent, 2,9 per cent, 3.0 per cent and 3.0 per cent respectively by 2010. Assuming further liberalization of agriculture; i.e., E3 scenario with 85 per cent grain self-sufficiency rate, use would decline by 4.5 per cent, 6.3 per cent, 1.5 per cent, 4.6 per cent, 4.2 per cent and 4.7 per cent respectively, which is more than in any other scenarios. The total use of chemicals would be reduced by 2.78 million tonnes; pesticides would be reduced by 76,300 tonnes; and water consumption would be reduced by 182 million cubic metres.

It also means that after accession to the WTO, if the agriculture trade policy follows the market force, by 2010 the environmental pressures would be lessened by the fact that the reduction of 2.78 million tonnes of chemical use; 76,300 tonnes of pesticide use and 182 million cubic metres of water consumption would be achieved. This achievement would be largely attributed to the increase of grain imports. It is the environmental significance of agriculture trade liberalization.

Of course, the shifting of farmers and farmlands to non-agricultural sectors also contributes to positive environmental impacts. The shifting from grain production to vegetable, horticulture, livestock farming as well as other non-

grain sectors, may increase the use of chemicals and water resources. The CGE model shows that the integrated environmental impacts of China's accession to the WTO is very positive.

Although there are no good indicators to show ecological benefits after WTO accession, it's obvious that imported grains would be helpful for China to implement the Grain to Green Program. The figures, as evidence, have been shown in Qianan case study.

5. Policy Analysis of Agriculture Trade and Environment

Based on the above impact analysis, we will do a policy analysis of agriculture trade and environment in order to provide policy recommendations for the Chinese government to maximize positive environmental impacts and to minimize negative environmental impacts. This is how to promote sustainable development of the agriculture sector through trade.

5.1 Future Agriculture Trade Policy Options for China

In the past, nobody doubted the food self-sufficiency policy, since the agriculture policy's impacts on political, social and economic objectives were related to each other, and the environmental issue was almost ignored. During the poor period, China even exported grains to earn hard foreign currency. During the last two decades, production costs of grain have been increasing, revenues of growing grains for farmers have been decreasing and environmental problems have been getting serious. Now the conflicts between the political objective of food security and social, economic and environmental objectives are merging. Table 10 shows the comparisons between China's price and international prices that exactly reflects China's advantage and disadvantages. China's advantages are labour-intensive products and disadvantages are resource-intensive products (mainly land and water).

Table 10. Nominal protection rates (NPR) of China's major importing and exporting agriculture products in 2001.

Major Import Agricultural Products		Major Export Agricultural Products	
Agricultural Products	NPR	Agricultural Products	NPR
Wheat	12	Rice	-3
Super special wheat from U.S.	49	High quality Japonica rice	-11
High quality wheat from Canada	20	Average quality Japonica rice	-8
High quality wheat from Australia and Europe	11–12	Hybrid rice	-5
Imported wheat with same quality of China	8–10	Average quality Indica rice	3

Major Import Agricultural Products		Major Export Agricultural Products	
High quality Indica rice (Thai rice)	17	Pork	-30
Maize	32	Beef	-10
Soybean	15	Poultry	-17
Cotton	17	Apple	-4
Sugar	40	Garlic	-4
Oil	35		

*Notes: NPR of imported products = (Domestic price – CIF) /CIF*100 per cent*
*NPR of exported products = (Domestic price – FOB) /FOB*100 per cent*

Table 11 shows the trends of grain plantations during the last three decades. Even with strong food security policy intervention, the sown areas gradually decline.

Table 11. Growth rates of major grains sown area and yields in China, 1970-2003.

	1970-78	1978-84	1984-95	1996-00	2001-03
Rice					
Production	2.5	4.5	0.6	0.3	-4.8
Sown area	0.7	-0.6	-0.6	-0.5	-3.8
Yield	1.8	5.1	1.2	0.8	-1.0
Wheat					
Production	7.0	8.3	1.9	-0.4	-4.5
Sown area	1.7	0.0	0.1	-1.4	-5.9
Yield	5.2	8.3	1.8	1.0	1.5
Maize					
Production	7.4	3.7	4.7	-0.1	3.3
Sown area	3.1	-1.6	1.7	0.8	1.4
Yield	4.2	5.4	2.9	-0.9	1.8

Notes: Growth rates are computed using regression method.

Sources: NSBC, 1980-2003 and MOA, 1980-2003.

Therefore, the question has been raised—is China having food security problem? Is it necessary for China to feed itself?

From a trade and WTO perspective, China has two basic policy options:

- following market force, to import more grains and other resource-intensive products (and export more labour-intensive products); or
- against market force, to produce more grains domestically with certain economic, social and environmental costs. It's the way EU, Japan, Korea and others have chosen. This way may conflict with WTO subsidy rules for agriculture.

According to our quantitative analysis above, if China follows market force, by 2010 China will become the most important grain importing country after Japan. This would produce economic benefits and dramatically reduce pressures on its environment and ecosystems. Unfortunately, it seems that China's government is going in another direction. The newly issued No.1 document of the central government stresses the importance of food security again and the necessity of raising farmers' incomes. Quite a lot of subsidies are used to encourage farmers to produce grains. The Grain for Green Program has been slowed down and even stopped in some regions for this year.

This report is not going to answer the question of food security. The food security issue is very complicated and it needs an integrated decision-making process for all considerations, including national strategic, international political, social, economic and environmental aspects.

This report only raises the issue of environmental costs and unveils the environmental consequences of the food security policy. It also points out that environmental security shouldn't be ignored when considering food security. Food security and environmental security should be balanced.

5.2 Key Causes of Environmental Costs by Agriculture Production

China's WTO accession has strong environmental impacts, but it doesn't mean trade is the root cause of environmental degradation.

The first key reason behind environmental costs by agriculture production is the weak rural environmental management capacity, which is not able to internalize the rural environmental costs of agriculture production. Currently, less than six per cent of townships have environmental management bodies. The average number of staff at township-level environmental management bodies is 2.7 persons. Less than half work directly in rural environment management. Even at the county level, average number of staff at environmental organizations is 12.87 persons. Among them, less than half are governmental civil servants; the rest are contracted staff. Township and county level environmental management organizations are too poorly equipped to monitor rural environmental pollution and degradation and to enforce relevant environmental laws.

The second key reason for rural environmental costs is lack of coordination between agriculture policy and environmental policy. There are still many officials who have not realized that agriculture is one of the most polluting and ecologically degrading industries. China is now actually the biggest producer, importer and user of chemicals in the world. This is because of China's agriculture policy incentives, such as low customs tariff, subsidies, and chemicals as bonuses for farmers. For implementing food security poli-

cy, environmental security is often ignored. In 2003, China produced 430 million tonnes of grain products. To ensure food security to reach the target of 400 kg per capita, the Ministry of Agriculture set up a plan with target of 550 million tonnes of grain production in 2010. The plan has never been reviewed from an environmental management perspective. According to environmental impact assessment (EIA) law, such agriculture development regional plans or projects should be evaluated.

There are also other causes, such as lack of rural education and infrastructure, poverty stress, lack of investment, etc.

5.3 Policy Recommendations

For better dealing with relationships between food security and environmental security and better coordinating agriculture policy and environmental policy, the following policies are suggested to Chinese government.

To enlarge imported grains proportion under food security

The significance of grain importing is not only to ensure food security, it's also to indirectly import ecological and environment benefits through directly importing grains. Importing grain means less use of water resources, less use chemicals and less soil erosion, as well as more "Grain for Green" implementation, and more production of ecological benefits. The more grains imported, the more environmental security is ensured.

After accession to the WTO, China's economy is gradually integrating into the world economy. Its resources are widely allocated globally. Enlarging exporting of goods and services obviously will drive China's economic development; enlarging importing would release ecological and environmental pressures of resource-intensive production, although it may increase rural employment in the transition period from resource-intensive agriculture production to labour-intensive manufacture and horticulture, etc. Importing of resource-intensive products equals indirectly importing of ecological and environmental services, which would also promote sustainable development in China.

To strongly enhance rural environmental management capacity

The weakness of rural environmental capacity directly results in serious rural environmental problems. It's necessary to make environmental institutional arrangements to strongly enhance rural environmental management capacity. Enhancing rural environmental management capacity is the first necessary condition to internalize environmental costs of agriculture production. The central government should share more rural environmental responsibilities with county and township governments. The central government should also delegate more rural environmental tasks to lower level environ-

mental authorities with abundant financial resources. It's also necessary to train local environmental staff and to equip local environmental management bodies. Performing EIA on agriculture projects and regional development plans is urgently required to prevent new rural pollution.

With the proper rural institutional arrangements and enhanced rural environmental management capacity, it's possible to internalize environmental costs. Many measures can be taken, for example, to abolish direct and indirect subsidies for chemical use, to charge for irrigation water by metering, to have an ecological compensation scheme, etc.

If the environmental costs of agriculture production are internalized, the prices of grain products would be much higher than the current prices. This would reduce environmental degradation as more grain would be imported from countries with lower prices.

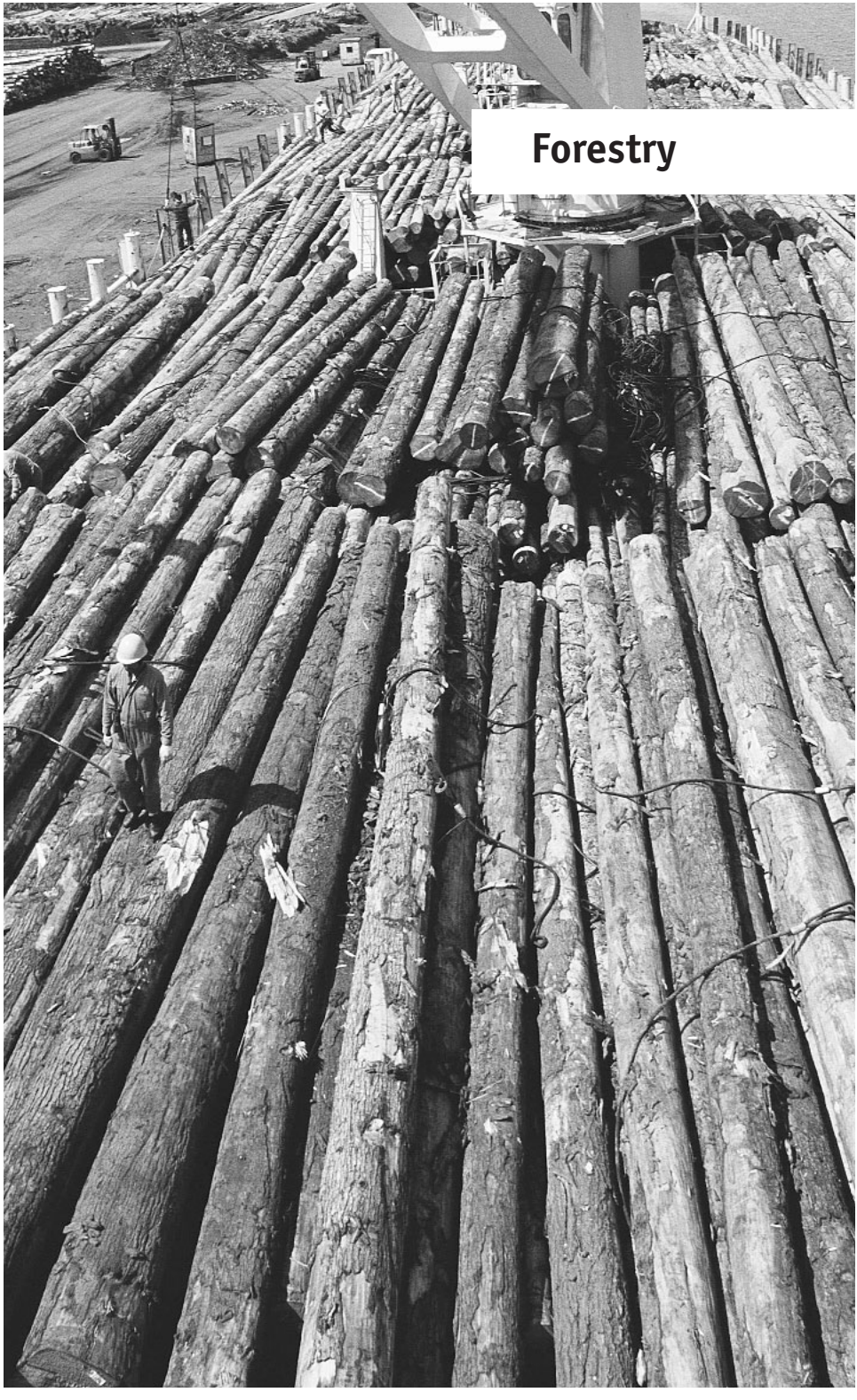
To adjust rural economy structure towards more labour-intensive rather than resource-intensive industries

The higher the proportion of labour costs and the lower the proportion of resource costs in production, the lower the environmental pollution and resource damage. Hence, farmers moving from agriculture to manufacturing, services and other labour-intensive industries should be strongly encouraged. Shifting from grain growing to horticulture, livestock feeding, fruit planting as well as labour-intensive planting should also be encouraged. So, the rural economic structure should be adjusted to more labour-intensive industries rather than resource-intensive industries.

To encourage domestic consumption and to increase export of organic food and green food, in order to promote sustainable agriculture

Ecological or sustainable agriculture is a farming system with good environmental performance, including high efficiency of water consumption and reduced chemical use. Certified organic food and green food are products of ecological agriculture. To enlarge consumption and exporting will demand more production of green food or organic food. The efforts should be made to both encourage domestic consumption and to enlarge exporting of organic food and green food. That could promote sustainable agriculture by consumption and trading.

When enlarging exporting and producing of green food and organic food, government measures should be compatible with WTO rules. "Green Box" policies are freely allowed and "Amber Box" policies are only partly allowed.



Forestry

Forestry

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1. Major Features of the Chinese Forestry Sector

Our study indicates that the Chinese forestry sector has the following notable characteristics:

- supply of a combination of industry and public goods;
- severe shortage of forest resources;
- overall low competitiveness in its forestry product industries, with the exception of labour intensive industries such as furniture and resin production;
- high degrees of dependency on timber imports; and
- a governance system that has a strong feature of a planned economy instead of market economy.

2. The Mechanisms by Which WTO Accession Affects Chinese Forestry

Understanding how WTO accession interacts with Chinese forestry is a precondition for assessing the impacts of the WTO on Chinese forestry.

2.1 The Spirit of the WTO[1]

This study assumes that the WTO pursues the principles of:

- non-discrimination;
- open market;
- fair competition;
- transparency in trade policy and legislation;

1 Du Houwen, *WTO Basic Organizational Rules and China's Strategies*, Xinhua Publishing House, Beijing.

- preferential treatment of developing country Members; and
- sustainable development.

2.2 Clauses that Concern Forestry in China's WTO Entry Documents[2]

2.2.1 Clauses that Directly Concern Forestry

Tariff Reduction in Major Forest Products

China has committed to reduce the tariff on 249 types of forest products after WTO accession. In 2002, China's average tariff for timber, paper and paper products was 8.9 per cent. Apart from continuing the zero tariff policy that had been applied to round logs, sawn wood and wood chip imports, there was an overall tariff reduction, of varying degree, for all other forest products, with an average rate of reduction at 33.5 per cent (Table 1).

Table 1. Tariff reductions for major forest products in China in 2002.

Product type	Previous tariff %	New tariff %	Rate of reduction %
Logs and sawn wood	0.0	0.0	0.0
Veneer	8.0	5.2	35.0
Panels and small wood products	15.0	11.7	22.0
Furniture	22.0	11.0	50.0
Wood pulp	0.0	0.0	0.0
Paper and paper boards	18.6	12.0	35.0
Paper products	6.0	3.5	42.0
Rattan, bamboo and grass and products	10.0	10.0	0.0
Resin	12.0	10.0	17.0

Changes in Forest Products Import Management

Most forest products in China are not subject to non-tariff barriers such as restrictions in import volume or authorized operation; but China does apply non-tariff management measures for the export of logs, sawn wood and resin and to the importing of plywood. According to commitments China made regarding non-tariff measures, starting from 2002 China will:

- include logs in the index of items banned from export;
- continue to limit the volume of sawn wood exports, with MOFTEC assigned to distribute sawn wood lumber export permits. However, the policy of non-restriction on re-exporting sawn wood made from imported logs made by the State Forestry Administration will be upheld;

2 References were mainly made to Yao Chantian *et al.*, *WTO and Chinese Forestry*, China Forestry Publishing House, Beijing, 2001.

- revoke the volume restriction on plywood imports and the administration of export permits on plywood. Authorized operation of plywood will be revoked three years after WTO admission; and
- revoke the export permit and authorized operation restriction on resin exports.

Subsidization and desubsidization

Twenty-four subsidized items are listed in China's WTO entry documentation, of which two items are directly relevant to forestry:

- preferential treatment policy for foreign firms;
- continuation of certain subsidies to forestry firms, that is, the tax refund policy of value added tax over exports of certain forest products;
- other subsidies that are indirectly relevant to forestry such as loans provided by state policy banks, fiscal subsidies on poverty alleviation and tax refunds on export products; and
- Trade-related Intellectual Property Rights Rules.

China's WTO entry working group report specifies that Chinese intellectual property rights legislation includes "Rules Concerning the Protection of New Plant Species in the People's Republic of China," and authorized the Ministry of Agriculture and State Forestry Administration to implement the protection of new plant species.

2.2.2 Clauses that Forestry Can Adopt

- preferential treatment arrangements for developing countries under the WTO;
- the tri-box policy in the Agricultural Agreement; and
- reasonable protections that are allowed by WTO rules.

2.3 The Mechanisms Through Which the WTO Acts Upon Chinese Forestry

Our study concludes that the macro-level institutions and policies in forestry will adjust according to WTO requirements in the following four major ways:

Liberalization-oriented forestry trade policy

Before joining the WTO, China had already made major changes to its forestry trade policies. In 1997, China, as a member of APEC and together with other APEC members, worked out a proposal to first pursue trade lib-

eralization in nine sectors that included forestry. In implementing this APEC proposal and in preparation for the WTO entry negotiations, China made a number of efforts to liberalize trade in the forestry sector. Major efforts included tariff reduction and the weakening of non-tariff barriers, as well as major changes in quota administration.

Globalized allocation-oriented forest resource strategy

Taking into consideration the domestic need for environmental protection and a relatively buoyant foreign exchange reserve, the Chinese government has adopted a forest resource strategy that favors trade:

- to switch from utilizing only domestic resources and markets to using both domestic and global forest resources and markets;
- to adopt an open policy strategy that is supported by wood import substitution and re-exporting of processed wood products;
- to benefit fully from comparative advantages that China enjoys and to expand the export of labour-intensive products such as furniture, and resource-based products such as resin.

Environment protection-oriented development strategy

China has adopted sustainable development as a fundamental state policy and will continue to pursue its current policy of forest conservation and wood importing.

Market economy-oriented forest institutional and policy changes[3]

These changes are reflected in the June 2003 "Resolutions on Speeding Up Forestry Development" adopted by the Central Communist Party Committee and State Council. As a government effort to transform the forest sector toward a market economy, this document proposes to:

- pursue specialized management in forestry;
- establish a forest administration system that separates government from business;
- further improvement in the forest property rights arrangements;
- fully develop private forestry;
- increase government input in forestry; and
- reduce the taxation burden in forestry.

3 *Resolutions on Speeding up Forestry Development by CCCP and State Council*, 2003. People's Press, Beijing

In sum, the forestry administration system and policies in China are gradually moving toward what is required by a market economy, and are becoming more and more suitable to the needs of trade liberalization and globalization. These changes are the combined result of Chinese socioeconomic factors, the situation within the forestry sector, and international forces. WTO entry has played an indispensable role in these changes. Given the understanding that institutions and policies are fundamental to forestry development, the institutional impacts that WTO entry is having in the Chinese forestry sector cannot be overemphasized.

The WTO will impact Chinese forestry via a number of linkages, including forest products, capital, technology, food and energy, as well as species. Our study focuses on the environmental impacts that WTO entry has via forest products.

3. An Assessment of the Environmental Impacts of WTO in the Chinese Forestry Sector

3.1 Characterization of the Environmental Impacts in Chinese Forestry Sector

Environmental impacts will be felt mainly in three ways:

- forest products and forest resources resulting from the import of goods such as forest products, food and energy;
- forest products industry; and
- investments in forestry.

Further, these chains of causality are classified as three types of environmental impacts, namely:

- product-trade impacts that concern changes in forest resources;
- forest industry impacts that concern degree of forest resources utilization and changes in industrial damages; and
- forest investment impacts that concern forest resources development.

These impacts are further considered as:

- the product level impacts;
- industry level impacts; and
- capital level impacts.

They are each discussed below.

3.1.1 Product Level Impacts

WTO accession will facilitate trade in goods and services. Following WTO accession it is anticipated that China will increase the import of wood products as well as food and energy products. This will contribute positively to Chinese forestry. In the mean time, however, the risk of invasive species brought by increased trade of goods and growing tourism and travel will rise.

Wood products

China's WTO entry will have limited further impacts on the import of logs, sawn wood, pulp and wastepaper, because the tariff rates for these products has been gradually reduced to zero since the late 1990s. Along with the removal of tariff and non-tariff measures for wood products imports, tariff rates for other wood products are also on the decline. By 2002, the average tariff rates on timber, paper and paper products were reduced to some 8.9 per cent, and many non-tariff trade barriers such as the quota on plywood imports and control on foreign exchange were being removed. By 2005, average tariff rates on forest products will be reduced to under five per cent.

Although Chinese imports of forest products have already reached a relatively high level, there is reason to believe that such imports will continue to increase in the foreseeable future: a) Market demands will grow further, driven by a huge population, growing economy, and increasing wood use in housing; b) Domestic supply will be limited, due to a grossly inadequate resource base, low efficiencies of processing and growing needs for conservation such as the logging ban on natural forests and the establishment of nature reserves; and, c) Global supply will be relatively adequate, particularly in regions such as Russia or certain developed countries with rich forest resources.

It should be noted that this predicted growth in wood products imports will not be fueled only by domestic demand. Instead, re-exporting will continue to grow, particularly furniture and other wood products. In these products China enjoys low labour costs, relatively well developed industry infrastructure and capacity, and reduced import tariffs in importing countries thanks to China's WTO membership. Overall, however, the importing of wood products in China is still a resource-based import substitution type of trade, as the roundwood equivalent (RWE) of imported forest products is still significantly greater than that of exported forest products. This implies tremendous protection of the Chinese forest resource base.

Food and energy

China has committed to revoke non-tariff barriers and to continue to lower import tariffs on grain importing after WTO entry. In the transition phase, tariff rate quotas will still be administered against wheat, corn and rice.

Today, certain domestically produced grain products are not competitive in price and quality; it is anticipated that most of these products that are subject to tariff quotas will be imported over time. The growth of grain importing in China is an inevitable trend. Likewise, paucity in domestic energy resources will lead to increasing importing of oil and gas.

Increased grain importing will lead to the conversion of some marginal farming lands to forests. In fact, the launching of the massive sloping farmlands conversion program was supported by an oversupply of grain at that time. With the further increase in grain importing after WTO entry, this so-called grain for ecology program has a better chance to be sustained.

After WTO entry, Chinese imports of energy will also increase. China is rich in coal resources; however, Chinese coal overall has a lower grade and high ash content, and domestic infrastructure for coal transportation remains to be further developed. Therefore, coal supply from Australia, Indonesia and Vietnam will be particularly competitive in coastal areas of China and coal importing in these regions is bound to increase. Oil is an even more important energy source for China. Domestic oil reserves are becoming increasingly insufficient to meet domestic energy needs. China will gradually revoke restrictions on the importing and distribution of crude oil and refined oil products. China is increasing its oil importing and will continue to do so.

The importing of energy will decrease demand for fuelwood. In particular, the Chinese degree of urbanization is significantly lower than that in countries of a similar level of economic development. This has been caused mainly by policy restrictions such as the Hukou, or Residence Permit system. Today, China is promoting rapid urbanization, particularly the development of small and medium towns. This urbanization movement will facilitate increasing use of petrol energy, reducing the demand for fuelwood from forests at the fringe of towns. The environmental impacts will be significant.

Species

Species invasion can bring about disastrous impacts on the ecological environment and the economy. This is rapidly becoming an unavoidable problem for China as well. Today, it is estimated that annual losses in China caused by invasive species is over 50 billion yuan. According to surveys by the State Forestry Administration, China has discovered 107 harmful invasive plant species, 32 harmful invasive insect species and 23 harmful invasive fungi or bacteria. These invasive species have intruded into most of China's ecosystems and are a source of long-term threats. For instance, invasive diseases have caused major losses in the pine forests in Southern China, that was dubbed as Smokeless Forest Fire. After WTO accession, this threat will further increase as commercial and human exchanges intensify.

3.1.2 Industry Level Impacts

After WTO entry, the forest products industry in China will inevitably be exposed to more intense competition; this competition will lead to the innovation or upgrading in technology, scale and structure and, therefore, raising productivity and efficiency. The overall impacts on the environment will be positive, because of savings in resource use. However, an expanding forest products industry may lead to increased aggregate pollution. Industry level impacts will be most acutely felt in two fields, i.e., technology and economies of scale.

Technological effects

Overall the Chinese forest products industry is being equipped with outdated machinery. While such equipment may save capital investment and allows for labour intensive operations, it may not be efficient in using wood resources and is often less productive. WTO entry will help China to upgrade the equipment and technology in its forest products industry and raise wood utilization efficiency. That is beneficial to forest conservation. The other direct impact is improved timberland management leading to significantly higher timberland productivity, particularly in China's plantation forests. With raised commercial timberland productivity, more forests will be conserved.

Effects on economy of scale

The Chinese forest products industry has long been plagued by repetitive capital construction, small mills and an over-fragmented industry structure. As was discussed above, 80 per cent of Chinese plywood mills have an annual capacity below 10,000 m^3, and 94 per cent of the 5,600 paper mills in China have an annual capacity under 10,000 tonnes. An industry dominated by undersized mills will inevitably be full of low-grade products. In particular, this industry is inefficient in resource utilization and highly polluting. Most of these undersized mills are not in a position to take measures to control pollution. Realizing such problems, the government departments in charge have tried various policies and arrangements to manage this industry, including forced closure, pauses in production, mergers and acquisitions. The achievement has largely been unsatisfactory. The fundamental reason is that these undersized mills are financially profitable businesses in a closed economy with pollution as an externality. With market protection gone after WTO accession, many of these undersized mills will find themselves financially unsustainable in the new market environment. This will prove to be a much more effective and efficient way of consolidating and upgrading this industry as it is market driven rather than government imposed. Such consolidation and upgrading will eventually benefit the environment.

3.1.3 Capital Level Impacts

Financial capital is vital to forestry development. China's WTO entry will bring increased investments in forestry. Such increase will come from increased public fiscal investments. It will also come from increased commercial capital that is attracted to forestry due to improved governance, policies and institutions in forestry investment. Increased investment will lead to improved forest management and a better play of the ecological functions of China's forests.

Increased public fiscal investments

Forestry is known for its pubic goods nature; it therefore should be a major field of public fiscal investment. The Chinese government has been paying increasing attention to forest resource development and conservation in recent years. The government has launched major ecological conservation programs including the sloping farmlands conversion program, the natural forest conservation program, the wildlife and wild fauna conservation program, and a number of programs aimed at desertification control. There is however concern that such increase in forest conservation is a temporary policy that has no long-term institutional guarantee. Such concerns are well grounded, as China is still in the process of developing its fiscal system and many of the basic public expenditure projects financed by the government have been known for lack of long-term institutionalized arrangements.

China's WTO entry will help ensure long-term stable investment by the Chinese government in forest conservation. Under WTO rules, the government should be focusing on macro-level governance and social functions instead of direct management of firm-level business activities. This will allow the government to focus on the provision of public goods, including forest conservation and environmental protection. Such a redefining of the role of government in a market economy will certainly help the Chinese government make budgetary investments in the existing major forest conservation programs an institutionalized arrangement.

This change is already being reflected in government investment in forestry in recent years. Between 2000 and 2003, the state drastically increased its investment in forestry, and by 2010 it is predicted that state government investment in forestry will reach a cumulative 700 billion RMB. Unlike the traditional pattern of government investment in forestry that has been dominated by capital investment in the forest products industry, today's government investment focuses on forest establishment and conservation (see Table 2).

Table 2. State government investment in forestry in 2000–2003.[4] **Unit: 100 million RMB.**

Year	2000	2001	2002	2003
Government investment	152.84	173.21	278.52	429
Share of government investment in total forestry investment	65.5	67.24	74.90	–

Table 3. The structure of Chinese government investment in forestry, 2000–2002.[5]

Year	2000	2001	2002
Ratio of forest establishment investment over forest industry capital investment	24:1	31:1	29:1

Increased commercial capital investments

The changes in forest institutions and policies after WTO have had a major effect in attracting the influx of private and overseas capital into the Chinese forestry sector. In 2003, the Chinese central government adopted a number of major policy changes in the "Resolutions on Speeding up Forestry Development." These resolutions are reflective of more open forest policies that would attract commercial capital investment in forest resource development. For instance, this government document clearly proposes full development of private business in the forestry sector, and encourages investments into forestry, irrespective of the ownership, sector or region that these investments come from. Investors of all sorts, be they rural households, urban residents, private entrepreneurs, foreign investors, business or non-business institutes, as well as government employees, are all encouraged to participate in forest resource development.

In this document, the state government vows to continue to administer the long-term low interest credit support policy to forestry, with interest subsidized by public finance. The document also encourages financial institutions to loosen requirements on loans borrowed by households and forestry workers and to be used in forest generation and timberland management. According to these resolutions, trees or standing stocks can be held as guarantee in applying for bank loans, and forest firms are encouraged to become public and raise capital for further expansion. In these resolutions arrangements are also made to reform the tax and fee system in China's forestry sector. While maintaining the tax breaks granted to forest investment, the document propose reducing or revoking many of the irrational or excessively burdensome taxes and fees on timber, including phasing out the special agriculture

4 *China Forestry Development Report 2001, 2002, 2003*. Chinese Forestry Publishing House, Beijing.

5 *China Forestry Development Report 2001, 2002, 2003*. Chinese Forestry Publishing House, Beijing.

produce tax on logs and bamboo. Finally, the document proposes streamlining the collection, management and use of forest regeneration funds, ensuring their being used in forest resource development instead of on administration expenditures of local forest departments.

These and other related policy changes are opening up the forestry sector further for private investment and forestry has become a major field of investment attractions. According to official statistics of the State Forestry Administration, there has been increasing investment in forestry by small or medium investors and such investment accounted for some 50 per cent of industrial timberland establishment in Guangdong Province in recent years. Overseas financial groups are also becoming increasingly interested in plantation development in China. According to reports in China Investment, APP (Asian Pulp and Paper) is planning to invest some 50 billion yuan to establish plantations of nine million mu in Guangxi.

Apart from commercial capital, WTO accession is helping China to gain access to forest conservation and environmental protection capital internationally. This includes grants and preferential loans designated for supporting forestry development in developing countries.

3.2 An Assessment of the Environmental Impacts of Forest Products Importing in China, Post-WTO Entry

Our analysis in Section 3.1 above reveals that the environmental impacts of WTO entry for China's forestry sector are reflected at the levels of products, industry and capital, and these impacts are mainly related to forest resources while some are related to industrial pollution. Realizing the challenge of a comprehensive assessment of these impacts, this study chooses to focus on the impacts of forest products importing and attempts to take quantitative measurements of their magnitudes.

3.2.1 The Relationship between Wood Products Importing and Forest Coverage Rate Change

The importing of forest products will certainly relieve pressure on domestic timber production. This study tries to depict this relationship in a 20-year time frame, as shown below. In Figure 1 there are three interesting points worth noting:

a) Prior to 1997, annual domestic timber production volume change exhibits a similar pattern as that of annual total wood product importing in RWE; this pattern is stable with a gradual increase over time, and importing had been a complement to domestic production. This suggests that domestic market demand has been a major determinant to domestic production and importing.

b) After 1997, importing started to grow at an accelerated speed, while domestic production started to decline significantly. That is, importing has become substitutive to domestic production. This clearly indicates that the massive ecological reconstruction projects in forestry have been made possible by reduced domestic timber production and surging imports. Timber importing has supported, and is instrumental to, domestic forest conservation.

c) The increase in the forest coverage rate in the past 20 years corresponds well with the general pattern of import growth; domestic forest establishment and resource development have also been supported by imports.

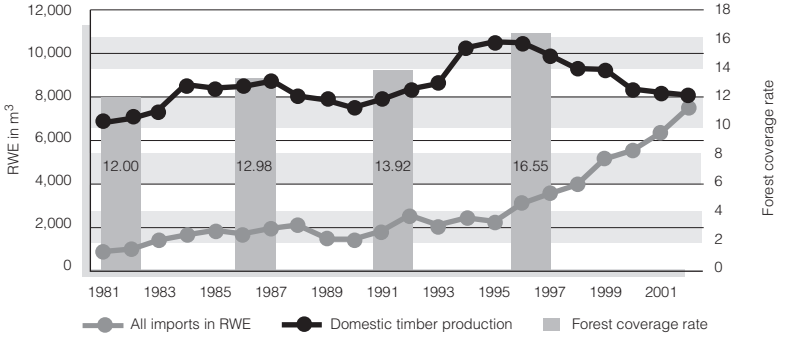

Figure 1. The relationship between domestic timber production, all wood imports in RWE and forest coverage rate change.

3.2.2 A Review of the History of Timber Importing in China

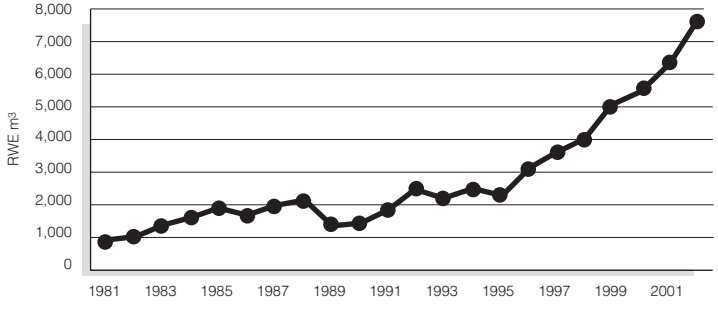

Figure 2. All wood products importing in RWE in China, 1981–2002.

Figure 2 shows how drastic the importing of forest products has been in China in the 22 years between 1981 and 2002. This overall growth can be further grouped into three phases:

First phase: 1981–1992

Annual importing was mostly under 20 million m^3 RWE during this phase; 1998 had the highest importing volume but it was less than that of 1981. After that the Chinese economy entered a period of adjustment and the volume of imports started to decline for some time. Overall, the import volume was relatively small and the degree of increase modest. During this phase the Chinese economy was beginning to be opened gradually, but government planning remained a dominant force in determining market demand. Timber production and trade were tightly controlled by the government and consumption was suppressed to certain degree.

Second phase: 1993–1998

The Chinese economy was furthering its transition toward a market economy and domestic consumption was allowed to grow freely. This led to further growth in imports, particularly in 1996. In 1996 the tariff rates for certain forest products were changed, with tariff rates on logs lowered from 15 per cent to five per cent, tariff rates for processed wood products were lowered from an average of 40–50 per cent to an average of 15 per cent. In 1997, as an APEC member, China started to pursue trade liberalization in nine sectors that included forestry. These measures together promoted the sharp increase in imports.

Third phase: 1999–2002

High domestic economic growth, newly implemented massive forest conservation programs and WTO entry together have prompted drastic growth in forest products importing during this phase. This surge has been phenomenal and only started to level off in 2002 and 2003. It should be noted that beginning from this phase the international conservation community has started to recognize China as a major player in the global timber trade and a potential threat to global forest conservation. There are two important factors that have promoted this recognition: First, the surge in importing volume has simply been too drastic and far reaching; China is suddenly beginning to buy timber anywhere and everywhere, and the global market can hear the giant sucking sound that the Chinese market is producing. Second, Chinese importing has been mostly from countries or regions that have a less than satisfactory record of forest stewardship, such as Indonesia, Myanmar, Cambodia, PNG, the Solomon Islands, the Congo basin or the Russian Far East. This has caused the international community to worry about the environmental impacts of China's growing timber imports.

1996 was a turning point in the history of timber importing tariff changes in China. Before 1996, China had a relatively high level of tariff and imports were generally less than 30 million m3 RWE. After 1996, tariff rates were reduced drastically and timber import trade has been close to free trade. We therefore deduct 30 million m3 from annual imports after 1997 and use the residual as the import volume increase caused by tariff reduction under WTO.

3.2.3 Chinese Timber Importing Trend and Volume Increase Forecast After WTO Accession and up to 2010

Zhu Chunquan *et al*. have forecast timber supply and demand and the import trend in China by taking into account economic growth, wood substitution and demand structural changes. Their results are shown below in Table 3.

Table 4. Chinese timber supply and demand and import forecast for year 2005 and 2010.[6] Unit: million m3.

Year	2005	2010
Total demand	178	213
Domestic supply	98	114
Needs for imports	80	99

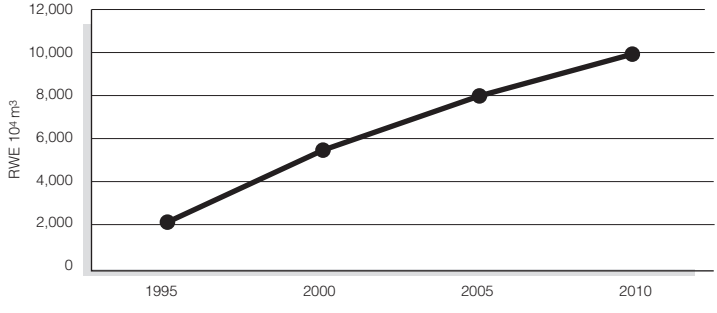

Figure 3. Chinese timber imports forecast to year 2010.

Figure 3 is based on the forecasts made above. The figure tells us that before 2010 Chinese imports of timber will grow further, but at a slower pace than in the late 1990s. Based on this forecast and the actual importing volume of 2002, and further assuming that the rate of annual import growth up to 2010 will be equal, we get the importing volume for each year between 2002

6 Zhu Chunquan: "China's Wood Market, Trade and the Environment."

and 2010, as detailed in Table 5. Then, based on the analysis in Section 3.2.2 and deducting 30 million m^3 from the import volume of each year, we get the annual residual of import increased caused by WTO entry. The accumulated volume is an impressive 497 million m^3 RWE.

Table 5. Annual total forest products import and import residual caused in China by WTO accession. Unit: 10^3 m^3 RWE.

Year	Import volume	Volume residual
2002	7,608	4,608
2003	7,737	4,737
2004	7,868	4,868
2005	8,000	5,000
2006	8,352	5,352
2007	8,719	5,719
2008	9,103	6,103
2009	9,503	6,503
2010	9,900	6,900
Total	76,790	49,790

3.2.4 An Assessment of the Environmental Impacts Caused by Increases in Forest Products Importing

Our analysis clearly indicates that increased forest products imports will benefit domestic forest conservation. These benefits are discussed below in quantitative terms, based on our assumptions above.

Reduced depletion of domestic forest resources

Between 2002 and 2010, Chinese WTO entry will enable China to import additional forest products by 497.9 million m^3 RWE in aggregate terms. The industrial forests in China have an average of 72.5 m^3 of standing stock per ha, and the conversion rate of logging is 61 per cent. Based on these figures, it can be calculated that this would save some 11.2583 million ha of forests for China. This saving is equivalent to seven per cent of China's total forest acreage at present (159 million ha). That is the additional savings caused by the WTO entry. If this calculation uses the total import volume in the nine years between 2002 and 2010, the saving would be around 17.36 million ha, equivalent to 9.2 per cent of China's total forest area today. That is about a one per cent saving per year. In other words, assuming this trend in import growth, an area as large as today's total forest in China will be saved from cutting in just some 70 years, or one rotation in northern China or about two rotations in southern China. Put differently, assuming no more forest products are imported from 2002 onward, to maintain the current level of domestic forest product consumption China will have to wipe out all of its forests in about just 70 years.

Conservation of domestic water resources

According to studies by Chinese scholars,[7] total water conserved by Chinese forests today is some 347.4 billion tonnes. The forests saved due to increased forest products importing after WTO would save some 24.318 billion tonnes of water, almost equivalent to the total water storage volume of the Three Gorges Reservoir after its completion (24.9 billion tonnes).

Conservation of domestic soil

According to research by Chinese scholars,[8] forests in China reduce soil erosion by 24.6 billion m^3 and prevent 4.92 million ha of land from suffering desertification or serious degradation each year. The savings in forests between 2002 and 2010 caused by WTO entry would help China to reduce soil erosion by 1.722 billion m^3 or protect 0.3444 million ha of land from serious degradation. In about 90 years that would add to a total area equivalent to the size of Taiwan.

Sequestration of carbon

Research by Chinese scholars[9] reports that the annual CO_2 sequestered by today's forests in China is estimated at 435 million tonnes, the savings in forests in the nine-year period above would be able to sequester some 3.045 million tonnes of CO_2.

Protection of biodiversity

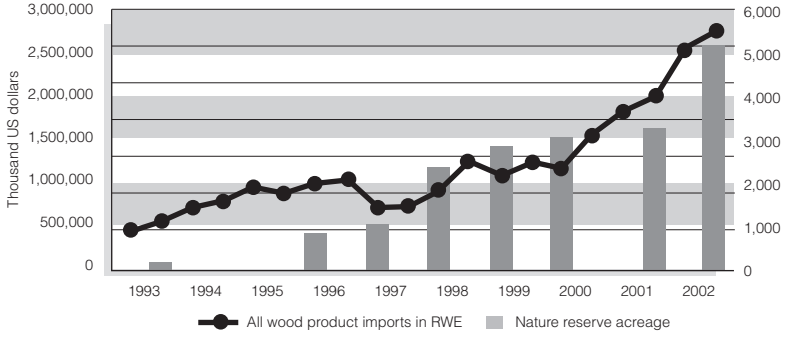

Figure 4. Historical growth in forest products imports RWE and nature reserve acreages.[10]

7 Jiang Zehui, *Modern Forestry*, China Forestry Publishing House, 2000.

8 Jiang Zehui, *Modern Forestry*, China Forestry Publishing House, 2000.

9 Jiang Zehui, *Modern Forestry*, China Forestry Publishing House, 2000.

10 Data for the acreage of nature reserves: State Forestry Administration: "National Plan for the Construction of Nature Reserves for the Protection of Wild Flora and Fauna and their Habitat," 1999.

As can be seen from Figure 4, the increase in the acreage of domestic nature reserves corresponds well with the increase of forest products importing. Over 60 per cent of these nature reserves are forest parks. Increasing forest products importing has made the reduction of domestic timber production and the designation of new forest based nature reserves possible. While it is difficult to predict the increase in acreage of forest-based nature reserves up to 2010, we can say for sure that continued importing of forest products will allow the government to retain existing nature reserves or even to designate more nature reserves.

3.3 Other Impacts that Increased Forest Products Importing Can Bring About

3.3.1 Domestic Timber Price Will Further Approach International Timber Market Prices

After WTO entry, the tariff and non-tariff barriers to the importing of logs and sawn wood were removed. This has made the timber market price inside China comparable to international market price levels, and resulted in a reduction in prices for certain domestic species. For instance, market prices for Chinese fir, a traditionally valuable commercial species in southern China, have come down by almost half since their peak in mid-1990s. This has caused hardship in forest farms and communities that depend on timber production. Coupled with the high taxes and fees charged against domestic timber production, this depression in domestic timber prices has contributed to the impoverishment in some of the traditional forest areas in China.

3.3.2 Export or Re-export of Furniture Will Continue to Grow

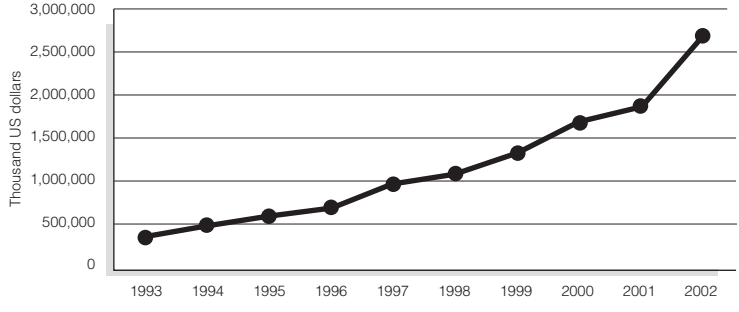

Figure 5. Value of Chinese furniture export.[11]

11 Data source: "Chinese Forestry Development Report 2003," China Forestry Publishing House, Beijing.

Inexpensive labour and land have attracted investment from overseas furniture makers and encouraged growth of the domestic furniture industry in China. Today, China has become a major home base for furniture production and export. Figure 5 clearly depicts the rapid and steady growth in Chinese furniture exports since the early 1990s. It is anticipated that this trend will continue after WTO entry. Between January and July of 2003 Chinese furniture exports further increased to US$4.01 billion, an increase of 30.6 per cent over the same period in the previous year. About 52.5 per cent of this export has been targeting the U.S. market. Needless to say, increased Chinese importing of timber has been fueled and driven partly by the increase in furniture exports.

It should be noted that increased timber importing in China after WTO accession could also create certain negative impacts on the Chinese environment, such as the increasing risk of species invasion. However, on balance, the overall environmental impacts inside China are positive and enormous.

3.4 Cross-border Environmental Impacts

3.4.1 Major Timber Supplier Countries to China

China has sourced wood from over 150 countries or regions, but its supply has come mainly from a handful of countries. In 2002, for example, timber exports from five countries—Russia, the U.S., Indonesia, Canada and Malaysia—represented over half of total Chinese timber imports.

The more primitive products, such as logs, have mainly come from Russia, Malaysia, Gabon, Papua New Guinea, Indonesia, Myanmar, Germany and New Zealand. These countries are mostly in the tropics, or in the temperate forests of Russia. Germany supported most of its log exports from Africa, while New Zealand is an exception as its exports to China come almost exclusively from plantation Radiata pine forests. Therefore, tropical Southeast Asia, the Congo Basin in Africa and the Russian Far East are China's three major log supply sources. Russian logs have dominated the log market in China in recent years, while imports from New Zealand and Papua New Guinea have grown rapidly in the past few years. Log imports from New Zealand reached 0.82 million m^3 in 2001, doubling the volume in 2000, and equivalent to 7.5 times of the import volume in 1997. Log imports from Papua New Guinea reached 0.91 million m^3 in 2001, an increase of 20 per cent over 2000, or equivalent to five times of the log imports in 1997.

More processed timber products such as wood pulp mainly come from Canada, Indonesia, Russia, the United States and Chile, while paper and paper products mainly come from Chinese Taiwan, Korea, the United States, Indonesia and Japan. And wastepaper imports mainly come from the United States and Japan. Today, China is the biggest importer of wastepaper in the world and has contributed significantly to the use of recycled paper.

3.4.2 Forest Resource Changes in China's Major Timber Supplier Countries

Forest depletion has become one of the focal issues of global environmental concern. A report by FAO in 2003 points out that global forests are disappearing at a rapid rate of 0.4 per cent per annum, and the rate of disappearance is twice as high for tropical forests. Logging is a major cause of deforestation. The forest coverage rate in Africa has decreased from 60 per cent in early 20th century to 10 per cent at present; two thirds of the tropical rain forests in South America has already disappeared, and over half of the world's large virgin forests in the Amazon Basin have been cut.

Deforestation has been equally astonishing in some of China's timber trading partner countries. In 1994 the Forestry Minister of Indonesia pointed out that at the beginning of the first five-year plan (1969/70–1974/75) Indonesia had 144 million ha of natural forests, and by the fifth five-year plan this has been reduced to 113 million ha. As the country started the sixth five-year plan in March 1994 there were only some 92 million ha of forests left, of which only 25–25 million ha were real natural forests. Malaysia had some 20.07 million ha of natural forests in the middle 1985, which was about 61.1 per cent of the total national territory. By 1992, however, this had been reduced to some 19.11 million ha, or a decrease of three percentage points in forest coverage rate. Myanmar (formerly Burma) was one of the earliest countries in the world that adopted scientific management of its forests and its forests had been conserved well for a long time. However, in the past 20 years, serious depletion has occurred, resulting in an annual loss of forest acreage of 0.22 million ha.

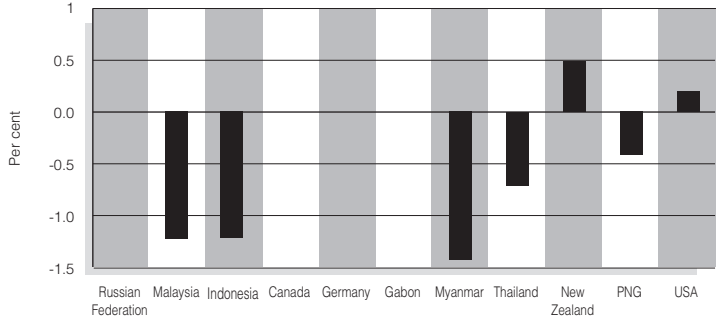

Figure 6. Forest acreage change rates in China's major timber supply countries, 1990–2000.[12]

12 Data source: FAO 2001, The Russian Federation, Canada, Germany and Gabon all had insignificant rates of change.

There are multiple causes of forest depletion in these countries, ranging from farming land reclamation, over-cutting of fuelwood, derivative logging, overgrazing, natural disasters and policy failures. Trade-related logging has been identified as a major cause—or even the leading cause—in some countries.

It is, however, worth noting that not all countries that have increased exports in large volume to China have experienced a major reduction in forest resources. Countries such as Russia, Canada, Germany and Cuba have experienced little change in their forest resources, while countries such as the U.S. and New Zealand have actually had an increase in their forest resources. The key is forest management in the supplying countries. If a country is pursuing good forestry domestically, exporting timber may actually reinforce sustainable forest management and encourage investment in forestry. Of course, in the case of logging in some of the virgin forests (particularly tropical rain forests) this may not hold, as industrial logging in some of these regions is simply not going to be sustainable, irrespective of logging and forest regeneration practices. Nevertheless, if sustainable forest management institutions are well established in these countries, such logging would be avoided in the first instance.

3.4.3 The Problem of Illegal Timber Trade

Illegal timber trade can exist in one or all of the stages including logging, transportation, processing and exporting. Some of the common practices of illegal trade include unauthorized cutting; hiding the real volume being logged; reporting of a wrong type of species being cut; illegal shipping to evade taxes or fees; and illegal hunting of wildlife. Illegal cutting can be done in protected areas, but can also occur in designated logging areas via cutting protected species or over-cutting in volume. Table 6 records the estimated share of illegal logging in some major tropical timber producing countries, while the highest share of illegal logging is 90 per cent, even the lowest rate is at 34 per cent.

Table 6. The share of illegally logging timber in some tropical timber producing countries.[13]

Country	Estimated % of wood harvested illegally	Source
Bolivia	80	Contreras-Hermosilla (2001)
Brazil	85	Greenpeace (2001)
Cambodia	90	World Rainforest Movement and Forest Monitor (1998)
Cameroon	50	Global Forest Watch Cameroon (2000)
Colombia	42	Contreras-Hermosilla (2001)
Ghana	34	Glastra (1995)
Indonesia	51	Scotland (2000)
Myanmar	80	Brunner (1998)

13 Data source, ITTO, Tropical Forest Update, 2002.

There is also the problem of illegal trade in the timber products China has been importing. For instance, the official statistics in Myanmar for timber exported to China was 0.74 million m^3, but estimates from the Chinese side were double. While the hidden nature of illegal timber trade makes it difficult to give accurate figures of the volume of timber from illegal trade, a simple comparison of the import statistics in China with that of the exporter countries would give us clue on the magnitude of the problem.

Table 7. A comparison of Chinese timber import statistics and export statistics in China's major supplier countries.[14] **Unit: 000 m^3, %.**

Exporting country and product	1998			1999			2000		
	Export	Import	Diff.	Export	Import	Diff.	Export	Import	Diff.
Cameron, logs	192	240	25	171	216	26	0	220	-
Indonesia, logs	28	35	25	88	382	334	6	618	10,200
Indonesia, sawn wood	52	317	510	77	580	653	20	931	4,555
Malaysia, sawn wood	265	399	51	140	552	294	116	495	327
Myanmar, logs	40	186	365	24	335	1,296	20	558	2,690

From Table 7, it can be seen that recorded statistics from Chinese Customs are mostly far above the export statistics in the supplier countries. If the difference is small, the difference may be explained away by the difference in coding and statistical methods between China and its trading partners. However, the import volume of logs from Indonesia in 2000 was 102 times that of the export volume in Indonesia. In the same year, recorded imports of Myanmar logs were 26.9 times greater than what was recorded on the Myanmar side. This suggests that there must be a serious degree of illegal timber trade. This has been confirmed by widely-reported illegal timber export in these two countries.

Illegal timber logging and trade is a destructive practice that not only damages global forests but also brings serious negative social and economic impacts. While there are no accurate data, there are estimates that each year governments in these countries lose billions of dollars in taxes and other revenues because of illegal trade. In Indonesia, annual tax evasion in timber trade is believed to be US$600 million, which is four times greater than the government investment in the forestry sector each year, and twice the expenditure on the governmental agricultural aid plan (Baird 2001). Besides, illegal timber trade can result in loss of jobs and impoverishment of forest-dependent communities (Contreras-Hermosilla 2001).

14 Data source, ITTO, Tropical Forest Update, 2002.

3.5 The Responsibilities that China and the Rest of the World Should Assume in Timber Trade

Economic globalization and trade liberalization have promoted globalized resource allocation, and have made it possible that one country transfers stress on its forests to other countries via international trade. For instance, major timber importers such as China and Japan are bringing foreign exchange revenue to their supplier countries, but at the risk of aggravating the environmental issues in these supplier countries. Therefore, environmental issues resulting from timber trade-related forest loss are no longer limited by country borders, rather, they are rapidly becoming global issues that require cross-border coordination and participation. Since this trade is being carried out against the general background of global trade liberalization and is being driven by free market forces, simple condemnation, opposition or boycotting would not be effective in addressing its environmental implications. The real solution rests in concerted efforts in changing the institutions that govern such trade, including the institutions and policies that govern the practices of logging and its distribution of benefits.

China is a major partner in today's international timber trade. Without such massive importing, the paucity of domestic resources would aggravate, and the ambitious domestic forest conservation programs would have been impossible to implement and sustain. From the standpoint of domestic environmental protection, China is a major beneficiary of global timber trade. This requires China to assume the responsibilities of a major timber importer. There are a number of initiatives that are within China's reach, such as improved communication with its trading partners; awareness building about the environmental impacts of timber trade; strengthened law enforcement in timber importing; active participation in forest certification initiatives; providing technical or even financial aid to some major trading partners; opening up domestic control over timber exports; and reforming domestic forestry policies to increase domestic timberland productivity.

Advanced western developed countries are major exporters of processed fiber products, and importers of labour-intensive products such as furniture. They have the capacity to assume a greater role in addressing the environmental consequences of global forest products trade. They can provide support via aid in capital, technology and information; they can also promote the consumption of environmentally-friendly wood products such as certified products. This is particularly important because a large share of China's imported timber has its end market in these developed countries.

4. Summary and Policy Recommendations

4.1 Summary

- China is poor in forest resources. Per capita standing stock in China is only 12.6 per cent of the world average; and per capita forest acreage is only 21.3 per cent of world average. China has only three to four per cent of the world's forest resources, it will be a great challenge for China to meet the wood demand of 20 per cent of the world's population and the ecological conservation needs with only seven per cent of the world's land territory.
- In China, forestry is a sector with heavy influence on the planning economy. After the establishment of People's Republic of China, the government has made timber production the major task of the forest sector and invested little in forestry. This has further aggravated the shortage of forest resources. With the world's fastest growing economy in the past two decades and the growing consumption of wood, the domestic supply/demand gap in timber is widening in China.
- After WTO accession Chinese timber trade policy was further liberalized, with the reduction of tariff rates, and revocation of certain non-tariff trade barriers such as import quotas. Consequently, Chinese timber importing surged. Today, China is already the world's largest net wood importer. In 2002, the RWE of all wood and wood-based products reached 94.4588 m^3. Of course, this increase has been driven by dwindling domestic supply and by growing domestic demand and competition for lands from conservation needs. Trade liberalization under WTO has facilitated the full play of these market forces in an expanded market.
- After WTO accession, the Chinese forest products industry will inevitably be exposed to more intense international competition and will lead to upgrading in technology, scale and structure, and in the rise of productivity and efficiency. The overall impacts on the domestic environment would be positive, leading to resource savings and reductions in industrial pollution in the forest products industry. However, it is uncertain whether the reduction in pollution per unit of output will be outweighed by the increase in aggregate pollution to result from expanded industry scale.
- According to our estimates, in the nine years between 2002 and 2010, China would import an additional 497.9 million m^3 of timber because of the ease in timber trade brought about by China's

WTO entry. This is equivalent to a saving of seven per cent of China's total forest area. Other benefits would include conservation of additional 2.4318 million tonnes of water: equivalent to the total storage of the gigantic Three Gorges Reservoir; a reduction of 1.722 billion tonnes of soil erosion and prevention of land desertification of 344,400 ha; an additional carbon sequestration in the amount of 3.045 million tonnes; and the provision of support to nature reserve establishment and biodiversity conservation.

- WTO entry would also exert other impacts such as lowering domestic timber prices to that of the international market, discouraging investment in forestry and reducing income generation opportunities in forest-dependent communities. Furniture exports will continue to grow and drive further importing of timber.
- Massive timber importing by China may transfer the risk of forest loss to its trading partner countries, particularly in countries with less than satisfactory records of forest stewardship. The illegal timber trade existing in China's timber importing today risks not only damaging the environment in producer countries, but also China's prospects for sourcing reliable and economic wood in the long run.

4.2 Policy Recommendations

As the largest developing country and the largest net timber importer, China is obligated to assume a role in protecting the global environment. There is no excuse under WTO that can exempt a country from addressing the environmental consequences of trade. Unfortunately, this awareness still needs to be absorbed by the Chinese government and among citizens. While continuing to take actions to fulfill the commitments China made in its WTO entry, China should endeavour to build the image of a responsible timber consumer and increase its domestic timber productivity via drastic reforms of its domestic forest policies that are not consistent with the spirit of WTO.

- China should fully assess its existing timber trade policies according to WTO principles and eliminate trade distortions such as the escalating tariff rates (zero tariff on logs and sawn timber and high tariff on processed wood products); further open the forest product export market; revoke wood export quotas and bans; and reduce further the tariff rates of imported secondary products such as furniture.
- China should endeavour to establish a semi-official coordination group comprised of China and its major timber trading partners (both importing and exporting countries) to cooperate on timber trade related issues. Some of the major issues that this group should

address include checking illegal timber trade; sharing of timber trade-related intelligence; and monitoring trade impacts on the environment and local economies. The group should be based in Beijing, led by China, and should include major trade partner countries such as the USA, Canada, Russia, New Zealand, Germany, Indonesia, Malaysia, Myanmar, Papua New Guinea, the Solomon Islands and a number of countries in the Congo Basin. Such a group can be maintained affordably by inviting embassy staff members to represent these countries.

- China should assume the responsibility of a major timber consuming country and work with other western wood products importing countries to promote independent forest certification, and to provide assistance to third world exporter countries in the form of capital, technology and information about promoting environmentally-friendly timber trade and educating consumers about sustainable forest management.

Aquaculture

Aquaculture

ZHAO Yumin, ZHENG Hongxing, BAI Ming, LIN Xuegui

Preface

Marine aquaculture has been a major economic activity in China since the 1980s. It is in operation across 11 provinces along the coastlines, with state enterprises hiring 1.436 million direct employees and a further 376,400 employees in related sectors—processing, transport and distribution. The private sector is estimated to involve three or four times that number. The total output of marine aquaculture stood at 14.15 million tonnes in 2002, accounting for over 31 per cent of the nation's aquatic products. Due to the development of marine aquaculture, China has succeeded in sustaining its export capacity of aquatic products and in expanding its share in the world market despite a continuously diminishing stock of wild resources in its adjacent seas. Although China is the biggest exporter of marine products in the world, its exports make up less than six per cent of its total output.

China's WTO accession promises new opportunities for the sector, which is becoming strategically important for rural economic expansion. In an effort to make the sector more export oriented, the environmental effects of marine aquaculture can no longer be ignored for two reasons. First, owing to shortcomings in the biological system and culture method, most marine aquaculture activities are associated with certain environmental problems, some even represent a source of serious pollution. Second, marine aquatic products are environmentally sensitive since water quality has a great bearing on product quality. Pollution deriving from the aquaculture itself contributes to decreasing water quality, high frequency of red tides, exposure to disease and abuse of drugs and, hence, low quality of products, which dampens the export effort. As the marine aquaculture sector has become highly vulnerable to trade and environmental regulations applied by China's principal buyers, the development model that totally ignored environmental effects is no longer sustainable. After accession to the WTO, China immediately experienced a sanction on its aquatic exports to the EU for failing to meet requirements on drug residuals.

Against this backdrop, this study tries to make an in-depth assessment of the environmental impact of Chinese marine aquaculture in the post-WTO era.

It combines analysis with forecasts, since China is still in the post-accession transitional period and the environmental impact has yet to manifest itself fully.

Relevant policies

China's entry into the WTO will produce notable effects on its market access policies for marine aquatic products, largely because China's tariffs on imports will be slashed to a varied extent among product lines. This is, however, not the focus of this study, as the environmental impact of changing policies on imports of aquatic products is rather limited. This conclusion is based primarily on two considerations. First, China is the world's largest producer of marine products but not the number one consumer, so there is an abundant supply of aquatic products in the home market. Foreign imports cannot gain easy access to this market with their extra preservation and transportation costs, although they may enjoy a competitive edge over local products. Second, as Chinese per capita income remains at a comparatively low level, premium-class foreign products can only take up a small market share and are not competing directly with the local industry. Based on this analysis, the effects of more liberalized import policies on the environment will be less significant. Indeed, a series of deregulation policies and measures—such as liberalizing farm goods, policies on land-intensive products (which are closely associated with the agricultural restructuring policies) and export incentives—will affect China's marine aquaculture sector to a greater extent, thereby yielding more serious environmental impacts.

The reasons for choosing this topic

The trade and environmental effects of China's marine aquaculture sector are a significant issue. With a distinct comparative advantage, the sector has developed at rapid speed since the 1990s and has been a major source of the country's agricultural trade surplus for years. But adverse environmental effects came with this fast growth and have become an acute problem; and have even caused major harm to the environment of certain regions. At the same time, marine products are environmentally sensitive, in that the ways of growing them not only affect the environment, but also the quality of the products themselves. During the mid-1990s, a penaeid shrimp disease broke out, causing extensive damage to the shrimp-culture sector, and almost brought an end to shrimp export; at the time the most important item among Chinese agricultural exports. This disastrous outcome of pell-mell development laid bare the necessity of trade and environmental coordination that many people did not realize at that time.

China's WTO accession offers more possibilities for the sector to expand its market at home and abroad. But to realize these possibilities and to build up a highly competitive and sustainable sector depends on how fully environmental considerations are incorporated in the country's development policies.

I. WTO Impact: Expanding and Upgrading the Marine Aquaculture Sector

A. Cross-sectoral Effect: Agriculture vs. Marine Aquaculture

Marine aquaculture forms part of China's agricultural sector. In its protocol of WTO accession, the Chinese government has made a series of commitments. These include cutting tariffs, setting up tariff quotas for some major farm products, opening up the import and export of these products to the non-state sector, reducing the role of state trading, and working out a scientifically-based inspection and quarantine system for import commodities. The government has also committed to eliminating farm export subsidies and keeping its domestic support measures—such as trade-distorting Amber Box support—under 8.5 per cent of the nation's gross agricultural product. These commitments mark a major shift from China's longstanding protective agricultural policies, and will directly and significantly affect the trade of grains, oil crops, sugar and cotton, since these basic farm products had been most heavily protected in the days of the planned economy. Aquaculture was, on the other hand, among the first deregulated industries in China. It is burdened with few distorting institutional and regulatory effects, and may only be influenced marginally by the changes in import tariffs. Nonetheless, the indirect effects on the aquatic industry are noticeably acute as a result of the imperative agricultural restructuring. Here are some of the conclusions drawn by Chinese scholars lately:[1]

The Impact of China's WTO Accession on Agriculture

Economic effects

- Increased import of land-intensive farm produce;
- Reductions in sown area and agricultural output;
- Lower prices for basic farm produce; and
- Decreased farmers' income from land-intensive farm produce.

1 Yang Yongzhe, "WTO and Strategic Restructure of China Rural Economy," 2001, China Agriculture Publishing House.

Social effects

- Promotion of structural adjustment of agricultural production;
- Reduced employment in production of basic agro-products; and
- Increased use of farmland for other purposes.

Environmental effects

- Reduced use of fertilizer and pesticide; and
- Reduced use of underground water for irrigation.

The Impact of China's WTO Accession on the Marine Aquaculture Sector

Economic effects

- Expanded breeding areas and scale;
- Improved breeding technologies and methods, encouraging industry progress toward intensive development;
- Boosted consumption of marine products; and
- Increased attractiveness of the industry to foreign capital and enhanced export potential.

Social effects

- Reduced poverty through opening up new sources of income for farmers;
- Promotion of the development of related industries;
- Promotion of the development of regional economies; and
- Strengthening of the nation's food security.

Environmental effects

- Optimum use of resources: reduced over-fishing to promote sustainable use of marine resources; and reduced over-farming to promote sustainable use of arable land;
- Increased emission of inorganic nutrient salts in seawater, leading to a high intensity of red tide and changes in the offshore composition and distribution of the biotic populations;
- Increased threat to the remaining mangrove forests;
- Destroyed habitats of indigenous animal and plant species; and
- Increased risk of salinization of soil and underground water.

The above indicates the different effects on China's primary farm and marine aquaculture sectors associated with WTO accession. The former tend to contract, in terms of resource uses and total output, while the latter is expected to expand. The different effects on primary farm produce and marine aquaculture are produced for the following reasons:

Differences in natural resource endowments

Compared with other major agricultural producers, China only has limited per capita cultivation land and freshwater resources, accounting for seven per cent and 25 per cent respectively of the world average. With the nation's population expected to reach 1.6 billion in 2030, per capita freshwater resources will be further reduced, along with drastic reductions of farmland and rising costs of cultivation. As the domestic market becomes more deregulated, the weaknesses of China's farm production, namely abundant farm labour vs. insufficient land resources, and relatively low productivity, will become increasingly acute. The Chinese government will face the crucial tasks of guaranteeing food security, increasing income for farm households and providing employment to redundant rural labour. Noting the principles of comparative advantage, the Chinese government is making efforts to shift from land-based traditional farming to the new mega-agriculture, which makes full use of the various resources. Hence the development of a marine aquaculture sector is deemed a necessity, as China has rich seawater resources. To be more specific, China has 18,000 kilometres of continental coastlines and 14,000 kilometres of island coastlines. Within its contiguous ocean territories to the west of the North Pacific Ocean, there are 2.81 million square kilometres of inshore fishing grounds less than 200 metres deep, and 157,000 square kilometres of shallow waters less than 20 meters deep. There are also 21,700 square kilometres of tidal-flat areas, of which a total of 6,700 square kilometres is appropriate for aquaculture. With only 20 per cent of the coastal shoals and 0.5 per cent of shallow waters less than 20 meters in depth actually utilized, China's marine aquaculture sector appears to have a huge development potential.

Differences in the income elasticity of demand for land-intensive produce and marine aquatic products

Land-intensive produce (typically grains) and seawater fish and shrimp have different income elasticity of demand. A calculation over a 10-year period reveals that the elasticity of the former is far less than that of the latter, whether in urban areas or rural regions. This indicates that marine aquaculture has a great market potential on pace with household income growth. According to studies and the actual changes in local household income over the past couple of years, the steady growth of per capita household income since China's WTO accession has boosted the consumption of marine

aquatic products. The effects of this higher income on grain consumption are not as obvious.

Differences in the core competence of land-intensive produce and marine aquaculture products

Great disparities exist between primary farming in developed countries and in China, not only in resource endowments, but also in mechanization, commercialization and the industry scale and benefits resulting from government subsidies. China cannot catch up with those nations within a short period of time.

Yet most developed nations do not have a well-developed marine aquaculture sector. Instead, they have made extensive investments in the marine fishing and culture sectors of developing countries. These investments are often government-subsidized. However, the marine resources in the developing countries cannot meet the increasing demands of the market. While huge differences remain between China's primary farm produce sector and those of developed countries, the differences are not so significant between Chinese marine aquaculture and that of other developing nations backed up with foreign direct investment. This means that China's marine aquaculture sector is not far behind the sector in developing countries in technologies, business scale and economic benefits. Neither is China surpassed by them in the possession of marine resources, on which marine aquaculture relies. In fact, China has a competitive edge in both the quantity and quality of the labour force needed, and that makes its marine aquatic products more competitive on the world market than its land-intensive produce. Hence, China's marine aquaculture sector is much more export-oriented than its agricultural industry, with its seawater shrimp breeding in particular more export-oriented than the marine aquaculture sector as a whole. Moreover, Chinese aquatic exports are not government-subsidized, unlike the export of its land-intensive produce.

Difference in administration regime

China's primary farm produce has long been subjected to the state trading regime both for foreign trade and local trade. Fundamental changes have only taken place very recently. The new regime is still evolving and authorities and farmers are accumulating their knowledge and experience in dealing with this globalized market. In contrast, benefiting from earlier market liberalization, the production and management of aquatic products are highly marketized, especially in coastal areas, where an export-oriented growth mechanism has long been developed, so there should be little difficulty in integrating with global markets. The producers and administrative authorities have a keen sense of markets, which enables them to flexibly adjust the production and product structure according to changes in market conditions.

One of the structural effects generated from WTO accession of the agriculture sector is to provide more opportunity for China to tap into the potential of marine aquaculture.

B. Favourable Policy Environment

After China's accession to the WTO, the expansionary trends of the marine aquaculture sector will remain or become even stronger. The driving forces come from the favourable policy environment within which aquaculture operates.

Structural adjustments in the face of agricultural liberalization

In the face of increasing pressure in WTO accession negotiations to liberalize its agriculture, aquaculture has been given priority in the development of rural economic structural adjustments. According to the Tenth Five-year Plan (2001–2005) of National Agriculture and Rural Economy, the development of aquaculture should be accelerated. "The proportion of fishery output value in the total agricultural output value will be increased from the 10.9 per cent of 2000 to 13 per cent of 2005… By 2005, the proportion of aquaculture output in the total fishery output will reach 67 per cent." In recent years, through concerted efforts in structural adjustments, the marine aquaculture sector of coastal areas, which were once characterized by a backward rural economy, has expanded rapidly and has become a pillar industry for agriculture and the rural economy. It is a major source of increased income for coastal populations.

Strengthen food safety and nutrition under the conditions of liberalized markets

With the liberalization of Chinese agricultural markets after accession to the WTO, the question yet to be answered is how to strengthen the food safety in the open market. The experience of recent decades shows that the role played by arable farmland and ocean fishing is limited and decreasing. China is increasingly facing the problem of short supply in diversified land resources. With the growing economy and population, and also the expansion of soil erosion and desertification, the area of cultivated farmland has been decreasing. It is evident that the growing population cannot merely rely on cultivated farmland for food supply. Nor is it likely to depend on ocean fishing for increasing the supply of its food and nutrition requirements, since the wild stock of fishing resources has been decreasing all the time. On the other hand, marine aquaculture has a positive role to play in enhancing food safety in a liberalized market. Marine aquaculture features less occupation of arable land and a high rate of feed return. At present, marine aquaculture produces three times more than China's annual grain imports in the 2000–2002 period. In addition, due to its high-quality protein and low-

energy nutritive products, marine aquaculture contributes positively to the population's dietetic composition. The China Food and Nutrition Development Program (2001–2010), promulgated by the government in early 2002, clearly points out: "in order to ensure rational food absorbing and improving the overall nutrition level of China's residents, the per capita consumption of aquatic products will be increased from the current 11.7 kg to 16 kg by 2010." Therefore, after the opening up of China's domestic market for farm products, the development of marine aquaculture will be of great significance in enhancing China's food safety.

Facilitating an orderly transfer of the labour force

Unemployment is high in China's agricultural sector. The problem will be even worse with the opening-up of China's agricultural markets to WTO Member countries. Estimates by Ministry of Agriculture show that unemployment in China's agricultural labour force increases by about 10–12 million every year. The high unemployment leads to lower income and rural poverty. One of the government countermeasures is to provide more job opportunities and to encourage farmers to move into emerging and growing industries. Looking back at the last two decades, the employment rate in the aquatic sector has steadily increased. Under the central government's major policy to encourage and support farmers' transfer, restrictive regulations and discriminatory practices that hindered labour flows were gradually eliminated by local governments. Preferential policies have been formulated by some coastal regions to encourage local or inland farmers to engage in aquaculture. For example, in some areas the fees for resource use paid by non-native labourers who are engaged in marine aquaculture are reduced by half. Moreover, the growth of marine aquaculture has been accompanied by the development of other relevant sectors, such as fish drugs, feed-stuff industry, fishery machinery, aquatic processing and circulation services. Thus it has become a new source of job creation in rural areas.

Diversified investment mechanism

With China's WTO accession, there has been an upsurge in aquaculture investment. In 2002, fixed investment in aquaculture totalled 2.57 billion yuan, an increase of 14.2 per cent and 25.4 per cent over 2001 and 2000. Policies of "whoever invests and explores will benefit" are adopted to encourage people from different regions and different sectors to invest in marine aquaculture.

With China's WTO accession, foreign investors are becoming more confident in China's investment and market climate. The inflow of FDI was particularly pronounced in China's aquatic industry. In 2002, foreign capital accounted for 10.4 per cent of total investment in China's fishery sector. The

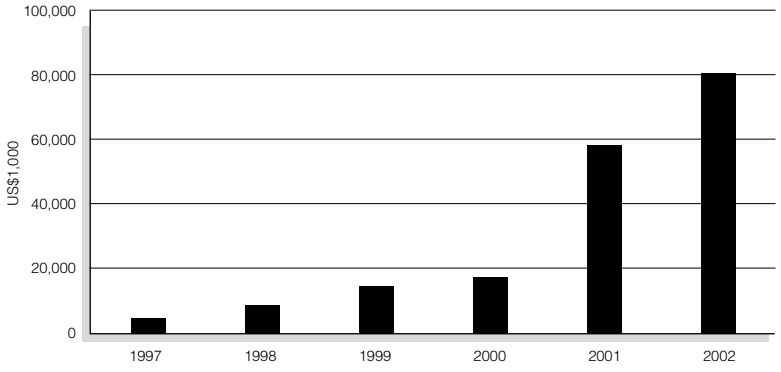

Figure 1. Foreign direct investment in fishery sector (US$1,000).

great bulk of this investment went to the aquatic processing sector. On January 1, 2004, a new *Catalogue for the Guidance of Foreign Investment Industries* was implemented, according to which, foreign investment is encouraged to enter marine aquaculture for the production of popular species of high-quality and of local specialties. Various joint ventures, cooperative enterprises either between Chinese and foreign investors or between local investors of different regions and different sectors, are invited to engage in marine aquaculture. Joint venture fishery development enterprises with foreign investment are granted preferential treatment, including the elimination of local income tax, and enjoy a reduction of (or the exemption from) income tax on enterprises in accordance with relevant national laws. All these investment policies have basically created a diversified investment mechanism for China's fishery industry and provided a boost to China's aquaculture.

C. Intensified Export Drive

Over the years, China's export growth of marine aquaculture products has outpaced the export growth of total aquatic exports. A number of products, such as yellow croaker, mussels, oyster, clam and shrimp, enjoy considerably higher market share and have become a driving force behind China's sustained growth in aquatic exports.

Despite the favourable environment created after China's accession to the WTO, export of aquatic products remains a highly risky activity for Chinese enterprises. The export of aquatic products experienced ups and downs over the past decades, while imports achieved steady growth during the same time.

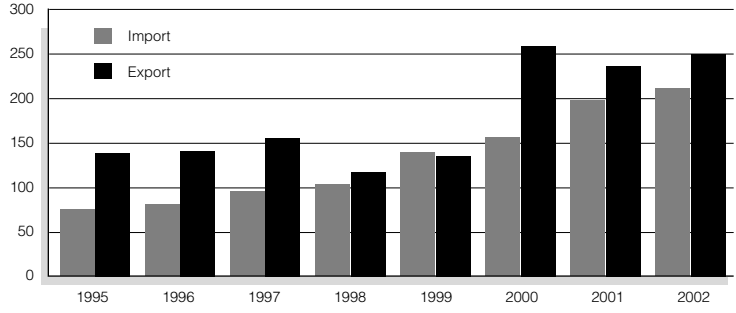

Figure 2. Export/import of aquatic products.

Aside from WTO membership, China's aquatic trading is faced with a somewhat changed environment. The tariff and quota systems, which were once key restrictive measures of major importing countries, have been reduced or replaced by technical standards and regulations pertaining to product quality, safety and sanitation. Since China's WTO accession, 35 notifications of TBT and SPS measures on aquatic products were received by WTO from over 20 member countries. These measures are not directed particularly against China, but China's major trading partners all intensified their safety and sanitary requirements on imported aquatic products, which has had a substantial impact on China's exports.

Table 1. Major technical barriers facing China's post-WTO marine aquaculture exports.

Date	Catalogue record	Country/region	Notification
2002/04/03	G/SPS/N/NLD/56	Netherlands	Amendments to the Commodity Law concerning food pollutants.
2002/04/11	G/SPS/N/THA/89	Thailand	Notification of Ministry of Public Health, (No.250) B.E.2545 (2002) concerning requirements for shrimp and processed shrimp.
2002/07/09	G/SPS/N/BLR/1	Belarus	Production and processing of fish products—a draft for sanitary statutes and requirements.
2002/08/07	G/SPS/N/PER/42	Peru	Sanitary requirements for micro-organism, sanitary quality and safety for food and beverage for human consumption.
2002/08/13	G/TBT/N/BRA/4	Brazil	Establish the requirements for defining the net weight of frozen fish, crustaceans and mollusks.
2002/10/23	G/TBT/N/USA/25	USA	Guide in line with the Act of State Administration of Agricultural Markets (1946) to countries that use

Date	Catalogue record	Country/region	Notification
			labels of origin on a voluntary and provisional basis concerning beef, mutton, pork, fish, perishable farm products and peanuts.
2002/10/24	G/TBT/N/ZAF/19	South Africa	Frozen lobster and its related products.
2002/10/24	G/TBT/N/ZAF/18	South Africa	Frozen fish, frozen marine mollusks and related products.
2003/01/08	G/SPS/N/USA/654	USA	Quantitative limits on triclopyr.
2003/03/03	G/SPS/N/EEC/193	EC	Commission draft on amendments to Annex III, X, XI of EC Regulation (999/2001) adopted by the European Parliament and Council concerning controlling, inspecting and specified risk materials.
2003/03/04	G/TBT/N/BRB/1	Barbados	National labelling standards (BNS 5, Section 7: 2002) for meat and poultry parts/cuts and fish and fishery products.
2003/03/13	G/TBT/N/DOM/1	Dominican Republic	NORMDOM No.560, fish and shellfish, fresh fish. Regulation.
2003/05/01	G/SPS/N/EEC/198	EC	Commission Decision on health conditions and certificate requirements for live fish (including eggs and gametes) for farming, or live fish and related products for human consumption, or for further processing before human consumption.
2003/07/04	G/TBT/N/BRA/121	Brazil	Technical requirements (No. 63) promulgated by Ministry of Agriculture on November 13, 2002, concerning identifying fishes, sardines, tuna-fish, bonito-fish.
2003/08/15/	G/TBT/N/NIC/25	Nicaragua	Compulsory technical requirements on environmental controls concerning fish and shellfish processing factories.
2002/08/27	G/TBT/N/KOR/39	Korea	Draft on labelling concerning genetically modified aquatic products.
2002/08/23	G/SPS/N/KOR/114	Korea	Amendments to inspections for aquatic products and quarantine requirements for living aquatic animals intended for farming at domestic environments.
2002/7/25	G/SPS/N/TPKM/21	Chinese Taipei	Amendments to quarantine requirements for imports of live fish and their sperms, eggs, and frozen/chilled uneviscerated fish products.

Date	Catalogue record	Country/region	Notification
2003/07/30	G/SPS/N/NZL/254	New Zealand	Sanitary requirements for imports of fish food, fish bait, *Artemia salina* and *Artemia franciscana* from all countries.
2003/08/28		Mexico	Official Standard Draft, PROY-NOM-215-SSA1-2002; commodity and service. Processed aquatic products. Sanitary requirements.
2003/08/29	G/SPS/N/GTM/18	Guatemala	Sanitary regulations over processing of aquatic products and by-products.
2003/09/01	G/TBT/N/MEX/78	Mexico	Official Standard Draft, PROY-NOM-214-SSA1-2002£¬commodity and service. Fresh, chilled and frozen aquatic products. Health specifications and inspections.
2003/09/05	G/SPS/N/BGR/8	Bulgaria	Decree No.10 (04/05/2000), veterinary and hygienic requirements for production and marketing of fishery products.
2003/09/05	G/SPS/N/BGR/9	Bulgaria	Decree No.11 (04/05/2000), minimum hygienic requirements for processing and preservation of fishery products on fishing vessel.
2003/10/10	G/TBT/N/SLV/3	EL Salvador	Specified fishery products – sampling, values, methods and ceiling contents for the control of the levels of lead, cadmium and mercury.
2003/10/10	G/TBT/N/SLV/31	El Salvador	Aquatic products – visual inspection for parasites.
2003/10/10	G/TBT/N/SLV/3	El Salvador	Specified aquatic products – quantitative limits and analytical methods for TVB-N.
2003/10/15	G/SPS/N/EEC/219	EU	Draft revising Commission Decision 2002/657/EC (08/07/2003).
2003/10/15	G/SPS/N/PHL/49	Philippines	Fishery Administration Decree No.221 /2003, harmonized imports of live fish and fishery/aquatic products, including aquatic microorganisms and biomolecules, 1981/134/FAO.
2004/02/18	G/SPS/N/THA/110	Thailand	Circular No.273, Ministry of Public Health, 08/07/2003, requirements for food pollutants.
2004/03/08	G/SPS/N/MAR/18	Morocco	Draft 2-97-1003: sanitary and qualitative inspection for marine and freshwater products.

Source: TBT-SPS Notification and Enquiry of China

To deal with the tough requirements, the central and local governments stepped up their efforts in building up regulatory and standards regimes for the marine farming industry and redefined their support policies.

1. Administrative laws and regulations were promulgated, which covered:
    - Standardized farming activities including the specific requirements for rearing density, inter-culture technique, nutrient balance technique and regulation of water quality.
    - Requirements for using fish drugs, feed-stuffs and feed-stuff additives; establishing new regulations concerning the source of fish drugs, feed-stuffs and feed-stuff additives; technical guidance for drug use, drugs and feed-stuffs that are strictly prohibited; the safety limits for synthetic fish food; and inspection of feed-stuffs and feed-stuff processing enterprises.
    - Establishment of a daily record system for rearing enterprises and a checking and inspection system for fishery administrations. Revisions were also made to marine farming policies.
2. Relevant national standards have been revised. After China's WTO accession, in line with the need of qualitative safety controls over the entire process of aquatic exports, the government accelerated the formulation and amendment of national standards concerning environmental quality of water areas, aquatic inputs, technical requirements, quality, safety, inspection and quarantine measures. In 2002, a series of national standards were issued, which included the Quality of Marine Organisms, the Quality of Marine Sediments, and Technical Requirements for Marine Farming Inspection.
3. Upon WTO accession, China made further revisions to support policies for the marine aquaculture sector in accordance with the new features of the international trading environment. For years, in order to expand the marine farming industry, local governments in coastal areas promulgated supporting policies aimed at increasing the rearing areas or cage numbers, or directly linked to these targets. With China's WTO membership, these policies have been changed or are in the course of change. In the face of post-WTO situations, some local governments put forward new ideas and measures. The focus has been shifted from expansion in quantity to encourage the development of green and uncontaminated aquatic farming, to set up certificates of origin and to build-up safeguard systems concerning seed stock, feed-stuff, prevention and control of disease, and quality. Subsidies and financial awards are provided to support this transformation of the growth model.

II. Environmental Effects of Marine Aquaculture

It was only in recent years that great concerns were voiced regarding the environmental impact of China's marine aquaculture sector. Until the mid-1990s, Chinese experts were still unaware of the industry's environmental hazards. This was for a number of reasons. During the initial and intermediate stages of development of marine aquaculture, more attention was paid to economic returns, and the negative environmental effects were not so noticeable at those stages of development. Moreover, people were still in the learning process and acquiring necessary knowledge. Two examples illustrate this point. In 1994, Chinese and foreign scholars conducted a comprehensive environmental study in the Hangzhou Bay area of Zhejiang Province, with support from the World Bank. Their final report almost failed to mention the pollution sources of the local marine aquaculture sector. And in 1998, the Zhejiang Provincial Oceanography Bureau also conducted a full-scale survey of seawater pollution, but again, the sector was not included in report findings that identified and assessed pollutants in the province. This oversight is mainly attributed to the fact that aquaculture-induced pollution is much less serious than pollution caused by industry; agriculture; urban sewage; and harbour pollution caused by transportation or by oil and gas. It is also due to the relatively ineffective supervision of this industry and the insufficient technical know-how and expertise at that time. Along with the rapid growth of the industry in recent years, however, the environmental effects of marine aquaculture became notably acute. As pointed out for the first time by *The State Bulletin on Marine Environmental Quality* in 2002, pollution from marine aquaculture itself; the degradation of marine varieties; damaged habitat of local animals and plants; and the attacks of outside species were all issues of concern brought about by the marine aquaculture sector.

A. Marine Aquaculture: the Systems, Methods and Wastes Derived

The systems of marine aquaculture

Marine aquaculture can be divided into the autotroph ecological system and the heterotroph ecological system, in accordance with their particular forms of energy intake. The autotroph system primarily relies on solar radiation as the direct source of energy. It is an open system, free from any feeding during the breeding periods, and is often employed to cultivate seaweed and shellfish. In the case of seaweed cultivation, once the seeds are put in, the solar energy and nutrients in the water will work together to produce seaweed. Such a system somewhat lessens the burden for seawater to provide nutrition. However, during intensive culture, the growth of seaweed may

affect the equilibrium of carbonate in the water, and lead to rising pH values. Besides, bushy seaweed may also block the flows of water and reduce the exchange rate of seawater. The heterotroph system, on the other hand, makes use of artificial feeding to supply energy. Nowadays, most of the world's marine aquaculture industries adopt semi-intensive or intensive culture methodologies, regardless of the autotroph or the heterotroph systems, and their breeding processes are invariably subject to artificial controls to a certain extent.

The methods of marine aquaculture

Marine aquaculture can be classified in three major categories based on breeding area:

1. Culture in tidal-flat areas of inter-tidal and super-tidal zones. This type of culture usually adopts bottom breeding, seed fast-holding culture, enclosure culture/pond culture as in the breeding of oysters, leeches, fish and shrimp, etc.
2. Raft culture in shallow waters, bottom breeding and cage breeding, such as the culturing of mussels, scallops, pearl shells, sea tangles, and various fishes, etc.
3. Indoor culture, as in abalone breeding. Shallow water breeding and tidal-flat area culture are among the leading forms of breeding adopted by China's marine aquaculture sector.

Some breakthroughs have been made in China over recent years in marine aquaculture methods. The breeding water body has been more fully utilized, as multiple culture methods were interchangeably employed (inter-culture, rotary-culture and poly-culture) away from the unitary breeding method of the past. In some regions, however, unitary and high-density culture methods are still prevalent in large breeding grounds, as the authorities there ignored the scientific proof and placed undue emphasis on the size and output of local aquatic culture sectors.

Waste produced by marine aquaculture

All cultured biological species cause direct pollution to their habitat the extent of which depends on the intensity of the systems by which these species are cultured. Three systems are in popular use: the extensive system, the semi-intensive system and intensive system. In addition to the culture systems, the varieties, their life process and some environmental factors—like salinity and water temperature—may also influence the level of waste emission.

B. Environmental Problems Related to Marine Aquaculture

1. Pollution of nutrient salts

Chinese scientists have proven[2] that the pollution of nutrient nitrogen and phosphorus is the principal cause for the degradation of the nation's coastal waters. A comprehensive environmental assessment jointly completed by Chinese and foreign experts in the Hanzhou Bay area in 1994 not only identified inorganic nutrient salts as the principal pollutant, but also estimated the source of the pollutants. The study failed, however, to discuss the release of nitrogen and phosphorus as a major source of pollution, for Zhejiang Province had only 14,000 hectares of total seawater breeding grounds and produced an annual 20,582 tonnes of fish and shrimp in the mid-1990s. At the time, the entire country had only 236,700 hectares of total marine aquaculture grounds and 311,205 tonnes of annual aquatic production. Now, marine aquaculture has expanded to 44,300 hectares in Zhejiang, and surged to 396,000 hectares across the country, the gross output of the sector stands at 1,122,730 tonnes annually. The release of nitrogen and phosphorus into the sea by the nation's marine aquaculture sector cannot be neglected any longer.

Many research papers have concluded that the dewatering of aquatic culture has put an increased nutrient load in the neighbouring waters, and that the nitrogen and phosphorus released from marine aquaculture constitute a source of eutrophication of the water body. Funge Smith and other experts have done research on the substance equilibrium in shrimp intensive culture ponds. They found that the breeding process only makes use of 10 per cent of the nitrogen and seven per cent of the phosphorus, while the remainder distributes into the environment. According to a calculation by Tovar and others on the nutrient load in seawater intensive culture, for one tonne of fish cultured, the discharges of TSS, ROM, BOD, Trianitrogen and P stand respectively at 104.57 kg, 235.4 kg, 34.61 kg, 14.25 kg and 2.57 kg. Affected by feed dregs and excrement, there is a high level of eutrophication in the shrimp and fish ponds, in which inorganic nitrogen normally reaches 7.9–88.46 μmol/L, inorganic phosphorus reaches 0.04–1.2 μmol/L, and the COD value is mostly three times that of the natural seawater areas. In the process of marine aquaculture, pond waters are often exchanged with coastal waters so as to maintain good water quality, leading to an enormous discharge of inorganic nutrient salts into the sea. These untreated discharges accelerate the eutrophication process of the seawaters. According to some

2 *The Recovery and Management of Island and Coastal Biological Systems*, written by Ren Hai and others, Science Press, Beijing, 2003.

technical data monitored, total inorganic nitrogen varied between 7.98–65.97 μmol/L and averaged 27.76 μmol/L, total inorganic phosphorus varied between 0.07–0.97 μmol/L, with 64 per cent of the substance exceeding 0.45 μmol/L, while the COD value reached 1.62–4.52 μmol/L. This shows that Chinese coastal waters close to marine aquaculture areas have a high level of eutrophication.

The significant growth of nutrients in seawater not only causes direct or indirect death of fish and the disruption of coral reefs, but will also bring about major change to the ecosystem in the foreseeable future. Development in recent years has proven that in the wake of increased eutrophication in coastal waters, massive inputs of exotic nutrient salts will drastically transform the biotic community of phytoplankton, their quantitative distribution and the diversity of marine species. This transformation will probably yield a serious and irreversible impact on the entire food chain. According to a report by the State Oceanography Bureau of China, the total number of plankton in major river deltas of the Yangtze and Liaohe in June 2002 was four or five times that of June 1959. Still worse, the varieties of the plankton in seawater also changed over the same period, with the number of poisonous plankton much higher.

2. Chemical pollution

Various chemicals are used in marine aquaculture to cure diseases, sweep away harmful organisms, and sterilize and keep in check fouling organisms. These medicines, disinfectants and antiseptics all have become important factors that directly affect the environment of the sea. According to a report by Solbe, the United Kingdom now employs a total of 23 chemicals in its aquaculture, and in 1990, Norway used more antibiotics in the fishery than in agriculture. Admittedly, a considerable part of the chemicals used in aquatic culture will distribute throughout the environment, and cause short- or long-term degradation. Take the Zhujian Delta, Canton for instance. The excessive use of $CuSO_4$ around the delta area, which was meant to cure cultured shrimp of certain diseases, has caused extremely severe pollution in the regions' water.

While it is true that marine aquaculture leaves less chemical residue along rivers and coastal waters than human activities in other sectors, including agriculture, the effects of the chemical pollution from aquaculture are still felt in some parts of China. Although the use of chemicals cures diseases and clears up pests, the residues may subdue plankton and useful bacteria and organisms in the water, do them harm or even kill them. In the case of low-density chemicals and chemicals that have a stable effect, the residues may accumulate in the body of water organisms

and, through the food chains, jeopardize the water ecosystem or even humans.

3. Substrate eutrophication

Almost all research findings have indicated that the contents of C, N, P and the oxygen consumption of the culture pond bottom mud are apparently more than those contained in the sediments of the neighbouring water body. What is more, the remnants of fish feed are also frequently found in the mud. This shows that aquatic culture changes the transport and deposition modes as well as the oxygen dissolving state of the substrate.

The piling-up of feed remnants and excrement in culture pond bottoms activates the movements of micro-organisms, and quickens the process of nutrient salt regeneration. At the same time, the resolution of falling dead organisms during the culture period increases the oxygen consumption of the substrate, speeds up the reaction of denitrification in the absence of oxygen and produces poisonous substances H_2S and NH_3. Take the example of the deep-water Niutou Island Bay of the Zhujiang Delta, Canton. After years of cage culture, it was discovered that the deposited sulfide contents were 10 times greater than the sulfide sediments outside the Bay. Massive survey evidence has also indicated that water areas that experienced full-scale organic decomposition are soon free of any organisms.

C. Effects of Marine Aquaculture on the Offshore Ecological Environment

1. Effects on marine organisms

Water bodies for fish farming are artificial ecological systems characterized by fewer trophic levels, due to unitary farming species, simple biotic constitution and the source of nutrients from artificial products. Some biotic factors are deliberately enforced while others are weakened or even removed from the system, leading to impediments to substance circulation and changes in the pattern and structure of biotic systems. Ecological equilibrium for aquaculture is achieved mainly through artificial means. If something goes wrong with a segment of the food network, the whole system will feel the impacts and give rise to a series of adjustments. Aquaculture changes the biotic populations and their offshore distribution. From a sustainability perspective, marine aquaculture for unitary species in a large area will disturb the natural ecosystem, setting off transformation from biodiversity to unicity and variance of the inner circulation. When the variances become large, substance circulation will be disrupted and the whole system becomes fragile, creating a threat to the sustainable development of marine resources.

The ecosystem will change because of large output of nutrient salts from marine aquaculture, decreased nutritional quality of the food chain and increased risks of red tide.

The frequent occurrence of red tide also implies that the marine ecological equilibrium has been disturbed. Sea areas that have often suffered from red tide are usually those that have been contaminated by too much inorganic nitrogen and phosphate. It has been confirmed that the occurrence of red tide has a great deal to do with an increase of nutrient salts of nitrogen and phosphate, and micro-elements of iron and manganese as well as some organic compounds. In the mid-1990s, when red tides were found as few as 10 times a year on average, people tended to believe that red tides are developed along with huge ecosystem of high productivity and environment of high fish production capacity. Any measures aiming to reduce the red tide will run the risk of a decline of fish productivity and a need to balance the change of the ecosystem. However, in 2003 when the country was hit by red tide more than 100 times, the destruction brought about by red tide exceeded the benefit of increased fish productivity associated with higher levels of nutrient salts in the seawater. Not only is the frequency of red tides increasing and the size of the area affected growing year by year, but also poisonous species are becoming evident. Some non-diatoms are able to release toxins that can be fatal to fish. When the poisonous substances are absorbed by mollusks, the toxins will be stored and accumulated within the body of mollusks and ultimately harm the health of human beings.

The destruction of the sea bed grass habitat is another problem. According to the *China Marine Environment Bulletin*, shrimp culture in recent years has thickened the sediments on the sweet sedge and the *thalassia testudinum*, and weakened the photosynthesis. The whole sea bed grass has shown signs of aging and degradation. Sea bed grass is regarded as the habitat with some of the highest primary productivity for the shallow sea creatures. Its destruction will significantly contribute to reducing the biomass in the shallow sea.

2. Destruction of inter-tidal zone and mangrove forest

Revealed by the statistics of Paez and Osuna, over the recent years, much low land in the coastal area of the world has been converted into fish or shrimp ponds. These areas used to be mangrove forests, saline-alkali land swamp marsh as well as farm land, and had certain ecological and economic functions. They were habitat, spawning grounds and shelters for many fish and mollusks. Some saline-alkali land served as drainage when floods, windstorms and typhoons came. The mangrove forest can absorb nitrogen and phosphate from seawater, which helps to reduce the level

of eutrophication and hence the risks of occurrence of red tide. In addition, these low lands have served as a buffer in the process of water exchange between the mainland and offshore.

As in the other parts of the world, these important parts of the land in China have been seriously harmed by human activities including marine aquaculture. According to the *Marine Environment Bulletin* issued by the State Marine Bureau, the mangrove forest along the southeast coast in China has been reduced to 15,000 ha in 2003, down from 50,000 ha in the 1950s. Natural and human factors contributed to this rapid disappearance of mangrove forest. But the main disturbance forces have been found to come from human activities, marine aquaculture in particular. Ninety per cent of the country's mangrove forests are found in Guangdong province. Since the 1980s, this province has converted approximately 8,000 ha to other uses, of which 98 per cent has been used for fish or shrimp ponds.

Converting the low land into fish or shrimp ponds has some consequences. One of them is destruction of the habitat of many sea creatures. For instance, there are very few birds looking for food and shelter in Futian, Shenzhen since the mangrove forests have been ruined.

Marine aquaculture has contributed to the eutrophication of offshore waters in more than one way, reducing the materials that can absorb and transform nitrogen and phosphate by cutting down the mangrove forest on the one hand, and increasing the levels of nitrogen and phosphate discharged from fish or shrimp culture by expanding the scale of culture area and enhancing the rearing intensity. The harmful effects of marine aquaculture, from the perspective of increasing the level of eutrophication, is larger than past estimates, which only took into account the input of nitrogen and phosphate from culture activities and ignored the role of mangrove forests in limiting the level of eutrophication.

3. Salinization of soil and underground water

A study from Taiwan, China,[3] shows that marine aquaculture experienced a very prosperous period more than 10 years ago but has since declined under environmental pressures such as strata subsidence, seawater invasion, and the salinization of soil and underground water. Excessive extraction of underground water for culture purposes is largely responsible for all those environmental harms. Constrained by the local environment, marine aquaculture was then moved to mainland China

3 E.P.A., Research on Salinization of Soil and Underground Water from *Marine Aquaculture*.

and some other surrounding countries. The late 1990s witnessed a boom in shrimp farming in the coastal area of China, funded and guided by people from Japan and Taiwan province.

Currently, building shrimp ponds above the super-tidal zone and drawing seawater or brackish water underground for rearing shrimp—the model copied from Taiwan province—is popular among those who want to make a quick profit from culture. It has been calculated roughly by some people in this trade, that for one rearing period, usually lasting three months, the output from one mu (666.6 square metres) pond is above 500 kg and the net profit generated from the output of one mu is in the range of 20,000 yuan. That is why the marine aquaculture for shrimp in Hainan has expanded swiftly, from 10,000 mu (6,666 ha) to 40,000 mu (26,667 ha) in about three years. However the rapid expansion of shrimp culture is accompanied by some environmental harm, such as salinization of soil and underground water.

4. **Overdrawing the underground water**

In recent years, industrial fish farming around the Bohai area has seen remarkable success and achieved good profit. Over-investment, driven by the promise of economic gain, has led to the establishment of too many facilities. People are very keen to engage in this profitable activity, irrespective of their local environmental conditions, such as underground water and marine resources. Investors from other parts of the country are also eager to participate. As the wells are too many and too crowded, underground water has been overdrawn, resulting in a dramatic decrease of underground water levels and even exhausted wells in a short period of time.

III. Pollution Trends in the Post-WTO Period

A. Projection of Output of Marine Aquaculture

To make a projection of China's marine aquaculture output against the background of joining the WTO, an OLS regression model is constructed, with the assumption of the supply curve. The price level on the domestic seafood market creates two kinds of effects. On one hand, in terms of the income effect, price increases in China's seafood market contribute to income increases and to the output scale expansion to China's marine aquaculture sector accordingly. On the other hand, in terms of the substitution effect, the price changes in China's seafood market also result in price changes relative to other items and then the changes in seafood demand. Therefore, the effects to output scale of China's marine aquaculture sector largely depend factors outlined in Table 2.

Table 2. Analysis on the main reason of effect output scale of China's marine aquaculture sector.

Explanation Variable	Effects to demand	Effect to supply	Conclusion
AGDP reflects the per capita GDP (RMB yuan)	Strongly positive	Changes of labour costs	Positive
F/FP reflects the price parity between seafood and food	Negative	Strongly positive	Positive
IP reflects agriculture price index (1995=100)	No direct effect	Negative	Negative
Dummy means transition of statistics system, the year of 1995 or before is 0 and the year of 1996 or after is 1	To amplify the substitution effect	To amplify the substitution effect	To amplify the substitution effect

With the background of WTO accession, after making up the original model and assuming the related explanation variables, it is also necessary to forecast the output of China's aquaculture industry. However, in terms of product structure, it is found that fish, shrimp and crab have occupied more and more of the market. From 1997 to 2002, the percentage of fish in the total output of China's marine aquaculture sector has risen from 3.22 per cent to 4.62 per cent. At the same time, the percentage of shrimp and crab in the total output of China's marine aquaculture sector has risen from 2.05 per cent to 4.63 per cent. Without anything else happening, these trends will continue in the near future. Therefore, it is reasonable to forecast the fish output and shrimp and crab output during 2003–2020. However, along with the expansion of the output scale, it is more and more difficult to maintain these trends.

Table 3. Output forecast (thousand metric tonnes).

Year	Less			Normal			More		
	Total	Fish	Shrimp & Crab	Total	Fish	Shrimp & Crab	Total	Fish	Shrimp & Crab
2003	13,146	650.7	674.4	13,105	648.7	672.3	13,070	647.0	670.5
2004	14,440	762.4	813.0	14,364	758.4	808.7	14,284	754.2	804.2
2005	15,221	853.9	933.0	15,420	865.1	945.3	15,616	876.1	957.3
2006	16,040	952.8	1,063.4	16,553	983.2	1,097.5	17,076	1,014.3	1,132.1
2007	16,902	1,059.7	1,205.1	17,769	1,114.1	1,266.9	18,671	1,170.7	1,331.2
2008	17,805	1,175.2	1,358.5	19,074	1,258.9	1,455.3	20,411	1,347.1	1,557.4
2009	18,757	1,299.8	1,524.9	20,472	1,418.7	1,664.4	22,324	1,547.0	1,814.9
2010	19,755	1,434.2	1,704.9	21,969	1,594.9	1,895.9	24,412	1,772.3	2,106.8
2011	20,542	1,542.7	1,840.5	23,234	1,744.9	2,081.8	26,255	1,971.8	2,352.5
2012	21,360	1,657.6	1,984.4	24,581	1,907.5	2,283.5	28,257	2,192.8	2,625.1
2013	22,223	1,780.1	2,140.1	26,012	2,083.5	2,504.9	30,422	2,,4368	2,929.6
2014	23,116	1,909.4	2,302.3	27,529	2,273.9	2,741.9	32,776	2,707.3	3,264.5
2015	24,047	2,046.4	2,474.5	29,148	2,480.5	2,999.3	35,323	3,006.0	3,634.7

Year	Less			Normal			More		
	Total	Fish	Shrimp & Crab	Total	Fish	Shrimp & Crab	Total	Fish	Shrimp & Crab
2016	25,018	2,191.6	2,659.4	30,870	2,704.2	3,281.5	38,084	3,336.1	4,048.3
2017	26,025	2,344.8	2,852.3	32,696	2,945.9	3,583.5	41,081	3,701.4	4,502.5
2018	27,080	2,507.6	3,057.3	34,642	3,207.9	3,911.1	44,321	4,104.1	5,003.8
2019	28,180	2,679.9	3,164.6	36,706	3,490.9	4,122.3	47,838	4,549.4	5,372.2
2020	29,321	2,861.8	3,410.1	38,904	3,797.0	4,524.6	51,641	5,040.2	6,005.9

B. Method to Estimate the Release of Nutrient Salt from Marine Aquaculture

Large scale marine aquaculture increases the output of dissolved and suspended waste, which will induce some changes of offshore waters within a certain sphere. In spite of a relatively small quantity of marine aquaculture waste in comparison with those discharged from industries, agriculture and municipal sewage, an increasing number of people have become concerned about the effects of marine aquaculture on the local sea. As indicated above, the release of nutrient salts such as nitrogen and phosphate from marine aquaculture is one of the major factors causing eutrophication of the local sea area. The following focuses on the changes of discharge of N and P from marine aquaculture after China's accession to the WTO.

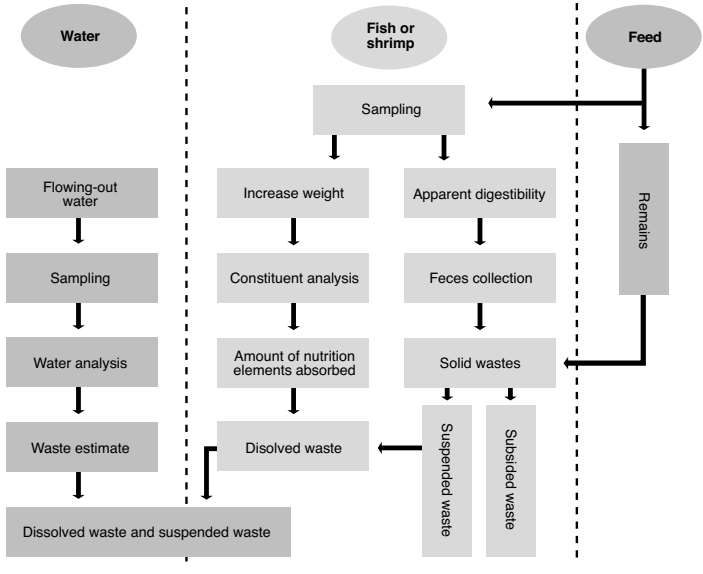

Figure 3. Indication of waste estimation of aquaculture by biochemistry.

(Based on the work of Cho, 1991)

Waste from aquaculture exists in two forms: one is suspended organism or in-organism; the other is granulate of organism or in-organism. The total amount of waste can be calculated in two ways: biological analysis and chemical analysis. The former is based on the feed used, the weight of the living body and the total content of nutrients in the living body; the latter is through analysis of the constituents of seawater. Figure 3 gives a rough indication of the processes and the linkages between the two methods. As water quality is affected both by marine aquaculture and land source pollutants in terms of N and P, it is difficult to distinguish the different sources of pollutants by the chemical method. In this case, the biological method is adopted to quantify the effects of marine aquaculture on the seawater.

From the perspective of biological analysis, food is a sole source of waste directly from within the fish farming system. So the total waste can be estimated based on the differences between the total feed thrown into the water and the part utilized by fish. Further, through a range of substance equilibrium equations, we can precisely measure various forms of discharge. In this research, estimation of the total discharge of N, P from marine aquaculture is based on the following equation:

$$T_i = FP \times FC_i \times KC_i \times (1\text{-}DC_i)$$

T_i is total discharge of pollutant i; FC_i is feed coefficient[4]; FP is total output of marine aquaculture; KC_i is the percentage of chemical element i of the feed used; DC_i is a percentage of nutrient that has been transformed to organism.

C. Estimated Results of Nutrients Released from Marine Aquaculture

Until 2020, along with the expansion of China's marine aquaculture production, the total discharge of nitrogen and phosphate is likely to keep rising—but at a decreased pace—in spite of regulatory and technological efforts. However, the discharge of nitrogen and phosphorous on the average production basis for fish and shrimp will drop steadily from 101 kg and 32 kg to 75 kg and 24 kg respectively. The decrease in average level is largely attributed to the improvement of technology in feed formulation and manufacture as well as in culture method, which results in higher efficiency of feed and a reduction of the solid waste.

4 Feed coefficient, also named as nutritional coefficient, is an index to measure the nutritive value of feed for fish, generally expressed as the ratio of volume of feed eaten by fish and an increase of the weight of the fish: FC=C/ΔB. When C and ΔB are expressed in dry weight, it is called coefficient of production effect. In measuring the portion of feed eaten by fish to maintain and grow, the percentage of an increase of weight in feed eaten by fish is adopted. This is called feed conversion efficiency: E=100ΔB/C. For growth analysis, feed conversion efficiency is growth efficiency. Feed coefficient itself reflects the relations among fish (specification, rearing density), feed (quality, feeding dose and methods), physico-chemical factors (water temperature, dissolved oxygen) and water exchange between cages.

Table 4. Estimated results for discharge of N and P.

Year	Variety	Output T	FC	N%	P%	N discharge T	P discharge T
2003	Fish	648,700	1.8	6.6	2.1	61,652	19,617
	Shrimp	672,300	2	6.7	2.1	72,071	22,589
	Sub-total	1,321,000				133,723	42,206
2004	Fish	758,400	1.8	6.6	2.1	72,078	22,934
	Shrimp	808,700	2	6.7	2.1	86,693	27,172
	Sub-total	1,567,100				158,771	50,106
2005	Fish	865,100	1.7	6.6	2.1	77,651	24,707
	Shrimp	945,300	1.9	6.7	2.1	96,269	30,174
	Sub-total	1,810,400				173,921	54,881
2006	Fish	983,200	1.7	6.6	2.1	88,252	28,080
	Shrimp	1,097,500	1.9	6.7	2.1	111,769	35,032
	Sub-total	2,080,700				200,021	63,112
2007	Fish	1,114,100	1.6	6.6	2.1	94,119	29,947
	Shrimp	1,266,900	1.8	6.7	2.1	122,231	38,311
	Sub-total	2,381,000				216,350	68,258
2008	Fish	1,258,900	1.6	6.6	2.1	106,352	33,839
	Shrimp	1,455,300	1.8	6.7	2.1	140,407	44,008
	Sub-total	2,714,200				246,759	77,848
2009	Fish	1,418,700	1.5	6.6	2.1	112,361	35,751
	Shrimp	1,664,400	1.7	6.7	2.1	151,660	47,535
	Sub-total	3,083,100				264,021	83,287
2010	Fish	1,594,900	1.5	6.6	2.1	126,316	40,191
	Shrimp	1,895,900	1.7	6.7	2.1	172,754	54,147
	Sub-total	3,490,800				299,070	94,338
2011	Fish	1,744,900	1.5	6.6	2.1	138,196	43,971
	Shrimp	2,081,800	1.7	6.7	2.1	189,694	59,456
	Sub-total	3,826,700				327,890	103,428
2012	Fish	1,907,500	1.5	6.6	2.1	151,074	48,069
	Shrimp	2,283,500	1.7	6.7	2.1	208,073	65,217
	Sub-total	4,191,000				359,147	113,286
2013	Fish	2,083,500	1.4	6.6	2.1	154,012	49,004
	Shrimp	2,504,900	1.6	6.7	2.1	214,820	67,332
	Sub-total	4,588,400				368,833	116,336
2014	Fish	2,273,900	1.4	6.6	2.1	168,087	53,482
	Shrimp	2,741,900	1.6	6.7	2.1	235,145	73,702
	Sub-total	5,015,800				403,232	127,184
2015	Fish	2,480,500	1.4	6.6	2.1	183,359	58,341
	Shrimp	2,999,300	1.6	6.7	2.1	257,220	80,621
	Sub-total	5,479,800				440,579	138,963

Year	Variety	Output T	FC	N%	P%	N discharge T	P discharge T
2016	Fish	2,704,200	1.4	6.6	2.1	199,894	63,603
	Shrimp	3,281,500	1.6	6.7	2.1	281,421	88,207
	Sub-total	5,985,700				481,316	151,810
2017	Fish	2,945,900	1.3	6.6	2.1	202,207	64,338
	Shrimp	3,583,500	1.5	6.7	2.1	288,113	90,304
	Sub-total	6,529,400				490,320	154,643
2018	Fish	3,207,900	1.3	6.6	2.1	220,190	70,061
	Shrimp	3,911,100	1.5	6.7	2.1	314,452	98,560
	Sub-total	7,119,000				534,643	168,620
2019	Fish	3,490,900	1.3	6.6	2.1	239,615	76,241
	Shrimp	4,122,300	1.5	6.7	2.1	331,433	103,882
	Sub-total	7,613,200				571,048	180,123
2020	Fish	3,797,000	1.3	6.6	2.1	260,626	82,926
	Shrimp	4,524,600	1.5	6.7	2.1	363,778	114,020
	Sub-total	8,321,600				624,404	196,946

Table 5. Average discharge of nitrogen and phosphate (kg).

Variety	Year	N discharge	P discharge	Year	N discharge	P discharge
Fish	2003	95	30	2012	79	25
Shrimp		107	34		91	29
Sub-total		101	32		86	27
Fish	2004	95	30	2013	74	24
Shrimp		107	34		86	27
Sub-total		101	32		80	25
Fish	2005	90	29	2014	74	24
Shrimp		102	32		86	27
Sub-total		96	30		80	25
Fish	2006	90	29	2015	74	24
Shrimp		102	32		86	27
Sub-total		96	30		80	25
Fish	2007	84	27	2016	74	24
Shrimp		96	30		86	27
Sub-total		91	29		80	25
Fish	2008	84	27	2017	69	22
Shrimp		96	30		80	25
Sub-total		91	29		75	24
Fish	2009	79	25	2018	69	22
Shrimp		91	29		80	25
Sub-total		86	27		75	24

Variety	Year	N discharge	P discharge	Year	N discharge	P discharge
Fish	2010	79	25	2019	69	22
Shrimp		91	29		80	25
Sub-total		86	27		75	24
Fish	2011	79	25	2020	69	22
Shrimp		91	29		80	25
Sub-total		86	27		75	24

IV. Main Findings

1. The development of China's marine aquaculture sector is a part of the structural effects brought about by China's WTO accession. It will help to enhance the overall utilization ratio of resources, to put the food safety system on a more rational and lower-cost basis, and will improve China's ability to cooperate in the global economy. Therefore, it will be of significant value to the economy, society and the environment.

2. There is little possibility of China's aquatic production being hurt by foreign products after WTO accession. China's aquatic products still have some comparative advantages in international markets, which will create a solid foundation for implementing the "Export Expansion" strategy. There is still room for giving further play to China's rich aquatic resources, cheap labour force and widely popularized farming techniques.

3. The economic and environmental benefits that China sees from the development of marine aquaculture sector will outweigh its adverse impacts on environment.

4. During the initial stage of China's WTO accession, the marine aquaculture sector has concentrated on production expansion, which has featured growing output and pollutant emission load. Within a longer period of time after WTO accession, due to internal and external pressures, the marine aquaculture sector will experience intensive reform, specifically designed to enhance technology and improve the quality of products. Consequently, the environmental pollutants caused by marine farming will decrease at this stage, and the industry will become more ecologically-friendly.

5. Regulations and standards on products and production processes are gaining importance in regulating the international trade of aquatic products. These regulations and standards of importing countries are affecting the comparative advantages of China's marine aquaculture sector. The key factors in expanding China's aquatic exports lie in building up a healthy and ecological farming mode and providing clean, sanitary, and

safe products. In this sense, the requirements imposed by major importers concerning product quality, safety and sanitary conditions against China's aquatic exports has compelled governments at all levels to consider environmental factors when designing trading policies. These positive countermeasures will not only actively promote China's aquatic exports but will also strengthen marine environmental protection.

V. Recommendations

WTO accession has brought a dramatic expansion in aquaculture exports, which are currently about as large as net agriculture imports. These exports are threatened by product quality issues, in particular as a result of "red tide," which appears to be the result of land-based pollution.

1. China should initiate a program of marine environmental quality, including the control of land-based, non-point source pollution. This will contribute to making the aquaculture sector more competitive internationally while preserving existing markets.
2. Aquaculture producers frequently have insufficient information concerning market requirements in other countries. China should establish a program to make such information available systematically.
3. China should participate actively in the development of relevant international standards for aquaculture products and for the quality of marine waters that support aquaculture.

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Automobiles

Automobiles

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Introduction

Since China's accession to the World Trade Organization (WTO) in 2001, the automobile sector[1] in China has been experiencing rapid change. There are many contributing factors, including a stronger economy, a general increase in income and improvement in infrastructure. The explosive expansion of the automobile industry has increasingly been powering economic growth and benefiting consumers. But there have also been environmental impacts. WTO accession has led to dramatic changes in production and consumption of automobiles in China. While trade liberalization is not an environmental instrument *per se*, it does produce considerable impacts on the environment—some positive; some negative.

After a brief description of the automobile industry at the time of WTO accession and identification of major environmental issues related to the sector, this chapter will examine changes in the Chinese automobile market as a result of WTO accession and the environmental impacts—both primary and secondary—of these changes. Finally, policy options and recommendations to promote the sustainable development of the automobile industry will be presented for consideration.

Overview of the Development in the Automobile Industry

Development path of the industry

With technical assistance from the Soviet Union, China started producing automobiles in the 1950s. Until the early 1980s, the automobile sector was

1 The focus of this paper is mainly on the impact of China's accession to the WTO on cars. Although other motor vehicles such as vans, trucks and motor cycles are also of interest for discussion, the most dramatic changes occur in the car market in China. Therefore, automobiles are used in a similar manner to cars unless otherwise specified.

under strict central planning in terms of investment, production and consumption. The market was highly isolated from the world. In 1971, total production of automobiles was only 100,000. No private ownership of cars was possible as motor vehicles were categorized as capital rather than consumer goods. There have been quite a few ups and downs in automobile production over the past three decades, but the overall trend since the middle of 1990s has been steady and accelerating (Figure 1).

In the 1980s, when China's economic reform was introduced, the automobile sector gained momentum and began to expand rapidly. By 1992, the number of automobiles produced in China exceeded one million. This figure was doubled in the year 2000. In 2002, production grew to 3.25 million, with sales revenue of 671.35 billion RMB, accounting for 5.5 per cent of the country's total industrial sales (Table 1). The output for 2003 increased by 35.2 per cent to 4.44 million units. According to projections by the China Association of Automobile Manufacturers, total production will reach between 5.10 and 5.34 million units in 2004. This will include 1.31–1.37 million heavy duty vehicles; 1.29–1.35 million coaches (buses); and 2.5–2.62 million passenger cars.[2] This rapid expansion has made the automotive sector an increasingly strong pillar of the Chinese economy (Table 1).

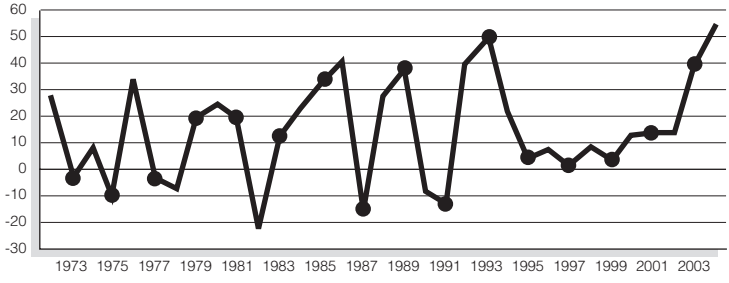

Figure 1. Growth rate of automobile production, 1971–2003.

Table 1. The changing position of the automobile sector among China's industries.

	1990	1995	2000	2001	2002	2003*
% of sales revenue over total industry	2.2	3.3	3.9	4.4	5.2	6.2
Ranking among industrial sectors	15	11	10	8	7	6
% of profit over total industries			3.9	5.7	7.8	10.3

* Estimates based on information available for the first quarter in 2003.

Source: Various Yearbooks of China's automobile industry; Auto Digest 2003.

2 China Industry News, *Automobile Weekly*. Author: Qixin, February 11, 2004.

Explosive expansion of the automobile industry after China's WTO accession positioned China as one of the five biggest producing and consuming countries. Over the past two years, the number of automobiles produced in China has doubled and China has surpassed France to become the fourth largest producer of automobiles in the world. Around 2008, China will likely surpass Japan to become the second biggest producer of automobiles in the world.[3]

Major problems associated with the sector

With the expansion of the industry, a number of serious problems emerged. First, the scale of production by individual manufacturers was—and is still—small. In 2002, there were 127 motor vehicle factories (excluding parts manufacturers) in China, spread over 27 provincial regions. Only two of the 127 have a production of over half a million; eight factories produce between 0.1 and 0.4 million; and 95 produce fewer than 10,000. Seventy out of the 127 produced fewer than 1,000 automobiles each in 2002.[4] There were only 20 car manufacturers in 2002 but the number increased to 32 in 2003 (Jiang, 2004). In terms of production scale, the annual output ranged from a few hundred to 400,000 (Figure 2).

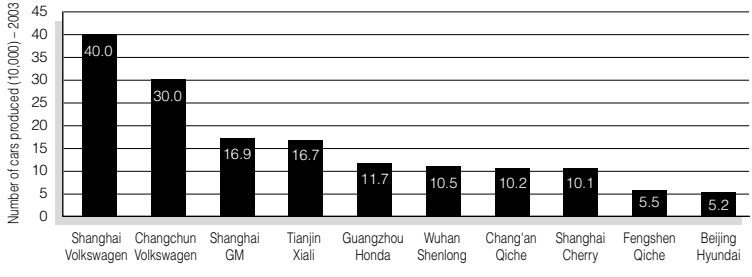

Figure 2. Top 10 automobile makers in China, 2003.

Source: Jiang (2004).

Second, the increase in motor vehicles causes air pollution, especially in urban areas. Due to slow travel speeds and less restrictive standards, emissions by cars in Chinese cities were estimated to be 10 times higher than those in developed countries. A World Bank (1997) report shows that Beijing had one tenth the number of cars of Los Angeles, but emissions of pollutants were almost the same (p. 72). In the middle of 1995, it was

3 *Market News*, February 10, 2004. Sensitive Industries in retrospect after two years accession to the WTO.

4 *China Economic Times*, August 19, 2003. p. 1.

reported that lead was found in children's blood in Shanghai (China Environment Yearbook, 1997). The phase-out of leaded gasoline in China in the late 1990s has eliminated lead pollution, but cars continue to emit other pollutants. In particular, the rapid increase in car numbers will result in heavier pollution despite improved emissions standards, simply because reduction per car is easily offset by the increase in the number of cars.

Third, demand for oil poses a serious challenge for the energy supply. Coal reserves are huge in China but oil reserves and production are rather limited. In 1993, China became a net petroleum importer. In 2003, China became the second largest oil importing country, importing 95 million tonnes of oil. This trend is projected to continue (Zhou, 2003). Much of the oil is used in the transport sector, as acknowledged in China's tenth five-year plan for the automobile industry: motor vehicles consume 85 per cent of the nation's gasoline and 20 per cent of its diesel. The projected demand for oil is 290 million tonnes for 2010 and 380 million tonnes for 2020 (Zhou *et al.*, 2003, p. 33). About 40–50 per cent of the demand will have to be met by imports. In the long run, oil shortages will be a limiting factor for the automobile sector.

Fourth, encroachment on land for roads and parking constitutes an increasing challenge for the expansion of the automobile sector. Cars have to be where people are, and roads must connect destinations. As population is concentrated in the fertile coastal and central parts of the country, there is a limited amount of land available for road construction and parking. In the Yangtze Delta, highways were built in the middle of 1990s with four lanes only. Due to increasing traffic flows, two more lanes are being added. This is more expensive than construction of six lanes at the very beginning, but land availability was a key reason behind the initial decision to build narrower highways. In rural areas in Zhejiang Province, fancy houses are everywhere but many have no access road for cars or parking space. In Beijing and many other cities, there is no free parking for residents in residential areas. A parking space can sell at a price higher than RMB 100,000 and rent of an underground parking space is RMB 6,000 a year in downtown Beijing, which is higher than the annual income of an unskilled worker. Car ownership in China is still low. Table 2 compares the number of cars in China to the numbers in a few other major countries, indicating the challenges that China will have to face. Car-centered industrial societies that are densely populated, such as Germany, the United Kingdom and Japan, have paved an average of 0.02 hectares per vehicle. And they have lost some of their most productive cropland in the process (Brown, 2001). Similarly, China faces even more acute pressure on its cropland base for industrialization and urbanization. Although China covers roughly the same area as the United States, the majority of its 1.3 billion people are concentrated in just one

third of the country—a 1,000-mile strip on the eastern and southern coasts where the cropland is located.

If China were one day to achieve the Japanese automobile ownership rate of one car for every two people, it would have a fleet of 640 million, compared to only 23 million in 2003. Assuming 0.02 hectares of paved land per vehicle in China, as in Europe and Japan, a fleet of 640 million cars would require paving nearly 13 million hectares of land, most of which is being cropped. This figure is some 10 per cent of the national total arable land and over one half of China's 23 million hectares of rice land. Most of the rice land is located in the rich south and eastern parts of the country where double or even triple cropping is practiced to produce 135 million tonnes of rice, the principal food staple. When farmers in southern China lose a hectare of double-cropped rice land to the automobile, their rice production takes a double hit. Even one car for every four people, half the Japanese ownership rate, would consume a substantial area of cropland (Brown, 2001).

Table 2. Current and potential land area consumed by cars in selected OECD countries, India and China.

Country	Current size of vehicle fleet (1) (million)	Vehicle ownership level (2) vehicles/ 1,000 population	Total road distance (million km)	Total current land area used by cars(3) (million ha)	Vehicle fleet size (4) (million)	Total paved area (5) (million ha)
U.S.	213.5	768	6.31	15.92	213.5	15.92
Japan	71.7	565	1.15	1.32	71.7	1.32
Canada	17.3	557	0.90	2.28	17.3	2.28
Germany	45.8	558	0.66	0.75	45.8	0.75
India	8.2	8	3.32	3.79	513	10.25
China	12.8	10	1.21	1.38	650	13.00

(1) cars plus commercial vehicles in 1998; (2) vehicles per 1000 people; in 1998 (3) parking plus road; (4) for industrialized countries, the actual numbers in 1998; for China and India, the total is calculated assuming two people per vehicle; (5) assuming the lower rate of 0.02 ha/vehicle figure from Japan and western Europe as the reference figure for calculation.

Source: Lester Brown, 2001, Jiahua Pan, 2003.

Future trends

The scale of production and sale of automobiles will rocket for at least the next decade for a number of reasons. First, the level of car ownership is still low. A car for every four people would result in a number of 320 million, a figure that appears incredible. Second, purchasing power is increasing along with the growth of the economy. In 2003, per capita GDP reached US$1,100 and ordinary wage earners were joining the club of car owners. Third, purchasing power is further enlarged by the decrease in prices due to

WTO accession. And fourth, road, services and other related institutions are becoming more user-friendly, thereby facilitating the expansion of the motor vehicle fleet. Figure 3 shows the overall trend of production of automobiles in China, with projections up to 2010.

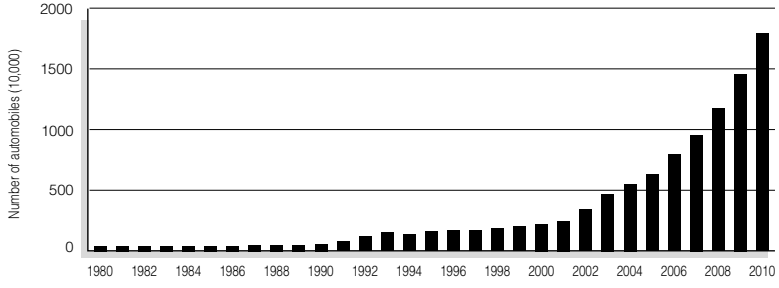

Figure 3. Automobile production, 1980–2010.

Source: data for 1980–1999, Yearbook of the China Automobile Industry 2000; for 2000–2003, actual production figures from various sources; for 2004–2010, estimates from various sources available at Web pages.

Changes in the Automobile Market after China's WTO Accession

Commitment by China for its accession to the WTO

For the automobile industry, commitments have been made in the following four areas:

1. *Tariff reduction*. Import duties are to be reduced from an average of 80–100 per cent in 2001 to 25 per cent by July 1, 2006, for cars. For parts, the rates will be reduced from the current 30 per cent to 10 per cent for the same period.
2. *Gradual increase of import quotas*. Quotas will increase by 15 per cent per year with final removal of quotas by January 1, 2005. The base quota was US$6 billion in 2001. For 2002, the quota was US$7.935 billion; US$9.125 billion in 2003; and $10.494 billion in 2004.[5]
3. *Opening up the financial and service market for the automobile sector in China*. National treatment will be granted to foreign financial and service providers.

5 Zhao Yun, Car Import Issues. *Economic Observer*, September 1, 2003. p. A26.

4. *Removal of investment restrictions*, such as proportion of local contents and foreign currency balances.

Changes in supply

Even before China became a full member of the WTO in November 2001, negotiation of the accession terms generated considerable debates and expectations with respect to possible changes of the automobile market in China. Competition from outside China would drive prices down and compel Chinese automakers to improve the quality of the domestic product. The combination of supply and demand resulted in an explosive expansion of the automobile market, in particular, the car market in China, immediately after China's WTO accession.

Two overall trends can be observed from the statistics over the transitional period (2001–2004). Table 3 shows that the rate of increase in automobile production before 2001 was rather stable, though relatively high, at about 13 per cent. The market power of WTO accession was explosively felt in 2002, with 40 per cent higher output than the previous year. This trend continued in 2003. The increase in production is projected to be somewhat lower for 2004. The other trend is the change of structure of automobiles. In 2002 and earlier, cars accounted for one third or less of the total number of motor vehicles produced. But the share of cars increased to 45.4 per cent in 2003 and is expected to reach 50 per cent in 2004 (Figure 4).

Table 3. Changes in automobile production, 1998 to 2004.

	1998	1999	2000	2001	2002	2003	2004
Automobiles produced (10,000)	163	183	207	234	326	444	526
% change over the previous year		12.3	13.1	13.0	39.3	35.5	18.6

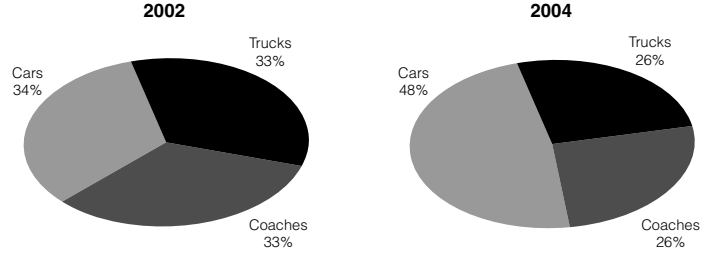

Figure 4. The increase in car production.

In 2003, the number of cars produced domestically was 55 per cent higher than in 2001. Total sales of cars in China in 2002 were 1.126 million, 56

per cent higher than in 2001. In 2002, 127,394 automobiles were imported with a total value of US$3.17 billion. The total quota for 2002 was US$7.935 billion. The number of automobiles imported represented 3.9 per cent of domestic production, but it accounted for 17.3 per cent of sales in China. During the first five months of 2003, automobile imports were worth US$5.42 billion, a 118.1 per cent increase over the same period in 2002. Excluding parts, total number of cars imported was 72,399, worth US$1.968 billion (RMB 16.275 billion). For the same period, sales of domestic cars numbered 680,000, worth RMB 70–80 billion.[6]

Decline in prices and gains in consumer surpluses

Prices of automobiles were once set high by the state. With a closed market, the prices of motor vehicles in China before China's accession were 50 per cent or more higher than those in OECD countries. This is quite unusual as labour costs were only five per cent of counterparts in OECD countries. The cost of production may have been high in China due to diseconomies of small scale and inefficient management. In the transitional period (2001–2005), the automobile manufacturers still enjoyed a high level of monopoly power. General Motors sold 8.235 million vehicles worldwide, with sales revenue of $184.632 billion and a profit of $4.452 billion. The rate of profit was only 2.41 per cent. In China, total sales of the three biggest producers[7] totaled 1.8525 million vehicles, with sales revenue of RMB 166.6 billion and profit of 19.26 billion. The profit rate was 11.56 per cent, nearly five times higher than General Motors. Labour productivity among China's three largest manufacturers is 6.5 vehicles per employee while the figure for General Motors is 23.33 per employee. For some expensive cars, net profit per car can be more than RMB 100,000![8]

Due to lack of competition, automobile manufacturers enjoyed a high rate of profit. Total sales revenue was RMB 151.5 billion, 30.8 per cent higher than in 2001, and, with a profit of RMB 43.1 billion, an increase of 60.94 per cent over the previous year. The average rate that the overall of average in China (10–15 per cent). This high profit explains two general trends in recent years: (1) more investment and new entries in the sector; and (2) drastic price cuts.

In the first half of 2003, price cuts averaging 6.9 per cent were announced for three types of cars. The highest cut was 18 per cent.[9] Cuts were even larger in the second half of 2003. For 2003 as a whole, average price cuts were

6 *China Automobile Abstract*. Number 267, October 9, 2003.

7 China No. 1 Automobile, Donfeng (China No. 2 Automobile) and Shanghai Automobile.

8 *Automobile Digest*, September 23, 2003.

9 *Jinghua Times*, July 30, 2003, p. B36; *China Economic Times*, August 19, 2003, p.1.

9.06 per cent. Deeper cuts were expected for 2004, the last year of the transitional period, at a rate higher than 10 per cent (Guo, 2004).

Some analysis indicates that the prices for less expensive domestic cars are somewhat close to world market pries due to intensifying competition. The scope for further price cuts, however, is large and consumers will gain more (Table 4).

In terms of consumer gains, the figure was over RMB 1.1 billion in 2002.[10] In 2003, the price cut was 9.06 per cent and the sales of cars were 1.97 million. Assuming an average price of RMB 150,000, the price cut was about RMB 13,600 per car. Then the total consumer surplus was as high as 27 billion. At the end of the transitional period in 2005, further price cuts will take place and consumer gains might be over RMB 50 billion.

Table 4. Comparison of prices in Chinese and world markets (2003).

	Type	World market price (10,000 RMB)	China (10,000 RMB)	China/ world
Higher price spectrum	Audi A6	17.8	37.9–42.7	> 2.0
Middle spectrum	Honda/Accord	19.6	25.9	1.32
	Mazda	15.3	26.3	1.72
Lower spectrum	VW/Jetta	7.5–8.4	10.00	
	Aoto/Xiali	3.0	4.0	
Imported	Toyota/Camry	18.5	> 41.6	2.25
	Benz S600	100	> 200	> 2.0

Survey made by Automobile Digest, September 23, 2003.

Overall Impacts of WTO Accession

China's WTO accession has generated considerable social and economic impacts, most of which are direct, observable and, in general, positive. That proves the benefit of trade liberalization. However, some negative environmental impacts can also be associated with positive socio-economic impacts.

Employment and contribution to the economy

The automobile industry employs over half a million people. Statistics show that one employee in the automobile sector needs six employees in related sectors, such as sales, services, repairs, finance and insurance, and oil stations. Therefore, the total employment generated by the sector is around 3.5 million. For each Renminbi (RMB) yuan produced in the automobile sector, the amount of value added would be 0.65 and 2.63 in the upper and lower stream respectively.

10 Total sales of cars in China in 2002 were 1.126 million. If the price cut on average per car is 10,000, consumer gain would be as high as RMB 11 billion.

Corruption and smuggling

Owing to huge differences in car prices between China and the rest of the world, car smuggling was highly profitable despite high risks. Quotas are allocated until 2004. One car import permit can sell for RMB 100,000.[11] Some government officials and custom officers engage in corruption under quota management systems. But once they are removed as a result of WTO accession, there would be no opportunity for corruption and no need for smuggling.

Increase in safety

The quality of cars has been improving and safety standards have been increasing. In 1986, there were fewer than three million motor vehicles in China and there were 0.29 million accidents. In 2002, the number of vehicles totaled 21 million and the number of accidents was 0.77 million. The number of cars increased by an annual rate at 12.4 per cent between 1986 and 2002 while accidents increased by 6.3 per cent per annum. For the same period, the number of deaths increased from 50,000 in 1986 to 109,000 in 2002, with an average annual rate of growth of about five per cent. In terms of deaths per 10,000 vehicles, the figure for 1999 was 15.45 and the figure was slightly reduced to 13.71 in 2002 and down further to 10.8 in 2003. According to the latest bulletin on traffic accidents from the traffic bureaus for 2003 (Lu, 2004; Huang *et al.*, 2004), the number of vehicles increased by 34 per cent but road accidents were 13.7 per cent lower than the previous year, with 4.6 per cent fewer deaths and 12.1 per cent fewer injuries.[12] These figures are still appalling in comparison with the figures of deaths per 10,000 vehicles in France (2.5); United States (2.0); Japan (1.3); and South Korea (8.2). Air bag systems are installed in most new cars.

Table 5. Rail speed by 2005 on major lines.*

	Distance	Current time requirement	2005
Beijing – Harbin	1,290 km	12 h 29 m	9 h 59 m
Beijing – Shanghai	1,300 km	14 h	11 h 57 m
Beijing – Nanchang	1,200 km	13 h 44 m	11 h 59 m
Beijing – Wuchang	1,230 km	12 h 1 m	9 h 59 m

*This target was put into operation before May Day holiday week in 2004, seven months earlier than planned.

11 *Economic Observer*, September 1, 2003. P. A26.

12 Figures were by Transport Bureau of the Ministry of Public Security, Xinhua News Agency. See *Ningbo Daily*, October 3, 2003.

Impact on other transport

Road transport has forced other modes of transport to improve services and efficiency. The Ministry of Railways has announced that the speed of trains will be increased further and maximum speed per hour will be over 200 km (Table 5).[13]

Development of urban metro systems

Due to ever intensifying urban traffic congestion and pollution, trucks have largely been excluded from the city proper areas in China's big cities. In Beijing, no trucks are allowed within the fourth ring from 7 a.m. to 11 p.m. In Wuhan, only loaded trucks are allowed to go through No. 1 Yangtze bridges. But urban residents have to travel in the city for their daily life. As the density of buildings is extremely high and space for surface road systems is rather limited, most of the Chinese big cities have now initiated or planned underground and surface fast rail systems. In Beijing, a 157 km metro system is to be built by 2008 as part of the infrastructure for the Olympics, with an investment of RMB 63.8 billion. Shanghai's metro line will be further extended by 193 km, requiring RMB 75.7 billion. A total investment of RMB 73.8 billion will add 170 km of new lines to Guangzhou's metro system. Similar plans are proposed in other big cities, including Tianjin, Nanjing, Wuhan, Chongqing, Changchun and many others.

Sustainable rural development

So far the most direct and positive impacts are related to urban areas and industrial sectors. Nevertheless, China's accession to the WTO and the growth of the automobile industry can have similar impacts in rural areas and the agricultural sector. In general, many such impacts can be positive from a social and economic perspective but can also be negative from an environmental perspective.

Employment and road connections

Skilled labour is required in the manufacturing process of automobiles and rural labourers are generally unqualified for such positions without training. However, ordinary car repairs and car washing do not require sophisticated skills or large amounts of capital investment. Many of the rural labourers can find employment in these areas. In urban areas, they can join the companies as employees and in rural regions where roads are connected they can even have their own business along the road and in townships and villages.

13 Xinhua News Agency, *Jinghua Times*, September 17, 2003, p. A02.

A second category of impacts is related to road connections. There are several positive impacts on the rural economy:

1. *Development of rural tourism*. As road access is made to remote rural areas, urban residents drive their own cars or join tourist groups to visit villages far away from cities, thus creating demand for local services and products for income generation.
2. V*illagers can travel farther away and with higher frequency* for medical care, employment and cultural life in urban areas, thus making more opportunities and options for rural people.
3. *Larger markets can be linked to rural regions*. In most cases in China, agricultural products from remote rural areas cannot find their way to market. This isolation from the outside world leads to poverty. With road connections, local products can find their way to market and rural people will be able to generate income and have access to urban and industrial products.

A third category of impacts can also be largely positive from a social and economic perspective. One is increased agricultural production. With entry to the WTO, the quality of agricultural machinery has also been improved, along with cars, and the prices have decreased. Most importantly, the use of agricultural machinery requires scale of economy. Normally, combined harvesters do not move far and served only limited local areas. In China, wheat and rice ripen from the warmer southern to northern provinces but in the past, combined harvesters only serve local farmers due to poor road conditions. With good road connections to other provinces, the owners of such machinery can drive hundreds of kilometres from the south to the north for wheat and rice harvesting. The other impact is an increase in living standard. As the price of automobiles is lowered, some of the rich farmers can enjoy the purchase and use of motor vehicles. As the quality of motor vehicles is improved, safety is also increased in rural areas.

Environmental impacts in rural areas. As in the case of increasing numbers of cars in cities, there are two types of impacts in rural areas. From the positive side, the overall quality of new motor vehicles has been increased substantially after China's entry to the WTO due to the general increase in technology and spillover effects. Heavily polluting and less energy efficient vehicles are gradually driven out of the urban market. On the other hand, the phased out motor vehicles are often sold in the rural market. They are better than the old motor vehicles in use in the rural regions, but still these old and second-hand motor vehicles from cities are less safe, less energy efficient and more polluting. As a result, environmental problems associated with automobiles such as noise, exhaust pollutants and encroachment of land become more serious in the rural areas. As the numbers of motor vehicles in

the rural areas can also increase faster than the improvement of quality and efficiency, the overall environment may deteriorate before it gets better.

Secondary impacts. In the past decade or so, there have been many complaints from rural residents that their land had been taken away for road construction, thereby creating poverty and social instability. Road construction inevitably disturbs the natural environment and habitats for wildlife. In this respect, road networks can have negative impacts on wildlife. Another impact is more positive—biofuels, such as ethanol, that can substitute at least partly for fossil fuels (Pew, 2002). Due to lack of oil, part of the arable land can be used for production of oil-rich crops or grains for ethanol production. This has been in the experimental stage in China but the potential is attractive as it relates to energy security, employment and pollution reduction.

In summary, China's entry to the WTO will have impact in rural areas. There will be some positive social and economic effects, coupled with largely negative environmental effects. However, there are opportunities to generate effects that are positive for the environment as well as for social and economic development. One example is energy cropping for ethanol production. Also, to avoid pollution shifting to rural areas from changes in the automobile sector, compulsory dismantling of old cars must be strictly implemented and second-hand cars should be brought under control in the rural market.

Environmental Impacts

Exhaust emissions: a major source of pollution in cities

The explosive increase in car ownership has made exhaust emissions a key source of pollution.[14] In many southern cities, exhaust emissions have become the number one source. In Guangzhou for instance, exhaust emissions account for 22 per cent of air pollution while industrial sources cause 20.4 per cent and dust from construction sites accounting for 19.2 per cent of the total. Residents of Guangzhou once voted automobile exhaust the "most intolerable pollutant."[15]

In Shenzhen, things are more serious. Among the air pollutants, automobile exhaust contributed 70 per cent of the pollutants, emitting over 20 tonnes of harmful substances. The rate of emissions has been increasing by over 20 per cent annually. In northern China, where coal is the major source of energy and pollution, car emissions have become increasingly prominent due to traffic congestion and a growing number of cars.

14 Zhao Yongsheng, Lei Sheng, Car emissions the major source of pollution in cities. *People's Daily*, January 8, 2004.

15 *Ibid.*

The Euro II standard has been adopted in Beijing and Shanghai and is being applied to other Chinese cities from July 1, 2004. In 1999, when Euro I was first adopted, many automobile producers complained about its strictness. Within a couple of years, the standard was accepted by most automobile producers. Leaded gasoline has been phased out since July 1, 2000, and lead pollution has been eliminated. In order to control automobile pollution, more stringent standards will have to be applied. For instance, China's national standard for sulfur content in gasoline is 800 ppm as compared to 10 ppm in California.

Beijing introduced the Euro II standard on August 1, 2002, and automobiles that could not meet the standard by January 1, 2004, were not allowed to register.[16] On November 19, 2003, the Beijing Environmental Protection Bureau issued a directive requiring the application of new emissions standard for vehicles in Beijing.[17] Since January 1, 2004, the Euro II standard applies to heavy duty petroleum vehicles. For light vehicles and heavy duty diesel vehicles, the Euro II standard has applied since January 1, 2003.

Table 6 shows the concentration of air pollutants in urban areas according to the latest Beijing Environment Status Report.[18] In comparison with concentration levels in 1998, NO_2 levels increased by 2.7 per cent by 2002 while all the other pollutants were trending downward. In 2002, some 0.6 million vehicles were tested against emission standards, with 91 per cent passing the checks. In addition, 160 Euro III standard diesel buses were put into operation with low sulfur diesels. However, light vehicles are in general less stringent in meeting the standard. In total, 140,000 checks were made to light vehicles with 47,000 violating the standard.

Table 6. Concentration levels for major air pollutants in urban areas, Beijing, 1998–2002 (daily average, mg/m³).

	SO_2	NO_2	Particulates	Total suspended particles	CO
1998	0.120	0.074	na	0.378	3.3
1999	0.080	0.077	0.180	0.364	2.9
2000	0.071	0.071	0.162	0.353	2.7
2001	0.064	0.071	0.165	0.370	2.6
2002	0.067	0.076	0.166	0.373	2.5
2002/1998	-44.2%	+2.7%	-7.8%*	-1.3%	-24.2%

* Compared to 1999 level.

16 This directive was issued by the Beijing Environmental Protection Bureau on July 30, 2002, with approval from the State Council for the purpose of air quality control in Beijing. Beijing Environmental Protection Bureau, Air 2002 – 270.

17 Beijing Municipal Environmental Protection Bureau, Directive Air 2003 – 400. November 19, 2003.

18 Beijng Environment Protection Bureau, Environment Status Report. June 1, 2003.

Government policy context for environmental impact assessment

Industrial policy: automobile development. The new industrial policy for the automobile sector was announced in the second half of 2003 to replace the outdated sectoral policy from 1991.[19] According to government officials, this policy is designed to promote structural readjustment and organization; enlargement of enterprise scales; increase in industrial concentration; avoidance of lost investment and repetition of outdated technologies; encouragement of research and development by enterprises for innovation and technological progress; establishment of institutions for sectoral management on a legal basis; harmonization with related industries; and social and environmental requirements. More specifically, the new sectoral policy will focus on: (1) removal of all aspects that are inconsistent with the government commitment to WTO accession; (2) substantial reduction and simplification of administrative procedures and formalities, using legal and regulatory, technological and industrial standards to guide sectoral development; (3) brand strategy emphasizing sales and service systems by enterprises; (4) expansion of the scale of enterprises through merging and re-organization of existing enterprises; (5) demand-side management, encouraging the use of energy-saving and new energy vehicles by consumers; (6) protection of consumer rights; and (7) establishment of unified market by removal of regional and local protectionism.

No restriction on automobile sector. On February 4, 2004 the State Council removed the automobile sector from the list of over-invested sectors.[20] In the second half of 2003, four sectors were on the list of candidates for restriction of investment, including iron and steel, cement, aluminum and automobiles. Automobiles represented the only manufacturing sector on the list, the rest being materials sectors. As market prices for the three materials have been skyrocketing, investments from various sources are likely to result in over-capacity. The automobile sector, on the other hand, has been considered a pillar industry for the economy. This would suggest that investment in the automobile industry is still encouraged.

Compulsory implementation of Euro Standards. The Chinese Government has intensified its efforts to reduce motor vehicle emissions. In 2000, China stopped producing and selling leaded gasoline. In 2001, all new cars in the market were required to meet a Euro I emissions equivalent standard. In September 2003, diesel vehicles were required to meet the Euro II emissions standard. One year later in July 2004, gasoline vehicles are asked to reach the Euro II emissions standard (see Table 7). Such requirements have been met

19 Chen Bin, Deputy Director General of Industrial Department, State Development and Reform Commission. http://www.sina.com.cn, November 4, 2003.

20 Xu Feng, No restriction is made on investment in automobile industry. Economic Report for the 21st Century, February 13, 2003.

in Beijing and Shanghai already.[21] Considering the rapid increase in automobile production and pollution problems, stricter standards will be implemented for the sake of the environment. WTO accession has made the implementation of such government policies possible.

Table 7. Euro Standard[22] for emissions: targets to be followed by China.

Euro standard	China (for new vehicles)	Gasoline engine (g/km)			Diesel engine (g/km)	
		CO	NO_x	HC	NO_x	PM
1986		15	4.6		-	-
1989		-	-		14.0	0.5
1992 (Euro I)	2001	2.8	1.0		8.0	0.36
1996 (Euro II)	2004	2.3	0.3		8.0	0.25
2000 (Euro III)		2.3	0.15	0.2	5.0	0.10
2005 (Euro IV)		1.0	0.08	0.1	5.0	0.02
2008 (Euro V)					2.0	0.02

Incentives for replacement of old motor vehicles. In 2003, the Ministry of Finance and the State Economic and Trade Commissions circulated jointly their policy announcement No. 4, stipulating that trucks (4.5 tonnes and heavier) between eight and 10 years old are eligible for a RMB 4,000 subsidy when replaced with a new truck.

Assessment of Environmental Impacts

Methodology

The International Energy Agency (Schipper, Marie-Lilliu, Gorham, 2000; Schipper and Fulton, 2001) developed a general impact assessment equation for understanding environmental impacts from the transport sector. The simple form is as follows:

$$G = A * S_i * I_i * F_{i,j}$$

Where G is the total amount of emissions of a particular pollutant; A is total travel activities measured by passenger-km or tonne-km; i is travel mode; S_i vehicle travel by travel mode i; I_i is the energy intensity by travel mode i; and $F_{i,j}$ is fuel-type j under travel mode i.

In our application, this is modified to reflect the impact of WTO accession, i.e., the change of automobile numbers due to China's entry to the WTO.

21 Xie Zhenghua, March 2003.

22 The Euro Standard is implemented through emissions regulation by Economic Commissions for Europe (ECE) and emissions directive by the European Economic Community (EEC, now EU). Emissions regulations are accepted by member states on a voluntary basis where emissions directives are compulsory within EU member countries.

Although there were expectations before WTO accession, the real impact came after. As expressed earlier, the number of automobiles sold and produced changed drastically immediately after China's accession. Here only net changes of automobile numbers should be used for the analysis of impacts. This means that growth without WTO should be deducted. Second, emissions factors change due to improvement in automobile quality, in particular the compulsory implementation of Euro standards after WTO accession. Changes take place over the years, but WTO accession provides the opportunity for the government to apply stricter standards and for manufacturers to use the new standard due to accelerating rate of market integration into the world and the existence of a large consumer surplus. Third, WTO accession will have a long-term and persistent impact but the change in the transitional period can be of interest for understanding the immediate and direct impacts. That is, the period of investigation focuses on the transitional period.

Given the above considerations, the ASIF equation is modified as follows:

$$Q_j = \Sigma_{(I = 1,2,3,4)} K A_o (1 + \alpha) e_{ij}$$

Where Q_j is the total emission of pollutant j; K is travel activity measures as distance traveled in kilometres; A_o is the base year (accession year: 2001) production/sales of automobiles; α is the annual rate of increase in automobile production; e_{ij} is the emissions factor for pollutant j in year i. In this analysis, focus is made on the first three years after WTO accession, from 2001 to 2004. For all the new cars, an average life-cycle of 15 years is assumed (Greene and Schafer, 2003).

Scenarios

Three scenarios are identified for this assessment. The base year is 2001 when China became a member of the WTO. Major change took place immediately after China's entry into the WTO. And 2004 is taken as the end of the transitional period. That is the period for this assessment is 2001–2004. Longer-term analysis is possible and helpful, but the focus of this analysis is on the transitional period. Emission factors used are the parameters from Euro standards. Although in Beijing and Shanghai, Euro I and Euro II were applied earlier than in many other cities, government regulation made Euro I compulsory in 2002 and Euro II in 2004. As the change in the number of trucks and buses is not as drastic as for cars, the focus here is on cars though trucks and buses can be larger contributors to pollution. In terms of activity level, it is assumed that 35,000 km is driven for an average car each year. In addition, diesel and Liquefied Natural Gas (LNG) engines are not included in the analysis as the number of cars with such engines is limited. No consideration is given to cars not commercially available: hybrid, solar powered, ethanol and hydrogen cars.

Business as usual (BAU): The assumption is made that no abrupt change of automobile production/sales took place. Consider that automobile production would continue to increase over time as part of the economy. Using trend analysis, an 11.6 per cent rate of increase in automobile production is assumed as the base without WTO accession. Emissions are assumed to be at European levels in the late 1980s for all new purchases.

WTO case (WTO): Actual numbers for 2001–2004 (projected for 2004). The new Euro standard is used as the emissions factor. Because of the lower rate of emissions, total emissions may be much lower due to an improvement in quality of cars. In 2001, Euro I is applied to all newly purchased vehicles and Euro II is applied to all new purchases in 2004.

Combined: WTO case of car production/sales but emissions factor at business as usual case level (WB): In this scenario, the number of automobiles produced/sold uses the WTO case but emissions are assumed to be unchanged, i.e., the old, less stringent emission level.

Results

With respect to the change in automobile numbers, the increase from 2001 to 2004 is calculated at about 0.3 million or so under BAU. This number is very high in comparison with the pre-WTO accession years. Rational expectations might have an impact on the growth of automobile production and sales, but the explosive increase in automobiles records a number of 1.8 million, about eight times more than the baseline case (Figure 5), indicating the direct visible impact of WTO accession in 2001.

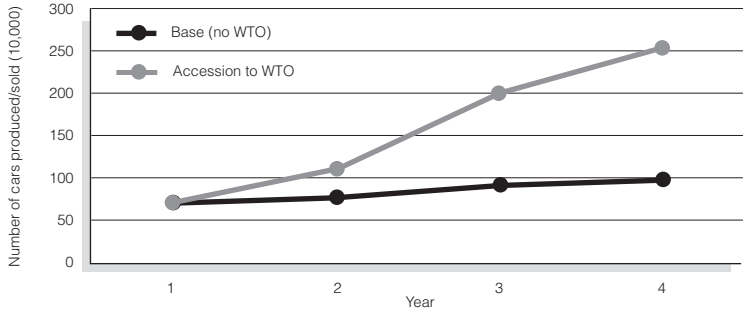

Figure 5. Increase of car numbers, base and WTO cases.

In the case of no WTO accession, CO emissions increase along with the number of cars. The net change is rather moderate from 5.5 million to 7.7 million tonnes without introduction of the Euro standard, though absolute

numbers are high. In the WTO case, emissions of CO are drastically reduced owing to the application of Euro I to all new cars in 2001 and Euro II in 2004. In 2002, the number of new cars sold increased by 40 per cent in comparison with the base case, but CO emissions were about a quarter of emissions if no Euro I was enforced. However, this environmentally benign impact was substantially offset by the large increase in car numbers. In 2004, the difference in emissions with and without WTO accession is halved as the number of cars sold is 160 per cent higher.

Another feature is noteworthy. With WTO accession, the immediate reduction of CO in the first year is very substantial, being 1.6 million tonnes in 2002 compared to 5.5 million in 2001. Then emissions continue to grow rapidly despite strict application of Euro I in 2002 and Euro II in 2004. There are two major reasons behind this phenomenon. First, the change of the emissions factor becomes marginally lower as the standards are stricter. With the application of Euro I, the CO emissions factor is reduced from 15.0 g/km to 2.8 g/km. Then from Euro I to Euro II, the change is from 2.8 g/km to 2.3 g/km. From Euro II to Euro III, emissions factor for CO emissions is kept the same without reductions. The other reason is the number of cars. There are more cars emitting although each car is emitting less. If the rate of emission per car is lower than the rate of increase in car numbers, the net outcome is certainly more emissions.

Nevertheless, the WB case generates more information on emissions reductions. Suppose no technology for low emissions was transferred to China but the demand for cars is assumed to grow at the same rate as WTO case in recent years. Then old high emissions technologies would be simply duplicated everywhere in a similar manner as small coal mines, just expand their physical scale without introduction of new technologies. Compared with the WTO case, WB scenario would emit 7.05 million tonnes of CO more for new cars in 2002 and 16.38 million in 2004 (Table 8). This case might be more relevant to understanding the environmental benefit from China's WTO accession. Without WTO accession, many Chinese enterprises might simply duplicate old and more polluting technologies to expand the automobile market. Such a case was seen during the last 20 years in rural township and village enterprises. This phenomenon has still not been eliminated.[23] With liberalization of the market, protection has to give way to competition and the net result is not only consumer surpluses in terms of lower price and better quality, but also a cleaner environment.

23 The central government has been shutting down small scale paper mills, coal mines, chemical factories, steel mills and thermal power plants. Due to lack of capital and technologies, local governments and companies simply copy the old and highly polluting equipment, resulting in serious pollution problems.

Table 8. CO emissions under different scenarios (10,000 tonnes).

Year	CO BAU	CO WTO	CO WB	WB-WTO	WTO-BAU
2001	553.90	553.90	553.90	0.00	0.00
2002	618.41	161.99	867.04	-705.05	-456.42
2003	690.12	296.81	1588.63	-1291.82	-393.31
2004	770.38	376.32	2014.17	-1637.85	-394.06

The overall trend for NO_x emissions shows a similar pattern to that of CO emissions (Table 9). Against the base scenario, WTO accession resulted in substantial reductions—over one million tonnes each year. If we look at the number in 2003, however the reduction is lower than the previous year. The reason is simply because the drastic increase in car numbers took away much of the positive environmental effect of the stricter environmental standard. Unlike the emissions factor for CO, the change of the NO_x emissions factor is gradual and step by step, from 4.6 g/km to 1.0 g/km under Euro I and 0.3 under Euro II, then 0.15 g/km under Euro III and further down to 0.08 g/km under Euro IV.

Table 9. Change of NO_x emissions (10,000 tonnes).

Year	NO_x BAU	NO_x WTO	NO_x WB	WB-WTO	WTO-BAU
2001	170.02	170.02	170.02	0.00	0.00
2002	189.82	57.86	266.13	-208.28	-131.96
2003	211.83	106.01	487.62	-381.62	-105.83
2004	236.46	40.32	618.24	-577.92	-196.14

Other environmental impacts

For other environmental impacts, the tendency has to be assessed case by case, with some more negative while others can be more mixed.

Road congestion. Simply because of the increase in car numbers, road congestion has become a growing problem for the authorities. In Shanghai, the number of new cars is limited for each year and permits for registration of new cars are auctioned to control car numbers and to raise resources for road improvement. But many people simply go to neighbouring provinces for car registration of new cars and use them in Shanghai. In Beijing, parking availability had to be shown to the registration office for registration of a new car from 2001 to 2003. This requirement was removed in early 2004, but car owners find it more and more difficult and expensive to park their cars. There are many cases that the car is damaged or removed on account of parking problems. This has become an issue of community stability. Despite continued efforts to construct new roads and underground networks, traffic congestion has been getting worse in all of the big cities. The parking problem and road congestion exist mainly in big cities and in the rich coastal and eastern provinces. In small cities and rural regions, this has yet to become a

serious issue. China is still among the countries with lowest car ownership at 6.7 cars per 1,000 people on average, as compared to 481 in the United States and 413 in Japan (*The Economist*, 2004, p. 68).

Traffic noise. There are two tendencies in traffic noise. One is positive: engines are of better quality and create less noise; the other can be negative: cars are penetrating all corners in populated areas. According to the overall assessment by the Beijing Environmental Bureau (2003), the average amount of road traffic noise in 2002 was the same as the previous year despite an increase in traffic of 26.4 per cent. There are a number of reasons for this: (1) road networks are improved with more access lanes; (2) heavy duty vehicles are diverted away from urban areas; and (3) new additions to the road system are mainly better cars that create less noise. Because of improvements to the road system, cars can go faster, thereby generating more noise. As a result, Beijing's municipal government has built noise insulation walls along the second and third ring roads to shield residential areas from traffic noise.

Other secondary environmental impacts. There are many other secondary environmental impacts that are associated with the development of the automobile industry in China. One such impact is the use of materials, in particular metals. In 2003, China produced 223.4 million tonnes of steel and imported another 25 million tonnes. Construction of infrastructure and buildings is one of the factors for such large production and consumption in China, but rapid expansion of the automobile industry is certainly among the major contributors. Therefore, emissions by the steel industry can be partly attributed to the automobile sector as automobile producers are the consumers of steel. Such analysis can also be applied to the oil sector. Automobiles are the end users and a large proportion of oil products are used to power automobiles. Also, waste of dismantled cars can be partly recycled but pollution cannot be completely avoided. Highways are built for automobiles and highways modify the natural environment, disturb and separate natural habitats. The routes of animals can be disrupted. Actual attribution of such impacts to China's entry to the WTO can be more complicated, but connections can be established.

Policy Implications

The automobile sector contributes to the growth of the economy, employment and quality of life. WTO accession helps rapid expansion of the industry and generates enormous consumer surpluses. From an economic perspective, WTO accession brings about more benefits than costs such as arable land encroachment for roads and parking and energy security concerns. In light of environmental impacts, the conclusion is different as more emissions are added due to an explosive increase in automobile numbers

despite stricter emission standards for new ones. Based on the above analysis, some policy implications are given below.

Long-term policies

Among three major categories of automobiles, cars grow much faster than the other two—trucks and buses. This trend is unlikely to be curbed in the short term but will have to be changed in the longer run. There are a number of reasons for this: (1) *Land availability*, in particular arable land. This year the government has already tightened its policy on the conversion of arable land to non-agricultural uses. For reasons of food security, land for large scale roads and parking will be strictly restricted. As automobiles have to accompany their owners and users, it is doubtful that Chinese will have the same way of life as their counterparts in North America or Europe. If space is limited, the automobile sector will soon meet its capacity. But the demand for transport will have to be met; (2) *Oil supply*. Oil reserves are insufficient and there is no guarantee of a stable and risk-free supply. (3) *Traffic congestion*. In big cities, traffic jams have become routine. This will not be tolerated in the long run. (4) *Local air pollution*. Lead pollution has been phased out, but other pollutants like particulates, NO_x and SO_2 have become dominant sources of pollution in cities. Environmental capacity will restrict the number of automobiles. (5) *Global environmental concerns*. Fossil fuels are carbon intensive and substitutes will have to be sought if international agreements are to be made on the mitigation of greenhouse gas emissions.

Accession to the WTO will help to find solutions for the above problems, but no other country is comparable to China in terms of scale and time. As a member of the WTO, China will contribute to finding solutions to the automobile sector. The following policy implications are in order:

1. *Rapid mass transit system.* In metropolitan regions, metro systems need to be systematically developed to reduce the pressure of surface road transport. Another strategic solution is rapid inter-city links by rail.
2. *Low- or zero-pollutant energy.* The use of LNG may help a little in the short run but in the long run, China will need to develop carbon- and other pollutant-free fuels, including bio-diesel, fuel cell, hydrogen and solar power. Development of new fuels will increase energy security and reduce pollution.
3. *Public investment in R&D.* The problems in the automobile sector after China's accession to the WTO are long term and the producers in the sector do not have the immediate pressure and resources for strategic investment in R&D concerning solar powered cars, bio-fuels and use of hydrogen. Public funding can reduce the risk of investing in the development of new technologies.

4. *Strict regulatory policies and their effective implementation.* Government policy can direct the development of the automobile industry. Since entry to the WTO, there is large scope for the government to maneuver for the benefit of the environment and the public at large in the long run without harming producers and consumers. The huge consumer and producer surpluses can be the basis for such a policy initiative: (1) *Higher environmental standards*. In Europe and Japan, Euro IV or its equivalent has been applied. The price of such cars in the world market is comparable to the Chinese ones. Therefore, immediate enforcement of Euro IV would not create losses to the producers and consumers. (2) *A levy on cars for R&D*. As there is huge scope for price cuts, the government can step in to impose a special levy for R&D on fuel efficiency, environmental protection, new fuels and safety measures. (3) *Oil tax*. Currently, the oil profits remain with the oil companies. The government may impose a tax on oil to have the gains from oil for public uses and to discourage wasteful consumption of oil. The rate of such a tax can be progressive. (4) *Compulsory dismantling of outdated automobiles*. Such motor vehicles should not be allowed in the second hand market. (5) *Enforcement of policies*. The making of policy is only the start of the process. Only when the policies are implemented can the effects be seen.

These long-term policy implications are somewhat strategic within the WTO framework. In the short run, China has to learn and use foreign technologies, but the market for long-term needs in China is the biggest. When China has the long-term technology developed, China will benefit from WTO accession to access the international market and contribute to environmental solutions on a global scale.

Immediate actions

In the short term, we have to cope with rapid increases in car ownership for the years to come. The long-term problems do have immediate impacts as a result of WTO accession. Consumers will benefit more towards the end of the transitional period and environmental impacts will become more and more serious from both local and global aspects. The following policy options may help mitigate environmental problems in the short run:

1. *Large producer and consumer surpluses.* The huge economic gains attributable to China's accession to the WTO should not be left to the producers and consumers. Rather, they should be used for the benefit of the environment. Examples include: (a) for R&D in low emission and high efficiency technologies; (b) for subsidies to the manufacturers adopting the most advanced technologies; and (c) for subsidies to the users for early replacement of outdated automobiles. The scope for price cuts is huge and part of these consumer and producer surpluses should go to the environment and technologies.

2. *Early application of higher level emissions standards.* As the life-cycle of automobiles is 15 years or longer, motor vehicles produced and sold in the market now with Euro II may still be in use until 2020. Euro I cars are not allowed in Beijing but they are sold outside the city. In this case, there is only a change of location, not in emissions. This longer-term impact has to be taken into account when emission standards are assessed, introduced and enforced. Tax relief is applied to automobiles with Euro III and compulsory Euro II is enforced. With WTO accession, it is possible to have the technologies from Japanese, European and American companies. This is a simple transfer of technology and the process should be greatly shortened to have the maximum positive spillover effect from existing technologies. Euro I and II are more lenient than Euro III and IV. Therefore, the policy should be to have Euro III and IV in place as early as possible.

3. *Speedier phase-out of old, inefficient automobiles.* Motor vehicles registered before WTO accession are more polluting and these will be on roads for the next five to 10 years or longer. The government is encouraging the phase-out of trucks that have been in use between eight and 10 years. More subsidies may be provided to speed up this process. This is because one motor vehicle before WTO accession can be twice or even ten times more polluting. Early phase-out can save environmental capacity for more automobiles without increasing total emissions. With WTO accession, the price of automobiles can be halved and the quality improved. So the resistance to this short-term policy may be minimal but the environmental benefits can be substantial. For the phased out motor vehicles, no permission will be allowed for re-sale and re-use. They should be sent directly to recycling plants.

4. *Discouragement of using large cars.* Small cars are more energy efficient in urban areas but the tendency in China is toward using larger cars. There are some cultural and psychological reasons behind this. Bigger cars may demonstrate social status, for instance. But some policies are also made in this direction. For instance, cars with engines smaller than one litre are not allowed to drive in the fast lane in the second and third ring in Beijing. The speed limit is 80 and most cars with engine sizes smaller than one litre can drive faster than the limit. Clearly this kind of discrimination is not well grounded. Instead, policies should be directed to discourage the use of large cars as they require more space, more oil and produce more emissions.

5. *Consolidation of automobile producers.* Economies of scale exist in the automobile sector. But in China the scale of production is in general small with some manufacturers producing fewer than 1,000 a year. Small-scale production is less economic and less competitive, and the

quality of products may be less guaranteed as limited resources would be invested for R&D from within the company. Local protectionism may be one of the reasons for such a pattern. After the transitional period, competition will speed up the consolidation process. The application of WTO principles within China can greatly reduce local protectionism and market fragmentation.

6. *Improvement of road systems.* Better roads save oil and reduce emissions. Aggressive plans to improve road systems are being implemented. In this regard, better planning and improved construction of roads are equally important. In Beijing, for instance, many junctions were built with inadequate foresight and have to be re-designed and re-constructed. Physical infrastructure must be made compatible with automobile requirements after WTO accession.

Policy initiatives

In general, there are three categories of policy initiatives: direct regulation, economic incentives and awareness raising for voluntary actions. Voluntary actions can be easily linked to regulation and incentives for better and more guaranteed results.

1. *Direct regulation.* Emission standards are regarded as the most effective way to control pollution. The introduction of Euro I and II has had observable results. Many similar requirements can also be made in the form of government regulations. Examples include the following: application of corporate average fuel efficiency (CAFÉ) standards (fuel efficiency), requirements for use of natural gas vehicles (low-carbon fuels) in some sectors such as taxis and buses, requirements for vehicle manufacturers to sell a certain number of low-carbon vehicles (LCVs), restrictions on road use to high-occupancy vehicles (increase vehicle occupancy), compulsory phase-out of inefficient and polluting vehicles.

2. *Economic incentive policies.* Incentives and disincentives guide the consumer and producer to act in line with environmental protection for their own benefit. Such policy initiatives are well documented in the literature and are widely applied by many governments. Among many such policies are transferable emission reduction credits for scrapped vehicles, engine manufacturers, etc.; vehicle registration fees based on emissions characteristics; environmentally-related fuel taxes; subsidies to producers and/or consumers of cleaner vehicles; take-back or refund systems for vehicles, lead-acid batteries, etc.; and making drivers legally responsible for emissions. Some policies can be tailored for specific purposes. For reduction of CO_2 emissions, for example, the following may be considered: increase in fuel tax based on carbon content (low-carbon fuels); vehicle taxes based on fuel efficiency; subsidies for fuel-efficient vehicles

(low-carbon vehicles); reduced tolls or charges for high-occupancy vehicles (vehicle occupancy); congestion pricing; and subsidies for use of alternative modes (other modes).

3. *Voluntary actions.* Environmental awareness in many cases can be more effective than carrot and stick policies. Without awareness, consumers and producers may not follow the regulation and incentive policies. Consumers and producers as decision-makers need information on environmental quality, emissions, fuel efficiency and other environmental and resource constraints. Environmentally-friendly options can also be important for the decision-makers for their own choices. For instance, one needs to know the options for reduction of emissions, such as increased fuel efficiency of vehicles, use of cleaner fuels, use of alternative-fuel vehicles, technological changes to current vehicles, treatment of exhaust emissions, increase of vehicle occupancy and shifts to other transport modes.

Conclusions and Discussions

The analysis of environmental impacts of the automobile sector associated with WTO accession is rather incomplete but some tentative and interesting conclusions may be derivable for better understanding of the issue.

From a social and economic perspective, China's accession to the WTO has generated unprecedented benefits to the Chinese economy. The automobile sector is capital and labour intensive, and to a certain extent, knowledge based. As a result, automobile production has been a leading sector contributing to the growth of the Chinese economy and employment. One plausible negative impact might be the fact that few automobiles manufactured in China bear a Chinese brand with independent intellectual property rights, as the overall level of technologies from foreign automobile makers outperform the outdated, inefficient ones by China's state-owned enterprises under the planning system. The biggest winner should be the consumer. With China's entry into the WTO, prices of cars have dropped by a third, and billions in surpluses benefit consumers. Still there is more room for price cuts. Therefore, an overall conclusion can be drawn that China's accession to the WTO has resulted in enormous social and economic benefits in China.

China's entry to the WTO has significant impacts on rural development in China. For employment and income generation, the role of the automobile sector is rather similar to that in urban areas, but at a lower level. Road connections to the rural regions create opportunities for rural employment, tourism in rural region, and access to market. The overall quality of automobiles is higher, too, because of technology spillover and shift of used, but good quality, automobiles—though not as high as that in the urban areas.

However, the outdated, less efficient and heavily polluting automobiles should not be allowed to go from urban to the rural areas for the safety of the rural environment and rural people.

With investment and up-to-date technologies more readily available in the automobile sector, the introduction, application and enforcement of stricter emission standards are made possible. From an environmental perspective, the following points can be drawn though the overall impact can be very mixed.

First of all, a technological leap with respect to emissions control is observable but still inadequate. Before WTO accession, emissions from the transport sector were largely neglected. With WTO accession, it is brought on to the agenda. Leaded gasoline was not completely phased out and Euro I was not introduced in China until 2001. In Europe, the replacement of Euro I by Euro II took four years (1992–1996), but in China the period is shortened to three years. This technological spillover effect is enlarged by WTO accession. As a result, for all cars newly entered into the market, emissions are reduced to comply with the standards. This is a gain for China but in comparison with OECD countries, the emissions standard is not as strict. Euro III was introduced in EU in 2000 while Euro II has just been required in China this year. If we look at the gasoline in the petroleum stations, 90# level oil is still in use with most at quality level 93#.

Second, WTO accession has contributed greatly to environmental quality control. As new emissions standards are much stricter, overall emissions for cars produced and sold in the market have been reduced by up to two thirds. This positive impact is further shown if the case WB (no improvement in emissions standard, but an increase in car numbers at WTO rate) is compared against the WTO case.

Third, the positive impact of stricter emission standards is offset by the explosive increase in car numbers. There are two direct and immediate consequences from WTO accession. One is immediate introduction of stricter emissions standards and the other is rapid growth of production and consumption of automobile products. The first is in line with environmental quality improvement but the other is in the opposite direction and offsets the positive impact.

Fourth, overall emissions are increasing. There are emissions reductions under the WTO case. As the number of automobiles increases, emissions will continue to grow despite new and stricter emissions standards introduced to replace the old ones.

This would lead to an overall suggestion that the existing pattern of production and consumption is not sustainable given environmental and

resource constraints. The increase in automobile numbers has already posed serious concerns with respect to energy security, land encroachment and environmental pollution. Conventional reduction of pollutants at a gradual rate will not work. This is because the marginal reduction rate becomes increasingly smaller and more costly. The growth of numbers will easily overtake the small rate of marginal reduction of emissions. Cost will prevent further reductions along the same way of production design and consumption.

But this does not mean that little can be done in the automobile sector. As the prices of cars in China now are still much higher than the world market level, there are two choices here: one is to slow down the process of price cuts while the above-average profit in the automobile sector is used to increase energy efficiency and reduction of emissions; and the other is to continue the process of price cuts and give the benefits to consumers. On average, the price of cars in China now is over $1,000 higher than on the world market. Obviously, the first option is preferable as a better environment is in the interest of all, including car owners. This huge amount can certainly encourage another technological leap. The consumers and the general public at large are the ultimate winners from energy saving and environmental protection.

Regulations should be made to govern the used automobile market and appropriate inspections should be carried out. Several policy initiatives are necessary for enlarging the benefit of China's entry to the WTO. First, owners of old vehicles that cannot meet Euro I should be encouraged to replace them with better quality ones through a subsidy policy. This would not incur huge financial burdens as the number of such vehicles is rather limited in comparison with the increase in car production and consumption. Second, these phased-out old vehicles should be forbidden for sale and re-use in rural areas. This would require that inspections be regularly carried out.

The assumptions used in this analysis simplify a lot of complicated problems. With respect to environmental emission standards, some of the cars sold before WTO accession already met Euro I or even Euro II level. Even if the cars produced inside China could not meet the standards, those imported must have met the standards. Many of the automobile manufacturers were joint ventures before China's entry to the WTO and spillover of technologies might have already reduced emissions substantially in comparison with China's own technologies. Second, only cars are included in the calculation with trucks and buses being excluded due to lack of technical information. Emissions by buses and trucks can be even higher although they may not concentrate in urban regions. Some estimates can be made to provide a more complete picture. Third, there are some automobiles pow-

ered by LNG though fuel cell and hybrid motor vehicles are yet to be commercially available in the market. A scenario with cleaner technologies can be very informative but this is not included in this calculation. Fourth, for all the scenarios, only net changes are calculated. In reality, the motor vehicle fleet is in existence and much of the pollution is from these existing cars. Fifth, many of the old cars have to be withdrawn from the existing stock and replaced by new ones with lower rates of emissions. This replacement can release environmental capacity without reducing the number of motor vehicles. Normally the life-cycle of a car is 15 years or more.[24] This dynamic feature can be of interest for simulation analysis.

24 For taxis, the compulsory replacement is five years. On average, a taxi drives 100,000 km a year and in five years, the total distance driven would be some 500,000. For family cars, intensity of car use may be much less and , therefore, the car should last longer. For trucks, the government encourages early replacement. Subsidies are given to owners replacing trucks that are 8–10 years old. A 15-year life-cycle is used in this analysis.

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Energy

Energy

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1. Energy Sector in China

1.1 Energy Production and Consumption

Because of rapid economic growth, total primary energy consumption increased from 400 Mtoe in 1978 to 1,036 Mtoe in 2002, with an annual average rate four per cent (see Figure 1). Coal is the major energy source, representing 70.7 per cent in 1978 and 66.1 per cent in 2002 in total primary energy use (see Figure 2).

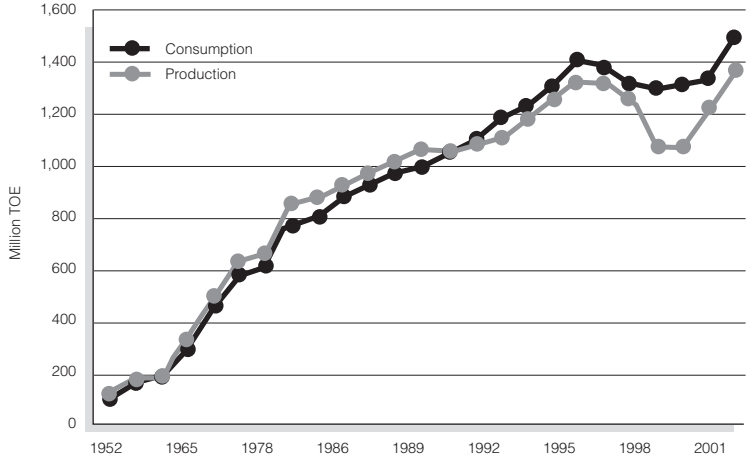

Figure 1. Energy production and consumption in China.

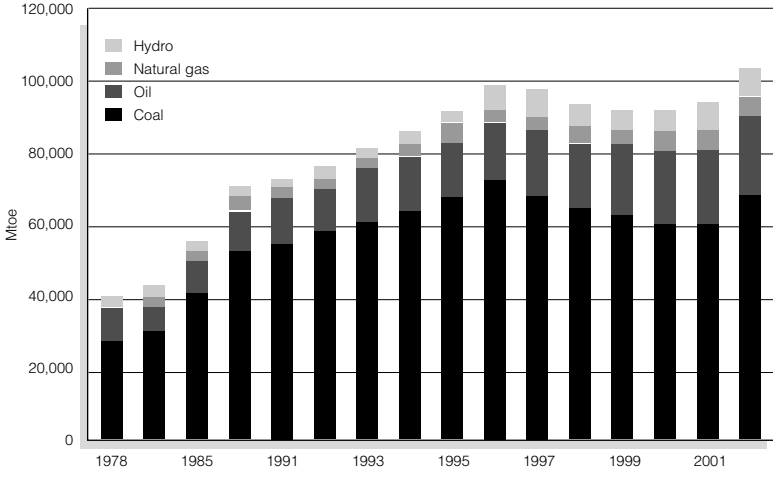

Figure 2. Primary energy use in China by energy.

China is the largest coal producing and consuming country in the world. Between 1980 and 2002, total raw coal output increased from 620 Mt to 1,380 Mt, with an average annual growth rate of 4.8 per cent. China's coal consumption accounted for 29.6 per cent of the world total in 2000.

From 1980 to 2002, total installed capacity increased from 66 GW (of which hydropower is 20 GW, accounting for 30 per cent) to 384 GW (of which hydropower is 92 GW, accounting for 24 per cent). In the same period, electricity output increased from 300 TWh (of which hydropower is 58 TWh, accounting for 19 per cent) to 1,654 TWh (of which hydropower is 288 TWh, accounting for 17 per cent).

Between 1980 and 2002, total crude oil output increased from 106 Mt to 167 Mt (average annual growth rate of 2.1 per cent). Of the total oil output in 2002, 149 Mt was produced inland, and the remaining 18 Mt offshore. Crude oil output in China accounts for 4.7 per cent of the world total.

In 2002, total natural gas output in China was 32.6 billion m^3. Total natural gas final consumption was 25.7 billion m^3, of which 6.00 billion m^3 was used for producing chemical fertilizers and other chemical products; 14.5 billion m^3 was used as industrial fuel; and 5.2 billion m^3 was used for urban residential uses.

Renewables, including wind power, photovoltaics and biomass, contribute small amounts of energy compared to mainstream energy supply. Modern renewables—wind, biogas and solar thermal and photovoltaic sources, as

opposed to firewood, crop waste and dung—contribute several million tonnes of coal equivalent annually.

Energy efficiency improvement and energy conservation are paid much attention in China's energy development strategy. Since the 1980s, China has formulated energy policy "giving equal priority to energy exploitation and energy conservation," emphasizing energy utilization in a sound and highly efficient manner, and the improvement of energy efficiency. Since the 1990s, energy conservation has been given priority in energy policies.

1.2 Petroleum Imports

China has become a net oil importer since 1993, shifting from its prior situation as a net oil exporter. Data from the China Customs Statistical Yearbook show that net crude oil and oil product imports reached 71.84 Mt in 2002, accounting for 30 per cent of crude oil and oil products consumption. The dependence on oil imports went up to 27 per cent in 2002 from 6.1 per cent in 1993. According to projections China will experience continuing dependence on oil imports with a widening gap between oil demand and supply (see Figure 3).

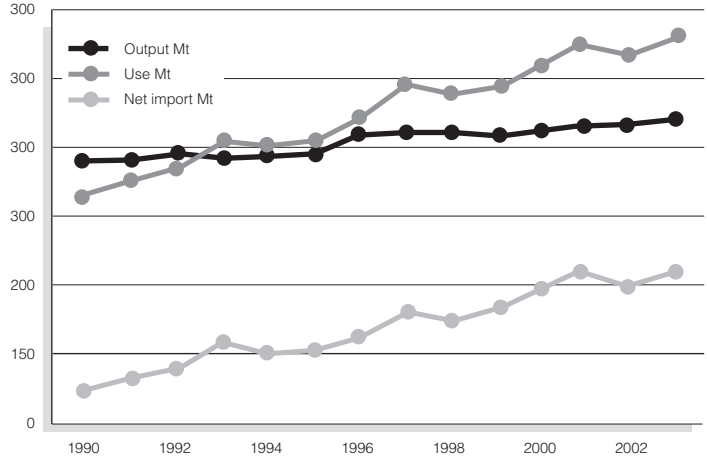

Figure 3. China oil demand and supply from 1990 to 2002.

1.3 Coal Industry

1.3.1 Status Quo and Characteristics

Coal output experiences rapid growth, and coal product optimized further

Energy is a driving force for the development of the economy, and the coal industry is a pillar of China's energy sector. Fast growth of coal output indi-

cates the growth of the national economy. In 2003, crude coal output was 1.608 billion tonnes, an increase of 215 million tonnes over 2002. Output of washed coal from state-owned key coal mines increased by about 13 per cent compared to 2002. Due to an effort by China's government to enforce the environmental protection policy, the proportion of washed coal was to be increased and the production of different grades of coal enhanced. The rate of coal washing was increased to 33.78 per cent in 2003 from 17.7 per cent in 1990.

Changes in regional distribution of coal output

In 2003, while China was continuing to intensify its coal exploitation in the eastern areas of China, coal exploitation in the western regions was also strengthened in line with the implementation of policies of western development, and west-east power transmission. It has become the largest coal production base in northern China, and its coal output accounts for 37.3 per cent of the national total. Coal output in eastern China and in the northwest region represents 16.5 per cent and 14.3 per cent respectively. The coal output of five provinces and regions exceeds 100 million tonnes, accounting for more than 60 per cent of the national total.

Changes in output of different coal enterprises

In 2003, coal output from state-owned key coal mines, state-owned local mines and township coal mines represented respectively 50.2 per cent, 32.2 per cent and 17.6 per cent of China's national total. Compared to that of 2002, the growth in coal output of these three types of coal mines was 45.1 per cent, 8.8 per cent and 46.1 per cent respectively. It can be seen that township coal mines still represent one of leading forces in China's coal production.

Changes in centralization of coal production

Centralization of coal production was further enhanced in 2003. There were more than 25,000 coal production enterprises in China in 2003. The sum of coal output of the enterprise groups ranked top 8 in the country accounted for 21.8 per cent of the national total. It increased by nearly one per cent over 2002. The number of enterprises with a capacity of over 10 million tonnes of coal output has increased to 23. Shehua Group has become the first extra-large coal enterprise with more than 100 million tonnes of coal output, making it one of the world's largest coal mining corporations.

Some indexes of coal production in the state-owned key coal mines taking a turn for the better

Average personnel efficiency for coal production in 2003 was 3.396 tonnes/person in China's state-owned key coal mines, an increase of 10 per

cent over 2002. And personnel efficiency for coal production of Shendong Company of Shenhua Group reached 100 tonnes/person, ranked first in the country. Tunnelling footage grew by 15 per cent over last year; and stope face increased by 33 per cent. Unit production was enhanced by 13.2 per cent; and the level of mechanization was also improved greatly.

1.3.2 Problems and challenges

Faced with the demand for coal by the the rapidly growing economy and addressing the challenge of WTO accession, the coal industry in China still must face and deal with the following issues in future development:

1. *Irrational structure of the coal industry itself*. The structure of enterprise organization is both small and dispersed. Average annual output of large and medium coal mines is only 800,000 tonnes, and less than 10,000 tonnes for small coal mines. Percentage of coal washing and screening reached 33.8 per cent in 2003, but it is far behind the international level of 50–95 per cent. Overall technical equipment is at a low level, and the degree of mechanization does not reach 40 per cent in China. It continues to use backward methods to mine coal, relying mainly on heavy manual labour.
2. *Insufficient resources*. Per capita coal possessed by China is limited, and a precise survey of reserves is unavailable. The relationship between resource distribution and development of the economy is disadvantageous. This means that there is a great quantity of coal reserves in the western areas, which has an undeveloped economy, poor natural conditions, and a fragile ecological environment. Exploitation is limited by external conditions such as railway transport and energy conversion.
3. *Environmental restrictions*. Coal mining areas have a very fragile ecological environment. This has resulted in a great number of social issues due to environmental damage brought about by coal mining.
4. *Poor economic benefits*. Due to the bad economic conditions that prevailed for many years, a lot of losses have occurred in coal mine enterprises that not yet been resolved, and production safety and employee living conditions are not handled properly. The level of sustainable production has become an issue for 44 per cent of state-owned large and medium coal mines. The financing required for ventilation and safety is about four billion RMB yuan.
5. *Rigorous safety requirements for production*. In recent years, the number of deaths has been about 6,000 people each year in China due to coal mine accidents. In 2002, the mortality rate per million tonnes of coal mined was 4.64 in China, which greatly exceeds the number in developed coal-producing countries.

6. *More and more severe challenges from the international market*. Coal imports increased to 10.82 Mt in 2002 from two Mt in previous years. It directly influences domestic coal production, in addition to increases in the import of high quality energy such as oil and natural gas, and energy intensive products such as finished steel, building materials and chemical products.

1.4 Oil and Natural Gas

1.4.1 General Brief

Oil and natural gas play a very significant role in national economic development and state safety, and also provide energy and raw materials for the chemical, pharmaceutical and fertilizer sectors. Oil and gas are used in industry, agriculture and daily living. And thus oil and gas resources have been called "lifeblood of human society," "driving force for economic development" and "lifeline of national strategy."

Oil and gas resources

China is endowed with relatively rich oil and gas resources. According to results of the second national oil and gas resources evaluation conducted in 1994, the total amount of oil resource was 94 billion tonnes, and total amount of conventional natural gas resource was 3.8 billion m^3. The remaining exploitable reserves in 2000 were 2.46 billion tonnes, accounting for 1.8 per cent of world total.

Oil and gas production

Oil production in China has been increasing since 1990. Total oil output went up to 166.77 million tonnes in 2002 from 138 million tonnes in 1990, making China the fifth largest producer in the world. Total gas output was increased to 32.6 billion m^3 in 2002 from 15.3 billion m^3 in 1990, with an average annual growth rate of 5.5 per cent, and ranked 16th in the world.

To meet increasing needs for oil and gas, and to guarantee oil supply safety in the future, China is intensively exploring domestic oil and gas resources, and has already cast its eyes overseas. Currently, China has enjoyed share control, purchase of shares and independent rights for oil and gas exploration and exploitation in Sudan, Indonesia, Venezuela, Peru, Canada, Kazakhstan and Uzbekistan. Remaining exploitable reserves of controlled overseas oil are over 400 million tonnes. Oil production capacity each year is 13 million tonnes.

Oil and gas import and export

China has become a net oil importer since 1993, with increases in the amount of oil imported year after year. Net oil imports reached 69.5 million

tonnes in 2002, 46 per cent of which were coming from the Middle East. Oil imports from African countries have grown quickly, reaching 15.8 million tonnes, representing 23 per cent. China's share in the world trade has climbed to 3.3 per cent from less than 0.2 per cent in 1990.

Oil processing

From 1990 to 2000, capacity of oil refineries in China grew to 269 million tonnes per year from 145.21 million tonnes per year. The amount of oil processed increased to 202.38 million tonnes per year from 107.23 million tonnes per year in 1990. China can basically satisfy its own needs for oil products. China has approximately 200 oil refining enterprises. The unit capacity of production facilities in most enterprises is small, operation under capacity, poor technical and economic conditions and high energy consumption. In 2000, comprehensive energy use of oil refining in China was more than 90 kgoe/t, nearly twice as high as the 53 kgoe/t best level internationally.

Main production enterprises in oil and gas industry

At present, CNPC, SINOPEC and CNOOC are the most powerful oil and gas production companies, integrated upstream and downstream.

As the largest crude oil and natural gas producer, constructor and manager of oil and gas pipeline networks, in 2001, CNPC produced 106.53 Mt of crude oil in China and 20.6 billion m^3 of natural gas. It processed 86.94 of oil, and obtained 8.31 million tonnes of overseas shared oil, and 577 million m^3 of natural gas.

In 2001, Sinopec produced 37.91 million tonnes of crude oil and 4.61 billion m^3 of natural gas. It processed 101.42 million tonnes of oil, with an output of 61.14 million tonnes of gasoline, diesel and kerosene products and 2.15 million tonnes of ethylene. Its rate of occupation reached 65 per cent in regional retail sale markets.

In 2001, CNOOC's oil and gas output was 23.29 Mtoe.

Oil and gas pipeline construction

By the end of 2000, China had 14,200 km of oil pipeline; 12,600 km of gas transport pipeline; 3,400 km of oil product pipeline; and 2,100 km of submarine oil and gas pipeline. CNPC possesses 6,884 km oil transport pipeline, distributed in 14 provinces and cities; and Sinopec has 2,978 km of oil transport pipeline. The ongoing construction of the West-East pipeline network is not included in above-mentioned data.

1.5 Electric Power Industry

1.5.1 General Brief

Installation capacity and power generation

Statistical data show that, by the end of 2002, total installed capacity reached 357 GW in China, in which coal-based power accounted for 74.4 per cent; hydropower for 24.14 per cent; nuclear power for 1.25 per cent; and others for 0.14 per cent. Total power generation was 1,654.1 TWh in 2002, of which coal-based power generation accounted for 81.75 per cent; hydropower for 16.6 per cent; nuclear power for 1.6 per cent; and others for 0.05 per cent. Coal-based installation and power generation characterize over 95 per cent of thermal power generators.

Power generation technology

In the last 20 years, the level of thermal power technical equipment has gradually improved. Newly added thermal power generation capacity was mainly in the form of units with capacity of 100–200 MW in 1980s. While entering into 1990s, it was units with capacity of 300–600 MW. By the end of 2000, total installation of steam turbine generators with capacity of over 300 MW of per unit accounted for 40.7 per cent of national thermal power installation; 200–300 MW generators for 17.4 per cent; 50–200 MW generators for 25.6 per cent; and less than 50 MW generators for 16.23 per cent.

Energy consumption and efficiency

In 2002, China consumed nearly 700 million tonnes of coal for power generation and heat supply, accounting for 50.8 per cent of national coal consumption, and about 33 per cent of national primary energy consumption. Average energy use of power supply for thermal power unit is 383 gce/kWh, and 356 gce/kWh for energy use of power generation, which is about 60–70 gce/kWh less than that of an international advanced level.

1.6 Environment Issues in China's Energy Development

1.6.1 Environmental Issues in Coal Development

Since the 1970s, China's government has focused on environmental protection, but limited by the state of the economy and technical development level, it cannot devote enough resources to it. The following are some of the environmental issues related to the development of the coal sector:

1. Damaged land resource by coal exploration. By 2000, about 48,000 ha of land had subsided. On average, 0.2 ha of land will subside for every 10,000 tonnes of coal mined. This has increased by more than 20,000 ha per year. But the rate of recovery is now only about 20 per cent.

2. Coal exploration has damaged water resources and caused pollution. For example, 19 per cent of underground water was polluted to some extent in North China. There are 2.2 billion tonnes and 28 million tonnes of wastewater discharged respectively from various coal mining and coal washing processes.
3. Backfill from coal production reached an accumulated total of three billion tonnes, with a rate of increase of 150 to 200 million tonnes per year. This occupied land and damaged rivers and there was burning of wasted coal stone pile.
4. Methane was emitted during coal mining process, which accounts for around 10 per cent of total methane emissions from anthropogenic sources. Methane emissions from China's coal industry accounts for up to one third of total methane emission from coal mining in the world.
5. Coal combustion is a major source of air pollution in China. SO_2 emissions were 19.5 million tonnes in 2001 and around 85 per cent of that came from coal combustion. Acid rain fell in more than one third of the country.

1.6.2 Environmental Issues of the Oil and Natural Gas Industry

There are many impacts from oil and natural gas exploitation, exploration, processing, transport and use. Oil leakage, wastewater and polluted water discharge will cause pollution from oil exploration, such as oil well accidents, leakage from off shore oil wells, processing water and others.

Evaporation and leakage from oil stock and transport will also cause environmental problems. Evaporation mainly comes from oil tanks, and the loading and unloading process. Vaporized substances are hydrocarbon and sulfurated hydrogen. Leakage mainly comes from accidents, such as pipe line breaks, tanker accidents, etc. And washing water as well as mud in oil tanks can also cause environmental damage.

Wastewater, exhaust gas and waste residue are major pollutants from oil refineries. Wastewater has harmful compounds transformed from sulfur, oxygen and nitrogen contained in crude oil. There were three to four tonnes of wastewater discharged per tonne of oil processed in 1980s in China. Major pollutants in exhaust gas include SO_2, H_2S, NO_X, CO, hydrocarbon components and dust. Most exhausted gas is bad for human health. Waste residue is mainly chemical waste, which has toxicity and can damage soil, water and air.

There is wastewater from natural gas exploration that may contain sulfur, lithium, kalium, bromine and cesium.

1.6.3 Environmental Issues Related to the Power Generation Industry

Power generation in China ranks second in the world just after the United States. There were 1,654 TWh generated in 2002 of which 95 per cent came from coal fired power plants. Power generation consumed 656 million tonnes of coal in 2002.

Most of the coal used in power generation does not go through a washing and selection process, and therefore has a high ash rate. Therefore, coal used in power generation is a major source for SO_2, NO_x and dust, which are significant causes of acid rain in China. And at the same time it is also the major emitter of CO_2.

According to data from the *China Environment Year Book*, in 2002 there were 6.7 million tonnes of SO_2 emitted from power generation, accounting for 34.6 per cent of the national total; dust emission was 2.9 million tonnes, accounting for 29 per cent of the national total. Estimated by experts, there were about 4.7 million tonnes of NO_x emitted from power generation. In 2002, there were 1.9 billion tonnes of wastewater and 146 million tonnes of waste residue discharged by this sector.

2. Analysis, Methodology and Major Assumptions

2.1 Methodology

There are already some studies on the impact of WTO accession on major economic sectors. But the analysis for the energy industry is still lacking. Zhou Shulian *et al.* reported their study on the impacts of WTO accession on various sectors including oil and natural gas, and the power industry in a qualitative way. There have also been some papers published that discuss, in a qualitative way, the possible impacts on energy industries. Moreover, these studies focus on a specified sector rather than undertake an overall analysis of the energy industry. Here we try to use a methodology to present a picture of the impact of WTO accession on the energy sector to cover all energy related activities, and present the results in qualitative and quantitative ways.

We use models to show some results for the possible impact of WTO accession. In order to give quantitative results, scenario analysis is normally used. Several scenarios could be defined and the analysis could be presented by comparing different scenarios. However, it is very difficult to clearly define these scenarios because it is impossible to describe the scenario without WTO accession, otherwise there would need to be much more extensive assumptions for this scenario. Therefore, we decide to introduce two scenarios: one is the scenario to describe possible future with WTO accession with a focus on domestic commodity demands, which we call the *baseline*

scenario; the other is a scenario that presents much stronger involvement of China's economy in world markets, meaning that more energy intensive products will be produced in China to satisfy domestic and international demand, causing a high energy demand future, hence the *high demand scenario*.

The baseline scenario describes the possible future of energy demand and production in China. This scenario incorporates recent energy development in China and most recent energy forecast studies. This scenario will be used to present possible futures for the energy industry as well as energy import and export analysis. The high demand scenario presents a high demand future for the energy industry in China and potentially high energy imports, attempting to give a picture of a higher energy demand future.

Energy imports, energy markets and the relative environment effect will be the main focus. The time horizon will be from 2000 to 2030. SO_2, NO_x and CO_2 emissions are reported here for environmental impact analysis.

2.2 Model

The IPAC-Emission model is selected from Integrated Policy Assessment Model for China (IPAC) for the quantitative analysis. The model will project future energy and pollutant emissions. Several scenarios were defined to compare the effects of WTO accession on the energy sector.

The IPAC-Emission model was a global model developed for GHG emissions scenarios study. It divided the world into nine regions covering United States (U.S.), Pacific OECD (OECD-P), Europe OECD and Canada (OECD-W), Eastern Europe and Former Soviet Union (EFSU), Middle East (ME), China, other Asia (S.E. Asia), Africa, and Latin America (LA). Major emission sources including energy activities, industries, land use, agriculture and forests, can be simulated in the model framework. The model consists of three modules: Macro economic module, end-use module and land-use module. The macro economy module was developed based on the Edmonds-Reilly-Barns (ERB) model (Edmonds *et al*. 1983), a macroeconomic partial-equilibrium model, dealing with energy activities and forecasting energy demand over the long term. It uses GDP and population as future development drivers, combined with other energy-related parameters to forecast energy demand based on the supply and demand balance. The end-use module is originally a part of the Asian-Pacific Integrated Model (AIM), a bottom-up, energy-technology model, developed by National Institute for Environment Studies and Kyoto University of Japan. The land-use module was developed from the Agriculture Land Use Model developed by Pacific-Northwest National Lab (PNNL), to provide GHG emissions from land use.

2.3 Model Assumptions and Scenario Definition

Major assumptions used in this impact study are given in following tables including population, GDP growth and mix. Assumptions for population come from other studies. GDP growth rate mainly follows government targets and studies from the Development Research Centre.

Table 1. Population assumptions (million).

	2000	2010	2020	2030
Population	1,285	1,393	1,472	1,539
Urban	413	531	633	754
Rural	872	862	839	785

Table 2. GDP growth in China.

	2000–2010	2010–2020	2020–2030
GDP Growth Rate	7.8%	6.6%	5.6%

In order to analyze energy trading it is necessary to make assumptions about a global future. IPCC SRES B2 scenario was taken as a global scenario. IPCC SRES scenario is a scenario family developed by IPCC in 2001, and includes seven scenario groups. B2 scenario is a world with good intentions, which it is not always capable of implementing. This storyline is most consistent with current national and international developments. On balance, the B2 world is one of central tendencies that can be characterized as natural progress among SRES scenarios. Human welfare, equality and environmental protection all have high priority, but the world proves unable to tackle these concerns at a global level and resolves them as best it can regionally or locally. Generally high educational levels promote both development and environmental protection. Education and welfare programs are widely pursued leading to reductions in mortality and to a lesser extent fertility. This results in a central population projection of about 10.4 billion people by 2100, consistent with the United Nations median projection. GWP grows at an intermediate growth rate of two per cent per year, reaching about US$235 trillion in 2100. The B2 storyline also presents a generally favourable climate for innovation and technological change especially in view of high educational levels compared to today and relatively efficient markets at the regional level. B2 is a world of "regional stewardship" that, in some regions, is particularly frugal with energy and many other natural resources. Consequently, energy system structures differ among the regions. Overall high priority is given to environmental protection, although global policies prove elusive and regional polices vary widely. Major assumptions are given in Tables 3 to 5.

All of China's emission scenarios were developed under the B2 scenario. In IPAC-emission model, international energy trade was included in the study based on cost effective resource availability.

Table 3. Key scenario drivers assumed for the developing Asia-Pacific and the world in IPAC-Emission model.

Item	Assumptions
Developing Asia-Pacific population	4.7 billion in 2050 5.0 billion in 2100
Developing Asia-Pacific GDP growth rate	5.7% from 1990 to 2050 3.8% from 1990 to 2100
World population	11.7 billion in 2100
World GDP	$250 trillion in 2100
GDP/capita trends	Disparity remains GDP/capita of OECD becomes seven times of non-OECD (now 13 times).
AEEI	1.0%–1.2%
International Trade	Low trade across regions High trade cost
Urbanization	Increase in developing world before 2050, decrease in developed world

Table 4. Assumptions for each scenario for the developing Asia-Pacific and the world.

Item	Assumptions
Resource availability	Oil/gas: medium; Biomass: high
Energy exploitation cost	Medium
Non-carbon renewable energy cost	High for nuclear, medium for solar and others
Biomass availability	Medium
End use technology efficiency improvement	Medium
Social efficiency improvement	Medium
Transport conservation	High
Dematerialization trend	Medium
Land use productivity improvement	Medium
Meat-oriented food habit	Low
Desulfurization degree	High

Table 5. Factors for key driving forces.

Driving forces	Sectors	Factors	Policies to promote the change
Social efficiency change	Industry	Value added change within the sector. Products structure change within one sector.	Various policies relative to value added such as price policy, national plan for key industry, promote well working market. Market-oriented policies, national development policies.
	Residential and commercial	Energy activity change within the sector.	Public education, price policies.

Driving forces	Sectors	Factors	Policies to promote the change
	Transport	Change of transport mode Traffic volume conservation.	Transport development policies, public education.
Technology progress		Efficiency progress for technology. Technology mix change for one fuel. Fuel mix change.	Technology R&D promotion, market-oriented policies, international collaboration. Market-oriented policies, environmental regulation. National energy industry policies, import & export policies, tax system.

We use two scenarios in order to analyze the impact of WTO accession. One is the baseline scenario, another is a high demand scenario. Because it is hard to describe the scenario without WTO accession, the two scenarios defined here are both scenarios for WTO accession. The definition is given as follows:

- Baseline scenario: this scenario gives a basic trend to describe future economic activities after WTO accession. There will be better international trading and China's economy will be part of the global economy. Therefore energy supply in China can rely on international markets and resources.
- High demand scenario: This scenario presents a high demand for energy in the future. The major driving force is that after WTO accession, China will become a centre for manufacturing, which will bring the production of more energy intensive products to China, such as steel, non-ferrous products and building materials. But at the same time, more technology transfer and R&D on high efficiency energy use technologies is also assumed here.

The basic assumptions for the two scenarios are the same, such as population and GDP growth. Sector service output for the two scenarios is given in Table 6.

Table 6. Energy intensive products assumption in the model.

	Unit		Baseline scenario		High demand scenario	
		2002	2020	2030	2020	2030
Steel	Mt	182.4	260	250	310	320
Copper	Mt	1.63	4.5	5.2	5.2	5.8
Aluminum	Mt	4.51	10	14	12	18
Ethylene	Mt	5.43	12	16	14	20
Ammonia	Mt	36.75	47	49	50	56
Chemical fertilizer	Mt	37.9	48	50	52	58
Cement	Mt	725	1,000	900	1,100	1,100
Glass	Million case	234.4	480	530	520	560
Vehicles	Million	3.25	11	12	15	17

3. China's Energy Sector Commitments Following WTO Accession

3.1 Basic Principles

1. Transparency

China undertakes that only those laws, regulations and other measures pertaining to or affecting trade in goods, services, TRIPS or the control of foreign exchange that are published and readily available to other WTO Members, individuals and enterprises, shall be enforced. In addition, China shall make available to WTO Members, upon request, all measures concerning TRIPS or the control of foreign exchange before such measures are implemented or enforced. In emergency situations, laws, regulations and other measures shall be made available at the latest when they are implemented or enforced.

2. Non-discrimination

Except as otherwise provided, foreign individuals and enterprises and foreign-funded enterprises shall be accorded treatment no less favourable than that accorded to other individuals and enterprises in respect of:

i. the procurement of inputs and goods and services necessary for production and the conditions under which their goods are produced, marketed or sold, in the domestic market and for export; and

ii. the prices and availability of goods and services supplied by national and sub-national authorities and public or state enterprises, in areas including transportation, energy, basic telecommunications, other utilities and factors of production.

3.2 Right to Trade Related to the Energy Sector

Without prejudice to China's right to regulate trade in a manner consistent with the WTO Agreement, China will progressively liberalize the availability and scope of the right to trade so that within three years after accession, all enterprises in China shall have the right to trade in all goods throughout the customs territory of China, except for those goods listed in an annex which continue to be subject to state trading. Such right to trade shall be the right to import and export goods. All such goods shall be accorded national treatment under Article III of the GATT 1994, especially transportation, distribution or use, including their direct access to end-users.

In addition, the Protocol on Accession has further provision on state trading, which includes the following two items: 1) China shall ensure that import purchasing procedures of state trading enterprises are fully transparent, and in compliance with the WTO Agreement, and shall refrain from

taking any measure to influence or direct state trading enterprises as to the quantity, value, or country of origin of goods purchased or sold, except in accordance with the WTO Agreement; and 2) As part of China's notification under the GATT 1994 and the Understanding on the Interpretation of Article XVII of the GATT 1994, China shall also provide full information on the pricing mechanism of its state trading enterprises for exported goods.

Annex 2A1 and 2A2 of the Protocol respectively list 84 products subject to state trading in import which include crude oil and processed oil; and 134 products subject to state trading in export which include coal, crude oil and processed oil.

3.3 Non-tariff Measures Subject to Phased Elimination Related to the Energy Sector

The non-tariff measures related to the energy sector are import licence and import quota, which shall be implemented by China.

3.4 Energy Products and Services Subject to Price Controls

According to Article 9 of the Protocol, China shall allow prices for traded goods and services in every sector to be determined by market forces, and multi-tier pricing practices for such goods and services shall be eliminated; and only some specific goods and services may be subject to price control.

3.5 Subsidies Related to the Energy Sector

According to Article 10 of the Protocol, China shall eliminate all subsidy programs falling within the scope of Article 3 of SCM Agreement upon accession. Subsidies to be phased out include: 1) subsidies provided to certain state-owned enterprises which are running at a loss, among which there are some related to the energy sector; 2) the priority in obtaining loans and foreign currencies based on export performance; and 3) preferential tariff rates based on localization rate of automobile production.

3.6 Commitment on Reduction of Energy Products' Tariff

In general, the tariff reduction of energy products was started before China's accession to the WTO, so the tariff commitment at the time of access to the WTO was similar to that of 2000 except for some specific products. The data show that the tariff on all kinds of coal and related products are not changed, and that parts of petroleum oils, natural gases and electrical energy and their related products are changed only to a small degree.

3.7 Specific Commitments on Trade in Energy Services

China's commitments in the energy sector are not only on tariff and non-tariff barrier reductions related to energy products, but also on commitments on market access and national treatment for trade in energy services, with the closer integration of trade in energy products and energy services. So, the environmental impacts of China's WTO accession in the energy sector should include environmental impacts of trade liberalization both in energy products and in energy services.

Considering that energy services is one of the most important sectors for of all WTO Members, trade liberalization in energy services is very slow. China made commitments on offshore oil-field services and onshore oil-field services. It shows that there is greater trade liberalization in offshore oil-field services than in onshore oil-field services, especially relating to the limitations to market access and national treatment of the commercial presence in onshore oil-field services.

4. The Impact of WTO Accession on the Energy Industry

In this section we describe direct impact and indirect impact on the energy industry resulting from WTO accession. We then analyze the impact on each energy sector.

4.1 Direct Impact

Direct impact includes changes in import and export through import tax reduction and deregulation for foreign firms entering into the Chinese energy industry, and market competition through increased foreign investment.

Once China enters the global market, there will be much more energy supplied from international markets to China than anticipated before. With the development of the economy and of the reform process in China, the economy is getting much stronger in the coastal areas, and these regions will have a much increased right to deal with energy supply in their own way. From the perspective of energy supply security, multiple energy supply sources, clean energy supply and environmental requirements, there will be more and more energy supplied from international markets. For example, recently there are energy import plans in several provinces including Guangdong, Shanghai, Jiangsu, Shangdong and Beijing. They plan to import LNG and LPG. After the construction of infrastructure such as LNG terminals, there will be more import demand. It is forecast that there will be 120 billion m^3 natural gas imported by 2010 and 350 billion m^3 in 2020. WTO accession is a strong basis for such energy import planning. And it is believed there could be more energy imports because of WTO accession.

4.2 Indirect Impacts

Indirect impacts include:

1. technological progress in the energy industry;
2. energy demand change because of output change in other sectors on account of WTO accession; and
3. change of management of energy companies.

Normally, foreign investment would bring advanced technology to China, together with advanced management practices. Historical experience shows foreign investment will promote localization of advanced technology in China, and diffusion of international management systems to Chinese companies. In the area of energy, foreign investment will bring production technology, transmission and processing technology for natural gas and oil, advanced power generation technologies and advanced coal production technologies. These technologies will impact on technology development in China. Diffusion of advanced technologies and management systems will improve energy efficiency in China.

4.3 Energy Demand

China's entry into the WTO will improve China's prospects in the global economy. There will be some impact on China's industrial development after WTO accession and, therefore, impacts on future energy demand.

The following factors could impact future energy demand:

- China could be one of the world's major manufacturing centres in the future, which will bring more energy intensive industry to China. It is widely assumed that manufacturing will shift from industrialized countries to developing countries. In recent years, the steel industry, the non-ferrous industry and the machinery manufacture industry extended quickly in China. This will increase energy demand in China.
- More advanced technologies could be transferred to China. WTO accession could provide more opportunities for technological collaboration among countries by way of government collaboration and commercial collaboration. This will bring more advanced technologies to China.
- The international energy market can provide stable energy supply for China and keep energy prices stable, providing a good basis for energy demand in China. This could be a factor to stimulate more energy use in China.

By using the IPAC-Emission model, energy demand is calculated. Baseline scenario results are given in Figure 4 and Figure 5.

Primary energy demand in baseline scenario could go to 2.99 billion tce in 2020 and 3.85 billion tce in 2030. The annual growth rate from 2000 to 2030 is 3.6 per cent, while energy elasticity is 0.58. Coal will remain the major energy source in China—it will be 2.2 billion tce in 2030, representing 58 per cent of the total energy demand. There is a rapid increase in natural gas demand in China. The share of natural gas in total primary energy use was four per cent in 2000 and it will be 17.3 per cent in 2030, with an annual growth rate of 10 per cent.

Among final energy uses, electricity and natural gas increase rapidly. Electricity demand increases from 160.4 million tce in 2000 to 682.4 million tce in 2030. Natural gas demand increases from 30.7 million tce in 2000 to 624.4 million tce in 2030. Coal and oil demand show a slow increase. Coal use in the residential sector will generally decrease and be replaced by gas and electricity. Coal will be mainly used in large equipment such as boilers. Demand for oil products used for transport will increase quickly with the rapid increase in vehicles in China. Oil use in transport will increase from 105 million tce in 2000 to 457 million tce in 2030.

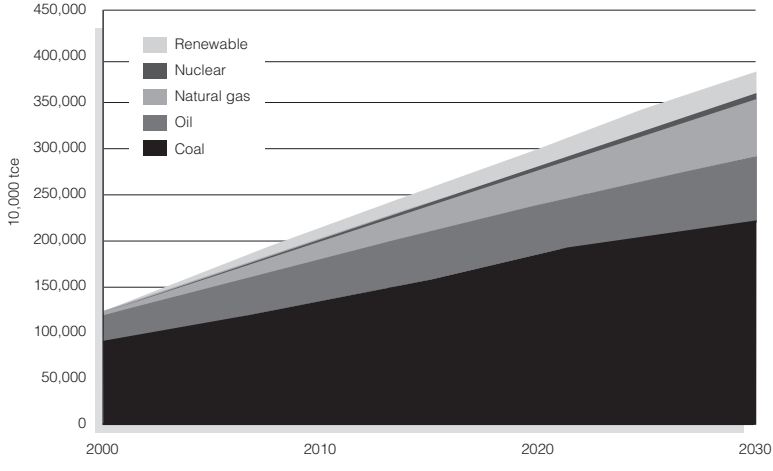

Figure 4. Primary energy demand in China.

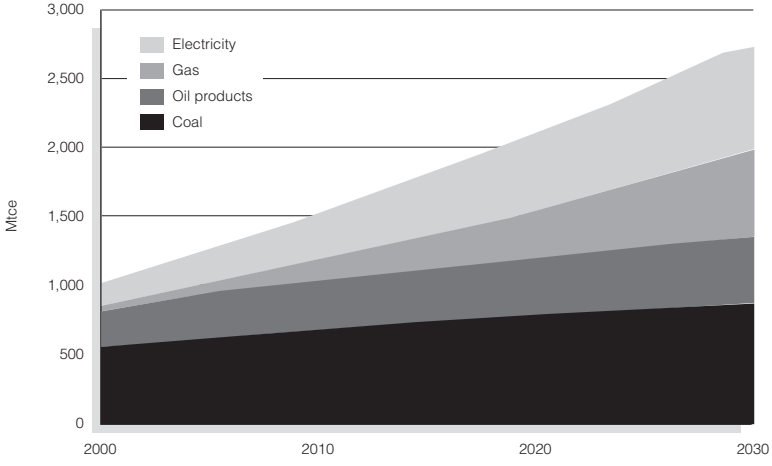

Figure 5. Final energy demand in China.

We also simulated primary energy demand for high demand scenario (see Figure 7). The primary energy demand in 2030 would be 4.2 billion tce, which is 350 million tonnes higher than the baseline scenario. Among the total primary energy, the coal share is 59.1 per cent; oil 16.1 per cent; natural gas 17.8 per cent; and nuclear 1.2 per cent. Because this scenario assumed better international markets, it relies more on imported energy such as natural gas and oil.

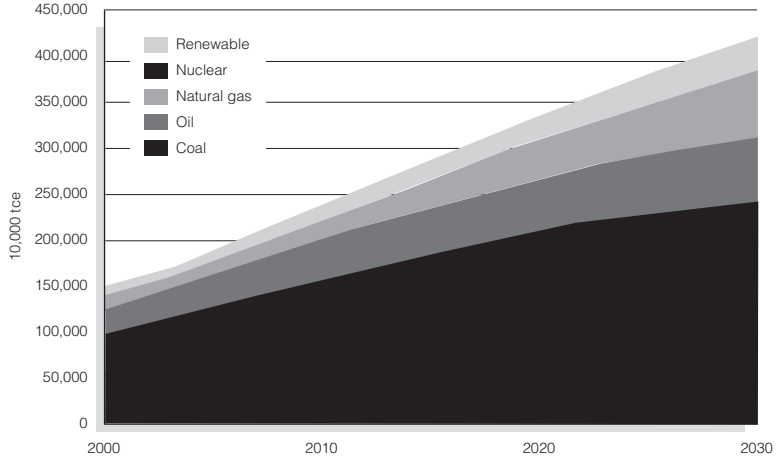

Figure 6. Primary energy demand in high demand scenario.

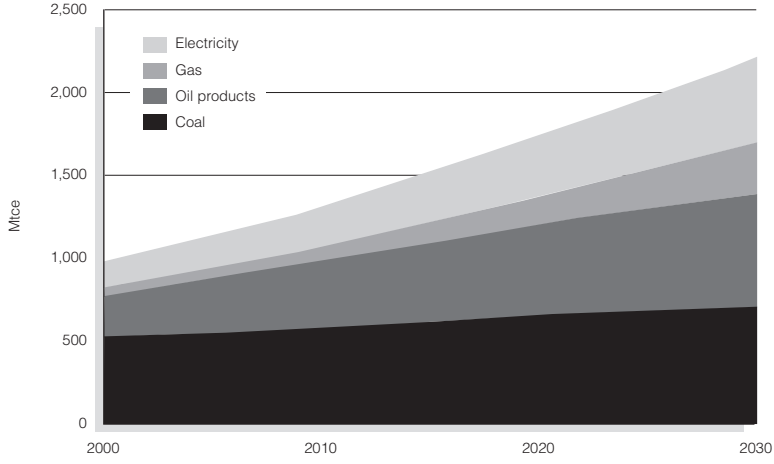

Figure 7. Final energy demand in high demand scenario.

4.4 Energy Production

There are several studies on domestic energy production in the future. This study also simulated future energy production in China. Figure 8 and Figure 9 give energy production in the baseline and high demand scenarios. Coal production could be 1.87 billion tce by 2020 and 2.11 billion tce by 2030. Experts from the coal industry in China estimated the upper boundary of coal production could be 1.7 billion tce by 2020. Therefore, coal demand will create significant pressure for coal production in China. Oil production will be 190 million tonnes in 2020 and 175 million tonnes in 2030. This is within the forecast of experts from the oil industry, which ranges from 180 million tonnes to 200 million tonnes in 2020. Natural gas production will be 133 billion m^3 in 2020 and 312 billion m^3 in 2030. The production of natural gas is within the range of natural gas production forecast by energy experts, which ranges from 130 billion m^3 to 150 billion m^3 in 2020. Nuclear power generation will increase quickly in future, but still represents a small share because of its high cost. The model results shows that nuclear power generation could go to 256 TWh in 2020 and 344 TWh in 2030, compared with 16.7 TWh in 2000. The installed capacity will be 39,400 MW in 2020 and 53,030 MW in 2030. Hydro power output will increase from 224 TWh in 2000 to 555 TWh in 2020 and 722 TWh in 2030, with capacity reaching 154 GW in 2020 and 201 GW in 2030.

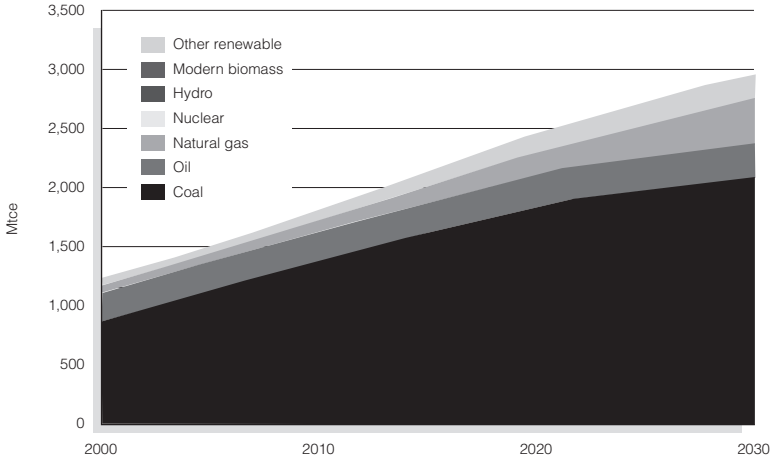

Figure 8. Energy production in baseline scenario.

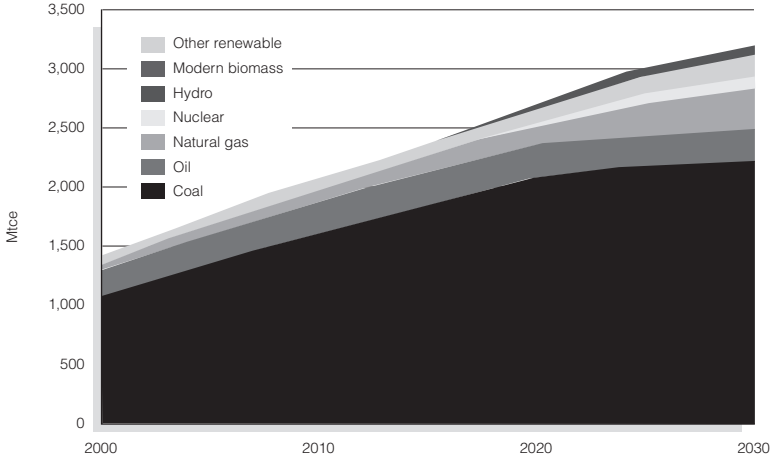

Figure 9. Energy production in high demand scenario.

4.5 Energy Imports

Based on the calculated energy demand and production, we can calculate energy imports for the future. Figure 10 and Figure 11 show energy imports for China in the two scenarios. It can easily be seen from the figures that future fossil energy imports could reach 537 million tce in 2020 and 804 million tce in 2030 (in 2000, the United States imported 870 million tce).

Oil will be the major energy to be imported, by 2020 and 2030 the imported oil would reach 230 million tonnes and 300 million tonnes, natural gas imports will reach 154 billion m^3 and 183 billion m^3 respectively. Even coal will be imported after 2020, with 129 million tonnes coal imported by 2030.

In the high demand scenario, energy import is much larger. Total fossil energy imports will be 636 million tce in 2020 and 971 million tce in 2030. There will be more coal imported in this scenario, reaching 269 million tonnes in 2030.

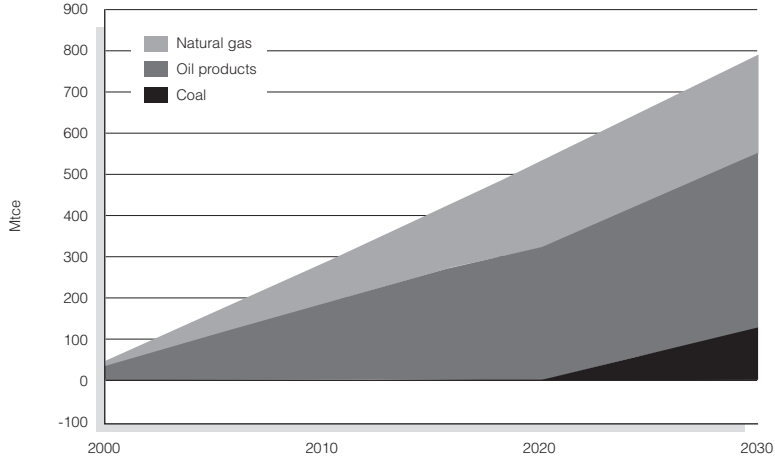

Figure 10. Energy imports in baseline scenario.

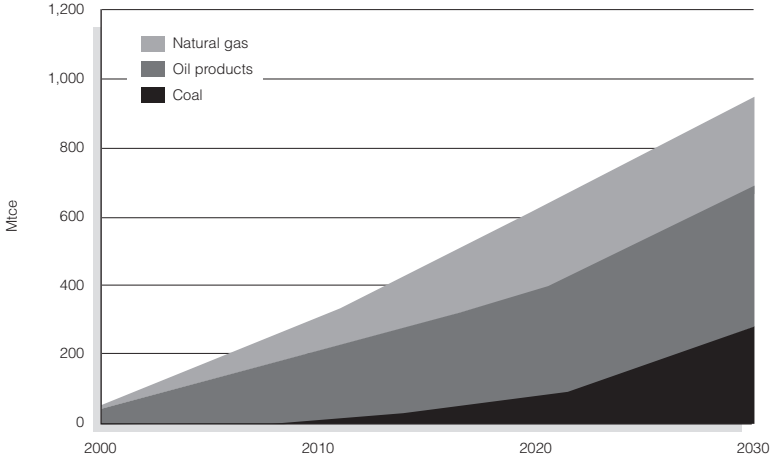

Figure 11. Energy imports in high demand scenario.

4.6 Impact on Coal Industry

After WTO accession, China can export more coal with tariff reduction and exemption. Therefore, the price of coal from China could be more competitive on international markets. This could provide better conditions to extend trade in coal between China and other countries. However, with increasing energy demand, China could be a coal importer in the future. There will be potential for coal imports in southeast China along the Yangtze River in Zhujiang delta, and the coastal area in southern part of east China with six provinces. These provinces form the most developed area in China. Since this is a coastal area, it is easier to import coal from other countries, and coal fired power plants located along coast and river are easily reached by ships.

Potential international sources for coal supply for China include Australia, Vietnam, Indonesia and others. There already were coal imports from these countries when China faced energy shortages previously. Australian coal has the greatest potential for Chinese import. Even though coal from Indonesia has a lower price it is limited by coal quality. Coal from Vietnam is limited to the border area in Gaungi and Yunnan.

Coal quality will be the major factor for imported coal from other countries. By comparing coal quality for power generation and coking coal, quality and variety are the main factors. For example, China mainly imports low ash content and high quality coal from Australia, even when there is enough domestic coal supply. Low ash, high quality coal from Australia has no competition in the Chinese market. For coal variety, domestic coal will be complemented by imported coal. After accession to the WTO, imported coal will have a better competitive position in China.

The better price of Chinese coal could not compensate for lesser quality. If we compare coal price and quality between domestic coal and international coal by weighted quality, there will be no advantage for domestic coal. Therefore, China's coal industry must make full use of local resources to obtain better quality coal in order to respond to the possible impact of international competition.

If we analyze from the viewpoint of conditions for coal export, the following observations are possible:

1. After WTO accession, the international market is opened for domestic coal by the agreement on tariff reduction and common most-favoured-nation clause. Discrimination will be reduced, which means there will be a bigger market for domestic coal to be exported.
2. Export rights for domestic coal enterprise will increase while national treatment is given to foreign companies.

3. The cost of exported coal will be reduced.
4. Settlement for trade will be easier with improved financial services. Chinese RMB will be fully convertible in the near future.
5. There will be better conditions for coal export while uncertainty continues for oil and natural gas. This will be good for domestic coal export with a focus on Japan and Korea.

In general, WTO accession will extend the scale of coal imports and exports in China. The amount of coal export depends on competition in international coal markets. However, with the rapid increase of domestic energy demand, domestic demand will be the major factor for the coal market. It is expected coal import will be the main tendency for future coal trade.

4.7 Impact on Oil and Natural Gas Industry

Even though it is difficult to assess the impact of WTO accession on the oil and natural gas industry, we can describe the impact as direct and indirect, and qualitative and quantitative impact.

Direct and quantitative impact is caused by energy products import tariff and quota, including:

1. Crude oil import tariff reduced from 16 yuan/tonne to 0 from January 1, 2000.
2. Gasoline import tariff reduced from nine per cent to five per cent from January 1, 2000.
3. Crude oil import tariff reduced from 16 yuan/tonne to 0 from January 1, 2000.
4. Natural gas import tariff reduced from nine yuan/tonne to 0 from January 1, 2000.
5. Lubricant import tariff reduced from nine per cent to six per cent from January 1, 2000.

Import tariffs for other energy products have not been not changed: the kerosene and jet fuel import tariff remains nine per cent; import on diesel, fuel oil, naphtha and LPG remains six per cent.

Concessions to import quota and permit include:

1. Non-state owned trade in crude and petroleum products: 8.28 million tonnes crude oil trade permit for non-state owned companies in 2002, and the permit will increase 15 per cent per year. The quota will end in January 1, 2006. For petroleum products, 4.6 million tonne import permit allocation is allowed for private companies, and it will increase at a

rate of 15 per cent per year. The quota for petroleum products import ended on January 1, 2004.

2. Open retail and wholesale business: three years after China entered WTO, foreign investment will be allowed to undertake retail business for petroleum products, five years after WTO accession foreign investment will be allowed into wholesale trade of crude oil, petroleum products and fertilizer.

The decrease of tariffs on crude oil and petroleum, trade permission for non-state owned companies, elimination of quotas and opening wholesale and retail operations will remove protections from which oil and natural gas companies benefited. They will face more international competition in crude oil, petroleum products and natural gas, and also face retail competition. These measures will increase the efficiency of China's oil and natural gas industry. The oil price will have a much stronger relationship with international market prices, and in the meantime there will be a stronger impact from China on international markets.

The indirect and qualitative impact could be more important than the direct and quantitative impact. One example is the impact on oil demand of lowering tariffs for automobiles. According to the WTO accession agreement, tariffs for automobiles will be reduced from around 80 per cent and 100 per cent to 25 per cent in 2006, and tariffs for automobile components will be reduced to an average of 10 per cent. Import permits and quotas for automobiles and components will be removed January 1, 2005. This will decrease the purchase price of vehicles and increase choice in the automobile market in China. Therefore this will increase automobile ownership and demand for oil.

Another example for indirect impacts is the concession for fertilizer import quotas. According to WTO requirements, 1.3 million tonnes of carbamide could be imported with a tariff of four per cent, while the normal tariff is 50 per cent. By 2006, import of carbamide will increase to 3.3 million tonnes with the tariff. Low tariff carbamide import will bring pressure on price and market of domestic producers. Five years after WTO accession, foreign companies will be allowed to retail fertilizer. This will impact not only domestic fertilizer market but also natural gas demand. Fertilizer production consumes 40 per cent of natural gas in China.

This qualitative impact will cover not only energy trade and consumption, but also foreign investment in China's energy industry. With the WTO principles of non-discrimination, national treatment and transparency, the environment for foreign investment will be much improved. And with the principle of national treatment, different financial and tax mechanisms in upstream industry for foreign companies and China's companies will gener-

ally disappear. As a Member of the WTO China will also continue the reform of state owned enterprises, including energy companies, and provide more opportunities for mergers among Chinese companies and between Chinese companies and foreign companies.

The most direct impact after WTO accession is the creation of a new competition situation in China's petroleum products. First, petroleum product import special operations will disappear. That means companies other than China Petro-Chemical, Petro China and China Chemical, both domestic and foreign, will be able to work on petroleum products import, and there will not be any limitation on the import amount. Second, foreign companies could get into wholesale market, which would open up the market controlled only by China Petro-Chemical and Petro China.

4.8 Impact on Power Industry

Impact on sustainable development of power industry

After accession to the WTO, there will be a small amount of trade in electricity. Therefore the direct challenge faced by the power industry in China is not significant. Because transmission of electricity needs a grid, the amount and pattern of electricity trade has technical limitations. In general there will not be a strong direct impact on the power industry. But there will be indirect impact. It is considered that WTO accession will create the conditions for sustainable development of the power industry.

Impact on power demand

According to research results from the Development Research Centre, annual average growth rate of GDP before 2010 with WTO accession will increase nearly one per cent compared to a situation without WTO accession. If calculated by electricity power elasticity 0.6 to 0.8, electricity power demand will increase 0.6 to 0.8 per cent. In general, electricity power demand will show a stable increase. Electricity use will increase quickly in tertiary industry and the residential sector. With economic development and an increase in the standard of living, requirements will change for power supply quality and service.

Impact on technology equipment of power industry

After WTO accession, advanced technology and equipment introduced from other countries will increase with improvement of import and export levels in China. Such introduction or transfer could compensate for shortage of some kind of technology and equipment and increase the share of advanced technology and equipment. The overall level of equipment in the power industry may be improved by technology collaboration and transfer. With technology collaboration, the capacity to produce advanced technology in China may also be improved through learning and absorbing.

Impact on law and regulation of the power industry

According to the review results on "Electricity Law" and existing electricity power administration regulation, there is no direct conflict between existing law and regulation system and WTO accession. But some management regulations need to be revised or stopped.

Impact on power company operation environment

After WTO accession, major changes in the operating environment include: more opening to outside and more channels for fund raising; a decrease in the cost of fund raising; and power companies will be able to choose in both international and domestic markets for the purchase of equipment and fuel, importing some necessary equipment, technology and good quality fuel. This is good for improvement of power generation fuel mix, raising the capacity for market competition, realizing international operations; power companies will, however, face much more serious market competition and risk the loss of technical labour.

Impact on power system reform

Under WTO, market opening and fair trade and the international electricity market price mechanism, supply and demand mechanism and competition will be widely applied in the power industry in China. In opening the market for power generation, foreign investment will be further extended, and electricity sale markets will also be generally opened. China's power industry will generally be merged into the world electricity market and, in the process, keep pace with the international power industry. There will be a competitive power market. All these will accelerate market reforming processes for the power industry in China.

4.9 Rural Energy

More and more commercial energy will go to the rural residential sector in the future. LPG will be an important energy for rural family cooking. With full use of natural gas in cities, LPG will be shifted to rural areas. Coal use will increase quickly for cooking and space heating. With the increase in rural incomes, electricity demand will grow quickly for electric appliances and hot water supply (see Figure 12).

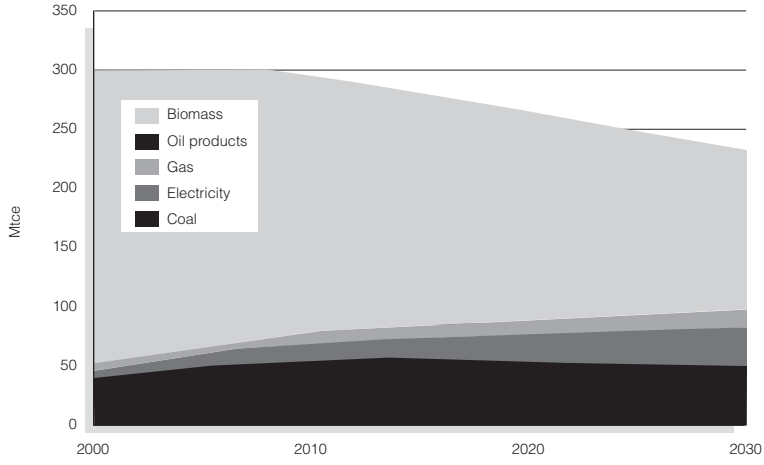

Figure 12. Rural energy demand in China.

4.10 Emissions

With the calculation of energy demand, several pollutant emissions were also calculated. Figures 13 to 16 give SO_2, NO_x, TSP and CO_2 emissions from energy activities. SO_2 emissions will keep increasing until 2010 with the rapid increase of coal use in China. After 2010, more and more desulfurization technologies will be used and therefore SO_2 emission will be uncoupled from fossil fuel use. Compared with the high demand scenario, SO_2 emissions for baseline scenario in 2010 is 4.5 million tonnes lower, but will still increase 9.45 million tonnes from 2010. This will be a major challenge for government target. Because of a lack of policy to control NO_x, its emissions keep rising. The same trend is seen for TSP emissions.

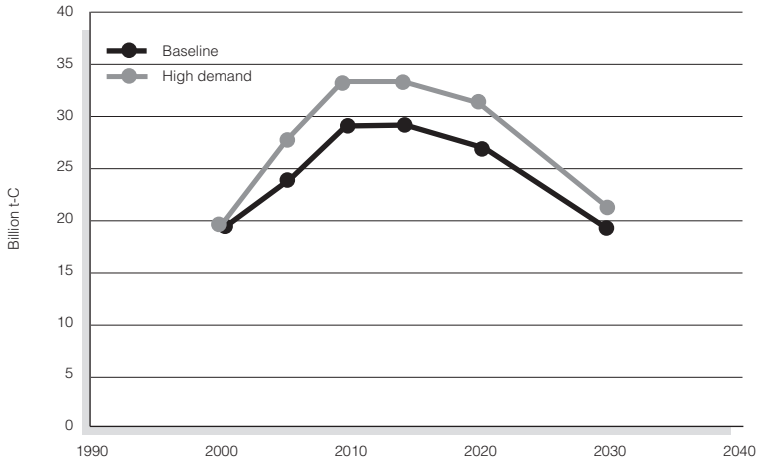

Figure 13. SO_2 emissions in China.

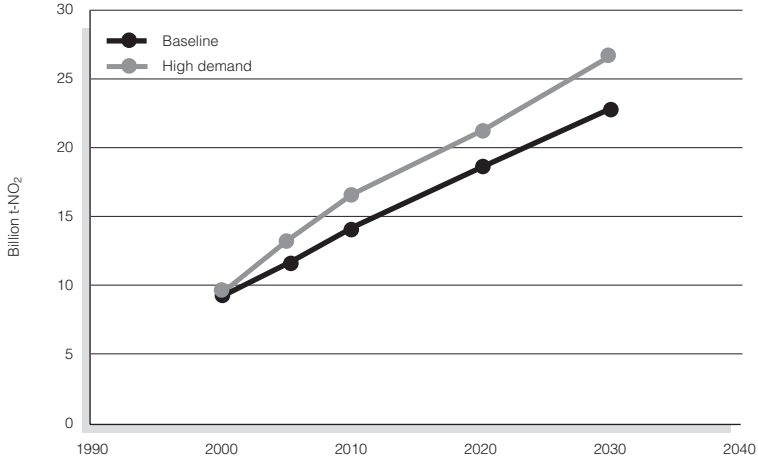

Figure 14. NO_x emissions in China.

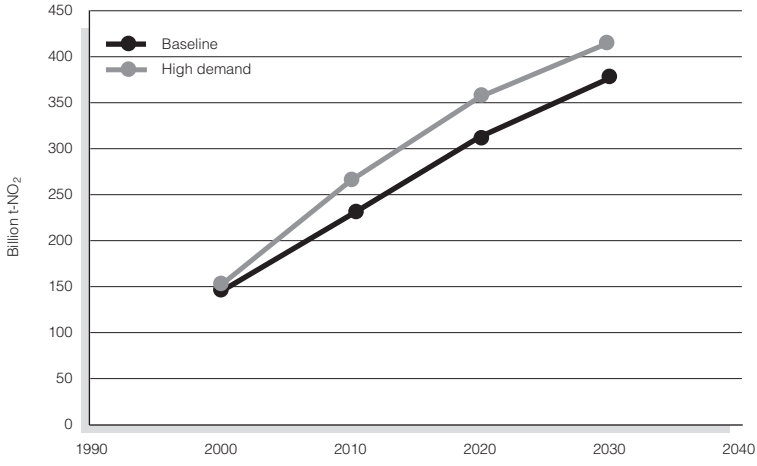

Figure 15. TSP emissions in China.

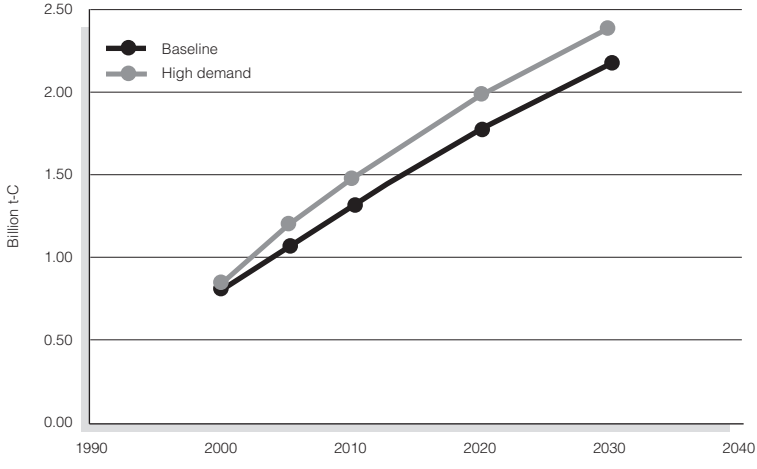

Figure 16. CO_2 emissions in China.

5. Conclusions

5.1 Energy Industry and Energy Import

With the accession to the WTO, energy demand in China may increase rapidly because:

- With WTO accession, China's economy has a better environment to grow rapidly.
- With integration into the international energy market, the energy price may be lower.
- Because of low labour and material costs, China is becoming a major manufacturing base. More energy intensive industry will occur in China

Scenarios study in this report shows the energy demand in 2020 could range from 2.4 billion tce to 3.4 billion tce depending on technology progress, energy intensive sector development, etc., (Figure 17). Such big energy demand will put serious pressure on energy supply.

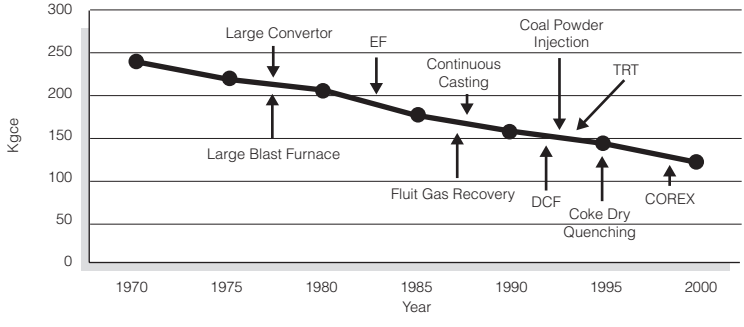

Figure 17. Technology progress and energy efficiency improvement in the steel making industry.

Studies show that by 2020 the domestic oil supply could reach 200 million tonnes; natural gas 160 billion m^3; and coal 2.8 billion tonnes. That means for the lowest energy demand scenario there will be 200 tonne of oil, 100 billion m^3. Such large energy demand and imports exerts big pressure on the energy industry in China. A well designed strategy for the energy system and energy industry in China should be prepared. Suggestions from this study are as follows:

- There will be a rapid development period for the energy industry in the next several decades. The energy industry in China should

develop a fuller understanding of the anticipated pressures. A long-term development strategy is essential.

- Much more effort should be made in energy resource exploration to enhance the domestic natural gas imported; for high energy demand scenario, there will be nearly 400 million tonnes of oil; 260 billion m^3 of natural gas; and 300 million tonnes of coal imported.
- The energy industry should prepare early for the international market. China's energy industry should look for international energy supply sources, and needs to establish infrastructure for energy imports. China's energy utilities lack the experience needed to join the international trading system. They should recruit high level technical people and introduce a modern enterprise system.
- Like developed countries that have large energy imports, China should establish an energy security system.
- Domestic energy supply should be considered within the international energy supply system.
- Multi-energy system should be established to diversify energy use. Renewable energy should be developed as an alternative energy source. Bio-fuel for motor vehicles could reduce energy imports.
- Technological progress should be emphasized to seek lower energy demand in the future.

5.2 Rural Energy

With the increase of incomes, more and more commercial energy will be used in rural areas. Improvement of energy use in rural area is very important for the energy system and the local environment. This change could be rapid and the energy industry should be prepared for it. Increased energy demand in rural areas will create a challenge for the energy distribution system. Besides the use of coal, LPG supply to rural areas, and the distribution of natural gas should be put into the schedule, especially in developed areas. Energy supply in developing regions and remote areas is still an important task for government. Technologies should be further developed and diffused to support energy development in these areas. Renewable energy should be strongly promoted in suitable rural areas to reach dual targets for energy supply and environment.

5.3 Environment

Environmental issues will be a major factor to influencing energy development in China. So far there are already serious environmental problems caused by energy activities, especially for coal mining, transport and com-

bustion. If there will be a more than 2.5 billion tonnes of coal production and combustion in China in 2020, the environmental impact will be very significant and there will need to be innovation options to abate the impact. The following are realized in the study:

- With accession to the WTO, environmental problems could worsen with increased energy demand, when there are no strong countermeasures to abate pollutions.
- Accession to the WTO provides opportunities to go to a clean energy future through clean technology transfer and higher environment standards.
- A clean energy system should be established by covering all the processes in energy activities with government intervention.
- Various national laws, regulations, and standards for the energy industry should be prepared to reach the target of clean energy system. So far there is a weak legal system to promote clean energy.
- Clean coal technology should be emphasized to mitigate emissions from coal combustion. Because only a few countries in the world are using coal on a large scale, development of clean coal technologies depends on these countries. China is the biggest country to use coal, and in the future, coal use will increase quickly which could take more than 40 per cent of the world total coal use in 2020. Therefore clean coal technology is crucial for China. China should have its own development plan for clean coal technology. It is better to work closely with other countries on a new generation of clean coal technology.
- Clean energy technologies should be further diffused in China. Some technologies such as hybrid cars, or direct injection diesel vehicles already show good commercial potential in other countries. They should be introduced at an early time in China.
- Vehicle emission norms should be tightened in China to control emissions from transport.

General recommendations could include:

- A response system should be established by stockholders for the coming energy demand and import. A long-term energy development strategy should be prepared by government; energy utilities should be ready for energy supply; energy security system should be established.
- Effort for energy conservation is essential for China to reduce demand and to release the pressure for energy supply, and in the meantime to reduce the cost.

- Large use of fossil fuel will cause serious environmental problems that could be far away from government targets. A full range of policies and measures is required to abate pollution.
- Technology is the key issue for clean energy and a lower energy demand future. Technology R&D must be emphasized. International collaboration for technology transfer and diffusion should be encouraged. Clean coal technology development should be further emphasized by China and a few other countries.
- There will be a large possibility for China to become a manufacturing centre in the world relying on energy intensive and resource intensive products because of low cost. This trend should be controlled to avoid China becoming a country to provide raw material and causing damage to the environment. External cost should be included in production costs, to avoid possible environmental damage and economic damage.

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Textiles

Textiles

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1. The Development of the Chinese Cotton Textile Industry and the Environment

1.1 Introduction to the Cotton Textile Industry

The cotton industry is the largest sector of the Chinese textile industry and it has become a pillar that supports the development of China's entire textile industry and related industries. And cotton satisfies the clothing needs of more than one billion people in China. China ranks first in the world in production capacity, and in cotton yarn and fabric production. It has been playing a leading role in the world cotton textile industry. The leading position has been consolidated over the past few years.

Since the 1980s, driven by the implementation of reforms and increasing domestic and overseas market demand, the cotton textile industry in China has been developing rapidly. After China joined the WTO, as quota restrictions were lifted, the cotton textile industry enjoyed a new opportunity to make further progress. The cotton industry has a new outlook with increasing exports and improved competitiveness on the world market (See Figure 1).

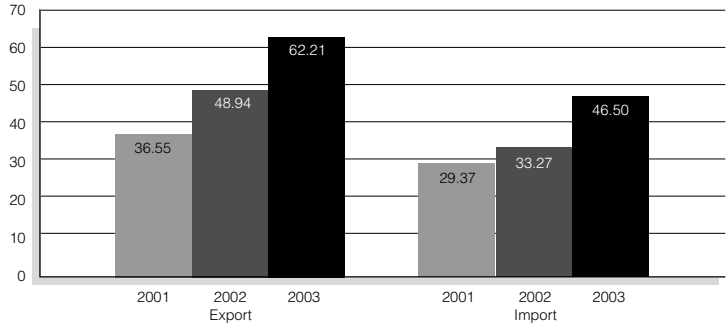

Figure 1. Increasing imports and exports of cotton and cotton goods (US$100 million).

Source: Related statistics of the customs.

1.2 Major Environment-related Problems Faced by the Cotton Textile Industry

1.2.1 Water Pollution

Sewage from the cotton textile industry comes mainly from the printing and dyeing processes. Figure 2 shows the main sources of pollution. Sewage (including sewage from the pre-treatment process, dyeing or printing process, and finishing process) is mainly organic in nature. The main components of the sewage are synthetic organic substances and natural organic substances, and include certain substances that are not biodegradable.

Contributing six per cent of the total, the textile industry is one of the major contributors of industrial sewage in China. Within the textile industry, cotton produces 80 per cent of the sewage. Over the past few years, the government has been taking increasingly strict control of industrial pollution and urging industries to adjust structures and upgrade products. As a result, the ratio of treated water in compliance with national standards is increasing. However, when judging the cotton sector as a whole, the sewage pollution problem is still very severe.

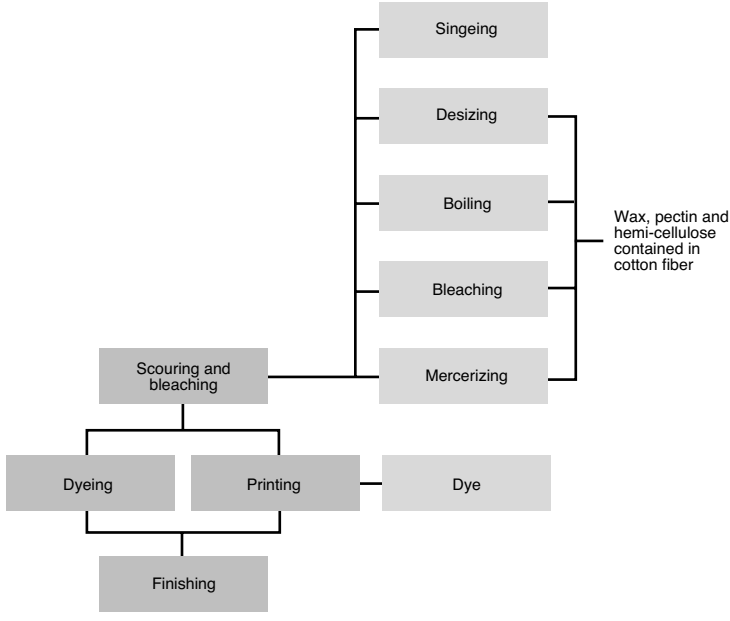

Figure 2. Sources of pollution in the cotton printing and dyeing processes.

Table 1. Wastewater discharge in China's textile industry (million tonnes).

Wastewater type	1995	1997	2000	2001	2002
Total wastewater discharge	1,164.25	1,027.67	1,256.49	1,326.98	1,366.00
Direct discharge into the sea	18.82	68.57	94.21	55.71	26.57
Direct discharge into treatment plants	99.41	588.03	848.15	-	-
Discharges that are up to the national standard	717.59	666.17	978.91	1,215.65	1,281.37
Ratio of treated water up to the discharge standards (%)	61.6	64.8	77.9	91.6	93.8

Source: Environmental Yearbook of China, the State Environmental Protection Administration.

Wastewater from the textile industry is mainly due to:

- high water consumption;
- problems in wastewater control;
- backward equipment. The equipment used by Chinese textile producers lags far behind the equipment used by foreign counterparts. The industry has a low automation level and low utilization efficiency of raw materials. The water consumption per unit product is about 50 per cent higher than in developed countries; and
- problems concerning dyes. In general, dyes made in China usually have lower dye uptake and because of lack of effective management in the dyeing process, dye residual in wastewater is higher. The sewage discharge per product is nearly double the amount discharged in developed countries. This leads to wasted resources and even worse sewage pollution.

1.2.2 Noise Pollution

Noise pollution is a long-standing problem of the textile industry. Due to the special features of its production process and equipment, the noise pollution in a cotton mill is quite severe. The noise in many workshops is higher than 90 dB and the noise in weaving rooms can reach 100–105 dB-(A). Some workshops have taken sound-absorbing, sound-silencing and sound-insulating measures, and have replaced shuttle looms. However, there are only about 700,000 sets of shuttle-less looms installed in China and there are nearly 700,000 weavers. Solving the noise pollution problem will remain an important environmental protection task of the textile industry.

1.2.3 Air Pollution

Waste gas of the textile industry mainly comes from about 20,000 boilers, which have a total capacity of about 60,000 tonnes of steam. In 2000, the textile industry consumed 13.85 million tonnes of coal, and emitted 153.4 billion standard cubic metres of waste gas from fuel burning, including 257,000 tonnes of SO_2 and 119,000 tonnes of soot. In 2002, the textile industry consumed 16.90 million tonnes of coal, emitted 205.9 billion standard cubic meters of waste gas from fuel burning, including 240,000 tonnes of SO_2 and 107,000 tonnes of soot. The textile industry produces less pollution than other big coal consumers such as power and metallurgical industries.

2. Environmental Impacts of WTO Accession on the Cotton Textile Industry in China

2.1 Environment-related Opportunities and Challenges Faced by the Cotton Textile Industry after China's Accession to the WTO

Since China's accession to the WTO, China is gradually becoming an integral part of the global economic system and this will accelerate with the advancement of global trade liberalization. With phased out quota restrictions and with a growing industry, the Chinese cotton textile sector will face new environmental issues.

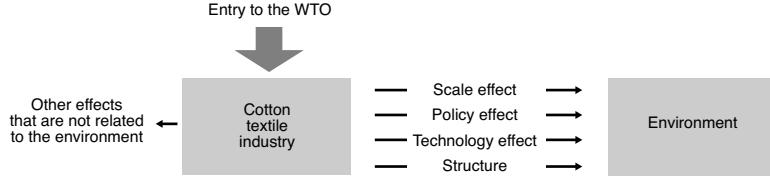

Figure 3. The effects of China's entry to the WTO on environmental issues of the cotton textile industry.

2.1.1 The Scale Effect

Before China joined the WTO, quotas had been the most significant barrier hindering the development of the textile industry. China suffered the serious quota restrictions in wide categories of textile products from many importing countries, such as EU and the United Stated. Under the bilateral agreements reached between China and the United States, EU and Canada in 2001, 275 categories of textile and clothing products exported from China were placed under quota restraint, covering nearly all categories of exported textile products. After China joined the WTO, according to the Agreement on Textiles and Clothing (ATC), quota restrictions would be lifted in stages and the Chinese textile industry would gradually be integrated into the trade liberalization process. This will significantly promote development of the Chinese textile industry.

After China became a Member of the WTO, the United States and some major importing countries in Europe lifted restrictions on 97 categories of textile products in 2002. This means that about US$4 billion worth of textile products are without quota restrictions, representing the value of about one third of textile exports from China to quota-restricted markets. As the quota restrictions will be completely phased out, textile and clothing

exporters will enjoy a better environment and this will further expand the overall scale of the Chinese cotton textile industry.

Expanding of Chinese cotton textile industry may bring about many changes in economic and environmental aspects,. Main changes are as follows:

1. ***As production increases significantly, there will be greater resource consumption and pollution discharge.***

   Compared with other countries, China has strong competitive advantages in terms of labour and textile fiber resources. Labour costs in China are 20–40 times lower than in developed countries such as Japan and the United States, and two to four times lower than in some developing countries such as Thailand and Turkey. In 2000, China's textile fiber production was 19 per cent of the world total. After China entered the WTO, such advantages have become even more evident, resulting in increased production and export of textiles and garments. According to the General Administration of the Customs of China, the year-on-year growth rate of China's textile and garment export was 2.31 per cent in 2001; 15.66 per cent in 2002; and 27.72 per cent in 2003. Driven by strong global demand, the cotton textile industry in China operates exceptionally well, with production of major products increasing markedly.

   As far as the environment is concerned, without dramatic improvement of technological standards, increased production will inevitably lead to increased consumption of various resources, such as water, electric power, various auxiliaries, additives and dyes, etc. If the percentage of standard sewage discharge remains unchanged, increased resource consumption will impose a heavier burden on the environment through increased sewage discharge and chemical oxygen demand (COD) discharge.

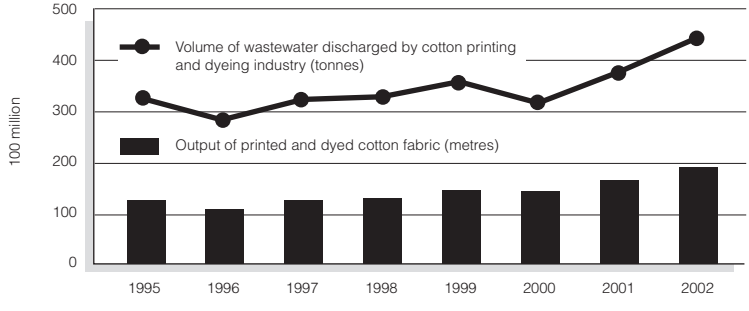

Figure 4. The relationship between wastewater discharged and output variation of the cotton textile industry.
Source: Environmental Yearbook of China (from 1994 to 2003).

2. *The pollution burden is increasing along with the number of small-sized enterprises.*

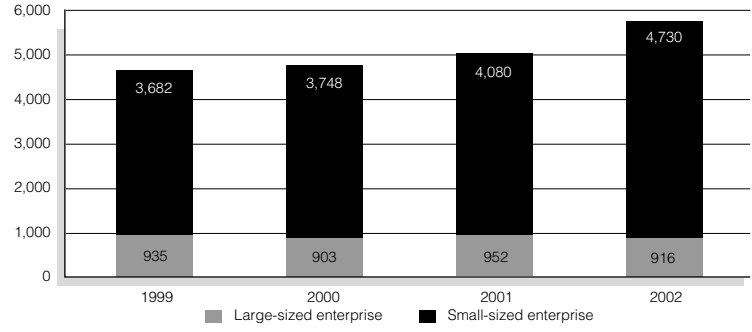

Figure 5. The growth of cotton textile enterprises of different sizes, 1999–2002.

Source: The Statistical Centre of China National Textile Industry Council.

For investors, the cotton textile industry requires low initial capital and technology investment. Over the past five years, small-sized[1] enterprises mushroomed. From 1999 to 2002, the number of small-sized cotton enterprises increased sharply by 28.5 per cent. After China became a member of the WTO, such a trend has become more evident (see Figure 5). About 85 per cent of the enterprises of the cotton textile industry are small-sized ones, but they only contribute 50 per cent of the gross value of industrial output. Most of these small-sized enterprises lack capital and technology for environmental protection and the ability to institute environment controls. They will create a heavier burden of sewage discharge with increased production. Since the pollution sources of small-sized enterprises are scattered, it is hard to control the problem. Looking at the cotton industry as a whole, large- and medium-sized enterprises have made greater progress in environmental protection. However, since they are fewer in number, their effect on environmental protection is not strong enough to counteract the negative effect generated by small-sized enterprises.

3. *The introduction of foreign investment into the pollution-intensive industries will increase pressure on the environment*

After entry to the WTO, China opened more sectors to foreign investors and foreign investment came into China at an accelerated rate. Under such a situation, profound change has taken place in the capital structure

1 Small-sized enterprises in the cotton textile sector refers to those enterprises with an annual output less than five million yuan RMB.

of the cotton textile industry. Most enterprises have developed a diversified capital structure. From a short-term point of view, the introduction of foreign investment has enhanced the vitality of enterprises and sped up technological progress as the technology and environmental management of foreign-funded enterprises are generally of a higher standard than those of native enterprises. However, from a long-term perspective, since the cotton textile industry is pollution-intensive—especially the cotton printing and dyeing sectors—foreign investment will expand production and consequently increase the consumption of resources such as water, electricity and gas. At the same time, the increased use of various dyes and auxiliaries will also place a greater burden on the environment.

2.1.2 The Policy Effect

Because China joined the WTO, industry-, trade- and environment-related policies will promote the rapid and healthy development of the cotton textile industry while exerting an effect on environmental protection.

1. *Industry-related policies*

   After China joined the WTO, in order to help the cotton textile industry cope better with the new situation, the government re-adjusted a series of policies on raw material supply, total production capacity control and industrial restructuring. These policies not only promote the development of the cotton textile industry, but also generate certain effects on the environment. These policies include:

   - the policy on cotton import which changed the quota license control on cotton imports into tariff quota control;
   - the policy on controlling total production capacity of the industry;
   - upgrading production process and equipment and products; and
   - macro guidance to investment.

2. *The increased import of dyes after China's entry to the WTO will help to reduce environmental pollution*

   With an improvement in textile product quality, the industry in China has imposed stricter requirements on dyes and the demand for eco-friendly dyes is increasing. Imported dyes are better than locally-made ones, and more expensive. According to China's commitments to the WTO, the tariff rate on dye imports will drop from the present 10.8 per cent to 6.5 per cent in 2008. By then, the cost of imported dyes will drop accordingly and Chinese enterprises will use more and more imported dyes. As imported dyes are more eco-friendly than locally-made ones, they will help to reduce environmental pollution.

3. Policies on domestic environmental pollution prevention and control

Closing small and heavily-polluting factories in 15 industries

The Decisions of the State Council on Some Environmental Problems (1996) required the closing of small and heavily-polluting factories in 15 industries. Statistics from SEPA show that 1,167 factories are to be closed, or 1.64 per cent of textile factories in China.

Cleaner production and green certification

In June of 2002, the Standing Committee of the People's Congress of the People's Republic of China approved the "Cleaner Production Promotion Law." The Chinese textile industry began to introduce a clean production auditing system, the certification of ISO 14000 series of international environmental management system standards and the certification of environmental labelling of products in the 1990s. By reducing energy consumption, some textile enterprises have improved labour productivity and reduced pollution.

Up to now, more than 30 enterprises have been granted the environment label and the certificate of "Anti-moth Wool Textile Standard" for their products. The up-to-standard products include grey real silk, grey fabric, apparel fabric, adhesive lining, bed linen, underwear, outerwear and babies' articles as well as knitting wool, woolen sweaters and wool blankets.

By June of 2002, 225 Chinese enterprises had become the holders of Oeko-Tex Standard 100 certificate; most of them are foreign trading and export-oriented enterprises as well as solely foreign-funded enterprises or Sino-foreign joint ventures.

Formulating and completing environment-related standards

Over the past few years, China has formulated and completed a series of environment-related standards, some for finished products and some for production processes. They mainly include:

- Criterion for the Formaldehyde Content of Textile Products (GB18401-2001);
- Water Consumption Quota for Printed & Dyed Cotton Products; and
- Technical Requirements on Environment-friendly Textile Products.

2.1.3 Technology Effect

Compared with developed countries, the textile industry in China still lags behind in terms of overall technological level. Taking the cotton textile industry as an example, only one third of the cotton spinning equipment is

up to the technological standards of the 1990s, while the rest is at 1980s and 1970s levels. The share of international state-of-the-art equipment is very low, and this is especially true for cotton weaving equipment.

After China joined the WTO, with the progress of the industry restructuring campaign and the accelerated introduction of foreign investment, the overall technological level of the Chinese cotton textile industry is improving. For example, the proportion of shuttle-less looms increased markedly. Related statistics of China National Textile Industry Council show that in the January–November period of 2002, the cotton textile industry imported US$3.08 billion worth of advanced technology and equipment, an increase of 35.16 per cent over the same period of the previous year, hitting a record high. At the same time, the sales of locally-made advanced equipment also grew by nearly 30 per cent. The imported state-of-the-art technology and equipment will play an important role in increasing labour productivity, saving energy and reducing pollution generation and discharge.

A most important technology means to solve environmental pollution generated by the cotton textile industry is strengthening the construction wastewater treatment facilities. The wastewater treatment capacity has increased gradually in recent years; it exerted a positive effect to reduce the pollution and upgraded the wastewater discharge standards. However, the existing wastewater treatment capacity cannot accommodate the continuously increasing wastewater discharge. The government must strengthen the control and management of the construction of wastewater treatment plants.

Table 2. Facilities for wastewater treatment of of textile enterprises.

	Number of enterprises (unit)	Number of facilities for treatment of wastewater (set)	Number of facilities functioning for treatment of wastewater (set)	Original costs of facilities for treatment of wastewater (10,000 yuan)	The running charge in the same year (10,000 yuan)	Volume of treated wastewater up to the discharge standards (10,000 tonnes)
1997	5,852	3,861	3,357	274,714	88,312	66,617
1998	5,477	4,066	3,648	343,745	96,791	65,517
1999	5,528	4,552	4,162	409,931	79,585	76,837
2000	6,077	5,134	4,888	504,177	103,321	97,891
2001	6,643	5,379	-	-	222,130	121,565
2002	6,622	6,665	-	-	753,841	128,137

Source: Environmental Yearbook of China.

2.1.4 The Structural Effect

Since the 1990s, and especially since China joined the WTO, under the background of the market economy, the cotton textile industry has been restructuring and reforming its internal structure, production scale control, raw material structure, regional distribution, technological structure and product mix. Up until now, there had been an industrial structure with state-owned enterprises and foreign-funded enterprises as the mainstay, supplemented by collective-run and individual-run enterprises. As more and more Chinese textile enterprises become involved in international competition, the following two situations might occur:

a. Industrial structure and product mix will become more rational; enterprises will be re-organized; products will be up to a higher grade; and the textile industry will improve cost-efficiency and gradually reduce its pressure on the environment;

b. Driven by high demand on the market, a large number of small-sized enterprises that are equipped with backward technology and equipment, will enter the cotton textile industry. This will lead to surplus low-standard production capacity; fierce competition of low-quality-price products; weakened competitiveness on the world market; decelerated development of the industry; and significant negative effects on resources and environment.

2.2 Model Forecast

Sewage is the most important pollutant generated by the textile industry and 80 per cent of the sewage comes from cotton printing and dyeing. Therefore, the model here is mainly used for forecasting the effect of China's WTO entry on the environmental issues of the cotton textile industry. The model sets abolition of quota restrictions as the most influential factor brought by China's entry to the WTO and the year 2001, when China joined the WTO, as the benchmark year. The model is designed to forecast—driven by great demand on both domestic and foreign markets—the change in the production, sewage discharge, and the generation and discharge of COD in the sewage of the cotton textile industry in the period from 2001 to 2010. Based on this study, the comprehensive effect of China's entry to the WTO on the environment of the Chinese cotton textile industry is evaluated.

This model sets up the production model of the future cotton textile industry based on the relationship between production and the exogenous variables of the macro economy (such as year, population, GNP, GDP and economic growth). Then, it forecasts the effects on the environment based on the pollution discharge factor per unit of production.

The data of this model come mainly from the textile industry's economic, production, import and export, and pollution generation figures published by the Statistical Centre of the China National Textile Industry Council and the State Administration of Environmental Protection from 1990 to 2003. It sets up the environmental evaluation model by using the systematic estimation method.

2.2.1 The Forecast of the Impacts of China's Accession to the WTO on the Development of the Chinese Cotton Textile Industry

Due to the special nature of the data, it is hard to directly forecast the production of printed and dyed fabric and knitted fabric. Therefore, the model first forecasts the gross value of product of the Chinese textile industry and then calculates the production of printed and dyed fabric and knitted fabric.

1. *The model for forecasting the gross value of product of the Chinese textile industry*

   The choice of model and method depends on the nature of the case being studied. In this study, different factors are not linked by a unidirectional cause-and-effect bond, but by an interaction relationship. Therefore, we use the systematic estimation method to make the model forecast. The related formulas for the model are set as follows:

   Formula 1:

   $$Output = a_0 + a_1 * GDP + a_2 * GDP(-1) + a_3 * EX + e_1$$

   Formula 2:

   $$EX = b_0 + b_1 * Q + b_2 * WGDP + b_3 * LOG(Output) + e_2$$

   In which:

   $Output$ = Gross value of textile industrial output

   GDP = The GDP of China

   $GDP(-1)$ = The GDP of China (one phase behind)

   EX = Export value of the textile industry

   Q = Policy variable in the change of trade rules

   $WGDP$ = The world GDP

   e_1 = Random in equation 1

   e_2 = Random in equation 2

   According to the mode identification theory, the model is over identified. We estimate the parameters by using the Three-Stage Least Squares method by the Eviews software and get the forecast model:

Formula 1:

$$\hat{Output} = 1056.47 + 0.12 * GDP - 0.09 * GDP(-1) + 9.82 * EX$$
$$(5.51) \quad (3.21) \quad (-3.32) \quad (4.26)$$

$$R^1 = 0.98_1 \; d = 2.4$$

Formula 2:

$$\hat{EX} = -1868.09 + 513.28 * Q + 0.13 * WGDP + 213.5 * LOG(Output)$$
$$(-5.72) \quad (7.26) \quad (2.79) \quad (4.2)$$

$$R^2 = 0.98_1 \; d = 2.0$$

Every indicator in the model is verified and this model can be used for forecasting.

Suppose that China's annual economic growth rate remains at seven per cent up to the year 2010 and the annual average inflation rate is 3.4 per cent in the 2000–2010 period, the model can forecast the gross value of textile industrial output from 2004 to 2010.

The forecast shows that, by the year of 2005, when quota restrictions are phased out, the gross value of industrial output of the Chinese textile industry will increase by 49.2 per cent (compared with the pre-WTO-entry period) to RMB 1,783.90 billion yuan and further grow by 34.7 per cent to 2,200.50 billion yuan in 2010 (See Figure 6).

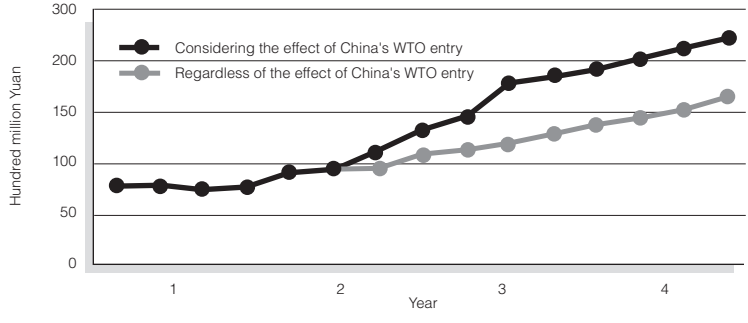

Figure 6. Illustration of the effect of China's entry to the WTO on the gross value of industrial output of the textile industry.

2. The forecast on the production of cotton textile products

The main products of the cotton textile industry include printed and dyed fabric, knitted fabric and yarn-dyed fabric. The production of these products is forecast on the basis of their respective coverage in the output value of the cotton textile industry and coverage of the output value of the cotton textile industry in that of the entire textile industry. According to the variations over the past few years, the production is forecast using the proportion method. By introducing the forecast gross value of industrial output of the textile industry into the model, we can get the forecast production of printed and dyed fabric, knitted fabric and yarn-dyed fabric as shown in Table 3.

Table 3. The forecast production of various products of the Chinese cotton textile industry (Unit: million metres)

Year	2004	2005	2006	2007	2008	2009	2010
Printed & dyed fabric, of which:	27,259	32,365	33,399	34,515	35,721	37,026	38,439
Bleached fabric	3,295	3,745	3,692	3,637	3,580	3,519	3,455
Dyed fabric	17,657	21,202	22,124	23,116	24,185	25,340	26,588
Printed fabric	6,306	7,418	7,583	7,762	7,956	8,167	8,396
Knitted fabric	37,962	45,073	46,513	48,067	49,747	51,564	53,532
Yarn-dyed fabric	4,638	5,507	5,683	5,873	6,078	6,300	6,540

2.2.2 The Forecast on the Effect of China's Entry to the WTO on the Environmental Issues of the Chinese Cotton Textile Industry

Based on the forecast production of cotton textile products, we forecast the sewage discharge, standard sewage discharge, the quantity of COD generated, COD discharge and energy consumption by using the pollution generation factor for different products.

1. The forecast on the sewage discharge and main pollutants of the Chinese cotton textile industry.

The model sets the year 2001 as the benchmark. It forecasts the respective sewage discharge under two different backgrounds: one as a member of the WTO (quota restrictions are lifted); and one not as a member of the WTO (quota restrictions are maintained). The forecast results are shown in Figures 7–9 and Table 4. The forecast results show that after China joined the WTO, the potential of increased production brought by the abolition of quota restrictions will lead to increased sewage discharge and COD generation. If the current proportion of standard discharge remains unchanged, the increased scale will cause a remarkable increase in sewage pollution.

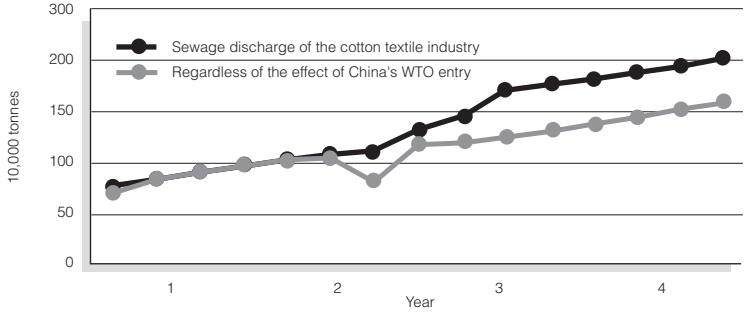

Figure 7. The forecast on the effect of China's WTO entry on the sewage discharge of the Chinese cotton textile industry.

Table 4. The forecast on the pollutant discharge of different cotton textile products.

Product and Process		Pollutant	2005	2010
Cotton weaving (printed and dyed fabrics, and yarn-dyed fabric)	Printing and dyeing	Sewage (10,000 tonnes)	72,349	88,032
		COD (10,000 kg)	18,770	22,838
	Bleaching and dyeing	Sewage (10,000 tonnes)	16,856	17,895
		COD (10,000 kg)	5,693	6,044
Cotton knitting (knitted fabric)	Bleaching as well as printing and dyeing	Sewage (10,000 tonnes)	80,681	95,821
		COD (10,000 kg)	14,874	17,665
Total sewage discharge of the cotton textile industry		Sewage (10,000 tonnes)	169,887	201,748
		COD (10,000 kg)	39,337	46,548

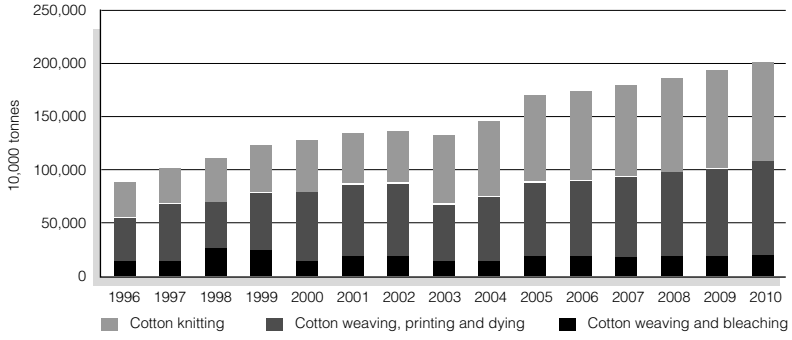

Figure 8. The practical and forecast sewage discharge by products of the cotton textile industry before and after China's WTO entry.

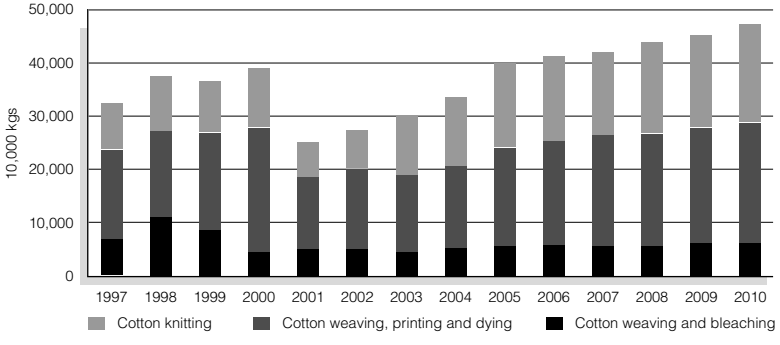

Figure 9. The practical and forecasted COD generation by products of the cotton textile industry before and after China's WTO entry.

Figure 7 and Figure 9 show that after China joined the WTO, the discharge of bleaching sewage of cotton weaving enterprises was reduced and kept at a stable level, while the discharge of printing and dyeing sewage increased. It can be predicted that, for some time to come, printing and dyeing sewage will continue to be the major environmental pollution source of the cotton textile industry and that strengthening the control and disposal of dyeing and printing sewage will be the primary task of the industry in environmental protection.

2. *The forecast on coal and water consumption*

Forecasting Coal Consumption

If we ignore the effect of technical advancement and other factors, after

China's accession to the WTO, the increased production scale of cotton dyeing and printing fabric will increase the consumption of coal in the cotton textile industry. Forecasting of its rising extent is showing in Figure 10.

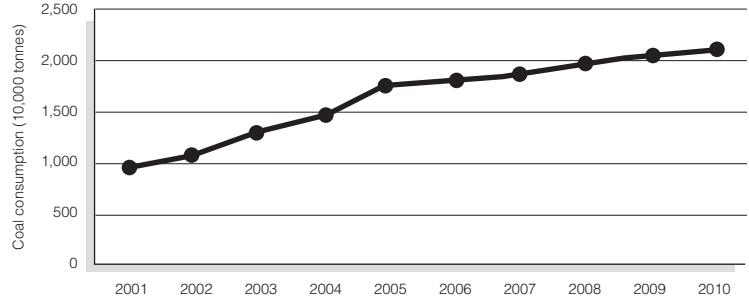

Figure 10. Forecast of energy consumption of printed and dyed fabric of China's cotton textile industry.

Forecasting water consumption

Cotton dyeing and printing account for most of the water consumption of the cotton textile industry. If we ignore the effects of technical advancement and other factors, after China's accession to the WTO, the increased production scale of cotton dyeing and printing fabric will increase the consumption of water in the cotton textile industry. Forecasts of rising consumption are shown in Figure 11.

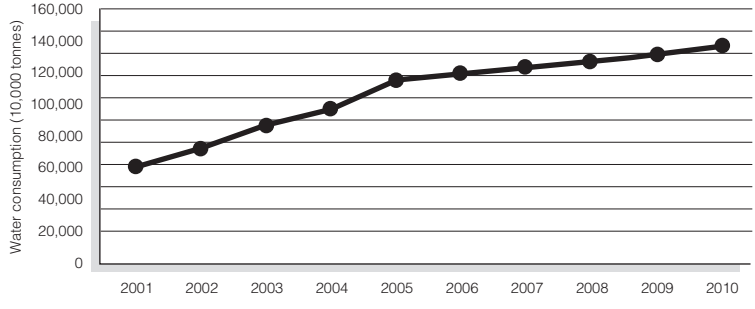

Figure 11. Forecasts of water consumption of printed and dyed fabric of China's cotton textile industry.

3. The effect of special protective measures and "green" trade barriers on textile products

If the export of textiles and garments from China encounters "green" barriers, it may decrease. This is equivalent to restoring quota restrictions. In addition, according to China's commitments to the WTO, once the export of textile products from China increases sharply, other textile-importing countries can impose special protective provisions on the import of textile products from China. This will restrain export growth and have an effect equivalent to the force of quota restrictions.

According to the "Model for Forecasting the Gross Value of Industrial Output of the Textile Industry," whenever the quota restraint increases by one per cent, exports will shrink by US$500 million and the gross value of industrial output of the textile industry will be reduced by RMB five billion yuan. So it is quite clear, after quota restrictions on textiles are phased out due to joining the WTO, technical trade barriers will become a significant obstacle for China's textile exports. This is another form of quota restrictions and it will have significant negative effect on the trade and foreign currency earnings of the government, as well as on textile-related enterprises and their employees.

Judged from the effect on the environment, it makes no difference whether the products are exported or sold on the domestic market. If the technological level of enterprises, as well as the standard and management policies for environmental protection remain unchanged, the effect on the environment brought by the development of the textile industry will not change significantly either. However, it is worth noting that, if the domestic environment-related policies remain unchanged, "green" barriers may cause a situation whereby the exported textile products are returned by importing countries because of environment standards. This will have a negative effect on people's health and on the domestic environment.

2.3 The Effect on Environment Brought by the Growth of the Chinese Textile Industry

2.3.1 Cobb-Douglas Production Function

This study will analyze the factors that drive the growth of the Chinese textile industry. In estimating the production function, we use the Cobb-Douglas production function model. The definition of the model is as follows:

$$\ln y_i = \ln A + \alpha * \ln K_i + \beta * \ln L_i$$

In which:

y_i = gross value of industrial output of the cotton textile industry in year $_i$

L_i and K_i = labour and capital investment in each year $_i$

α and β respectively stands for the flexibility of capital and labour output,

where $\alpha + \beta = 1$

A = a constant.

2.3.2 The Effect on Environment Brought by Technological Advancement of the Industry

According to the general production function theory, the effect of China's WTO entry on the growth of the Chinese textile industry is mainly reflected in increased labour, capital and especially technological advancement.

There are several methods available for measuring technological efficiency. Total factor productivity (TFP) is a comprehensive and widely used method. How much will technological advancement contribute to economic growth? In 1957, the American scholar Solow for the first time developed the quantitative calculating method by using the Cobb-Douglas production function and used in practice. At present, the Solow method is widely used in China and is also adopted by the World Bank to calculate total factor productivity.

From 1990 to 2002, the contribution of total factor productivity to the growth of gross output value of the cotton textile industry is lower than for the entire textile industry. In addition, in this period, the total factor growth rate of the cotton textile industry is lower than that of the entire textile industry.

Our estimates show that there is big gap between the cotton textile industry and the entire textile industry in terms of technological efficiency, indicating that there is substantial potential for the cotton textile industry to improve its technological level. Therefore, technological advancement will be one of the most important measures for reducing the increasing pressure on environment and resources of the cotton textile industry in the post-WTO-entry period.

2.3.3 The Effect on the Environment Brought by Capital Efficiency of the Industry

According to the model forecast, the flexibility of capital output of the Chinese cotton textile industry is 0.76 and that of labour output is 0.24. It means that, for the cotton textile industry, capital has higher output efficiency. This is to say that capital is very important to cotton textile enter-

prises and the importance of labour lies in quality as opposed to quantity. The rational and effective utilization and allocation of capital have a positive impact on the development of the textile industry.

From the perspective of environmental protection, clean production auditing, which is greatly promoted by the Chinese government, will play a positive role in improving the capital utilization efficiency and in reducing pollution. Enterprises can save resources, reduce pollutant discharge and save money by taking some simple measures such as clean production, controlling pollution at the source as well as low-waste and waste-free production. As the Chinese cotton textile industry has high capital output flexibility, cotton textile enterprises can take on the clean production targets for energy-saving, water-saving and reducing consumption and pollution. This will help enterprises improve environmental as well as economic benefits.

3. Conclusions

The following conclusions can be drawn from projections based on the above models:

Conclusion I: Entry into the WTO has brought unprecedented opportunities for the development of China's cotton textile sector. There will be an obvious increase in the sector's total output. The sector's expansion will bring considerable pressure on the environment and on natural resources. Some indications of this are as follows:

1. Compared with the data of the baseline year 2001 (when China joined the WTO), from 2001 to 2005, the total amount of industrial wastewater discharged from the cotton textile sector will increase to 1.7 billion tonnes, an increase of 640 million tonnes (60 per cent) over that of the baseline year. By 2010, the total amount of industrial wastewater discharged from the cotton textile sector will rise to two billion tonnes, an increase of 960 million tonnes (90 per cent) over that of the baseline year. Had China not joined the WTO, the total amount of industrial wastewater discharged from the cotton textile sector would have increased by 450 million tonnes (36.05 per cent) by 2005, and by 430 million tonnes (27.38 per cent) by 2010.
2. The amount of standard-compliant discharge of industrial wastewater from the cotton textile sector was 970 million tonnes in 2001, with the rate of compliance of 91.6 per cent. If this is used as a baseline and there is no change in this baseline after China's entry into the WTO, by 2005, the amount of industrial wastewater that does not meet the discharging standard will be increased to 140 million tonnes, an increase of 53.54 million tonnes over that of the baseline year. By 2010, the amount of non-compliant discharges will rise to 170 million tonnes, an increase of

80.3 million tonnes over that of the baseline year. To maintain the level of non-compliant discharges from the cotton textile sector at the level of 2001 after China's entry into the WTO and to make sure that output increases without increasing pollution, the rate of standard-compliant discharges of industrial wastewater must be increased to over 94.8 per cent by 2005 and to over 95.6 per cent by 2010.

3. The amount of COD (chemical oxygen demand) in the wastewater discharged from the cotton textile sector was 854,000 tonnes in 2001. Using this as a baseline, from 2001 to 2005, the amount of COD will reach 997,000 tonnes, an increase of 143,000 tonnes over the total in 2001. By 2010, the amount of COD will reach 1.18 million tonnes, an increase of 325,000 tonnes over 2001. Calculated on the basis of the rate of COD removal in 2001 (77.1 per cent), the amount of COD discharged will reach 228,000 tonnes by 2005 and 270,000 tonnes by 2010. To maintain the amount of COD discharged from the cotton textile sector after China's entry into the WTO at the level of 2001 and to ensure that production will increase without discharging additional pollutants, the rate of COD removal from the industrial wastewater of the cotton textile sector must be increased to over 80.3 per cent by 2005 and to 83.4 per cent by 2010.

4. Coal consumption for production per 100 metres of dyed cotton cloth amounted to 54.28 kg in 2001 and the consumption by coal equivalent in 2001 was 9.24 million tonnes. Using this as a baseline, coal consumption for production of dyed cotton cloth will reach 17.48 million tonnes by 2005, an increase of up to 89 per cent over coal consumption in 2001, if other factors like technological innovation are not taken into account. By 2010, coal consumption for production of dyed cotton cloth will approach 20 million tonnes, an increase of 116 per cent over that in 2001.

5. Water use for cotton dyeing reached 615.74 million tonnes in 2001, with 3.5 tonnes of water used per 100 metres of cloth. Given this baseline, by 2005 water use for cotton dyeing will approach 1,165,140,000 tonnes, an increase of 89.23 per cent over water use in 2001, and to 1,383,800,000 tonnes by 2010, an increase of 124.74 per cent over 2001.

Conclusion II: The projection based on the above models indicates that there will be a substantial increase in the production of dyed and printed cloth. However, there will not be an obvious increase in the output of bleached cloth, so there will be a smaller increase in the amount of wastewater discharged from cloth bleaching, with pollution maintained at the current level. In contrast, there will be an obvious increase in the amount of

wastewater discharged from dyeing. It can be projected that, for the near future, the main environmental problem of the cotton textile sector is still caused by the wastewater discharged from the dyeing processes. The increased portion of dyeing wastewater will add difficulties to wastewater treatment. Therefore, it is an important task for this sector to reduce the pollution of wastewater from dyeing.

Conclusion III: There will be a remarkable increase in the number of small enterprises in the cotton textile sector after China's entry into the WTO, due to the low threshold for the enterprises to enter into this sector. Due to their institutional flexibility and creativity, the role of small enterprises in promoting economic growth and employment opportunities should not be underestimated. Meanwhile, the environmental problems caused by small enterprises are noticeably serious, due to their own characteristics and poor management. If effective management practices are not introduced, the drastic increase in the number of small enterprises will bring about some negative impacts on the sector's development and on the environment. Given the fact that the cotton textile sector consumes a huge amount of resources and generates serious pollution, effective policy control is desirable to control the excessive expansion in the scale of this sector and to avoid unplanned expansion, and low-level duplication in construction and production.

Conclusion IV: The simulation based on the production factor model indicates that technological progress is one of the most important factors in enhancing cotton textile industry development in China. At present, the technological level and the technical efficiency of this sector is lower than the average level of the textile industry, so there will be considerable room for advancing technologies in this sector. Relevant studies show that the huge resources consumption and pollution of this sector are significantly related to the technological level of this sector. Therefore, advancing the technological level in this sector can partially offset the negative impacts brought by the expansion in sectoral scale on the environment and natural resources. This will also play a positive role in promoting the development of this sector and protecting the environment.

Conclusion V: The simulation based on the production factor model indicates that the cotton textile sector has high capital elasticity, and improving capital structure and deployment will play a positive role in the sector's development. Measures, such as promoting cyclic economy and cleaner production, could be taken to decrease production costs, save capital and improve labour and production efficiencies. The win-win for both economy and the environment can be accomplished through the use of capital elasticity.

Conclusion VI: In 2000 there were 4,888 normally operating sets of wastewater treatment equipment in the textile industry that were capable of treat-

ing nearly one billion tonnes of wastewater from this sector. Based on the above projection, the amount of wastewater discharged from this sector will rise to 1.7 billion tonnes and two billion tonnes respectively by 2005 and 2010. This means that the wastewater treatment capabilities need to be doubled by then to cope with the treatment of increased amounts of wastewater from this sector.

Based on the above studies, analysis and projections, some preliminary conclusions can be made.

First, the target of this study is those enterprises with a certain scale, considering the accessibility of data for this study. Therefore, those enterprises under a certain scale have not been included in the scope of this study. However, as known to all, the technological level and the environmental protection capabilities of these enterprises are much lower than those enterprises that have been included in this study. In addition, the fact is that the enterprises of this kind are many in number and small in scale, so their cumulative impacts on the environment may be even greater than those of larger enterprises.

Second, in general, there are some problems with the construction and operation of wastewater treatment facilities in China. Relevant statistics indicate that the rate of normal operation of pollution abatement facilities is considerably low, only half the total facilities are operational. It can be inferred from this that it is important to upgrade the rate of normal operation of the existing facilities in addition to increasing new facilities necessary for pollution treatment.

4. Policy Recommendations

As quota controls will be completely eliminated by 2005 after China's entry into the WTO, the cotton textile sector of China faces unprecedented development opportunities. In this situation, environmental protection also faces new challenges and opportunities. The following recommendations are proposed to enhance the win-win opportunities for the environment and the cotton textile sector, based on the results of this work.

1. ***To strengthen coordination and cooperation among the environment, cotton textile sector management and trade departments to promote mutual benefit.***

   The fundamental goal of China's development in a new era is to achieve sustainable development by following the scientific concept of development. As a pillar of China's economy, the textile industry must follow the principles of sustainable development and should play an important role in comprehensively enhancing the achievement of societal well-being

(Xiaokang). Environmental problems caused by the textile industry should be addressed and resolved in the process of its development. To this end, sector management, trade and the environmental departments must work together closely to formulate an integrated strategy in this regard.

As the Ministry of Textile Industry was removed, the environment management department within that Ministry also disappeared. For a long time, environmental management of the textile industry and relevant environmental statistics have been in a state of drift. In addition, the Tenth Five-Year Development Plan for the Textile Industry has not identified sustainable development and the environment as priorities. There are no specific provisions regarding the environment in that plan. If such a situation continues, the increasing environmental and resource problems brought by the textile industry will impose huge pressures on the environment and ecosystems, and consequently affect the sustainable development of the industry. Therefore, the environment department should strengthen supervision and management of the textile industry. Within the textile industry, an institution should be established to work with the environment department. The environment department and the industry management department should establish a mechanism for coordinated environmental management, including formulating the sector plan for environmental protection; developing and enforcing relevant environmental standards; and strengthening the environmental supervision and management of the textile industry.

2. ***To intensify the efforts of industrial restructuring to abate the pollution caused by its irrational industrial structure.***

The cotton textile sector is one of the major polluting sources of the textile industry. One important way to address the environmental problems of the cotton textile sector is to intensify the efforts of industrial restructuring. On the one hand, relevant policies should be further strengthened to control the expansion in industrial scale, to avoid unplanned investment, construction and production and low-level duplication in construction and production. In particular, the environmental standards for new enterprises must be upgraded to increase the environmental threshold for the enterprises to enter into this sector. On the other hand, an overall strategy will be formulated for industrial restructuring, upgrading the international competitiveness of products and strengthening environmental protection. The renovation of the traditional industry through adoption and application of new, high-level technologies should be encouraged to promote the upgrading and generational changes of the sector's products. Active efforts should be made to introduce and develop those technologies and processes that could decrease

energy resource consumption, produce little pollution and generate high yields. This helps abate the pollution caused by the irrational structure of the cotton textile sector.

3. ***To implement a new strategy for raw materials by taking advantage of the pollution-reduction opportunities arising from entry into the WTO.***

   As a result of joining the WTO, China will gradually decrease its tariffs for imports of cotton, dyes and textile machinery. This makes it possible for the enterprises in this sector to use international resources. The use of agricultural chemicals and fertilizers in cotton plantations usually has some impacts on soil and water. The production and use of dyes also generates pollutants. If raw materials of high quality and low price can be obtained in the international market, this should also be considered as a win-win strategy in terms of both the environment and economy.

4. ***To strengthen environmental supervision, particularly of small and medium-sized enterprises, in accordance with the characteristics of this sector.***

   The efforts to intensify pollution prevention and control in this sector must be combined with environmental management of the cotton textile sector. Considering the dominant position of small and medium-sized enterprises in this sector, and that there has been a drastic increase in the number of such enterprises after China's entry into the WTO, the environmental problems caused by SMEs are remarkable due to their technological constraints and limited scales of investment. Therefore, the following should be done to improve environmental management of this sector, with due consideration given to the characteristics of this sector:

   i) Strong environmental management must be a necessary condition for approving new enterprises. The rules of environmental impact assessment and of three simultaneities must be strictly followed in approving new enterprises in order to increase the environmental threshold for new enterprises to enter into this sector.

   ii) Active efforts should be made to promote the rapid development of industrial concentration by following the basic concepts of specialized distribution and reciprocity. Since the SMEs in the cotton industry mushroomed after entering the WTO, we should draw lessons from the textiles of Zhejiang. In Zhejiang, they established the system that the industry forms a complete chain of production and processing and cooperates in which enterprises are centralized in the areas and division of labour occurs on the basis of specialization. We can establish production groups and the marketing groups of SMEs through these lessons. According to the laws and regula-

tions of national environmental protection, the market control departments can develop the sewage disposal centres through measures such as imposing environmental taxation on SMEs. In this case, the control of the pollution of SMEs can be concentrated. The concentrated processing of discharges from small enterprises will help decrease the cost of pollution abatement as well as environmental management of these enterprises.

iii) While supervising and managing SMEs in accordance with the national policy for industrial pollution prevention and control, some special policies should be adopted for SMEs in accordance with their own characteristics to encourage them to implement environmental management. For example, assistance should be provided to SMEs to address their problems of diseconomy of scale. While implementing the polluter-pay principle, the control of the pollution of SMEs should be concentrated so as to reduce their cost of control. The governments should provide financial assistance to SMEs to implement some pollution prevention and control projects and adopt and implement cleaner production, including establishing special trust funds, fundraising and providing low-interest or no-interest loans.

iv) Law enforcement and environmental management and supervision must be strengthened, considering the fact that some SMEs do not take the initiative to implement environmental management and there are many cases of violations of environmental laws and environmental management rules.

5. *To upgrade technological innovation capabilities of the cotton textile sector and to promote technological progress in this field.*

The study shows that the technological level and efficiency of the cotton textile sector is lower than the average level of the textile industry, which results in a major contribution of this sector to pollution and to the consumption of natural and energy resources. Therefore, efforts should be made to enhance technological innovation in this sector by introducing international advanced technologies and equipment and strengthening capabilities of technological innovation on its own. In connection with the industrial restructuring, more environmentally friendly technologies, equipment and processes, as well as the life-cycle control, should be adopted and used to reduce the use and the waste of natural resources and minimize environmental pollution.

6. *To strengthen dyeing wastewater treatment.*

   The projection based on the models indicates that there will be a substantial increase in the production of dyed and printed cloth. However, there will not be an obvious increase in the output of bleached cloth, so there will be a smaller increase in the amount of wastewater discharged from cloth bleaching, with pollution maintained at the current level. In contrast, there will be an obvious increase in the amount of wastewater discharged from dyeing. It can be projected for the near future that the main environmental problem of the cotton textile sector will still be wastewater discharge from the dyeing processes. The increased portion of dyeing wastewater will add difficulties to wastewater treatment. Therefore, it is important for this sector to abate the pollution from dyeing wastewater. Therefore, the following should be done to improve the environment management of this sector:

   i) The government should provide tariff relief and related policies to support enterprises in bringing in equipment to dispose of dyeing wastewater.

   ii) Administrative measures must be taken to close down those enterprises that cannot meet the standards of pollutant discharge even after efforts are made to reduce the pollution.

7. ***To promote sustainable development of the cotton textile industry by benefiting from the international trends in environmentally friendly and green consumption patterns.***

   The cotton textile sector is prone to influences from the outside. As China removes its quota controls, the export of cotton textile products will show strong growth. In this context, increasing environmental standards of other countries will require enterprises in this sector to improve their environmental image. This will facilitate the sustainable development of this sector. The governments, relevant sector associations and enterprises should take a positive attitude and use this trend to their benefit. By strengthening publicity, providing guidance and establishing various preferential policies, more enterprises should be encouraged to implement cleaner production and work towards certification of ISO 14000 EM and environmental labelling. The enterprises in this sector should be encouraged to adopt the concept of cyclic economy so that they can effectively manage and use the resources and wastes.

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China's accession to the WTO has been the most important recent development in trade policy—for China and for the WTO as a whole. The impact on China's economy has been profound. The impact on the environment has also been significant.

This report by the Task Force on WTO and Environment of the China Council for International Cooperation on Environment and Development looks at six sectors where the environmental impacts are the most pronounced: agriculture, forestry, aquaculture, automobiles, energy and textiles.

These sectoral studies represent the most comprehensive assessment of the environmental consequences of trade liberalization policies undertaken by any country to date.

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