The Impact of China and Taiwan Joining the World Trade Organization on U.S. and World Agricultural Trade: A Computable General Equilibrium Analysis. By Zhi Wang, Commercial Agriculture Division, Economic Research Service, U.S. Department of Agriculture. Technical Bulletin No. 1858.

Abstract

This report quantifies the potential impact of China's and Taiwan's accession to the World Trade Organization on U.S. and world agricultural trade by means of a 12-region, 14-sector computable general equilibrium model for world trade and production. Integrating China and Taiwan into the global trading system could increase total world exports by as much as $78 billion (1992 constant prices), total world imports by $94 billion, and world real consumption by $45 billion annually, as well as induce more competition on labor-intensive products and reduce their prices. It could drive up the demand for capital- and skill-intensive manufactured goods, thus further improving industrial countries' terms of trade. The expansion of labor-intensive sectors in China could also induce contraction in agricultural exports from China and increase its net agricultural imports by as much as $8.4 billion annually, causing food and agricultural exports from other regions to increase. Total U.S. food and agricultural exports could increase by as much as $2.2 billion annually, with the non-grain crops and processed food sectors gaining the most. The biggest winner from China's WTO accession is China itself. WTO membership could bring a net welfare gain of about $20 billion a year for China, a substantial benefit compared with the gains for the United States.

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Summary

Both China and Taiwan are important players in international trade, and their roles will likely increase as China continues to industrialize. A World Trade Organization (WTO) without China and Taiwan as members will have difficulty in claiming to represent the global economy. Admitting China and Taiwan into the WTO would result in greater market access for U.S. agricultural products. By using a 12-region, 14-sector computable general equilibrium model for world production and trade, this report estimates that a WTO including China and Taiwan could raise U.S. real consumption by about $7.4 billion (0.12 percent of 1992 GDP) per year, U.S. food and agricultural exports by about $2.2 billion annually, and farm income for all U.S. farmers except rice growers.

Negotiations between China and the WTO members are still ongoing. China has to reform its foreign trade regime and further improve market access in order to gain entry to the WTO. Implementing reform measures according to WTO disciplines implies a substantial reduction in tariffs and non-tariff barriers in one of the world's largest and most rapidly expanding markets. The world economy and trade patterns will be affected. To better understand the future of the global economy into the next century, this report evaluates the impact of China's and Taiwan's accession to the WTO on U.S. and world agricultural trade. It shows that the comparative advantages of China, Taiwan, and the United States are in different economic sectors. As China, ASEAN, and South Asia compete for the labor-intensive goods market in developed countries and attract foreign direct investment, Japan, the EU, and the United States would compete for the technology/capital-intensive goods market and investment opportunities in China and other Asian developing countries.

Integrating China and Taiwan into the global trading system could have the following effects on world and U.S. agricultural trade:

- Total world exports could increase by as much as $78 billion, total world imports by $93 billion, and world real consumption by $45 billion annually (1992 prices).

- Net exports of labor-intensive products from China could increase dramatically, by about $40 billion a year. Competition in the world labor-intensive goods market would stiffen, demand for capital and technology-intensive products would go up, causing prices for textile and apparel to decline and prices for capital- and technology-intensive goods to increase worldwide, thus improving industrial countries' terms of trade (U.S. terms of trade could increase more than 1 percent).

- China's labor-intensive sector would expand and its agricultural exports contract; net food and agricultural imports could rise by $8 billion per year, causing food and agricultural exports from other regions to increase.

- In world grain markets, China and Taiwan would increase their net grain imports by $574 million and $95 million respectively (about 1.8 percent of base-year world grain exports), putting some upward pressure on world grain prices, especially for feed grains.

- Total U.S. trade would increase by $17 billion. Returns to land and skilled labor would increase; wages of unskilled labor would decline slightly.

- U.S. imports of textile and apparel would increase by about $12 billion, while exports of technology and capital-intensive manufactured goods would increase by $2.4 billion.

- U.S. food and agricultural production would expand by 0.4 percent, with output increases in all sectors except rice. Total U.S. farm exports would increase by $2.2 billion, most of which would go to China ($1.1 billion) and Taiwan ($0.9 billion), and the rest to Japan, Korea, and Hong Kong. Production and export expansion would attract more production factors into the U.S. food and agricultural sector and reallocate land resources.

- At the commodity level, the largest gain in exports would come from processed food sectors ($1.15 billion) followed by exports of non-grain crops ($662 million), feed grains ($274 million), and livestock products ($102 million). Exports of rice and wheat would decline slightly ($15 and $2 million), since in the simulations we do not assume any changes in the protection rate for rice and wheat in China and Taiwan.

- The increased price for U.S. food and agricultural exports and more efficient use of production resources translates into higher value-added in farm products, thus raising farm income. Total income earned for all crops except rice would increase because of China's and Taiwan's WTO accession, with feed grain and non-grain crops gaining the most (about 1 percent).

- A WTO with China and Taiwan would expand U.S. food and agricultural export market shares in Asia, including China (2.2 percentage points), Taiwan (5.2), Hong Kong (1.2), Korea (1.2), and the ASEAN countries, and make significant differences in rising U.S. shares of the feed grain and processed food markets.

However, the biggest winners from China's and Taiwan's WTO accession are China and Taiwan themselves. WTO membership would raise social welfare in China by about $20 billion per year ($4 billion for Taiwan). This is substantially more than the welfare gains for the United States from China's and Taiwan's WTO membership. Continuing unilateral liberalization by China and Taiwan in the post-Uruguay Round environment is necessary to avoid trade diversion resulting from other countries' trade liberalization.

There are important limitations of the analysis. It uses a stylized representation of the trade liberalization measures undertaken by China and Taiwan to meet the requirements of WTO accession. It focuses on tariff reductions and does not take account of China's pervasive non-tariff barriers (such as import quotas) and state trading behavior. Another shortcoming is that the model uses the same trade elasticities across all regions. In addition, it does not take into account other major aspects of WTO membership such as protection of intellectual property rights, enforcement of commitments, and cooperation in dispute settlement. The results, therefore, need to be interpreted with caution and may be best understood as indicative of real outcomes.

Abbreviations

APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of South-East Asian Nations
CEA	Chinese Economic Area (China, Hong Kong, and Taiwan)
CES	Constant Elasticity of Substitution
CET	Constant Elasticity of Transformation
C.I.F.	Cost, Insurance, and Freight
CGE	Computable General Equilibrium Model
EV	Equivalent Variation
FDI	Foreign Direct Investment
F.O.B.	Free on Board
GAMS	General Algebraic Modeling System
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GNP	Gross National Product
GTAP	Global Trade Analysis Project
HS	Harmonized Commodity Description and Coding System
ISIC	International Standard Industrial Classification
MFA	Multi-Fiber Arrangement
OECD	Organization of Economic Cooperation and Development
PPP	Purchasing Power Parity
ROW	Rest of the World
SAM	Social Accounting Matrix
WTO	World Trade Organization

The Impact of China and Taiwan Joining the World Trade Organization on U.S. and World Agricultural Trade

A Computable General Equilibrium Analysis

Zhi Wang

Introduction

For more than 30 years, Japan has been the economic center of Asia. But since the late 1980's, the Chinese Economic Area (CEA)—embracing China, Hong Kong, and Taiwan—has rapidly emerged as a new center for industry, commerce, and finance. It is currently the world's fastest growing economy in terms of investment, industrial expansion, and income and export growth. The emerging prominence of the CEA amplifies a key challenge to the World Trade Organization (WTO): how to integrate both China and Taiwan into the WTO.

Taiwan has long been an important trader in the world market. Market-oriented economic reforms during the last two decades and integration with Hong Kong have also made China a major player in international trade, with a total trade volume of $280.8 billion in 1995.[1] Since 1990, both China and Taiwan have been among the 15 largest trading countries in the world.

Since the early 1990's, China has been a leading market for foreign direct investment (FDI). In 1991-93, China was the largest single recipient of FDI among developing countries, receiving more than 20 percent of total capital inflows. Its FDI exceeded the combined total for Mexico, Argentina, Thailand, and Indonesia, which were the next four largest FDI recipients among developing countries. FDI (realized) in China reached $33.9 billion in 1994 and $37.8[2] billion in 1995, making China the second largest FDI recipient country in the world after the United States. This trend will likely continue in the future since the FDI to China is motivated not only by the search for low-cost production bases, but also by the opportunities provided by China's domestic market potential. A WTO without China and Taiwan as members will have difficulty in claiming to represent the global economy.

China withdrew from the GATT in 1950 and has applied to join the organization and its successor, the WTO, since 1986. A series of liberalization measures has been adopted by China in recent years to accelerate its market-oriented reform and bid for GATT/WTO readmission.

At the beginning of 1993, China reduced its tariffs on 3,371 import items and abolished import control of more than 367 commodities. The action reduced the trade-weighted average tariffs by 7.3 percent (Zhang and Warr, 1995). At the Asia-Pacific Economic Cooperation (APEC) summit meeting in November 1995, China's President Jiang Zeming made a commitment to cut average tariffs by at least 30 percent in 1996. According to China's General Administration of Customs, this new liberalization effort includes substantial tariff cuts on 4,994 tariff lines and lowers China's simple average tariff to 23.2 percent. China also eliminated quotas, licensing, and other import controls on 176 tariff lines, or more than 30 percent of commodities subject to these restrictions.[3]

Despite the dramatic decline in tariff barriers, however, the average nominal tariff rate is still too high to justify China's WTO membership. After eight rounds of multilateral talks on global trade, average tariff rates of developed countries have dropped from 40 percent in

[1] *China's Customs Statistics*, General Administration of People's Republic of China, Economic Information Agency, Hong Kong, December 1995, p.3.

[2] *China Statistical Yearbook, 1996*, State Statistical Bureau, Beijing, People's Republic of China, p. 598.

[3] *China Daily*, English edition, April 1, 1996, p. 1.

1948 to 4.7 percent in 1995. A simple average tariff of 15 percent is currently maintained by most developing countries. After implementation of the Uruguay Round, the tariff rate of WTO contracting parties will fall even further. China needs to continue implementing its commitment to further trade liberalization in order to gain WTO accession.

Negotiations between China and the WTO members are still ongoing, and China offered to reduce its average tariff by 62 percent from the 1992 level upon its accession, and will continue to lower its overall tariff to about 15 percent by the year 2000. As China's bid for WTO membership continues, and after China formally enters the world trading system, further reforms of its foreign trade regime are expected.

Implementation of these reform measures implies a substantial reduction in tariffs and non-tariff barriers in one of the world's largest and most rapidly expanding markets. Obviously, the world economy and trade patterns will be affected. What opportunities will the growing and liberalizing of Chinese markets likely bring to developing and developed countries around the world? What challenges will other countries face as the tremendous and low-cost Chinese labor force is integrated into the world economy? How will the increase in the export competitiveness of China's products affect world markets? What are the economic con- sequences for China and major WTO contracting parties, especially the United States, if China is excluded from the WTO and does not implement its liberalization commitments? To better understand the future of the global economy into the next century, we must analyze how and to what extent China's WTO accession would influence patterns of world trade, and evaluate the benefits and costs of Chinese and Taiwanese access to the WTO from both a U.S. and a global perspective.

This report evaluates the potential impact of China's and Taiwan's WTO accession on world trade with particular emphasis on its impact on U.S. agriculture. It estimates aggregate and sectoral gains and losses to trade, and provides an economic explanation for changing patterns of world trade. The evaluation, using a multi- region, multi-sector computable general equilibrium (CGE) model for world trade and production, focuses on differences arising from the Uruguay Round trade liberalization on agricultural and manufactured goods with and without China and Taiwan. The model includes China's major trading partners and covers major production and trade activities in the world economy in order to capture third-country and general equilibrium effects. However, the analysis at best captures only one aspect of the issue. It does not take into account other major aspects of WTO membership, such as complete removal of non-tariff measures, reduction of barriers in service trade and foreign investment, protection of intellectual property rights, securing of market access, enforcement of commitment, and cooperation in dispute settlement.

Factor Endowments and Net Trade Patterns

The CGE model used in this analysis is constructed around a 12-region, 14-sector Social Accounting Matrix (SAM) estimated for 1992 based on the Global Trade Analysis Project (GTAP)[4] database (Hertel, 1997). Details of this type of multi-regional SAM and its construction from the GTAP database are described in Wang (1994). The 12 regions are: (1) the United States, (2) Canada, (3) European Union (EU) (12 member countries), (4) Australia and New Zealand (AUS/NZL), (5) Japan, (6) Korea, (7) Taiwan, (8) Hong Kong, (9) China, (10) Singapore, Malaysia, Thailand, Philippines, and Indonesia, or the original Association of South East Asian Nations (ASEAN), (11) South Asia (India, Bangladesh, Nepal, Pakistan, Sri Lanka), and (12) Rest of the World (ROW). The 14 sectors include five agricultural sectors: (1) rice (including processed rice), (2) wheat, (3) other grains (most are feed grains), (4) non-grain crops, and (5) livestock; two food processing sectors: (6) meat and milk products, (7) other processed food; two natural resource sectors: (8) forestry and fishery, (9) mineral and energy; four manufacturing sectors: (10) textile and wearing apparel, (11) other light manufactures, (12) manu- factured intermediates, (13) machinery and transportation equipment; and (14) transportation, construction, and services, a portion of which is allocated to international shipping. The correspondence between the model and GTAP sectors as well as to the International Standard Industrial Classification (ISIC) is given in appendix table A.1.

This section outlines the base-year factor endowments, structure of net trade, and comparative position of each

[4] The Global Trade Analysis Project (GTAP) is a research project conducted at Purdue University. This is a global database and a standard modeling framework. The database (version 3, pre-release) is the major data source for the model used in the study.

economic region included in the model, and briefly describes the patterns of protection among the relevant regions. The purpose of this SAM-based data analysis is to provide an overview of each region's comparative advantages, structure, and trade linkages among the regional economies so as to facilitate understandings of simulation results reported later in this paper.

Factor Endowments

Table 1 presents the data on factor endowments, intensity, cost, and the relative size of the economic regions included in the model. It reveals several salient features of the world economy:

1) Production resources are unevenly distributed across the world.

The five high-income regions (USA, Canada, Japan, EU, and AUS/NZL) account for only 15 percent of the global labor force, but possess more than 75 percent of the world's capital stock. In contrast, more than half of the global labor force with less than 4 percent of the world's capital resides in the three low-income developing regions (ASEAN, China, and South Asia). The five high-income regions are also relatively abundant in skilled labor, since their skilled-labor share in the world is two or three times more than their world share of total labor force, while the same share is much smaller relative to their total labor endowment in China, ASEAN, and South Asia.

The United States, Canada, AUS/NZL, and ROW are relatively abundant in land (their land share in the world is larger than their labor share), while other regions are relatively abundant in labor (their labor share in the world is much larger than their land share).

2) Uneven distribution of factor endowments induces wide differences in factor intensities and costs among regions.

China and South Asia, as low-income developing countries, are poorly endowed with capital relative to labor. They have the lowest capital intensity (capital stock per worker), the largest shares of agricultural labor in their total labor force (around 60 percent of their labor force is in agriculture), and the highest rental-wage ratios. The reverse is true for the five high-income regions, while Korea and Taiwan, as newly industrialized economies, fall somewhere between the advanced high-income countries and those poor developing countries. Their agricultural labor share is much larger than that of high-income countries, but only one-third that of low-income developing regions. Their labor costs are only a third or fourth of high-income countries', but much higher than those of low-income developing regions. Compared with OECD, they have a much lower capital intensity, but a higher rental-wage ratio (table 1).

In terms of natural resources, Japan, Korea, Taiwan, and China are poorly endowed with arable land relative to labor. Therefore, they have the lowest land/labor intensities (arable land per worker) and relatively higher land returns (relative to labor and capital) compared with other regions. This is just the opposite of conditions in North America, AUS/NZL, and ROW. Land, as an abundant factor, earns a relatively lower return there. These factor endowment differences are quite important for understanding net trade flows across regions based on conventional trade theory.

Net Trade Patterns

Trade theories generally identify two types of international trade. Among developed industrial countries with similar endowments and technology, intra-industry trade is more common[5] whereas between high- and low-income economies with different factor endowments and stages of technology development, trade is still on an inter-industry basis. In our model, all trade data refer to trade with economies outside that region; trade flows within the region were netted out and treated as another source of domestic demand when the model database was constructed. The nature of the trade data in our model and the wide range in factor endowments and stages of economic development of the related regions suggest that perhaps the traditional Heckscher-Ohlin arguments (based on different factor endowment) may explain the trade pattern among them to a large extent.

Table 2 presents data on sectoral net trade by region in the base year. They show that, among the industrialized countries, labor-intensive manufactured goods (textile and apparel, other light manufactures) and mineral products are the major net imports (except Canada and Japan in other light manufactures), while capital- and skill-intensive manufactures (manufactured intermediates, machinery and equipment) are the major net export sectors (except for machinery and equipment in

[5] This refers to the trade between industries that produce commodities with similar input requirements and high substitutability in use, such as cars with similar characteristics, but manufactured by different producers.

Table 1--Factor endowment, intensity, and relative size of model regions, 1992

Item	USA	Canada	EU12	AUS/NZL	Japan	Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW
GDP and trade flows:						*Billion U.S. dollars*						
GDP	5943.72	572.33	7034.24	323.22	3644.92	307.31	211.46	76.51	384.43	389.46	325.85	3905.87
Exports	573.77	140.00	734.03	55.85	378.37	83.38	91.99	43.96	100.81	176.03	39.57	677.28
Imports	640.54	143.99	788.82	59.24	309.48	90.23	83.32	62.56	103.29	183.18	45.41	763.97
Relative size in the world:						*Percent*						
GDP	25.71	2.48	30.43	1.40	15.77	1.33	0.91	0.33	1.66	1.68	1.41	16.89
Exports	18.54	4.52	23.72	1.80	12.23	2.69	2.97	1.42	3.26	5.69	1.28	21.88
Imports	19.56	4.40	24.09	1.81	9.45	2.76	2.54	1.91	3.15	5.60	1.39	23.33
Share in the world factor endowment:						*Percent*						
Land	12.62	3.06	5.52	3.45	0.30	0.14	0.06	0.00	9.39	3.81	13.73	47.91
Agricultural labor	0.25	0.04	0.80	0.05	0.34	0.42	0.10	0.00	39.28	6.28	25.54	26.90
Unskilled labor	7.73	0.91	10.59	0.65	4.52	1.23	0.62	0.24	19.50	5.73	12.27	36.01
Skilled labor	14.05	1.22	11.75	0.84	3.74	0.68	0.34	0.16	23.70	3.05	5.60	34.87
Total labor	5.13	0.56	6.40	0.41	2.59	0.81	0.36	0.13	28.68	5.68	17.39	31.87
Capital	23.30	2.21	30.58	1.69	17.48	1.02	0.57	0.41	1.43	1.43	1.06	18.81
Factor share in value added:						*Percent*						
Land	0.32	0.63	0.38	1.43	0.84	5.65	1.98	0.05	9.30	5.26	7.42	2.64
Agricultural labor	0.68	1.64	2.33	1.06	1.80	5.15	4.23	0.05	22.18	4.56	14.31	3.25
Unskilled labor	35.69	34.65	35.04	35.56	42.24	35.72	43.04	28.87	17.66	16.64	28.21	25.92
Skilled labor	28.39	20.78	20.08	22.91	14.76	8.74	10.30	18.93	14.48	8.41	7.27	17.34
Total labor	64.76	57.07	57.44	59.53	58.80	49.60	57.58	47.85	54.32	29.60	49.78	46.51
Capital	34.93	42.30	42.18	39.05	40.37	44.74	40.45	52.10	36.38	65.13	42.80	50.86
Skill distribution of regional labor force:						*Percent*						
Agricultural labor	2.15	2.96	5.51	5.3	5.79	22.63	12.14	1.08	60.37	48.79	64.75	37.21
Unskilled labor	67.72	73.06	74.3	72.03	78.31	68.17	77.41	84.98	30.54	45.3	31.7	50.75
Skilled labor	30.13	23.98	20.19	22.67	15.9	9.2	10.45	13.94	9.09	5.91	3.55	12.04
Annual wages:						*US$1,000 per worker*						
Agricultural labor	13.55	21.61	17.93	6.07	16.37	3.06	7.34	1.06	0.15	0.22	0.15	0.4
Unskilled labor	22.72	18.51	20.03	15.01	28.48	7.05	11.71	8.10	0.24	0.86	0.60	2.36
Skilled labor	40.63	33.81	42.24	30.73	49.03	12.77	20.77	32.39	0.66	3.34	1.38	6.66
Average wages	27.92	22.27	24.40	18.10	31.04	6.67	12.13	11.41	0.23	0.70	0.33	2.15
Land rent:						*US$1,000 per hectare*						
Av. land return	0.09	0.07	0.31	0.08	6.21	7.3	4.13	4.86	0.19	0.3	0.1	0.13
Capital return:						*Percent of capital stock*						
Av. capital return	11.72	14.73	13.26	10.06	11.16	16.93	19.01	13.49	10.73	21.48	16.67	14.07
Capital (Land) intensity:						*US$1,000 per worker*						
Capital/labor	128.53	112.04	135.15	117.98	190.97	35.54	44.81	92.13	1.41	7.13	1.73	16.71
						Hectares per worker						
Land/labor	1.50	3.33	0.53	5.18	0.07	0.10	0.10	0.00	0.20	0.41	0.48	0.92
Relative factor price:						Ratio						
Rental/wage	0.42	0.66	0.54	0.56	0.36	2.54	1.57	1.18	47.34	30.87	49.81	6.55
Land rent/wage	0.33	0.33	1.27	0.46	20.01	109.42	34.03	42.58	85.82	43.50	31.00	6.19
Rental/land rent	1.28	2.00	0.43	1.20	0.02	0.02	0.05	0.03	0.55	0.71	1.61	1.06

Data source: Calculated from the 1992 multi-regional SAM estimated by the author form Version 3 (pre-release) GTAP Database and additional factor endowment data collected by the author: Land and total labor (economically active population) endowment data are from the FAO *Statistical Year Book*, 1993. China's arable land number is based on ERS estimate (Crook, 1993). The disaggregation between skilled and unskilled labor was based on International Labor Office *Year Book of Labor Statistics*, 1993, and various statistical publications from various countries.

Table 2--Sectoral net trade by region, 1992

Commodity	USA	Canada	EU12	AUS/NZL	Japan	Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW
						Billion U.S. dollars						
Rice	0.68	-0.07	-0.06	0.07	-0.00	-0.00	0.01	-0.15	0.18	1.04	0.72	-2.40
Wheat	4.23	3.61	1.90	1.06	-0.95	-0.53	-0.15	-0.03	-1.28	-0.88	-0.94	-6.05
Other grains	5.57	0.37	0.66	0.34	-2.40	-0.72	-0.66	-0.01	1.15	-0.25	-0.00	-4.04
Non-grain crops	4.82	-1.22	-15.40	1.79	-7.13	-0.93	-0.99	-1.18	1.66	3.85	1.72	12.99
Crop subtotal	15.30	2.69	-12.90	3.26	-10.48	-2.18	-1.79	-1.37	1.71	3.76	1.50	0.50
Livestock	0.57	1.16	-2.55	4.23	-1.81	-1.39	-0.24	-0.83	0.67	-0.18	-0.30	0.66
Meat & milk	1.98	0.22	4.17	6.53	-6.53	-0.55	0.58	-0.73	0.38	-0.62	-0.14	-5.29
Other food	4.45	0.04	5.67	0.64	-9.56	-0.83	-1.35	-1.76	1.80	6.67	0.07	-5.84
Total agriculture	22.30	4.11	-5.61	14.66	-28.38	-4.95	-2.80	-4.69	4.56	9.63	1.13	-9.97
Forestry & fishery	0.63	1.13	-5.83	1.21	-13.27	-0.19	0.71	-0.66	0.61	4.53	0.81	10.33
Energy and minerals	-48.02	8.57	-66.50	10.59	-52.87	-14.06	-2.71	-3.91	2.09	7.97	-5.34	164.19
Textile & apparel	-25.11	-3.21	-12.97	-1.99	-4.19	11.38	10.53	3.71	14.09	8.13	11.23	-11.60
Other light manuf.	-31.89	11.52	-25.92	-2.88	4.42	7.81	9.97	0.63	12.04	11.49	2.07	0.74
Manuf. intermediates	5.64	0.65	31.69	-0.30	15.47	-0.42	-1.87	-4.95	-11.95	-18.50	-5.97	-9.50
Machinery & equipment	-12.00	-11.13	41.36	-17.94	208.73	2.08	7.34	-10.84	-20.18	-20.76	-8.49	-158.16
Services	57.25	-8.40	31.19	-4.04	-43.68	-3.31	-7.88	5.76	7.00	-0.16	1.38	-35.12
Total	-31.19	3.24	-12.59	-0.70	86.22	-1.63	13.30	-14.95	8.26	2.31	-3.16	-49.09

Data source: Calculated from the 1992 mulit-regional SAM estimated by the author from Version 3 (pre-release) GTAP Database (Hertel, 1997).

North America because of its large deficit with Japan). The United States, Canada, and AUS/NZL are net exporters of food and agricultural products, while Japan has an enormous surplus in machinery and equipment (US$208 billion) and a small positive balance in other light manufactures. AUS/NZL has a surplus in all natural resource-based sectors but a deficit in all manu- factured goods. The rest of the world, as a natural resource-abundant region in the model, is a net exporter of minerals and all other resource-based products except food grains, and is a net importer of almost all manufactured commodities.

The trade patterns of China, ASEAN, and South Asia exhibit some similarities. They are all net importers of capital-intensive manufactured products (manufactured intermediates, machinery and equipment) and net exporters of labor-intensive manufactures and other primary products. The largest share of the trade surplus in China comes from textile and other light manufactures ($26 billion), while the ASEAN countries are more diversified. Minerals, other processed food, and forest and fishery products also contribute a significant portion of their trade surplus, although labor-intensive light manufactures are the largest trade surplus sector ($20 billion) in the region. This is consistent with the region's abundant labor and natural resource endowment relative to other regions in the world, especially to those regions in Asia.

The net trade data for Korea and Taiwan reveal that these two regions are net exporters of both labor-intensive manufactures (like the developing regions) and skill/capital-intensive manufactured goods (like the industrialized countries) on the one hand, and net importers of mineral products from developing countries on the other hand.

In world food and agricultural commodity markets, the United States, Canada, and AUS/NZL are net exporters, while Japan, Korea, and Hong Kong are net importers in all products. The EU is a net exporter of wheat, other grains, and processed food, but a net importer of rice, non-grain crops, livestock, and forest and fishery products. Taiwan, ASEAN, and South Asia are net exporters of rice, non-grain crops, and forestry and fishery products, but net importers of wheat, other grains, meat and milk, and livestock. China imports wheat while exporting rice, other grains, and non-grain crops, and is largely self-sufficient in livestock products. However, the surplus in agricultural trade reflects China's food self-sufficiency policy rather than its international comparative advantage.

Comparative Position of Each Region According to Its Factor Endowments

The data on net trade and factor endowments from the multi-region SAM reviewed above are generally consistent with intuition about these economies based on conventional international trade theory. At one extreme, China, ASEAN, and South Asia are seen as major competitors in labor-intensive nondurable manufactured exports and important importers of capital/technology-in-

tensive products. At the other extreme, the United States, Japan, and the EU are seen as major suppliers of capital/technology-intensive goods and as the final market for labor-intensive consumer products. Korea, Taiwan, and Hong Kong are intermediates between the two extremes: they are important suppliers of manufactured goods to China, and become both demanders and suppliers of technology/capital-intensive products from the United States, Japan, and EU, while still remaining important suppliers of labor-intensive goods for industrial countries.

Obviously, the comparative advantages of China, Taiwan, and the United States lie in different groups of economies. Tough economic competition occurs within each group, especially within the two extremes. This implies that the **United States and China are generally not competing economically, and their comparative advantages are primarily complementary to each other at their current stages of development.** As China, ASEAN, and South Asia compete for the labor-intensive goods market in OECD countries and attract FDI on the one hand, Japan, EU, and the United States will compete for the technology/capital-intensive goods market and investment opportunities in China and other Asia developing countries on the other hand.

AUS/NZL and the rest of the world are two special cases in the model. AUS/NZL is a land-abundant, high-income region, with structural features (capital intensity, shares of the service sector in the economy, and skill distribution of labor force) very similar to other industrialized regions. However, because its land/ labor ratio is much higher than that of other developed regions (even higher than in the United States and Canada), its comparative advantage lies in land-intensive sectors, leading to a trade structure distinct from other high-income regions. It has a trade deficit in all manufacturing sectors and more than 50 percent of its capital/ skill-intensive manufactures are imported from abroad.

The rest of the world, as a composite region in the model, exhibits many similarities with a middle-income country (with much higher capital intensity and a much smaller agricultural labor force than low-income countries). Therefore, its comparative advantage lies in medium-skilled and natural resource-based sectors. However, its external trade depends more on the EU market (50 percent of its imports are from the EU and 60 percent of its exports go to the EU) and on mineral products (30 percent of total exports), and its labor and semi-skill-intensive products face severe competition from Korea, Taiwan, and other Asian developing countries.

Domestic Tax Policy and Import Protection

Most general equilibrium analysis of regional economic liberalization focuses on the removal of *ad valorem* tariff equivalents on imports. The pattern and level of protection are very important in determining the impacts of trade liberalization. The larger the initial distortion, the greater the induced impact from an assumed policy change. For this analysis, the impact of China's and Taiwan's WTO membership (via participation in Uruguay Round trade liberalization) depends on the structure of pre-Uruguay Round trade barriers in the estimated multi-regional SAM. The initial sectoral import protection rates as percentage of f.o.b. value, along with sectoral tax rates on exports and domestic production in each region, are presented in table 3. Note that these rates include the tariff equivalent of non-tariff barriers for agricultural and food products, quota rent of the Multi-Fiber Arrangement (MFA) on textiles and apparel in most developing regions, and antidumping duties for the United States, Canada, and the EU.[6]

The import protection rates show that there are substantial variations among commodity groups and across regions. Most food and agricultural sectors in Japan, Korea, Taiwan, and ASEAN are highly protected (higher than 100 percent in some sectors), especially for grains. The high protection rates reflect high tariffs and many non-tariff barriers, such as import licensing and quotas, in those countries.[7] The average protection rates in other sectors are generally low, especially for mineral and energy products. But higher rates of protection apply to certain commodities in some regions. For example, the United States, AUS/NZL, Korea, ASEAN, South Asia, and China impose relatively higher rates on imports of textiles and apparel. China and South Asia also impose relatively higher rates on machinery and transport equipment.

The domestic production and export tax equivalent rates presented in table 3 indicate that most regions in the model subsidize agriculture. Even South Asia subsi-

[6] As documented by Hertel (1997), the protection data in the GTAP database (version 3, pre-release) included not only tariffs, but also non-tariff barriers in the case of agriculture and textiles/wearing apparel, and antidumping duties for Canada, the European Union, and the United States.

[7] The import protection rates of agricultural products for China do not include non-tariff barriers, since there are no quantitative measures currently available.

Table 3--Ad valorem estimation for domestic tax and protection rate by regions, 1992

Item	USA	Canada	EU12	AUS/NZL	Japan	Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW
						Percent						
Import protection rates:												
Rice	4.5	5.8	67.1	1.1	43.1	77.9	81.0	0.0	0.1	46.4	18.4	14.9
Wheat	13.0	26.0	57.0	1.0	308.0	272.0	307.6	0.0	0.0	155.5	15.3	17.7
Other grains	0.4	24.0	74.0	0.2	336.0	327.0	325.6	0.0	10.1	295.5	43.8	11.9
Non-grain crops	47.5	23.8	50.0	3.4	42.0	51.7	72.9	0.0	17.7	44.5	26.5	31.9
Livestock	1.7	0.3	1.1	0.0	0.8	100.4	3.7	0.0	19.8	66.2	18.6	14.9
Meat & milk	25.0	44.1	73.8	16.0	299.3	113.8	51.6	0.0	39.1	95.2	22.2	35.4
Other food	4.5	5.4	12.3	5.3	12.9	34.6	29.1	0.0	51.7	25.8	42.3	24.4
Forestry & fishery	1.4	0.1	5.4	0.1	3.5	8.8	15.9	0.0	16.0	25.2	9.5	9.1
Energy and minerals	1.2	1.1	0.4	3.1	2.2	5.5	5.0	0.0	9.3	6.4	17.5	11.7
Textile & apparel	18.7	13.9	11.9	36.1	10.4	19.9	8.0	0.0	63.5	27.2	58.8	24.0
Other light manuf.	4.6	4.9	3.2	13.0	5.0	14.7	4.1	0.0	38.9	13.8	32.2	14.2
Manuf. intermediates	8.5	3.0	8.4	10.1	3.4	15.9	5.0	0.0	20.2	11.8	48.0	11.9
Machinery & equipment	11.8	3.3	7.6	13.7	1.3	16.5	7.6	0.0	32.3	14.6	34.1	14.3
Average	9.8	4.6	8.6	13.0	19.7	22.6	13.6	0.0	32.0	17.0	33.5	15.7
Domestic tax equivalents:												
Rice	-31.1	0.7	-0.1	0.6	-5.2	-24.8	0.8	0.0	2.2	-0.5	-2.3	0.3
Wheat	-32.4	-15.6	-6.3	-0.8	-14.8	0.3	1.0	0.0	1.0	0.0	-4.7	-1.5
Other grains	-30.6	-6.5	-2.5	-0.3	-16.4	-8.1	0.0	0.0	2.5	-4.0	-0.6	-0.3
Non-grain crops	-5.2	-9.2	-71.0	0.1	-48.9	-36.7	1.0	0.0	4.1	-0.5	-2.2	0.0
Livestock	-3.6	-4.4	-9.2	0.7	-0.5	-14.5	1.8	0.0	0.9	0.7	0.5	-0.3
Meat & milk	-1.4	-14.1	2.8	2.9	-1.4	-3.0	2.1	0.0	2.8	1.3	3.2	-0.8
Other food	6.1	1.3	10.9	1.1	12.8	20.5	15.4	0.0	13.0	8.0	5.9	3.5
Forestry & fishery	2.1	2.0	-8.0	5.1	2.5	0.4	0.2	0.0	7.2	1.4	2.0	1.4
Energy and minerals	4.6	2.3	13.0	3.5	4.3	4.1	5.3	0.0	11.3	3.6	12.5	3.3
Textile & apparel	0.7	0.7	2.2	0.4	1.9	1.9	0.5	0.0	7.8	2.1	4.6	1.3
Other light manuf.	1.3	1.4	1.7	1.5	2.1	2.5	0.8	0.0	8.6	2.7	7.7	1.2
Manuf. intermediates	2.7	1.7	0.4	0.7	5.3	1.8	0.7	0.0	11.3	-0.7	9.4	1.8
Machinery & equipment	1.2	0.9	0.6	0.8	3.2	4.2	1.9	0.0	10.1	1.9	9.4	1.8
Services	5.9	4.5	2.3	2.2	3.2	4.1	2.6	0.0	7.7	2.3	3.7	2.4
Export tax equivalent:												
Rice	-1.2	0.0	-23.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Wheat	-16.7	-7.1	-67.5	1.1	-0.3	0.0	-0.1	0.0	0.0	0.0	0.0	0.4
Other grains	-1.3	-15.1	-70.6	1.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	-0.3
Non-grain crops	0.0	-5.0	-23.3	0.4	0.0	0.0	0.0	0.0	0.0	2.1	0.0	3.7
Livestock	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.5
Meat & milk	-6.2	-8.7	-46.3	-1.5	0.0	0.0	0.0	0.0	0.0	0.8	0.0	1.9
Other food	0.0	-0.2	-0.6	0.3	0.0	0.0	0.0	0.0	0.0	3.2	0.0	1.2
Forestry & fishery	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	5.1	0.0	1.4
Energy and minerals	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.1	1.9	0.0	4.2
Textile & apparel	0.0	0.0	0.0	0.1	0.0	5.8	5.7	12.5	13.0	22.1	19.3	8.4
Other light manuf.	0.0	0.0	0.0	0.6	1.3	0.4	0.6	0.5	0.0	2.9	0.0	0.1
Manuf. intermediates	0.4	0.1	0.3	0.5	1.0	0.4	0.6	0.1	1.5	3.6	1.2	3.5
Machinery & equipment	0.0	0.0	0.0	-0.8	5.1	1.9	2.3	1.9	0.0	6.1	0.2	0.2

Data source: Calculated from the 1992 multi-regional SAM estimated by the author from version 3 (pre-release) GTAP database (Hertel, 1997).

dizes some of its agricultural sectors. Only China and Taiwan tax agricultural production (although the tax rate is quite low). The United States, Canada, and the EU also heavily subsidize food and agricultural exports, and such subsidies are much higher in the EU than in North America. The export tax on textiles and apparel in Korea, Taiwan, Hong Kong, ASEAN, China, South Asia, and ROW is equivalent to quota rents generated from MFA. Exporters in these countries have to pay for the scarce export quotas before they can ship their exports. The effect of these quotas is similar to an export tax. Therefore, the economic distortion of those bilateral quotas are represented in the model by export tax equivalents, which differ by country of destination (Hertel et al., 1995).

All the structural information discussed above will have important implications for understanding the impact of China's and Taiwan's WTO memberships on trade patterns across regions. However, this informa-

tion cannot be considered in isolation, since changes in trade policies and protection levels in any of the regions and sectors will have impacts on other regions and sectors. It is on this point that the application of a CGE model that includes all major regions in the world can make a significant contribution to understanding and predicting the possible impact of China's and Taiwan's accession to the WTO on the trade pattern of other regions and U.S. agricultural exports to the world.

Structure of the Model

Twelve regions and 14 production sectors in each region are specified to represent the world economy. Each region is assumed to have basically the same structure. Four primary factors of production are modeled: agricultural land, capital, unskilled labor, and skilled labor. The division between skilled and unskilled labor is a distinction between professional workers and production workers.[8] Primary factors are assumed to be mobile across sectors, but immobile across regions.

Economic Agents and Factor Endowments

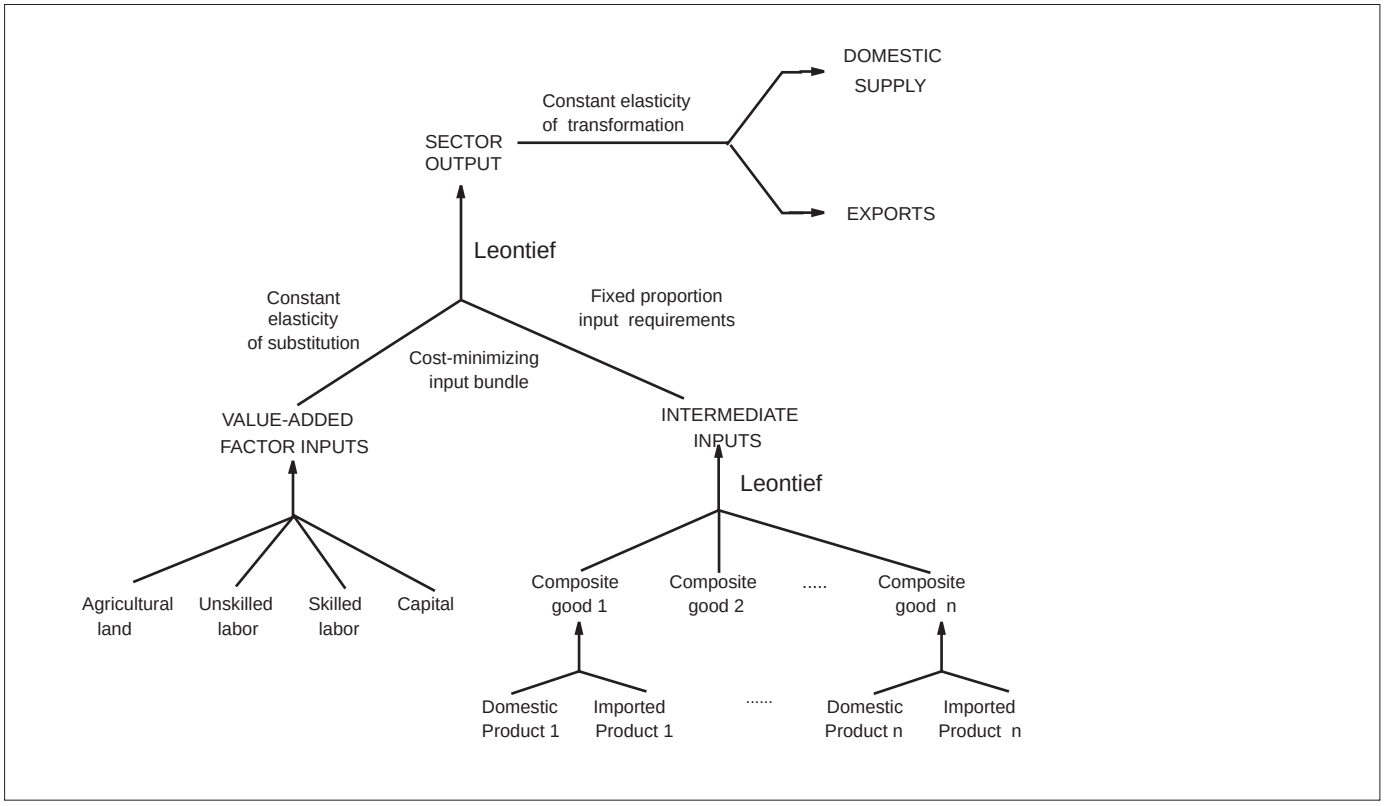
Three demand-side agents are assumed for each region: a private household, a public household (government), and an investor. Factor endowments are assumed to be owned by households and are set exogenously. Private households are assumed to sell the two categories of labor and to rent capital to firms, and to allocate fixed proportions of their factor returns to savings and expenditures, which buy final consumption goods from the firms. The investor simply collects savings from households, government, and firms, accounting for foreign capital inflows or outflows. Total regional savings is available to the investor as his budget to buy capital goods, which are assumed to consist of fixed proportions of the 14 composite goods for gross investment.

Production

Suppose there is one competitive firm in each sector for every region, which produces only one product. The production is characterized by two-level nesting. At the first level, there is a Leontief-type production function. Firms are assumed to use a composite of pri-

[8]Professionals include International Labor Office (ILO) occupation ground group 0-2 (professional, technical and related workers; administrative and managerial workers); production laborers are the aggregation of ILO occupation ground group 3-5 (clerical and related workers; sales workers; service workers) and 7-9 (production and related workers, transport equipment operators and laborers plus agricultural laborers).

Figure 1
Structure of production in the model



mary factors of production according to a CES cost function, and fixed-proportion intermediate inputs for the 14 composite goods. Strong separability of the production function is assumed at this level. There is no substitution between the composite primary factor and intermediate inputs. Technology in all sectors is assumed to exhibit constant returns to scale, implying constant average and marginal costs. At the second level, the four primary factors of production are assumed to substitute smoothly through a CES value-added function. The substitutability among them depends on their base-year shares in production and on the elasticity of substitution, which is assumed to be constant. The firm's output is assumed to be sold on the domestic market or exported to other regions through a constant elasticity of transformation (CET) function.

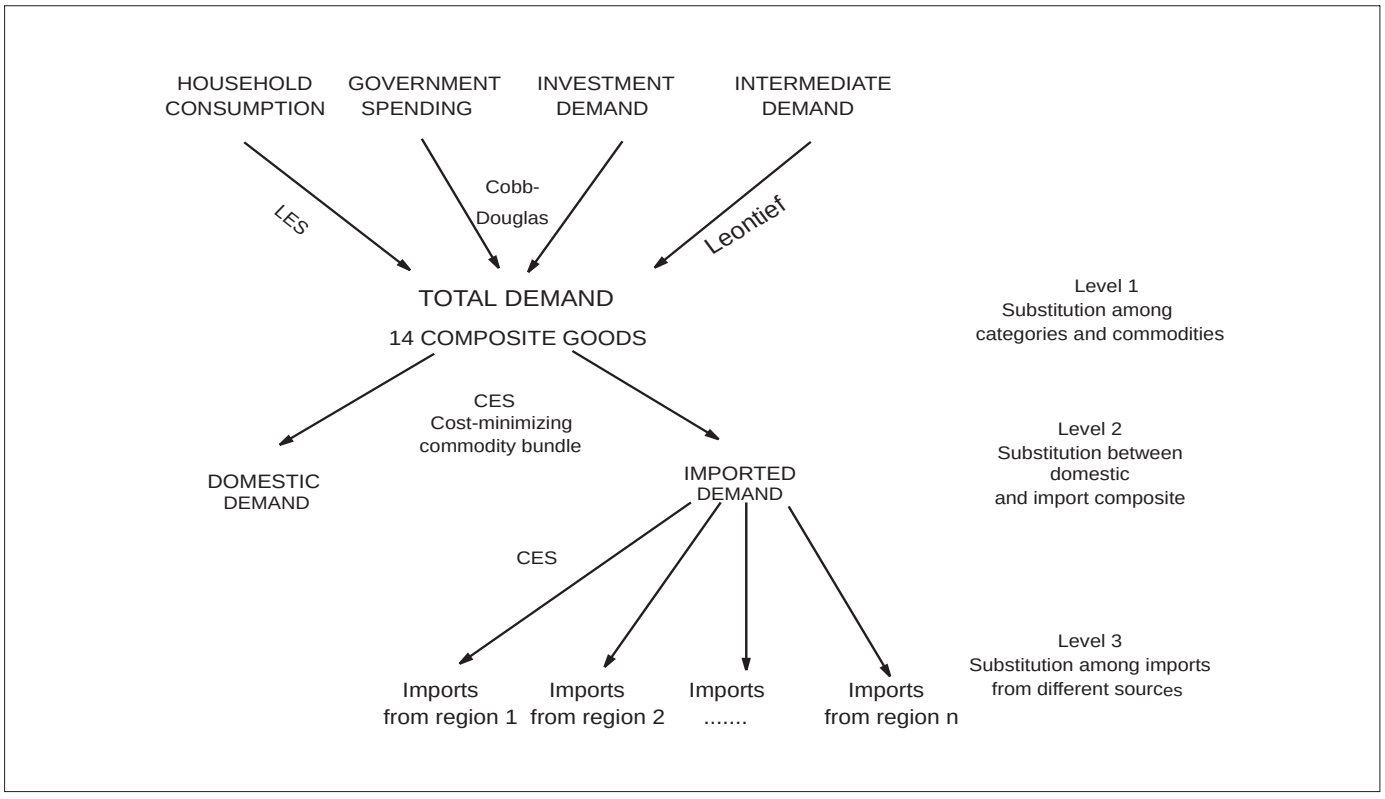
Demands

Agents in each region are assumed to value products from different regions as imperfect substitutes (the Armington assumption). Private households in each region are assumed to maximize a Stone-Geary utility function over the 14 composite goods, subject to their budget constraints. Government spending and investment decisions in each region are based on Cobb-Douglas utility functions, which generate constant expenditure shares for each composite commodity. In each region, intermediate inputs for the firms, household consumption, government spending, and investment demand constitute total demand for the same Armington composite of domestic products and imported goods from different sources. A two-level nested CES aggregation function is specified for each composite commodity in each region. The total demand is first divided between domestically produced and imported goods. Then the expenditure on imports is further divided according to geographical origin under the assumption of cost minimization. Sectoral import demand functions for each region are derived from the corresponding cost function according to Shephard's lemma. Complete trade flow matrices for all trade partners are part of the model solution.

International Shipping

There is an international shipping industry in the model to transport products from one region to another. Each region is assumed to allocate a fraction of the output of its transportation and service sector to satisfy the demand for shipping, which is generated by interregional trade. The global shipping industry is assumed to have a unitary elasticity of substitution among supplier sources. This means the margins associated with this

Figure 2
Structure of demand in the model



activity are commodity/route specific. In equilibrium, the total value of international transportation services at the world price equals the sum of the export proportions of the service sector's output from each region.

Trade-Distorting Policy

The government in each region is assumed to impose import tariffs, export subsidies, and indirect taxes, all in *ad valorem* terms. Tariff and tax (subsidy) rates vary by sector and by destination.

Price System

There are average output prices, composite goods prices, domestic consumer prices, domestic producer prices, export prices, import prices, f.o.b. prices, and c.i.f. prices in each region for goods with the same sector classification. The average output price is a tax-inclusive CET aggregation of domestic and export prices. The composite goods price is a tax-inclusive CES aggregation of domestic and import prices, which in turn is an aggregation of tariff-inclusive import prices from different sources. The domestic consumer price is the composite goods price plus sales tax. Buyers pay this price. The f.o.b. price of each Armington good is the firm's export price plus the export taxes or minus export subsidies. Adding to it the international transportation margins yields the c.i.f. price. The relation among the eight categories of prices in the model is illustrated in figure 3. An exchange rate, as a conversion factor, translates world market prices into domestic prices.

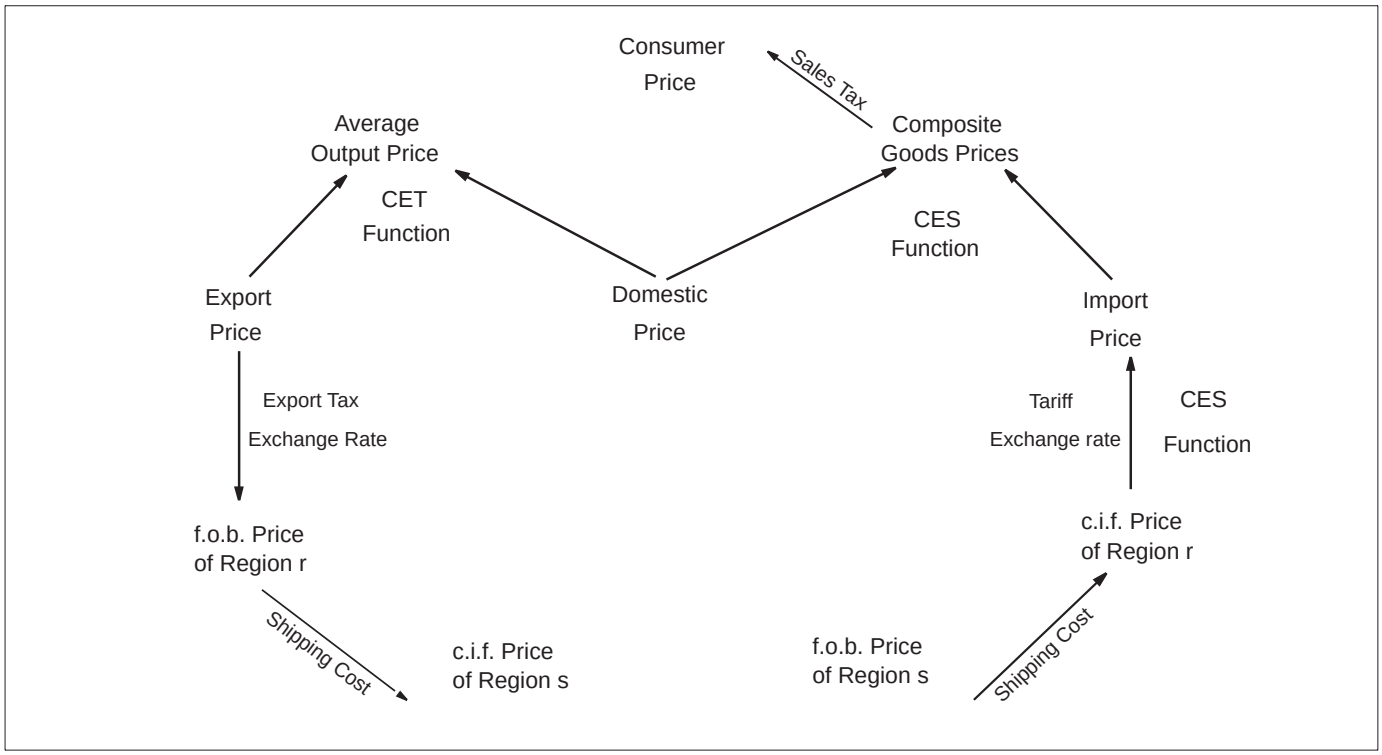
Equilibrium

Equilibrium is defined as a set of prices and quantities for goods and factors in all regions such that (i) demand equals supply for all goods and factors; (ii) each industry earns zero profit; and (iii) gross investment equals aggregate savings in each region.

Choice of Numeraire

In common with other CGE models, only relative prices matter. The absolute price level is set exogenously. A set of price indexes, which equal the share of domestic supplies at the base year multiplied by their price in each region, is used as the numeraire. The advantage of this choice of normalization is that it closely relates the equilibrium exchange rate defined in the model to the concept of "real exchange rate" in trade theory, the relative price of domestic goods and traded goods (de Melo and Robinson, 1989).

Figure 3
Price system in the model



Macro Closure

Macro closure of a CGE model has two aspects: macro accounting balances and assumptions about macro adjustment behavior. There are three major macro balances in each region: (i) the government deficit (surplus); (ii) aggregate saving and investment; and (iii) the balance of trade. Although each agent has a balanced budget in equilibrium, there is no presumption that bilateral trade flows between any two regions are balanced. They are determined endogenously. The government deficit or surplus is the difference between revenues and expenditures, one of which has to be fixed exogenously.

In the benchmark equilibrium, all three macro balances hold. The behavioral specification of macro closure in a CGE model involves choice of a mechanism by which macro balances are brought back to equilibrium when exogenous shocks disrupt the benchmark equilibrium during an experiment. Thus, a macro scenario is imposed on the CGE model, which then traces out the sectoral implications of the assumed macro behavior (Devarajan, Lewis and Robinson, 1990). Because the macro behavior is not based on optimizing behavior by rational agents in the model, different assumptions about the macro adjustment process may lead to different results.

Since the major purpose of this study is to estimate the impact of differential trade liberalization, the savings-investment gap is held constant in each region for all the simulations conducted by the model. This is achieved by keeping fixed the balance of trade, government expenditures, and aggregate investment in each region. Thus, the government deficit (saving) is endogenous and the model is investment-driven. If government revenue changes because of a reduction in tariffs, the macroeconomic effect will be either a change in the exchange rate or a change in household savings, or both, since the induced government deficit is financed by foreign capital inflows or domestic borrowing. Specifically, within each region of the model:

- The size of the balance of trade (deficit or surplus) stays constant; exchange rates adjust. The mix of goods imported and exported changes; the share of import sources and export destinations changes as international prices change, but the total balance of trade remains constant.
- The amount of government expenditure and gross investment is fixed; the size of the budget deficit (or surplus) and household savings adjusts.

By a macroeconomic identity, the fixed balance of trade implies that a constant sum of domestic savings and taxes in real terms is needed to finance fixed investment plus real government expenditures. Thus, any changes in real GDP in the model will go exclusively to changes in real consumption, making it easy to compare the results from different simulations.

The model is neoclassical in spirit.[9] Prices in each region's product markets are assumed to be flexible to clear the markets and are normalized by a numeraire chosen to be the price index of home products sold in the domestic market, which is fixed at unity. Each region is assumed to have a fixed amount of arable land specific to agriculture. Two versions of capital market closure are used in all counterfactual experiments in this study, which are discussed in some detail in the following section.

Static and Medium-Term Accumulation Effects

There are usually two types of gains from trade liberalization: the gains from more efficient utilization of resources, which lead to a one-time permanent increase in GDP and social welfare, and the gains from a "medium-run growth bonus," which compound the initial efficiency gain and lead to higher savings and investment. The static efficiency gains induce higher income and lower prices for capital goods, accelerate capital accumulation, and lead to more capital stock available in the economy. This in turn yields more output, leading to further savings and investment. As Francois et al. (1995) have pointed out, this type of midterm accumulation effect is different from any longrun, permanent growth effect induced by human capital and technology improvements, since it will ultimately decline to zero over time.

To quantify these two types of gains, two alternative capital market closures are used in the model: one static and one steady-state. Under the static capital market closure, the aggregate productive capital stock is fixed in each region, and the region-specific average

[9] To evaluate the effect of China's and Taiwan's WTO accession on employment, the model could also be made to further depart from the Walrasian paradigm by assuming wage rigidities in some regions in the model and thus to allow aggregate employment to vary to meet the labor demand and permit labor markets not to clear at the equilibrium. Thus, the model can generate Keynesian-type unemployment and postulate links between the macro balance and real side of the economies under study.

rental rate adjusts to ensure that regional capital is fully utilized. It is the empirical analog of the comparative-static analysis that is common in theoretical work. Under the steady-state capital market closure, the return of capital is held constant while the capital stock in each region is endogenously determined. This closure assumes that since each region's aggregate capital stock is at its steady-state level in the benchmark equilibrium, liberalized trade will increase capital returns due to more efficient allocation of resources. In a dynamic sense, this will lead to a higher savings and investment rate. More capital stock in the economy will drive down the marginal productivity of capital, thus decreasing the return of capital to its initial level. Although this simulation cannot provide information about the transition path of how the capital price in each region returns to its steady-state equilibrium after an external shock, it can shed some light on the approximate size of the accumulation effect from trade liberalization-induced investment growth in a classic Solow-type growth model at almost no additional implementation cost. The theoretical underpinnings of this approach are based on the concept of invariant capital stock equilibrium proposed by Hansen and Koopmans (1972), and it was introduced into CGE analysis to estimate the accumulation effects of trade liberalization by Harrison et al. (1995).[10]

A detailed description of the model and a list of equations can be found in Appendix C.

Impact of China's and Taiwan's Accession to the WTO

There are three counterfactual experiments carried out by the model:

Scenario I — The impact of Uruguay Round trade liberalization on the global economy. Table 4 presents the percentage reductions in import protection rates by sector and by region agreed to in the Uruguay Round. They are aggregated from the version 3 (pre-release) GTAP database, which is based on World Bank estimates, covering 31 GTAP sectors (except 6 service sectors) and 28 GTAP regions (except China and Taiwan). The average reduction in domestic agricultural support is 18 percent for developed countries, and 13 percent for developing countries, while the reduction of agricultural export subsidies is 36 percent for developed countries and 24 percent for developing countries, based on estimates from the GATT Secretariat (1994). To simulate the termination of the Multi-Fiber Arrangement (MFA) quota system, the quota rent-equivalent export taxes are eliminated for all develop- ing countries except China and Taiwan because they are not WTO members under this scenario.

Scenario II — The impact of China's recent (April 1996) unilateral tariff reductions. China's tariff cuts are aggregated from the Harmonized Commodity Description and Coding System (HS) tariff schedules published by China's Customs Administration[11] and weighted by 1994 trade data from the United Nations' commodity (COMTRADE) trade database. They are listed under the column labeled "China own" in table 4.

Scenario III — The impact of both China and Taiwan joining the global trade liberalization process by applying the same liberalization measures specified in the Uruguay Round agreement. An additional 35-percent cut on top of the tariff cut in Scenario II is assumed for China's WTO accession (see the column in table 4, "China WTO"). Tariff reductions for agricultural products for Taiwan are provided by its Council for Agriculture; 36-percent cuts are assumed for non-agricultural sectors.[12] Because China and Taiwan become WTO members under this scenario, they obtain the same benefits from the elimination of MFA quotas as other developing countries do.

For each of the three scenarios, experiments are repeated under the static and steady-state capital market closures described in the previous chapter; therefore, there are six simulations conducted in total.

[10] The increased capital stock from simulations under such a capital market closure may be interpreted as trade liberalization induced additional capital stock accumulation over a medium term.

[11] The data were provided by the Development Research Center, State Council of People's Republic of China.

[12] A relatively stylized representation of the offers rather than the actual offers made by China and Taiwan was used in this analysis. However, the model can be used to evaluate the actual offers when they are available. The assumption used here omits two important, but offsetting, features of China's import protection system: tariff exemptions and non-tariff barriers (NTB).

China's principal import barriers arise from its administrative system of tariff exemptions and approval of quotas and exchange controls, in addition to high nominal tariffs. Due to the lack of transparency in the administrative system and the interests of diversification of Chinese society, economic entities with inside connections can obtain more preferences. Those who meet preferential terms but without inside connections, such as large corporations from Europe and America, are less capable of acquiring the same preferential treatment as companies from Hong Kong and Macao who are more familiar with China's situation and have kinship relations. Elimination of preferential tariff reductions and exemptions will help lower the non-tariff barriers, leading to fairer competition.

As correctly pointed out by Bach, Martin, and Steve (1996), the neglect of the current tariff exemption system tends to overstate the impact of trade liberalization. The omission of NTB reductions tends to underestimate the effect. Incorporating tariff exemptions changes the magnitude of the simulation results, but would not alter the broad conclusions of this study.

Table 4-Simulation design: Reduction of import protection by sectors and regions

Item	USA	Canada	EU12	AUS/NZL	Japan	Korea	Taiwan	China Own	China WTO	ASEAN	South Asia	ROW
						Percent						
Rice	60.0	36.3	36.2	98.5	1.9	47.3	0.0	0.0	0.0	48.0	17.5	74.1
Wheat	69.2	69.2	36.0	36.0	37.3	95.2	-0.0	0.0	0.0	95.0	26.3	37.5
Other grains	74.2	74.2	35.9	36.0	46.4	70.9	38.5	8.5	40.5	70.8	95.4	15.0
Non-grain crops	31.8	2.0	36.0	27.2	7.9	7.7	49.5	17.8	46.6	23.2	15.0	22.8
Livestock	73.5	37.5	32.0	34.0	15.0	30.7	19.4	17.9	46.7	34.2	85.4	14.9
Meat & milk	30.6	31.6	5.8	65.8	35.1	66.9	55.2	0.6	35.4	33.6	78.0	24.0
Other food	19.5	19.2	19.5	19.5	19.5	86.1	14.0	26.7	52.3	77.4	98.8	63.3
Forestry & fishery	6.7	29.1	17.7	39.1	33.8	25.5	36.0	8.0	40.2	58.1	0.8	1.9
Energy and minerals	19.7	32.0	31.0	31.4	95.2	14.4	36.0	25.6	51.6	9.7	18.0	3.2
Textile & apparel	12.8	30.6	14.4	41.6	23.6	27.0	36.0	47.2	65.7	35.7	6.8	11.9
Other light manuf.	33.8	40.8	45.4	38.1	22.8	51.8	36.0	31.4	55.4	21.1	8.4	28.0
Manuf. intermediates	22.9	43.6	17.2	37.7	56.4	61.4	36.0	32.3	56.0	7.4	33.2	8.7
Machinery & equipment	10.8	23.2	25.8	26.1	94.0	41.4	36.0	24.1	50.7	19.3	26.2	8.6
Average	16.3	26.5	24.9	32.1	37.2	51.6	35.1	31.9	55.7	28.4	28.6	16.3

For each of those experiments, the CGE model generates results regarding the effects on social welfare, terms of trade, the volume of trade, output, the real wages paid to each factor, and changes in prices and resource allocation. However, our simulation results should be regarded as controlled experiments rather than as forecasts. In reality, actual trade and output patterns are affected by many more factors than just trade liberalization, such as domestic macroeconomic and income policy changes.

Aggregate Effects

Figure 4 summarizes the social welfare effects from the three scenarios under the steady-state capital market closure. It shows that the implementation of the Uruguay Round with and without China's and Taiwan's participation results in different welfare effects across regions. In scenario I, social welfare measured by the Hicksian equivalent variation[13] would increase in all regions except China and Hong Kong in both the static and the steady-state simulations, with a much stronger impact when the medium-term accumulation effect is taken into account (see appendix tables A.2 and A.3). China's unilateral trade liberalization would benefit all regions in the world, with itself benefiting the most. Specifically, the comparative statistics show the implementation of the Uruguay Round excluding China and Taiwan would entail a permanent social welfare loss of about $0.3 billion and $0.8 billion per year (or 0.1 percent and 1 percent of their 1992 GNP) for China and Hong Kong respectively.

Taking the medium-term accumulation effects into consideration, China's loss would be much larger ($1.25 billion). ASEAN countries gain the most (2.5 percent of their base-year GNP in the static case, 7.3 percent of their base GNP in the steady-state case), followed by Korea (1.5 percent and 5.1 percent of its base-year GNP, respectively). Taiwan also gains, but the gain is much smaller than that of Korea and ASEAN since it does not participate in the trade liberalization process.

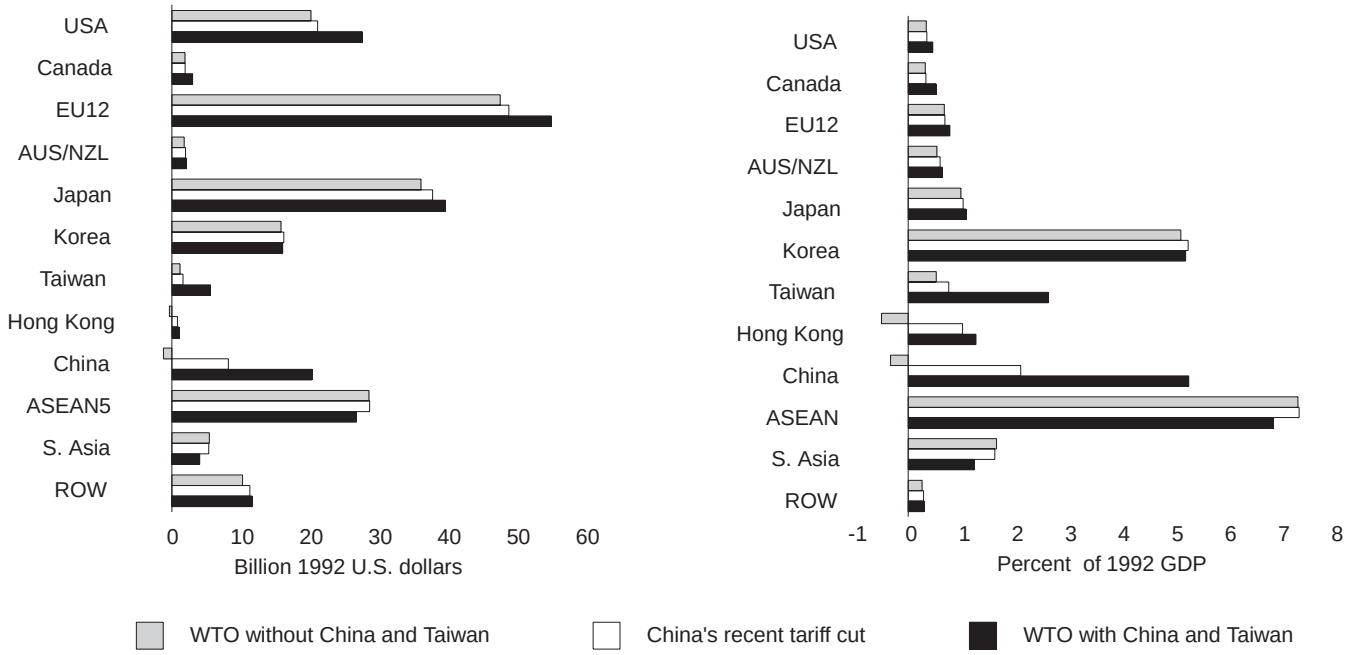
When China cuts its tariffs unilaterally as it did recently (scenario II), and when both China and Taiwan join the WTO (scenario III), social welfare increases in all regions except Hong Kong, which still suffers a small loss in the static case. Developed countries, especially the United States and EU, would gain more from China's and Taiwan's WTO accessions, while other developing regions would gain less than under the Uruguay Round without China's participation. The major beneficiaries from China's and Taiwan's WTO accessions are themselves. WTO membership would bring net social welfare gains of $24 billion to the world economy in the static simulation, with $10 billion (2.6 percent of China's base-year GNP) accruing to China, and $1.1 billion to Taiwan (about 0.5 percent of its base-year GNP). With the accumulation effect, China's net gain would more than double to $21.5 billion (5.5 percent of its base GNP), and Hong Kong would also

[13] Equivalent variation is the Hicksian exact measure of the change in consumer surplus. It is a money metric measure of how much better or worse off the representative household is in the equilibrium after policy change than in the initial equilibrium using the base prices as reference. It asks what income change would be equivalent to the household utility change resulting from the policy change. Mathematically,

$$EV = C\left[p^0, U(p^1, y^1)\right] - C\left[p^0, U(p^0, y^0)\right]$$

where C(.) is the expenditure function, and U(.) is the indirect utility function. The first term in EV is the minimum income necessary to reach utility level after the policy change $U(p^1, y^1)$ given price p^0. The second term in EV is the minimum income level necessary to reach the initial utility level $U(p^0, y^0)$ given price p^0. If EV is positive, the household is better off as a result of the policy change. Measured in base prices, an income greater than the household's initial income is needed to reach the new utility level $U(p^1, y^1)$.

Figure 4
Changes in equivalent variation (a measure of social welfare)



gain about $1 billion (1.3 percent of its base GNP). This is a significant benefit for China compared with the moderate gains for developed countries from China's WTO accession. These results indicate that China's continued unilateral trade liberalization during its WTO bid would raise its welfare.

Figures 5 and 6 summarize the changes in terms of trade and real exports of the three scenarios under the steady-state capital market closure. They show that in scenario I, the United States and the EU enjoy both a substantial improvement in terms of trade and an expansion in real export volume. They are clearly the winners from the Uruguay Round Agreement. Japan, AUS/NZL, Korea, ASEAN, Rest of the World, Hong Kong, and China suffer terms of trade losses, but gains in real exports. A unilateral tariff cut would worsen China's terms of trade further but expand its real exports by almost US$20 billion (more than 85 percent of total additional world exports). Other regions' welfare gains under this scenario are mainly due to improvements in terms of trade. Interestingly, when China participates in the WTO and Uruguay Round trade liberalization, the terms of trade improve in all developed regions, but worsen in developing regions, especially in ASEAN, South Asia, and the rest of the world. Joining the WTO would enable China to triple its export growth compared with the unilateral liberalization case (its real exports increase by more than 65 percent), and further increase export growth in the United States, Canada, Japan, and the EU, but decrease export growth in developing countries, especially China's Asian competitors such as ASEAN and South Asia. Compared with scenario I, their export growth rates decline by about 2 and 6 percent, respectively. Detailed results of major aggregate variables from all six simulations are reported in appendix tables A.2 and A.3.

Figure 5
Changes in terms of trade

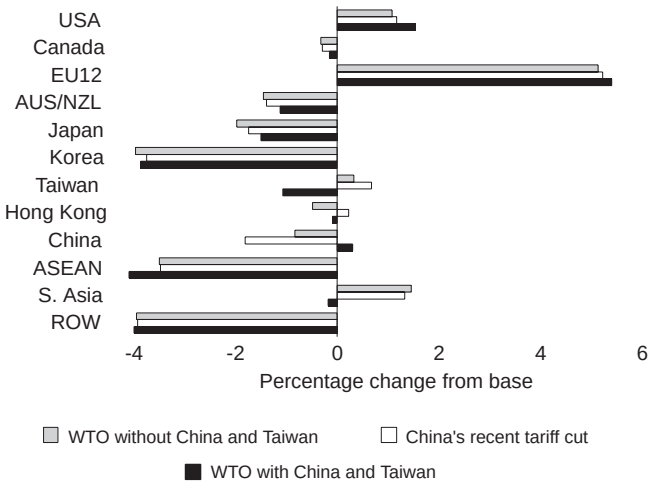
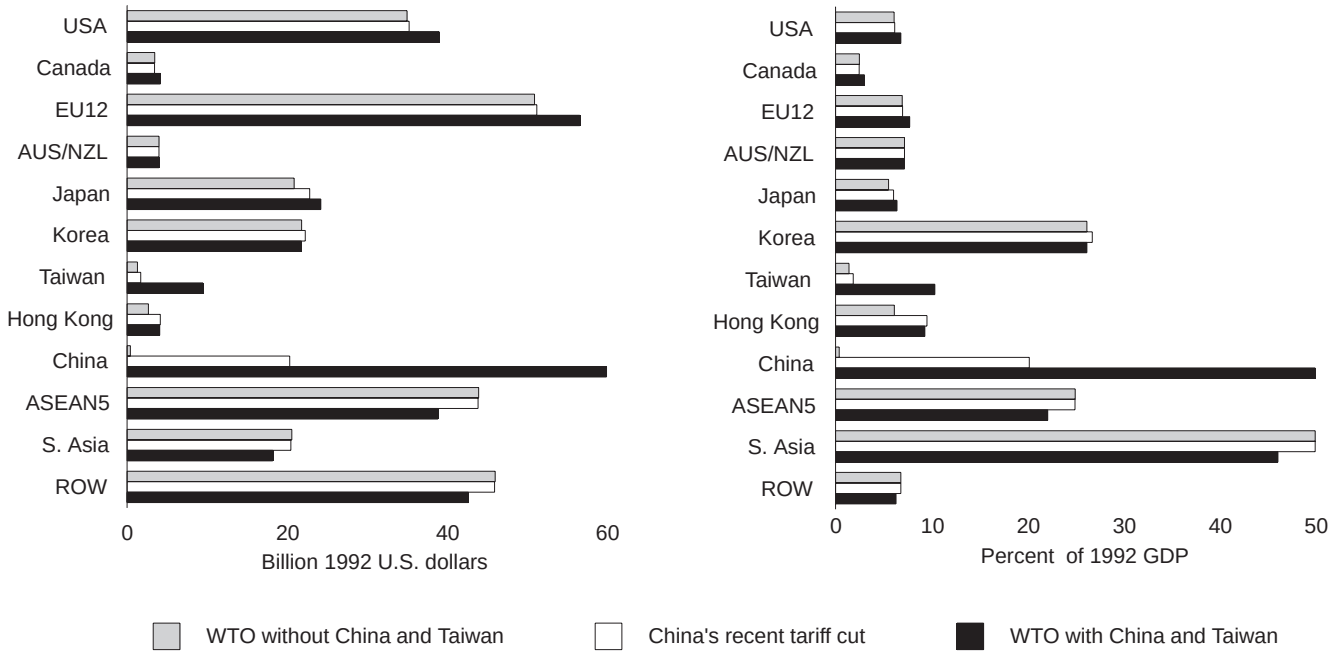


Figure 6
Changes in real exports

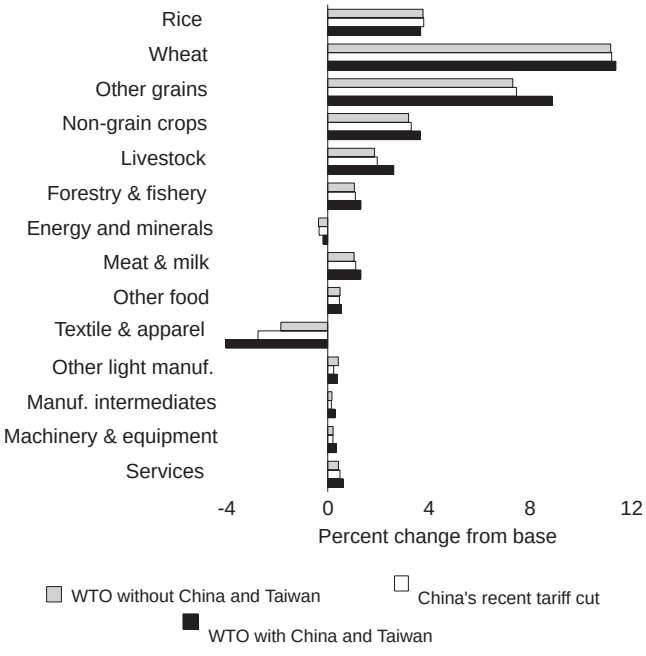


The aggregate results discussed above are dominated by efficiency gains and losses. As classical trade theory indicates, removing trade distortions leads to expansion of trade, realization of comparative advantage, and increased efficiency. Why would the implementation of the Uruguay Round with or without China and Taiwan entail such different macroeconomic effects across regions in the world? To fully understand the factors underlying these aggregate outcomes, it is necessary to look at the sector details, and the resource reallocation that occurs in response to Uruguay Round trade liberalization.

Sectoral Price Effects

Figure 7 summarizes changes in average c.i.f.. prices by commodity for the three simulation scenarios under the steady-state capital market closure. They show that the c.i.f. prices for almost all food and agricultural commodities increase everywhere in the world as industrial countries reduce agricultural subsidies. Phasing out the MFA intensifies competition in the textile and wearing apparel sectors, dramatically reducing export prices in developing countries and import prices in developed countries, the largest final market for such products. The expansion of production and trade induces higher demand for capital- and skill-intensive manufactured goods, thus driving up the world prices for such products, which are major exports from developed countries. These sectoral price changes account for the terms-of-trade improvement for developed countries, and their worsening for developing countries. Figure 7 also shows that China's and Taiwan's joining the WTO will increase the competitive pressure on labor-intensive products and demand for capital- and technology-intensive manufactures, pushing the f.o.b. prices for textiles and apparel into further decline, while the c.i.f. prices of manufactured intermediates and machinery and equipment increase further. This explains why China's

Figure 7
Changes in world market (c.i.f) prices



and Taiwan's joining the WTO will cause a terms-of-trade change favorable for OECD countries but unfavorable for developing countries.

In the world agricultural market, China's admission to the WTO and implementation of Uruguay Round reductions in subsidies and tariffs will slightly increase world prices for wheat, will decrease world prices for rice, and will drive up world prices for livestock products and feed grains, as the import demand for such commodities increases in China and Taiwan because of rising income. The world price of non-grain crops such as cotton, a major input in the textile sector, will also increase from textile production expansion in China.

Sectoral Trade Volume Effects

Table 5 presents estimates of differences in real trade volumes by sector between scenarios I and III under the steady-state capital market closure. China's and Taiwan's joining the WTO would increase world trade by about $172 billion (imports plus exports) at 1992 prices. More than 85 percent of the export gains would go to China and Hong Kong, another 11 percent would go to Taiwan. Developed countries also gain, but the real export increase for other developing regions would be less than if China and Taiwan continued to be excluded from the WTO. The opportunity cost is higher for developing regions. For instance, China's and Taiwan's participation would cost ASEAN countries about $5 billion and South Asia countries $2.4 billion in potential exports.[14] Sectoral trade data further show that China's and Taiwan's accession to the WTO would intensify competition for labor-intensive exports (their textile exports would increase by more than $65 billion), and drive up the demand for capital- and technology-intensive products (their imports of manufactured intermediates and machinery and equipment would rise

[14] If one takes scale effect into account, the results may be different.

Table 5--Differences in trade volume by sectors between a WTO with and without China and Taiwan[1]

Item	USA	Canada	EU12	AUS/NZL	Japan	Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW	Total
							Million U.S. dollars						
Exports													
Rice	-14.9	-0.0	-3.0	-2.0	-0.4	-0.0	0.7	0.0	-42.5	10.2	110.4	-5.9	52.6
Wheat	-2.2	60.1	0.6	-21.7	0.0	0.0	0.0	0.0	-2.0	0.5	5.4	-0.7	40.0
Other grains	274.8	17.0	1.0	31.4	0.1	0.0	0.5	-0.0	-389.1	2.1	0.5	48.1	-13.5
Non-grain crops	662.3	41.5	20.4	39.2	32.2	51.9	104.1	2.3	-1031.0	602.8	345.3	476.0	1347.0
Livestock	94.1	50.8	124.6	93.1	17.0	6.8	74.2	2.6	-336.0	29.6	9.8	168.0	334.5
Meat & milk	8.7	5.2	415.4	31.3	6.8	-6.0	385.0	-0.8	-203.2	98.1	148.2	73.0	961.7
Other food	1149.2	46.7	1590.2	-53.0	135.6	-166.5	537.1	209.0	-658.1	-9.9	141.6	328.6	3250.3
Food & agriculture	2172.0	221.3	2149.1	118.3	191.2	-113.8	1101.5	213.1	-2661.9	733.3	761.2	1087.2	5972.6
Forestry & fishery	119.7	33.8	14.1	140.7	16.1	-1.9	-96.1	-0.2	-357.4	268.1	105.0	315.0	556.8
Energy and minerals	182.1	66.6	171.2	-128.8	235.9	33.1	20.7	61.8	-79.1	966.7	317.0	1483.3	3330.5
Textile & apparel	-1099.8	-117.2	-1343.5	-140.3	2613.5	-318.1	6398.3	-1520.3	61740.3	-9823.9	-4618.2	-9226.9	42543.9
Other light manuf.	-28.7	-30.6	168.0	-21.7	699.5	-55.9	21.4	1113.8	2983.5	362.4	264.7	177.9	5654.2
Manuf. intermediates	658.0	125.3	1087.4	89.6	749.0	594.8	1108.2	1162.6	1094.7	801.6	265.4	653.2	8389.8
Machinery & equip.	1701.6	333.8	3100.8	-49.0	-821.4	-113.7	32.7	599.5	3517.5	1086.6	137.0	1224.9	10750.3
Services	309.3	92.8	316.7	-11.8	-332.7	-40.9	-361.7	-230.0	-529.3	527.8	393.3	923.5	1057.0
Total	4014.1	725.6	5663.8	-3.0	3351.1	-16.2	8225.1	1400.4	65708.2	-5077.5	-2374.6	-3362.0	78255.1
Imports													
Rice	2.5	0.2	8.2	0.3	0.2	0.2	-0.0	2.1	6.3	-0.8	-4.6	41.3	55.9
Wheat	1.0	0.0	0.4	0.1	3.9	-7.1	2.9	0.4	106.6	-2.7	-45.2	-17.4	43.0
Other grains	1.7	0.3	-1.0	0.0	-6.9	-34.0	93.5	0.2	27.4	-33.2	-5.5	-57.7	-15.3
Non-grain crops	49.7	-2.0	21.5	0.7	8.8	-1.1	1078.3	10.9	743.1	-166.0	-61.8	-118.0	1564.3
Livestock	-5.1	-0.8	-43.8	0.2	-6.0	3.4	-69.7	2.3	591.4	-13.4	-51.8	-26.6	380.0
Meat & milk	-9.9	-2.0	1.6	1.6	188.9	11.0	690.9	9.4	238.3	76.7	-25.9	-82.8	1098.0
Other food	81.3	-6.2	73.0	17.2	294.9	76.6	-114.4	45.1	4017.2	-108.7	-317.4	-229.1	3829.4
Food & agriculture	121.2	-10.4	59.8	20.1	483.8	49.1	1681.5	70.4	5730.2	-247.9	-512.2	-490.4	6955.2
Forestry & fishery	-22.4	-3.2	41.7	1.8	108.4	8.0	181.2	20.7	412.5	-47.1	-11.3	-6.9	683.5
Energy and minerals	281.1	15.6	468.1	41.1	1117.2	161.2	519.5	149.3	1259.6	-46.6	-259.1	-90.2	3616.8
Textile & apparel	12098.6	2152.5	15344.0	180.8	2344.5	316.4	946.8	862.6	17659.7	-1380.4	-183.2	2915.4	53257.5
Other light manuf.	621.9	10.5	535.0	65.7	602.6	55.8	443.0	292.0	4252.8	-111.3	-75.1	21.1	6714.1
Manuf. intermediates	94.2	-2.1	235.7	45.3	661.0	148.7	1778.8	484.3	7050.3	-281.3	-417.2	-465.6	9332.0
Machinery & equip.	20.6	68.3	22.1	56.3	713.4	83.2	1531.5	665.8	9520.5	83.7	-369.0	-417.8	11978.6
Services	28.1	-11.8	64.2	41.2	651.3	49.7	672.6	181.7	361.7	-374.7	-206.8	-400.1	1057.0
Total	13243.4	2219.4	16770.6	452.4	6682.1	871.9	7754.9	2726.8	46247.4	-2405.6	-2033.9	1065.3	93594.6

[1]Results from simulations at 1992 constant prices under steady-state capital market closure. A positive number indicates an increase in exports/imports from China and Taiwan joining the WTO.

nearly $20 billion), thus putting more pressure on developing countries and benefiting industrial countries. The United States and EU would import $27 billion more in textiles and apparel, but export about $6.5 billion more in machinery and intermediate goods. China's exports of manufactures would expand in all sectors, but more in textile and apparel products, since elimination of the MFA quota for Chinese products in developed countries' markets is one of the major incentives for China to join the WTO.[15] However, the export expansion in Taiwan is more diversified. Its exports of processed food would also increase moderately.

Changes in Share of World Exports

The simulations show that trade is diverted away from China and Taiwan if they are excluded from the WTO (table 6). Their share in total world exports decreases in most sectors, especially for textiles and apparel, in which China's and Taiwan's market shares would decline by 4.6 and 2.2 percentage points. The ASEAN countries and South Asia would benefit the most. The market share of ASEAN countries would increase from 8.2 percent to 19.3 percent, becoming the largest exporter of textiles and apparel in the world market. The market shares of South Asia also increase substantially from 7.4 percent to 11.6 percent. However, if China were to join the WTO and obtain the benefits from elimination of MFA quotas for its textile exports, its share in world textile markets would more than double from an already large base (13.5 percent), to nearly 30 percent and cut the market expansion of ASEAN and South Asia countries by more than half. This result highlights the high substitutability of textile and apparel products among developing countries, and the competitive pressure on world labor-intensive commodity markets that would result from fully integrating the giants such as China into the world trading system.

[15] Benefits from abolishing the MFA quota system constitute about 40-percent welfare gains for China under the static capital market closure, and 28 percent under the steady-state capital market closure. The figures are calculated from differences between two sets of simulations: one eliminates the MFA quota rent equivalent export tax for China and Taiwan, and one does not, while other policy instruments stay the same.

Table 6--Changes in shares of world exports[1]

Item	USA	Canada	EU12	AUS/NZL	Japan	Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW
						Percentage point deviation from shares in base year						
WTO without China and Taiwan												
Rice	-5.94	0.00	-2.93	0.32	-0.07	-0.02	-0.00	-	-2.54	-1.91	9.78	3.31
Wheat	2.40	10.76	-17.40	2.59	-	-	0.00	-	0.05	1.15	0.34	0.11
Other grains	-0.40	-1.11	-12.18	0.71	0.00	0.00	-0.00	-0.00	10.48	0.01	-0.00	2.50
Non-grain crops	0.22	0.07	-6.36	0.07	-0.06	-0.10	-0.06	-0.00	-0.02	-0.67	-0.41	7.33
Livestock	-0.72	0.08	0.66	-1.21	0.34	0.10	-0.36	-0.00	-0.52	-0.04	-0.18	1.87
Meat & milk	0.88	-0.38	-4.53	-4.83	-0.00	0.20	0.95	0.07	-0.18	0.38	11.56	-4.12
Other food	-2.28	-0.55	3.49	-0.46	0.25	2.45	-0.47	-0.20	-1.17	3.97	-0.35	-4.68
Forestry & fishery	0.43	0.11	0.26	0.05	0.16	0.18	0.91	-0.03	-0.27	-2.69	-0.57	1.47
Energy and minerals	0.04	-0.09	0.29	-0.11	0.21	0.02	0.00	-0.00	-0.05	-0.62	-0.22	0.53
Textile & apparel	-1.65	-0.42	-3.89	-0.08	-0.80	1.11	-2.17	-0.01	-4.56	11.11	4.34	-2.96
Other light manuf.	0.05	-0.48	0.67	0.01	0.96	0.79	-0.39	-0.13	-0.46	-0.39	-0.21	-0.41
Manuf. intermediates	-0.18	-0.33	0.41	-0.04	0.43	0.41	-0.14	-0.07	-0.11	-0.16	-0.07	-0.14
Machinery & equipment	0.24	-0.18	0.29	0.02	-0.24	0.19	-0.11	-0.12	-0.08	0.06	-0.02	-0.06
Services	0.13	0.04	0.57	-0.01	0.00	-0.01	-0.07	-0.20	-0.10	-0.47	-0.17	0.27
Total	-0.35	-0.24	-0.26	-0.02	-0.29	0.45	-0.18	-0.03	-0.23	0.89	0.52	-0.27
WTO including China and Taiwan												
Rice	-6.47	0.00	-3.04	0.24	-0.08	-0.02	0.01	-	-3.55	-2.06	11.90	3.07
Wheat	2.24	11.14	-17.40	2.36	-	-	0.00	-	0.03	1.15	0.39	0.09
Other grains	2.06	-0.96	-12.17	0.99	0.00	0.00	0.00	-0.00	7.12	0.03	0.00	2.93
Non-grain crops	0.69	0.08	-6.40	0.05	-0.03	-0.05	0.06	0.00	-1.46	-0.06	-0.03	7.14
Livestock	-0.47	0.20	1.17	-1.19	0.42	0.13	0.07	0.01	-2.82	0.12	-0.13	2.49
Meat & milk	0.49	-0.44	-4.17	-5.14	0.01	0.18	1.69	0.07	-0.66	0.53	11.64	-4.19
Other food	-1.83	-0.60	3.88	-0.55	0.31	2.24	-0.08	-0.05	-1.76	3.58	-0.27	-4.87
Forestry & fishery	0.50	0.12	0.21	0.38	0.18	0.13	0.56	-0.03	-1.35	-2.15	-0.31	1.77
Energy and minerals	0.03	-0.12	0.23	-0.19	0.26	0.02	0.00	0.02	-0.09	-0.39	-0.14	0.37
Textile & apparel	-2.70	-0.53	-6.36	-0.16	-0.52	-0.29	-0.72	-1.47	14.95	5.03	1.10	-8.33
Other light manuf.	-0.24	-0.66	0.35	-0.02	0.99	0.66	-0.49	0.24	0.46	-0.41	-0.13	-0.74
Manuf. intermediates	-0.35	-0.38	0.12	-0.06	0.38	0.47	0.04	0.16	0.08	-0.04	-0.02	-0.42
Machinery & equipment	0.17	-0.20	0.34	0.02	-0.55	0.15	-0.15	-0.07	0.23	0.11	-0.01	-0.05
Services	0.14	0.05	0.57	-0.01	-0.06	-0.02	-0.13	-0.24	-0.19	-0.39	-0.11	0.39
Total	-0.64	-0.31	-0.63	-0.06	-0.47	0.38	-0.01	-0.02	1.62	0.59	0.41	-0.86

[1]Results from simulations under steady-state capital market closure.
- = no change

The export expansion in industrial countries mainly occurs in capital- and skill-intensive sectors, offsetting the contraction in labor-intensive products. In world food and agricultural markets, the United States expands its market share in feed grains, while the EU dramatically reduces its share in world agricultural exports, especially for wheat and other grains (reducing its share in the world wheat market from 18.3 percent to less than 1 percent and in other grain markets from 12.5 percent to 0.3 percent). China's and Taiwan's accession to the WTO would reduce the export share of rice from industrial countries, but would raise Canada's market share of wheat and the U.S. share of feed grains and non-grain crops. In order to assess the impact of China's and Taiwan's WTO accession on world and U.S. agricultural trade, it is necessary to take a closer look at the impact on agricultural trade flows among regions.

Changes in Agricultural Trade Flows

Figures 8-11 present differences in real exports and imports for each region in five major food and agricultural products resulting from a WTO with China and Taiwan and one without them. Detailed results on differences of exports by destination are listed in appendix table A.5.

Comparing the differences between the two scenarios, it is obvious that China's and Taiwan's WTO memberships have a significant impact on world and U.S. agricultural trade. Agricultural exports from most regions increase, except for a decline in exports from China ($2.66 billion) and Korea ($114 million). While agricultural imports increase in China ($5.73 billion), Taiwan ($1.68 billion), and Japan ($484 million), they decline in ASEAN ($248 million), South Asia ($512 million), and Rest of the World ($490 million) (figures 8 and 9). Global real food and agricultural trade expand by nearly $13 billion. The most notable change is the dramatic increase in net agricultural imports by China ($8.4 billion annually, drop in exports plus increased imports). After becoming a member of the WTO, agricultural production in China would not be able to hold onto factors bid away by the expansion of its manufacturing industries, especially the labor-intensive sectors. Net food and agricultural imports would also increase in Taiwan, Japan, and Korea, but decline in ASEAN and South Asia.

The increase in agricultural exports from major food suppliers such as the United States, Canada, and Australia/New Zealand to China and Taiwan consists of exports diverted from other regions, while the increased agricultural exports from South Asia, ASEAN, and Rest of the World to China and Taiwan come with almost no diversion, as their exports to most regions increase (except ASEAN to South Asia). The major underlying reason for this disparity is that China's and Taiwan's participation in the WTO reduces exports of labor-intensive products to the world market from

Figure 8
Impact of China's and Taiwan's WTO memberships on world food and agricultural exports

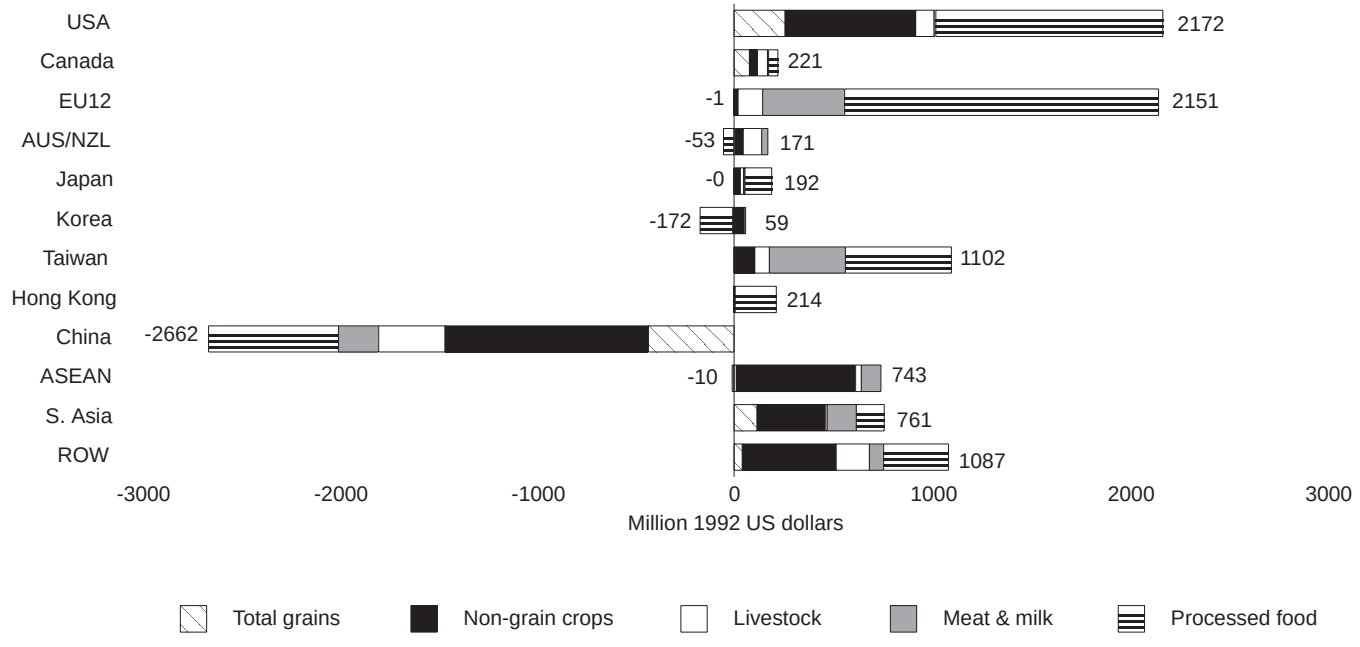
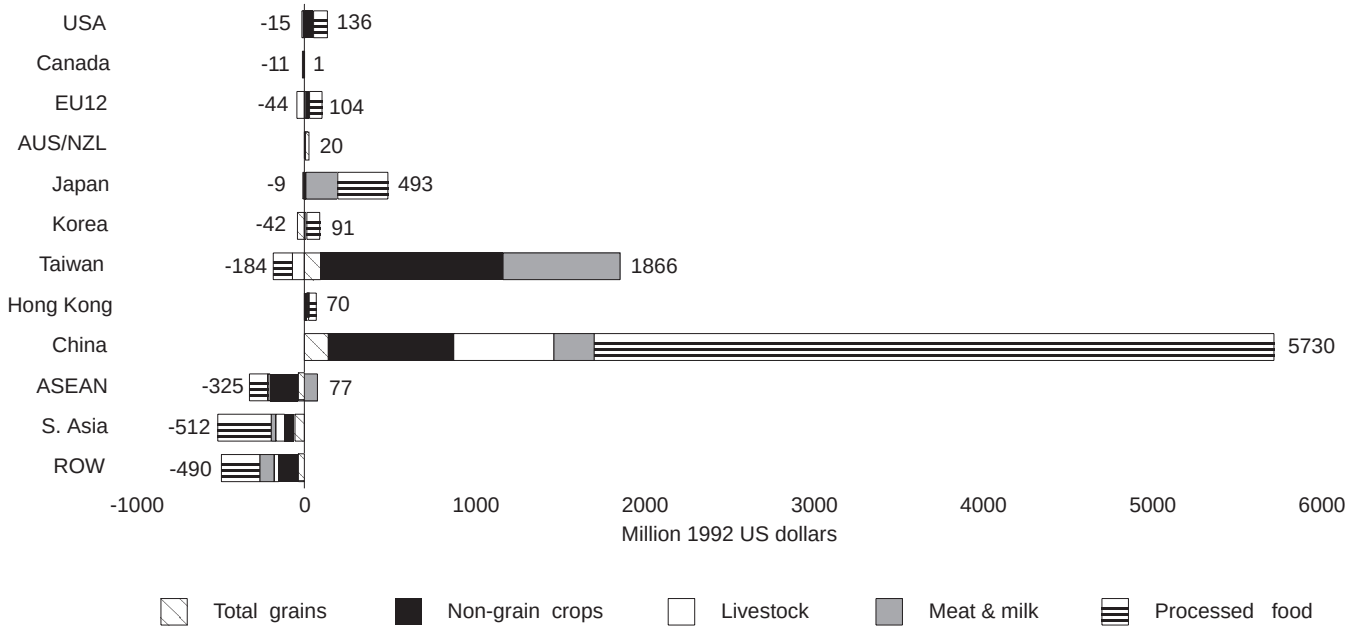


Figure 9
Impact of China's and Taiwan's WTO memberships on world food and agricultural imports



other developing countries, especially ASEAN and South Asia. The labor-intensive sectors in those regions cannot attract as many production resources as they can when the WTO excludes China and Taiwan, so more factors of production remain in those countries' agricultural sectors. The increased agricultural import demand from China and Taiwan when they join the WTO pushes up world food prices, resulting in the expansion of production and exports of agricultural products from ASEAN and South Asia countries.

At the sector level, China's and Taiwan's joining the WTO has the most profound impact on non-grain crops (including cotton) and processed food trade. Because non-grain crops are closely tied to the textile industry, China, Hong Kong, and Taiwan dramatically increase their imports of non-grain crops from the United States ($653 million), ASEAN ($455 million), South Asia ($66 million), Korea ($55 million), and Rest of the World ($230 million). In the meantime, China reduces its exports in this sector by more than $1 billion because of rising domestic demand. The food processing industry in China is also a labor-intensive sector and competes for production resources with the textile and apparel industries. It will be more difficult for this sector to hold on to factors after the deep tariff cut on processed food products upon China's WTO accession. Lower prices will reduce domestic outputs and increase imports dramatically (by about $4 billion). Another notable impact is on livestock products: exports of livestock products from Australia/New Zealand to China (largely wool) are expected to increase by more than 25 percent ($150 million). In the world grain market, China's and Taiwan's WTO memberships have important impacts on some regions (figs. 10 and 11). The most significant change is the increase in net grain imports by China and Taiwan ($574 million and $95 million, respectively). These increases represent a $93-million increase of wheat and an $85-million increase of feed grain sales from North America to the Chinese Economic Area, and a reduction of $42.5 million in rice exports and $389 million in feed grain exports

Figure 10
Impact of China's and Taiwan's WTO memberships on world grain exports

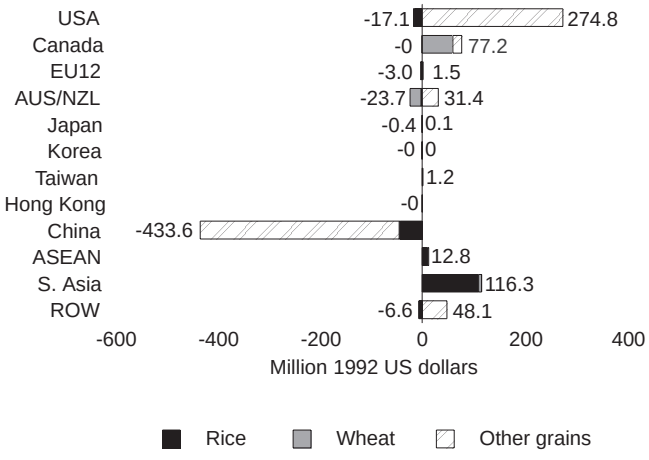
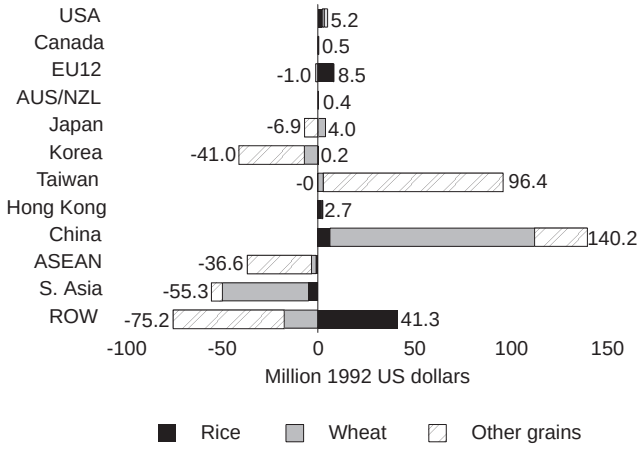


Figure 11

Impact of China's and Taiwan's WTO memberships on world grain imports



from China. In the meantime, rice sales from ASEAN countries to China and Taiwan would rise by $10 million, and rice sales from South Asia to other regions in the world would rise by $110 million. (Those two regions—ASEAN and South Asia—are relatively efficient rice producers in the world market.)

Changes in Factor Prices

The changes in factor prices from China's and Taiwan's WTO accession are shown in table 7. They are consistent with the aggregate welfare changes discussed above. Returns to arable land would increase in most regions in the world because expansion of China's labor-intensive manufacturing sectors would drive up the demand for agricultural products, especially land-intensive commodities such as crops. Higher crop prices induce higher returns to arable land (Stolper-Samuelson effect). The large increase in land returns in China and Hong Kong reflects the fact that arable land will become a more scarce production factor during China's industrialization process. The drop in Taiwan's land value reflects a market correction for overvalued land after agricultural protection is reduced.

Wages of labor will also increase in China, Hong Kong, Taiwan, Korea, and all developed countries, but decline in most developing countries, especially in ASEAN and South Asia. The decline in wages in ASEAN and South Asia countries implies downward pressure on wages in other developing countries because of intensified competition from China's and Taiwan's WTO accession (wage increases in these countries are less in scenario III than in scenario I). Impacts on wages in developed countries are very small. It is interesting to note, however, that in the static simulation, unskilled labor in Canada, the EU, and Hong Kong would suffer a slight loss in wages due to China's and Taiwan's WTO accession. In the steady-state simulation, wages of unskilled workers in these regions rise (when the growth effect is taken into account, gains are greater because of a larger pie). The wage differentials between skilled and unskilled workers, however, widen slightly as the export prices of skill-intensive products such as machinery and equipment increase in the developed countries, favoring skilled workers.

Impact on U.S. Agricultural Production and Trade

What are the effects on U.S. agricultural production and trade of China's and Taiwan's WTO accession? Table 8 summarizes the effects of its impact on U.S. agricultural trade by destination and source; tables 9 and 10 report the effects on U.S. agricultural production, prices of farm products, and farm income.

The data in the first two blocks of table 8 show that China's and Taiwan's WTO accession would increase total U.S. food and agricultural exports by about $2.2

Table 7--Changes in factor prices: Simulation results

Item	USA	Canada	EU12	AUS/NZL	Japan	Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW
						Percent						
Static Capital Market Closure												
Land	0.60	0.57	0.13	0.19	-0.12	0.17	-9.57	6.00	3.39	0.59	0.15	0.06
Unskilled labor	-0.03	-0.03	-0.01	0.01	0.04	0.03	1.67	-0.12	4.57	-0.53	-0.34	-0.05
Skilled labor	0.07	0.13	0.08	0.08	0.04	0.06	1.71	0.47	4.83	-0.14	-0.25	0.04
Capital	0.05	0.05	0.03	0.02	0.03	0.05	1.85	0.72	4.21	-0.09	-0.13	0.01
Steady-State Capital Market Closure												
Land	0.83	0.89	0.22	0.48	0.01	0.30	-8.22	8.58	6.60	0.56	0.09	0.12
Unskilled labor	-0.00	0.01	0.01	0.02	0.06	0.06	2.96	0.70	7.19	-0.64	-0.44	-0.04
Skilled labor	0.10	0.16	0.10	0.11	0.06	0.09	2.97	1.28	6.56	-0.26	-0.36	0.05

Table 8--Impact on U.S. agricultural trade[1]

(Difference between a WTO with and without China and Taiwan)

	USA	Canada	EU12	AUS/NZL	Japan	Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW	Total
							Million dollars						
Differences in food and agricultural exports by destination													
Rice	-	-0.4	-2.2	-0.0	0.0	0.0	-0.0	0.0	0.0	-0.1	-0.0	-12.2	-14.9
Wheat	-	0.0	-0.1	0.0	2.9	-1.7	1.2	0.4	23.7	-4.1	-17.4	-7.3	-2.2
Other grains	-	0.3	-0.9	0.0	82.6	87.8	75.8	0.0	-0.1	5.2	0.1	24.0	274.8
Non-grain crops	-	-3.3	-34.4	0.1	62.3	13.5	548.7	36.4	68.0	-7.3	-2.9	-18.8	662.3
Livestock	-	0.1	3.9	0.1	3.4	11.2	-10.3	9.2	75.7	0.5	-1.1	1.4	94.1
Meat and milk	-	-0.3	-0.7	0.1	-63.6	14.4	-0.8	10.4	62.6	-3.8	-1.4	-8.3	8.7
Processed food	-	-2.9	-10.8	1.5	29.0	18.7	307.9	17.3	861.5	-9.9	-25.3	-37.8	1149.2
Total	-	-6.5	-45.1	1.7	116.6	143.9	922.4	73.8	1091.6	-19.4	-48.0	-59.0	2172.0
Differences in food and agricultural imports by sources													
Rice	-	-0.0	-0.1	-0.0	-0.0	0.0	0.0	0.0	-0.0	0.1	2.5	-0.0	2.5
Wheat	-	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Other grains	-	0.2	0.0	-0.0	-0.0	-0.0	0.0	0.0	-0.0	0.0	0.0	1.6	1.7
Non-grain crops	-	-1.6	-0.3	-3.0	-1.4	-0.8	3.6	-0.3	-56.5	21.5	35.3	53.3	49.7
Livestock	-	5.7	1.5	-2.6	-0.1	-0.1	2.6	-0.0	-21.2	0.7	0.2	8.2	-5.1
Meat and milk	-	4.6	3.1	-26.6	-0.1	-0.0	0.4	-0.0	-0.4	0.1	0.1	8.9	-9.9
Processed food	-	8.6	4.1	-2.3	-7.1	-21.4	62.7	-2.9	-25.8	27.3	4.2	33.8	81.3
Total	-	18.4	8.3	-34.6	-8.7	-22.3	69.3	-3.2	-103.9	49.8	42.3	105.9	121.2
							Percentage points						
Differences in share of U.S. agricultural production and exports by destination													
Rice	0.31	0.09	-0.00	0.00	0.00	0.00	-0.00	0.01	0.00	-0.00	0.00	-0.10	-0.53
Wheat	0.06	0.00	-0.00	0.00	0.07	-0.03	0.03	0.01	0.51	-0.08	-0.37	-0.13	-0.16
Other grains	-0.60	-0.07	-0.26	-0.00	-0.08	1.00	0.74	0.00	-0.00	0.06	0.00	-1.39	2.46
Non-grain crops	-0.74	-0.44	-1.37	-0.02	-0.34	-0.11	2.94	0.13	0.30	-0.27	-0.03	-0.79	0.47
Livestock	-0.10	-0.32	-0.37	-0.02	-0.34	-0.56	-0.59	0.29	2.79	-0.07	-0.09	-0.72	0.25
Meat and milk	-0.00	-0.01	-0.01	0.00	-0.77	0.15	-0.01	0.12	0.71	-0.04	-0.02	-0.11	-0.38
Processed food	-0.33	-0.48	-1.09	-0.06	-0.50	-0.07	1.20	-0.01	3.66	-0.36	-0.22	-2.06	0.45
Total	-0.29	-0.28	-0.67	-0.02	-0.55	0.01	1.30	0.06	1.63	-0.21	-0.13	-1.14	0.30
Differences in U.S. food and agricultural market share across regions													
Rice	-0.07	-0.82	-0.88	-0.35	-0.19	-0.11	-0.28	0.01	-0.01	-0.02	0.00	-0.60	-0.53
Wheat	-0.00	-0.00	-0.07	-0.11	0.09	0.04	-0.21	0.31	-0.02	-0.24	-0.01	-0.02	-0.16
Other grains	-0.00	0.02	-0.05	0.66	2.64	6.24	0.03	0.25	-0.08	0.69	1.30	1.84	2.46
Non-grain crops	-0.11	-0.08	-0.12	-0.02	0.73	0.79	0.73	2.79	-10.30	0.81	-0.02	0.14	0.47
Livestock	0.01	0.28	0.16	0.07	0.39	0.60	0.99	1.07	3.26	0.49	0.15	0.32	0.25
Meat & milk	0.01	0.05	-0.02	-0.04	-1.07	0.42	-3.63	1.07	1.73	-0.08	-0.00	0.01	-0.38
Processed food	-0.02	0.01	-0.10	-0.08	-0.31	0.01	11.59	0.42	10.08	0.15	-0.06	0.00	0.45
Total	-0.02	-0.01	-0.08	-0.08	-0.11	1.16	5.17	1.15	2.24	0.10	-0.00	0.06	0.30

[1]Results from simulations under steady-state capital market closure.

Table 9--Impact on U.S. agricultural production and factor allocation[1]

	Structural change			Factor reallocation			
Sectors	Production	Exports	Imports	Land	Unskilled labor	Skilled labor	Capital
				Percent changes			
Rice	-0.40	-2.09	1.99	-1.13	-0.27	-0.37	-0.27
Wheat	0.13	-0.05	0.35	-0.49	0.29	0.20	0.29
Other grains	0.97	3.98	0.57	0.35	1.13	1.04	1.13
Non-grain crops	0.79	3.93	0.41	0.17	0.96	0.86	0.96
Livestock	0.16	3.68	-0.24	-0.46	0.32	0.23	0.32
Meat & milk	0.06	0.10	-0.15	-	0.07	-0.03	0.07
Processed food	0.42	5.19	0.54	-	0.44	0.34	0.44
Total	0.37	3.39	0.35	0.00	0.53	0.32	0.54

[1]Results from simulations under steady-state capital market closure.

Table 10--Imapct on U.S. farm income and prices of farm products [1]

(Difference between a WTO with and without China and Taiwan)

Sectors	Producer prices	Value-added prices	Consumer prices	Import prices	Export prices (f.o.b.)	Farm income
			Percent change			
Rice	0.04	0.23	0.02	-0.56	0.18	-0.28
Wheat	0.06	0.30	0.06	0.02	0.20	0.30
Other grains	0.06	0.29	0.06	-0.05	0.20	1.14
Non-grain crops	0.10	0.17	0.05	-0.09	0.23	0.96
Livestock	0.05	0.19	0.05	0.14	0.18	0.33
Meat & milk	0.03	0.01	0.04	0.08	0.17	0.07
Processed food	0.02	0.02	0.01	-0.09	0.15	0.44
Total	0.04	0.10	0.02	-0.05	0.05	0.54

[1]Results from simulations under steady-state capital market closure.

billion, and agricultural imports by $121 million, for a net increase of more than $2 billion. Most of the increased exports go to China ($1.1 billion) and Taiwan ($0.9 billion); the rest go to Japan, Korea, and Hong Kong, replacing exports that had previously come from China. This increase is basically the trade created from admitting China and Taiwan into the WTO (U.S. agricultural exports diverted from other regions are less than $200 million). At the commodity level, the largest gain is in exports from the food processing sector ($1.15 billion), resulting from deep tariff cuts occurring in this sector after China joins the WTO, as well as because such products are relatively cheaper to transport than other high-value-added agricultural products such as horticultural commodities. Exports of non-grain crops ($662 million) and feed grains ($274 million) rank second and third, followed by livestock products ($102 million). Exports of rice and wheat decline slightly ($15 million and $2 million).[16]

Although exports to Taiwan and China account for most of the expansion in U.S. agricultural trade, the commodity structure of the increases is quite different in the two markets. Non-grain crops would be the largest category of increased U.S. agricultural exports to Taiwan (60 percent), followed by processed food (30 percent) and feed grains (8 percent), and a decrease in livestock products. The increase in U.S. exports to China would mainly be processed food products (79 percent). Livestock products, non-grain crops, and wheat take the remaining 20 percent.

The data in the fourth block of table 8 (the data in the first column are changes in shares of U.S. consumption supplied by domestic producers) show that U.S. agricultural products would gain additional market shares in China (2.2 percent), Taiwan (5.2 percent), Hong Kong (1.2), Korea (1.2 percent), ASEAN, and Rest of the World, but lose market shares slightly in other regions when China and Taiwan are admitted to the WTO. This implies that China's and Taiwan's WTO memberships would enlarge U.S. food and agricultural export markets in Asia, especially in the Chinese Economic Area. The total world market share of U.S. food and agricultural exports would increase by 0.3 percentage point.

At the commodity level, China's and Taiwan's WTO memberships would make a significant difference in the U.S. share of the global feed grain market. U.S. exports would regain market shares in Japan, Korea, and South Asia that had been lost to China in the earlier 1990's. The U.S. share of the world feed grain market would rise 2.5 percentage points to more than 60 percent. The U.S. share in the processed food market in China and Taiwan would expand even more, rising 10 and 11.6 percentage points, respectively. Another notable difference is the U.S. share of livestock product markets in China and Hong Kong, which would rise 3.2 and 1.1 percentage points, respectively.

China's and Taiwan's WTO memberships cause a slight loss in the U.S. share of world markets for rice, wheat, and meat and milk, but gains in all other agricultural and food products, with feed grains gaining the most.

Table 9 reports the percentage change in production, imports, and exports as well as production factors in major U.S. food and agricultural sectors between a WTO with and without China and Taiwan. If China and Taiwan join the WTO, U.S. food and agricultural production would expand by 0.4 percent with output increases in all sectors except rice, and U.S. food and agricultural exports would increase by 3.4 percent. At the

[16] The tariff rates for rice and wheat, staple foods controlled by state trading agencies in China, are nearly zero. The tariff equivalents for rice and wheat factoring in the effects of state trading would surely be sizable. However, such data were not available.

sector level, exports of processed food would expand the most, 5.2 percent, followed by feed grains, non-grain crops (4 percent), and livestock products (3.7 percent), while exports of rice would decline by 2.1 percent. The production and export expansion would attract more factors into U.S. food and agricultural sectors and reallocate land resources. The skilled and unskilled labor forces in food and agriculture would increase by 0.3 and 0.5 percent, respectively, and capital stock in agriculture would increase by 0.5 percent.

How would these structural adjustments influence U.S. domestic food prices and farm income? Although the export prices (f.o.b.) of U.S. food and agricultural products would increase as a result of China's and Taiwan's WTO accession, U.S. consumer food prices would rise only slightly because of the fall in import prices (table 10). The increased price for U.S. food and agricultural exports and more efficient use of production resources translate into higher prices for value-added farm products, thus raising farm income, despite cuts in government subsidies for agricultural production and exports during the implementation of U.S. Uruguay Round commitments. Total income earned for all farm crops except rice would increase because of China's and Taiwan's WTO accession, with feed grain and non-grain crops gaining the most (about 1 percent).

Conclusions

The simulation results reported here provide a quantitative assessment of the potential impact of China's and Taiwan's WTO accession on U.S. and world agricultural trade based on the possible outcomes from Uruguay Round trade liberalization and recent unilateral tariff reductions by China. Although participation in the Uruguay Round is only a part of WTO membership, the results obtained so far indicate that integrating China into the global trading system will have several important effects on the world economy and U.S. agricultural trade.

It would increase total world trade by around $170 billion ($78 billion in exports and $94 billion in imports), and world real consumption by around $45 billion annually. Net exports of labor-intensive products from China would increase dramatically, by about $43 billion a year. Competition in the world labor-intensive goods market stiffens, demand for capital- and technology-intensive products would go up, causing prices for textiles and apparel to decline, and prices for capital- and technology-intensive goods to increase worldwide.

The expansion in labor-intensive sectors in China would also lead to contraction in its agricultural production and exports and would raise its net agricultural imports by $8.4 billion per year, causing food and agricultural exports from other regions to increase.

In world grain markets, China and Taiwan would increase their net grain imports by $574 million and $95 million, respectively (about 1.8 percent of base-year world grain exports), putting upward pressure on world grain prices, especially for feed grains.

For the United States, a WTO with China and Taiwan would raise social welfare (or net real consumption) by about $7.4 billion a year. Total U.S. trade would increase by $17 billion, with returns to land and skilled labor increasing. Only returns to unskilled labor decline slightly. Total U.S. food and agricultural exports would increase by more than $2.2 billion per year, with processed food rising the most.

The biggest winners from China's and Taiwan's WTO accession are China and Taiwan themselves. WTO membership would raise social welfare in China by about $20 billion per year, substantially more than the welfare gains for the United States from China's and Taiwan's WTO membership. Continuing unilateral liberalization in the post-Uruguay Round environment is a necessary procedure to avoid trade diversion resulting from other countries' trade liberalization and to improve the welfare position for China itself.

The results of this study provide useful insights in understanding the impacts of China's and Taiwan's accession to the WTO and demonstrate that CGE models can be a valuable tool for trade policy analysis. Since the model used in this analysis incorporates a relatively stylized representation of the trade liberalization measure offered by China and Taiwan to meet the requirements of WTO accession, the results obtained have to be interpreted with caution and may best be understood as indicative of the real effects. Specifically, it focuses on tariff reductions but does not completely take into account China's pervasive non-tariff barriers. It may be worthwhile in future work to design the simulations based on the actual offers, which are not currently available. In addition, the model used in this study is a stylized simplification of the world economy and is far from perfect.

The following points especially need to be emphasized:

First, the CES trade demand function used in the model embodies very strong assumptions: fixed sector and regional share parameters for imports, and expenditure elasticities of import demand equal to one. The first assumption largely determines the volume and direction of trade, with price changes affecting trade share only at the margin. The second assumption excludes income effects and does not permit the growth in the volume of trade worldwide to exceed the growth of world aggregate GDP. This obviously is unrealistic.

Second, there are significant economy-of-scale effects when the integration of China and Taiwan into the world trading system takes place. However, the constant-returns-to-scale assumption built into the current version of the model precludes the capture of these scale effects. Numerous studies have introduced scale effects into CGE models, for instance, the studies by de Melo and Tarr (1992), who analyzed the impact of trade policy with respect to the steel, automobile, and textile industries in the United States; by Mercenier (1992), who investigated the effects of the completion of the European Common Market; and by Roland-Holst, Reinert, and Shiells (1993), who studied the impact of North American economic integration. The common methodology is to add a fixed-cost component into those sectors that possess economies of scale so that when sector output increases, induced by the expansion of trade from liberalization, the sector's average cost curve will decline. Because the model used in this study was constructed using the duality approach, there will be no difficulty in introducing fixed costs in the model if sufficient data can be obtained to estimate the cost structure of the relevant industries.

Third, the model developed in this study follows the tradition of the first generation of multi-country multi-sector models developed by Whalley (1985) in that it assumes price homogeneity across countries, except for *ad valorem* tariff and domestic tax distortions. This assumption may be valid for analyzing trade policy among industrial countries, but may not be appropriate for Asia-Pacific countries that differ widely in their stages of economic development. As shown in Roland-Holst, Reinert, and Shiells (1993), neglecting a large body of evidence of substantial and persistent differences in purchasing power parity (PPP) values for individual consumers in different regions could seriously distort the relative magnitudes of their real response to multilateral trade liberalization, especially at the sectoral level, which is the merit of CGE models. Therefore, it is important to capture the inter-regional differences in relative prices by compiling the sectoral indices of PPP prices for each region involved and re-calibrating the model with those PPP prices as base year price indices instead of unity, the common practice in today's CGE modeling.

Fourth, the model used in this study focuses on the effects of protection reduction on trade flows without adequate attention to the impact of changes in capital flows among regions that arise from trade liberalization. The simple dynamic feature of the model cannot provide explanations of short- to medium-term adjustments before a new steady-state equilibrium is reached. It does not model foreign direct investment, nor does it evaluate current account effects and foreign indebtedness, which have become increasingly important in a world of high international capital mobility (McKibbin and Salvatore, 1995). Furthermore, empirical evidence and recent developments in endogenous growth theory indicate that investment in human capital is becoming increasingly important as the basis for shaping comparative advantage, which is a dynamic concept subject to significant change over time as the structure of production and consumption change during the process of economic growth. The static nature of the model precludes the study of these dynamic factors in estimating the impact of China's and Taiwan's WTO accession. Therefore, the real impact could be much larger than what is reported in this bulletin. This suggests that the introduction of human capital accumulation and financial market behavior into dynamic CGE trade models is an important research task ahead.

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Appendix A: Major Simulation Results

Appendix table A.1 —Sectors in the model and their GTAP-ISIC concordance

Sectors in the model	GTAP sector number and description	ISIC CODE
Rice	1 Paddy rice, 13 Processed rice	1110 (P), 1120 (P), 3116 (P)
Wheat	2 Wheat	1110 (P), 1120 (P)
Other grains	3 Other grains	1110 (P), 1120 (P)
Non-grain crops	4 Non-grain crops	1110 (P), 1120 (P)
Livestock	5 Wool, 6 Other livestock products	1110 (P), 1120 (P)
Forestry and fishery	7 Forestry, 8 Fishing	1210, 1220, 1301, 1302
Energy and mineral products	9 Coal, 10 Oil, 11 Gas, 12 Other minerals, 23 Petroleum and coal products, 25 Non-metallic mineral products.	2100, 2200, 2301, 2302, 2901, 2902, 2903, 2909, 3530, 3540, 3610, 3620, 3691, 3692, 3699
Meat and milk	14 Meat products, 15 Milk products	3111, 3112
Other food processing	16 Other food products, 17 Beverages & tobacco.	3113-3115, 3116 (P), 3117-3119, 3121, 3122, 3131-3134, 3140
Textile and apparel	18 Textiles, 19 Wearing apparel	3211, 3212, 3213, 3214, 3215, 3219, 3220
Other light manufactures	21 Lumber & wood products, 22 pulp, paper & printing, 20 Leather, fur & their products (including footwear not made of wood, rubber, or plastic), 31 other manufacturing	3231, 3232, 3233, 3240, 3901, 3902, 3903, 3909, 3311, 3312, 3319, 3320, 3411, 3412, 3419, 3420
Basic manufacture intermediates	24 Chemicals, rubber and plastic products, 26 Primary iron and steel, 27 Primary non-ferrous metals, 28 Fabricated metal products	3511-3513, 3521-3523, 3529, 3551, 3559, 3560, 3710, 3720, 3811-3813, 3819
Machinery and transport equipment	29 Transport equipment, 30 Other machinery & equipment	3841-3845, 3849, 3821-3824, 3829, 3831-3833, 3839, 3851-3853
Services	32 Electricity, gas & water, 33 Trade and transport, 34 Ownership of dwellings, 35 Private services, 36 Government services, 37 Construction	4101, 4102, 4103, 4200, 5000, 6100, 6200, 6310, 6320, 7111-7116, 7121-7123, 7131, 7132, 7191, 7192, 7200, 0000, 8101-8103, 8200, 8310, 8321-8325, 8329-8330, 9411-9415, 9420, 9490, 9511-9514, 9519, 9520, 9530, 9591, 9592, 9599, 9100, 9200, 9310, 9320, 9331, 9332, 9340, 9350, 9391, 9399, 9600

Appendix table A.2--Simulation results (static capital market closure): Major macro indicators

Item	USA	Canada	EU12	AUS/NZL	Japan	Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW	Total
						Percentage change from base							
WTO without China and Taiwan													
Social welfare (Billion US$)	14.73	1.39	36.48	1.13	20.86	4.52	0.79	-0.75	-0.32	9.90	2.91	2.71	94.34
As percent of base GNP	0.25	0.24	0.52	0.35	0.57	1.47	0.37	-0.97	-0.08	2.54	0.89	0.07	0.41
Cost of living index	-0.19	-0.22	-0.17	-0.28	-0.15	-1.24	-0.13	-0.62	-0.20	-1.61	-1.19	-0.25	NA
International terms of trade	1.05	-0.33	5.12	-1.59	-2.08	-4.13	0.17	-0.41	-0.93	-3.17	1.39	-3.95	NA
Real exports (Billion US$)	33.90	3.39	49.37	3.84	18.89	18.97	1.03	2.47	0.44	36.35	20.19	44.75	233.59
As percent of base exports	5.91	2.42	6.73	6.87	4.99	22.75	1.12	5.61	0.44	20.65	51.02	6.61	7.55
Real imports (Billion US$)	48.90	4.57	61.02	4.50	20.28	16.23	2.45	1.50	1.28	29.77	16.60	44.64	251.75
As percent of base imports	7.63	3.17	7.74	7.60	6.55	17.99	2.94	2.40	1.24	16.25	36.57	5.84	7.69
China's recent unilateral tariff cut													
Social welfare (Billion US$)	15.27	1.43	37.21	1.27	21.92	4.75	1.02	-0.12	4.13	9.91	2.85	3.39	103.04
As percent of base GNP	0.26	0.25	0.53	0.39	0.60	1.55	0.48	-0.16	1.07	2.55	0.88	0.09	0.45
Cost of living index	-0.19	-0.22	-0.18	-0.29	-0.16	-1.26	-0.16	-1.14	-1.88	-1.62	-1.18	-0.26	NA
International terms of trade	1.14	-0.31	5.21	-1.54	-1.82	-3.89	0.50	0.45	-2.02	-3.13	1.30	-3.93	NA
Real exports (Billion US$)	34.05	3.36	49.58	3.82	20.74	19.34	1.35	3.53	19.00	36.27	20.06	44.63	255.73
As percent of base exports	5.93	2.40	6.75	6.84	5.48	23.20	1.47	8.03	18.84	20.60	50.69	6.59	8.26
Real imports (Billion US$)	50.22	4.64	62.71	4.62	23.42	16.90	3.11	3.40	16.63	30.03	16.47	45.87	278.04
As percent of base imports	7.84	3.22	7.95	7.80	7.57	18.74	3.73	5.43	16.10	16.39	36.28	6.00	8.49
WTO including China and Taiwan													
Social welfare (Billion US$)	19.62	2.19	41.60	1.40	23.21	4.64	1.84	-0.23	10.09	8.78	1.95	3.39	118.47
As percent of base GNP	0.33	0.38	0.59	0.43	0.64	1.51	0.87	-0.30	2.63	2.26	0.60	0.09	0.51
Cost of living index	-0.24	-0.31	-0.23	-0.31	-0.17	-1.24	-0.44	-1.12	-3.94	-1.57	-1.09	-0.26	NA
International terms of trade	1.52	-0.16	5.39	-1.28	-1.58	-3.99	-1.26	0.16	0.04	-3.74	-0.18	-3.99	NA
Real exports (Billion US$)	37.52	4.06	54.76	3.82	21.92	18.85	8.20	3.21	61.97	31.66	17.89	41.30	305.15
As percent of base exports	6.54	2.90	7.46	6.84	5.79	22.60	8.92	7.29	61.47	17.99	45.21	6.10	9.86
Real imports (Billion US$)	61.32	6.68	77.08	4.89	26.46	16.95	9.23	3.51	44.19	27.52	14.62	45.28	337.73
As percent of base imports	9.57	4.64	9.77	8.25	8.55	18.79	11.08	5.61	42.78	15.02	32.20	5.93	10.32

NA = Not applicable.

Appendix table A.3--Simulation results (steady-state capital market closure): Major macro indicatiors

Item	USA	Canada	EU12	AUS/NZL	Japan	Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW	Total
						Percentage change from base							
WTO without China and Taiwan													
Social welfare (Billion US$)	20.10	1.86	47.49	1.74	36.04	15.75	1.12	-0.38	-1.25	28.50	5.40	10.20	166.56
As percent of base GNP	0.34	0.32	0.68	0.54	0.99	5.12	0.53	-0.50	-0.33	7.32	1.66	0.26	0.72
Cost of living index	-0.19	-0.22	-0.18	-0.29	-0.15	-1.26	-0.14	-0.60	-0.21	-1.55	-1.22	-0.25	NA
International terms of trade	1.08	-0.32	5.14	-1.45	-1.98	-3.97	0.33	-0.48	-0.83	-3.50	1.46	-3.95	NA
Real exports (Billion US$)	35.03	3.48	51.00	4.02	20.89	21.84	1.29	2.69	0.39	43.98	20.62	46.06	251.27
As percent of base exports	6.10	2.48	6.95	7.19	5.52	26.20	1.40	6.13	0.38	24.98	52.12	6.80	8.12
Real imports (Billion US$)	50.82	4.69	63.39	4.77	22.66	18.74	2.81	1.76	1.38	36.15	17.12	46.23	270.51
As percent of base imports	7.93	3.26	8.04	8.05	7.32	20.77	3.37	2.81	1.33	19.74	37.69	6.05	8.26
Percent increase of capital stock to return steady state	0.23	0.19	0.35	0.40	1.00	8.24	0.28	0.89	-0.78	7.86	1.71	0.35	0.62
China's recent unilateral tariff cut													
Social welfare (Billion US$)	21.07	1.91	48.73	1.94	37.70	16.18	1.60	0.78	8.12	28.60	5.31	11.28	183.21
As percent of base GNP	0.35	0.33	0.69	0.60	1.03	5.26	0.76	1.02	2.11	7.34	1.63	0.29	0.79
Cost of living index	-0.20	-0.22	-0.18	-0.30	-0.16	-1.27	-0.17	-1.08	-1.91	-1.56	-1.22	-0.26	NA
International terms of trade	1.17	-0.29	5.23	-1.39	-1.74	-3.75	0.68	0.23	-1.81	-3.48	1.33	-3.93	NA
Real exports (Billion US$)	35.28	3.45	51.28	4.01	22.87	22.30	1.69	4.18	20.37	43.92	20.49	45.99	275.82
As percent of base exports	6.15	2.46	6.99	7.19	6.04	26.75	1.84	9.51	20.20	24.95	51.77	6.79	8.91
Real imports (Billion US$)	52.37	4.78	65.27	4.92	25.99	19.50	3.57	4.06	17.94	36.48	16.99	47.62	299.50
As percent of base imports	8.18	3.32	8.27	8.31	8.40	21.62	4.29	6.49	17.37	19.92	37.41	6.23	9.15
Percent increase of capital stock to return steady state	0.25	0.19	0.37	0.43	1.04	8.38	0.55	2.33	2.71	7.89	1.69	0.37	0.70
WTO including China and Taiwan													
Social welfare (Billion US$)	27.51	2.97	54.88	2.08	39.59	16.01	5.57	0.97	20.26	26.67	4.03	11.61	212.14
As percent of base GNP	0.46	0.52	0.78	0.64	1.09	5.21	2.63	1.27	5.27	6.85	1.24	0.30	0.92
Cost of living index	-0.25	-0.32	-0.23	-0.32	-0.17	-1.25	-0.41	-1.08	-3.98	-1.52	-1.12	-0.27	NA
International terms of trade	1.54	-0.15	5.41	-1.12	-1.50	-3.87	-1.07	-0.09	0.31	-4.10	-0.18	-4.00	NA
Real exports (Billion US$)	39.04	4.20	56.66	4.01	24.24	21.83	9.51	4.09	66.09	38.90	18.25	42.69	329.53
As percent of base exports	6.80	3.00	7.72	7.19	6.41	26.18	10.34	9.31	65.56	22.10	46.12	6.30	10.65
Real imports (Billion US$)	64.06	6.91	80.16	5.22	29.34	19.61	10.56	4.48	47.62	33.75	15.08	47.29	364.10
As percent of base imports	10.00	4.80	10.16	8.82	9.48	21.73	12.68	7.17	46.11	18.42	33.21	6.19	11.12
Percent increase of capital stock to return steady state	0.34	0.31	0.42	0.42	1.08	8.34	4.46	2.97	7.10	7.54	1.41	0.38	0.83

NA = Not applicable.

Appendix table A.4--Differences of prices by sector: WTO with and without China and Taiwan[1]

Item	USA	Canada	EU12	AUS/NZL	Japan	Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW	World average
							Percent change						
World export prices (f.o.b)													
Rice	0.18	0.08	0.10	0.33	0.53	0.54	-1.29	0.00	4.27	-0.15	-1.30	0.01	0.30
Wheat	0.20	0.15	0.12	0.41	0.53	0.00	-1.64	0.00	5.08	-0.03	-1.26	0.02	0.38
Other grains	0.20	0.15	0.12	0.40	0.53	0.55	-2.47	1.74	5.13	-0.06	-1.34	0.02	0.42
Non-grain crops	0.23	0.15	0.12	0.40	0.53	0.54	-1.67	2.46	6.14	-0.12	-1.32	0.02	0.62
Livestock	0.18	0.17	0.12	0.41	0.51	0.57	-3.58	2.23	5.63	-0.09	-1.33	0.03	0.40
Meat & milk	0.17	0.13	0.12	0.37	0.44	0.48	-2.59	0.83	4.25	-0.15	-1.24	0.02	0.24
Other food	0.15	0.08	0.11	0.31	0.50	0.84	-5.63	0.65	2.89	-0.04	-1.21	0.01	-0.14
Forestry & fishery	0.12	0.03	0.11	0.31	0.51	0.39	1.17	0.78	5.39	-0.26	-1.32	-0.01	0.60
Energy and minerals	0.13	0.06	0.10	0.30	0.50	0.32	0.89	0.36	0.39	-0.19	-1.01	0.00	0.15
Textile & apparel	-0.58	-1.40	-0.56	-0.10	0.36	0.17	-5.37	0.01	-15.24	-0.40	-1.25	-0.20	-2.20
Other light manuf.	0.10	0.03	0.08	0.27	0.49	0.33	0.69	0.48	-2.03	-0.20	-1.15	-0.01	-0.08
Manuf. intermediates	0.14	0.06	0.10	0.29	0.49	0.33	0.70	0.52	-1.29	-0.10	-1.01	0.01	0.02
Machinery & equipment	0.13	0.09	0.11	0.29	0.51	0.35	0.29	0.45	-2.84	-0.01	-1.04	0.02	-0.14
Services	0.15	0.06	0.12	0.32	0.52	0.40	1.55	0.73	1.29	-0.24	-1.30	0.01	0.30
World import prices (c.i.f.)													
Rice	-0.46	0.01	-0.43	-0.22	-0.09	-0.16	-0.12	0.45	-0.12	-0.10	0.23	0.02	-0.08
Wheat	0.15	0.20	0.16	0.18	0.21	0.21	0.20	0.23	0.17	0.19	0.20	0.17	0.19
Other grains	0.10	0.20	0.20	0.26	0.78	3.56	0.20	2.49	0.24	4.14	4.23	0.37	1.45
Non-grain crops	0.06	0.22	0.15	0.23	0.60	0.56	0.47	1.90	-0.02	0.83	0.22	0.28	0.46
Livestock	0.31	0.25	0.59	0.32	0.55	0.47	0.63	3.45	0.23	0.78	1.01	0.42	0.75
Meat & milk	0.22	0.20	0.15	0.12	-0.18	0.30	0.31	0.96	0.13	0.38	0.18	0.22	0.25
Other food	0.04	0.15	0.07	0.07	-0.04	0.23	0.31	0.66	0.00	0.21	0.16	0.19	0.17
Forestry & fishery	0.36	0.26	-0.01	0.09	0.32	0.15	0.31	1.35	-0.02	0.39	-0.12	0.12	0.26
Energy and minerals	0.02	0.08	0.01	0.00	0.01	0.04	0.10	0.02	0.01	0.09	0.03	0.10	0.04
Textile & apparel	-5.79	-4.45	-3.92	-1.79	-2.43	-1.40	-0.64	-3.16	-0.18	-0.90	-0.66	-1.48	-2.23
Other light manuf.	-0.12	0.04	-0.08	-0.04	-0.09	0.01	-0.00	-0.65	0.28	0.13	0.01	-0.01	-0.04
Manuf. intermediates	0.12	0.14	0.05	0.14	0.06	0.18	0.21	-0.06	0.26	0.20	0.09	0.11	0.13
Machinery & equipment	0.20	0.16	0.17	0.21	0.06	0.24	0.24	-0.50	0.27	0.24	0.05	0.15	0.12
Services	0.17	0.17	0.13	0.19	0.15	0.23	0.25	0.23	0.19	0.17	0.14	0.16	0.18
Domestic consumer prices													
Rice	0.02	0.00	-0.02	-0.02	0.02	0.14	-1.64	-0.15	2.85	0.04	-0.06	0.00	
Wheat	0.06	0.12	0.02	0.09	-0.19	-0.17	-1.49	-0.36	3.16	0.34	0.13	0.07	
Other grains	0.06	0.12	0.02	0.09	0.23	2.79	-28.75	1.79	3.66	3.42	-0.09	0.07	
Non-grain crops	0.05	0.14	0.02	0.07	0.01	0.13	-9.88	1.07	4.14	0.21	-0.04	0.04	
Livestock	0.05	0.14	0.03	0.09	-0.01	0.12	-3.76	2.33	3.69	0.17	-0.05	0.03	
Meat & milk	0.04	0.10	0.02	0.06	-0.46	0.02	-5.68	0.20	1.87	-0.51	0.30	0.03	
Other food	0.01	0.05	0.01	-0.02	-0.04	0.38	-5.67	-0.06	-2.11	0.21	0.35	0.03	
Forestry & fishery	0.02	0.01	-0.02	-0.02	-0.06	-0.06	-0.32	0.54	3.12	0.03	-0.05	-0.00	
Energy and minerals	-0.01	0.03	-0.01	-0.05	-0.12	-0.16	0.14	-0.44	-1.61	0.08	0.62	0.01	
Textile & apparel	-3.04	-4.44	-2.18	-1.43	-0.54	-0.56	-1.43	-2.01	-18.38	-0.35	0.05	-0.55	
Other light manuf.	-0.07	-0.01	-0.04	-0.13	-0.06	-0.14	-0.20	-0.50	-9.61	0.13	0.18	-0.01	
Manuf. intermediates	-0.00	0.04	-0.00	-0.06	-0.04	-0.10	-0.20	-0.53	-5.51	0.26	0.62	0.03	
Machinery & equipment	0.02	0.10	0.03	-0.07	-0.03	-0.09	-1.55	-1.03	-9.39	0.36	0.59	0.08	
Services	0.01	0.03	0.02	0.01	0.00	-0.01	1.08	0.07	-0.11	-0.01	-0.02	0.01	

[1]Results from simulations under steady-state capital market closure.

Appendix table A.5--Differences in food and agricultural exports by destination[1]

(Difference between a WTO with or without China and Taiwan)

	USA	Canada	EU12	AUS/NZL	Japan	Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW	Total
						Million U.S. dollars							
United States													
Rice	-	-0.4	-2.2	-0.0	0.0	0.0	-0.0	0.0	0.0	-0.1	-0.0	-12.2	-14.9
Wheat	-	0.0	-0.1	0.0	2.9	-1.7	1.2	0.4	23.7	-4.1	-17.4	-7.3	-2.2
Other grains	-	0.3	-0.9	0.0	82.6	87.8	75.8	0.0	-0.1	5.2	0.1	24.0	274.8
Non-grain crop	-	-3.3	-34.4	0.1	62.3	13.5	548.7	36.4	68.0	-7.3	-2.9	-18.8	662.3
Livestock	-	0.1	3.9	0.1	3.4	11.2	-10.3	9.2	75.7	0.5	-1.1	1.4	94.1
Meat and milk	-	-0.3	-0.7	0.1	-63.6	14.4	-0.8	10.4	62.6	-3.8	-1.4	-8.3	8.7
Processed food	-	-2.9	-10.8	1.5	29.0	18.7	307.9	17.3	861.5	-9.9	-25.3	-37.8	1149.2
Total	-	-6.5	-45.1	1.7	116.6	143.9	922.4	73.8	1091.6	-19.4	-48.0	-59.0	2172.0
Canada													
Rice	-0.0	-	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0
Wheat	0.9	-	0.2	0.0	2.9	-0.4	0.4	0.1	67.8	-0.1	-10.0	-1.6	60.1
Other grains	0.2	-	0.0	0.0	5.1	1.4	0.0	0.0	9.0	0.0	0.0	1.2	17.0
Non-grain crop	-1.4	-	-0.5	0.0	12.5	0.2	7.1	2.2	22.6	-0.1	-0.6	-0.6	41.5
Livestock	5.2	-	0.7	0.0	0.2	0.6	-3.4	2.9	44.3	0.0	-0.1	0.2	50.8
Meat and milk	4.2	-	0.0	0.1	-3.9	0.0	3.0	0.4	1.9	-0.1	0.0	-0.5	5.2
Processed food	8.0	-	1.2	0.5	4.3	0.3	8.2	0.5	24.9	-0.1	-1.8	0.7	46.7
Total	17.1	-	1.5	0.7	21.1	2.2	15.4	6.1	170.5	-0.3	-12.5	-0.6	221.3
European Union													
Rice	-0.1	-0.0	-	-0.0	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-2.9	-3.0
Wheat	0.0	0.0	-	0.0	0.0	-0.0	0.0	0.0	0.5	0.0	-0.1	0.2	0.6
Other grains	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.4	1.0
Non-grain crop	-0.2	0.3	-	0.2	3.4	0.3	6.3	0.8	8.2	-0.0	-0.6	1.9	20.4
Livestock	1.3	0.0	-	0.2	1.6	4.6	-2.3	25.0	87.2	0.9	-1.5	7.5	124.6
Meat and milk	2.8	0.7	-	0.8	-16.3	0.3	390.4	8.3	57.5	-4.3	-9.0	-15.8	415.4
Processed food	3.8	1.0	-	4.2	23.9	13.7	-194.4	30.5	1818.2	-10.0	-49.4	-51.4	1590.2
Total	7.7	2.1	-	5.3	12.7	19.0	200.0	64.5	1971.9	-13.2	-60.5	-60.2	2149.1
Australia and New Zealand													
Rice	-0.0	-0.0	-0.7	-	-0.0	0.0	0.0	0.5	0.3	-0.1	-0.0	-1.9	-2.0
Wheat	0.0	0.0	0.0	-	-2.2	-5.7	0.0	0.0	6.0	-1.5	-10.0	-8.3	-21.7
Other grains	-0.0	0.0	-0.2	-	3.4	4.0	4.7	0.1	15.2	5.4	0.0	-1.1	31.4
Non-grain crop	-2.6	-0.5	-14.2	-	4.8	0.7	65.1	5.0	3.3	-12.2	-5.8	-4.2	39.2
Livestock	-2.4	-0.2	-6.3	-	-1.8	0.3	-26.5	7.9	150.1	-1.2	-21.9	-5.0	93.1
Meat and milk	-24.5	-3.4	-14.5	-	-46.0	-0.1	137.8	2.8	20.0	-9.3	-7.3	-24.1	31.3
Processed food	-2.1	-1.8	-3.2	-	-0.7	2.0	-27.8	2.2	-2.3	-7.1	-7.6	-4.6	-53.0
Total	-31.7	-5.9	-39.2	-	-42.6	1.1	153.3	18.6	192.7	-26.1	-52.7	-49.2	118.3
Japan													
Rice	-0.0	0.0	-0.0	-0.0	-	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.4	-0.4
Wheat	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other grains	-0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Non-grain crop	-1.2	-0.4	-1.5	-0.2	-	-0.1	32.4	2.1	3.9	-1.3	-0.6	-0.8	32.2
Livestock	-0.1	-0.0	-0.2	-0.0	-	-0.1	-7.2	2.3	22.8	-0.3	-0.0	-0.1	17.0
Meat and milk	-0.1	-0.0	0.0	-0.0	-	-0.1	-0.4	0.8	7.1	-0.2	-0.2	-0.1	6.8
Processed food	-6.5	-0.6	-4.1	-0.8	-	0.6	54.0	3.7	118.4	-17.6	-0.6	-10.9	135.6
Total	-7.9	-1.0	-5.9	-1.0	-	0.3	78.8	8.9	152.2	-19.4	-1.5	-12.3	191.2
Korea													
Rice	0.0	0.0	-0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0
Wheat	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other grains	-0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Non-grain crop	-0.7	-0.1	-0.7	-0.1	-0.1	-	31.4	5.5	18.4	-0.8	-0.6	-0.4	51.9
Livestock	-0.1	-0.0	-0.2	-0.0	-0.2	-	-0.2	1.1	6.8	-0.2	-0.3	-0.1	6.8
Meat and milk	-0.0	0.0	-0.0	0.0	-4.6	-	-0.2	0.0	0.3	-0.6	-0.8	-0.0	-6.0
Processed food	-19.6	-4.0	-31.2	-2.6	-48.8	-	-35.6	-0.9	55.7	-20.1	-11.8	-47.6	-166.5
Total	-20.4	-4.1	-32.0	-2.6	-53.6	-	-4.7	5.8	81.1	-21.7	-13.5	-48.1	-113.8

Appendix table A.5 (continued)--Differences in food and agricultural exports by destination

	USA	Canada	EU12	AUS/NZL	Japan	Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW	Total
							Million U.S. dollars						
Taiwan													
Rice	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.5	0.0	0.2	0.7
Wheat	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0
Other grains	0.0	0.0	0.0	0.0	0.0	0.4	-	0.0	0.0	0.0	0.0	0.0	0.5
Non-grain crop	3.1	0.6	3.6	0.2	29.7	2.0	-	6.2	28.7	28.1	0.6	1.4	104.1
Livestock	2.4	0.1	3.3	0.7	26.2	13.6	-	2.5	11.4	3.8	8.7	1.4	74.2
Meat and milk	0.4	0.0	0.0	0.0	380.2	1.1	-	0.4	2.6	0.0	0.1	0.1	385.0
Processed food	57.6	3.5	17.7	6.6	319.3	7.1	-	26.9	20.1	58.6	3.1	16.4	537.1
Total	63.5	4.3	24.7	7.5	755.4	24.2	-	36.0	62.8	91.1	12.5	19.5	1101.5
Hong Kong													
Rice	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0
Wheat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0
Other grains	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-0.0	0.0	0.0	0.0	-0.0
Non-grain crop	-0.3	-0.0	-0.3	-0.0	-0.0	-0.0	0.3	-	2.9	-0.1	0.0	-0.3	2.3
Livestock	-0.0	-0.0	-0.0	-0.0	-0.1	-0.0	-0.5	-	3.3	-0.0	0.0	-0.0	2.6
Meat and milk	-0.0	0.0	0.0	-0.0	-0.1	-0.0	0.0	-	3.1	-3.6	-0.0	-0.1	-0.8
Processed food	-2.7	-0.4	-1.0	-0.4	-1.3	-0.0	-40.4	-	262.2	-3.1	-0.0	-3.9	209.0
Total	-3.0	-0.4	-1.3	-0.4	-1.5	-0.1	-40.6	-	271.5	-6.8	-0.1	-4.2	213.1
China													
Rice	-0.0	-0.0	-0.0	-0.0	-0.1	0.0	0.0	-3.9	-	-1.5	-1.7	-35.2	-42.5
Wheat	0.0	0.0	-0.0	0.0	0.0	-0.1	0.0	-0.1	-	-1.7	0.0	0.0	-2.0
Other grains	-0.0	-0.1	-3.2	-0.0	-113.8	-125.3	-0.1	-0.6	-	-62.2	-5.4	-78.4	-389.1
Non-grain crop	-47.5	-8.6	-195.9	-6.6	-215.1	-41.2	9.5	-91.0	-	-189.1	-10.5	-235.0	-1031.0
Livestock	-18.7	-0.9	-91.4	-1.0	-39.3	-27.4	-9.7	-72.8	-	-16.0	-28.4	-30.5	-336.0
Meat and milk	-0.4	0.0	-12.4	-0.1	-76.1	-6.2	-2.6	-25.1	-	-48.0	-0.6	-31.8	-203.2
Processed food	-23.1	-6.4	-71.4	-3.9	-129.8	-15.8	-43.1	-62.4	-	-123.6	-14.6	-164.0	-658.1
Total	-89.7	-16.1	-374.4	-11.6	-574.2	-216.0	-46.0	-255.9	-	-442.1	-61.2	-574.8	-2661.9
ASEAN													
Rice	0.1	0.2	0.0	0.2	0.1	0.2	-0.0	5.3	5.1	-	-0.4	-0.7	10.2
Wheat	0.0	0.0	0.0	0.0	0.0	0.4	1.1	0.0	0.0	-	-1.2	0.2	0.5
Other grains	0.0	0.0	0.1	0.0	0.2	0.3	0.5	0.7	0.0	-	0.1	0.2	2.1
Non-grain crop	18.7	1.8	40.4	1.8	51.4	13.4	138.1	17.1	299.7	-	-7.8	28.2	602.8
Livestock	0.7	0.0	0.5	0.1	0.9	0.8	0.1	12.4	13.9	-	-0.1	0.2	29.6
Meat and milk	0.1	0.1	2.1	0.1	5.9	0.5	72.5	3.2	14.5	-	-1.9	1.0	98.1
Processed food	25.2	2.5	31.9	7.2	52.1	33.3	-141.3	16.8	100.2	-	-177.1	39.3	-9.9
Total	44.9	4.6	75.0	9.3	110.5	48.8	71.0	55.6	433.5	-	-188.3	68.4	733.3
South Asia													
Rice	2.3	0.5	11.8	0.2	0.2	0.0	0.0	0.0	0.0	3.2	-	92.1	110.4
Wheat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	-	0.6	5.4
Other grains	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.4	0.5
Non-grain crop	30.9	2.0	61.3	3.7	19.9	3.4	32.0	16.3	13.6	35.8	-	126.6	345.3
Livestock	0.2	0.0	2.7	0.0	2.0	0.3	0.0	0.4	3.0	0.1	-	1.1	9.8
Meat and milk	0.1	0.0	0.2	0.0	0.0	0.0	-0.0	0.0	0.4	142.6	-	4.9	148.2
Processed food	3.9	0.4	37.9	0.9	3.3	3.6	-2.7	1.5	8.1	32.6	-	52.1	141.6
Total	37.3	3.0	114.1	4.8	25.3	7.3	29.2	18.2	25.1	219.1	-	277.7	761.2
Rest of the World													
Rice	-0.0	0.0	-1.2	0.0	0.0	0.0	-0.0	0.0	0.2	-2.7	-2.2	-	-5.9
Wheat	0.0	0.0	0.3	0.0	0.0	1.0	0.0	0.0	1.1	0.1	-3.3	-	-0.7
Other grains	1.5	0.1	3.2	0.0	16.4	0.2	5.3	0.0	0.7	20.8	0.0	-	48.1
Non-grain crop	46.4	6.6	161.4	1.8	41.0	7.8	58.6	10.1	161.4	5.8	-24.9	-	476.0
Livestock	7.5	0.1	47.1	0.1	2.2	3.4	-1.2	12.0	97.0	1.0	-1.0	-	168.0
Meat and milk	8.1	1.0	26.5	0.4	-1.5	0.2	9.6	7.5	23.8	-1.0	-1.6	-	73.0
Processed food	31.4	3.2	100.9	2.8	22.6	7.9	16.5	7.2	142.9	1.5	-8.2	-	328.6
Total	94.8	10.9	338.2	5.1	80.8	20.4	88.8	36.8	427.2	25.5	-41.3	-	1087.2

[1]Results from Simulations under steady-state capital market closure.

Appendix B: Robustness of Simulation Results

Simulation results from CGE models are conditional on estimates of various elasticities and other parameters used in the model, and are often criticized by econometricians because the uncertainty surrounding those estimates may dwarf the quantitative results predicted by the model. In response to these concerns, conditional or unconditional sensitivity analyses are widely used to assess the robustness of the simulation results. In what follows, the robustness of major simulation results from this study are evaluated by using alternative parameter estimates.

Many policy applications of CGE models in recent years have included some evaluation of the sensitivity of their results, but they often were conditional in nature. The key elasticities regarded as uncertain were varied a given number of times, one by one, while holding all other parameters constant. Almost no attention was paid to how such variation should be combined.

Harrison et al. (1993) have shown that such procedures often overstate the robustness of model results in a multi-variate context. They advocate Unconditional Systematic Sensitivity Analysis (USSA) as an alternative. In such a procedure, a distribution is assumed for each uncertain parameter (assuming the parameters are independently distributed), and a certain number of parameter values are randomly selected based on discrete approximations of their distribution. The model is then solved for all possible combinations of the selected point values of the parameters, and estimates of the mean and standard deviation for the model's major endogenous variables are generated.

There are two problems associated with this procedure, however. One is the computational requirement caused by dimension explosion.[17] The other is that the random selection of point values may not generate accurate estimates of the means and variances of the endogenous variables (Preckel and Lanclos, 1993). Obviously, a statistically sound operational procedure is needed to sufficiently reduce the dimensionality and determine the most efficient combination of the point estimates selected based on the discrete approximation of the parameter distributions.

Orthogonal design, an experimental design method widely used in the natural sciences, is adopted as the means to conduct sensitivity analysis of the simulation results in the China and Taiwan WTO accession study. It is a method of arranging scientific experiments by selecting a small number of samples that can best represent a large sample based on mathematical statistics and orthogonal principles. As an efficient way to determine how the point estimates of different parameters should be combined, this simulation design method can significantly reduce the difficulty caused by dimensionality in USSA procedures.[18] Using this method to arrange simulations has two major properties (Bai, 1983):

1) *Even combination.* The selected simulations are evenly distributed in all possible combinations of the point estimate for a set of parameters. Each point estimate of every parameter, and each combination of those parameters' point estimates, appears the same number of times in the designed simulations.

2) *Compatibility*. In a set of selected simulations, for each point estimate of a parameter, other parameters play the same role in determining the simulation results, i.e., the effects of each parameter in the simulations are statistically independent. When all selected simulations are divided into groups according to a parameter's point estimates, the differences in results are caused only by the different values of that parameter. Thus, the results are directly comparable.

Table B.1 presents the simulation design for analyzing the sensitivity of results from the CGE model used in this study. It is based on an $L_9(3^4)$ orthogonal table, where the subscript 9 represents the number of simulations needed, 3 indicates that each parameter can have three point estimates, and superscript 4 indicates the number of parameters that can be analyzed based on this table. If one considers all possible combinations, there are $3^4 = 81$ simulations needed. The orthogonal design method requires only nine of them to be carried out. It is easy to see that each of the four sets of elasticities and their three point estimates (low, central, and high) are evenly or uniformly combined. Each point estimate for each set of elasticities has three simulations, and any point estimate for each set of elasticities is

[17] As noted by Harrison et al. (1993), in a model with M uncertain parameters and a sample size of N for each parameter, the required model solution under USSA would be N^M times.

[18] The problem of how to determine the best point estimates for each set of elasticities is not addressed here. The implicit assumption is that the elasticity values given in appendix tables B.2 and B.3 represent a discrete approximation of the true parameter distribution. Whether this assumption is accurate or not is open to question.

Appendix table B.1--Simulation design: $L_9(3^4)$ orthogonal table

Simulation No.	Combination of elasticity estimates σv_i	σe_i	σm_i	σt_i	Major results Change of EV
1	low	low	low	low	
2	low	central	central	central	
3	low	high	high	high	
4	central	low	central	high	
5	central	central	high	low	
6	central	high	low	central	
7	high	low	high	central	
8	high	central	low	high	
9	high	high	central	low	
mean in low					MEAN:
mean in central					STD:
mean in high					
extreme difference					

σv_i is the elasticity of substitution among different production factors.
σe_i is the elasticity of transformation (domestic sales via exports).
σm_i is the substitution elasticity between domestic and foreign products.
σt_i is the substitution elasticity among different import sources.

combined with each point estimate of other sets of elasticities once and only once. This is the so-called orthogonal property.

The property of comparability can be shown by considering the factor substitution elasticity, σv_i as an example. If we divide the nine simulations into three groups according to the value of σv_i, although the order of combination of the point estimates is different for the other three sets of elasticities, each takes three different values: low, central, and high. Therefore, taking each group as a whole, the other three sets of elasticities play a similar role in the simulations.

The differences among the three groups are only because σv has a different value if there are no cross effects. Therefore, by grouping the nine simulations according to the three point estimates for each set of elasticities, the results of the simulations at different levels of elasticity specification become directly comparable (using the mean value at each level). Moreover, different mean values at each level can be used to show the change trend of the endogenous variables as the elasticity value changes. The extreme difference between maximum and minimum mean values for each set of elasticities can be used as a rough criterion to determine which elasticity is most crucial to the simulation results.

The sensitivity analysis in this study follows exactly the design given in appendix table B.1.[19] The central, low, and high point estimates of related elasticities are listed in appendix tables B.2 and B.3.

Appendix figures B.1 and B.2 summarize the results from the sensitivity analysis and show the relationships between welfare gains (losses) and levels of different elasticities for the United States, Hong Kong, Taiwan, and China. They also illustrate the relative importance of different elasticities to the aggregate welfare changes. The detailed results from sensitivity analysis for the aggregate impact for the United States and China in the three simulations under steady-state capital market closure can be found in appendix tables B.4 and B.5.

As might be expected, variation in the elasticity values affects the predicted impacts of China's and Taiwan's WTO accession quantitatively. For the United States, the aggregate welfare and trade performance indicators have the same sign for each of the three sets of simulations,[20] and variations of their magnitude are moderate (most coefficients of variation are below or around 20

[19] One still should be cautious because this qualitative robustness of results may be partially due to the model's use of common set of substitution elasticity values for all regions. In reality, these parameters are often different, especially among regions at different stages of economic development.

[20] The sensitivity analysis does not include alternatives for the household income elasticity for two reasons. First, the estimates used in calibrating the model come from econometric studies and are both region and sector specific (Hertel, 1997). Second, and foremost, numerous studies (Whalley 1985, Harrison et al., 1993) suggested that parameter values that determine the strength of substitution effects rather that income effects were the most important in affecting the results from CGE models.

Appendix table B.2--Production and supply side elasticities

Sectors	Panel A elasticity of substitution factors (σv_i)			Panel B elasticity of transformation (σe_i)		
	Low estimates	Central estimates	High estimates	Low estimates	Central estimates	High estimates
Rice	0.73	1.05	1.36	2.73	3.90	5.07
Wheat	0.66	0.95	1.23	2.73	3.90	5.07
Other grains	0.66	0.95	1.23	2.73	3.90	5.07
Non-grain crops	0.66	0.95	1.23	2.73	3.90	5.07
Livestock	0.66	0.95	1.23	2.73	3.90	5.07
Forestry & fishery	0.66	0.95	1.23	2.73	3.90	5.07
Energy & minerals	0.82	1.17	1.52	2.45	3.50	4.55
Meat & milk	0.78	1.12	1.46	2.45	3.50	4.55
Other food	0.78	1.12	1.46	2.45	3.50	4.55
Textile & apparel	0.88	1.26	1.64	2.45	3.50	4.55
Other light manuf.	0.88	1.26	1.64	2.45	3.50	4.55
Manuf. intermediates	0.88	1.26	1.64	2.45	3.50	4.55
Machinery & equipment	0.88	1.26	1.64	2.45	3.50	4.55
Services	0.98	1.40	1.82	1.47	2.10	2.73

Data sources: Panel A is compiled from the GTAP database (Hertel, 1997), Whalley (1985), and Harrison et al., (1987) Table B3; Panel B is compiled from de Melo and Tarr (1992), Table B.3.

Appendix table B.3--Trade Substitution Elasticities

Sectors	Panel A elasticity of substitution domestic/imports(σm_i)			Panel B elasticity of substitution import sources (σt_i)		
	Low estimates	Central estimates	High estimates	Low estimates	Central estimates	High estimates
Rice	2.31	3.30	3.80	4.62	6.60	7.59
Wheat	2.31	3.30	3.80	4.62	6.60	7.59
Other grains	2.31	3.30	3.80	4.62	6.60	7.59
Non-grain crops	2.31	3.30	3.80	4.62	6.60	7.59
Livestock	2.31	3.30	3.80	4.62	6.60	7.59
Forestry & fishery	2.31	3.30	3.80	4.62	6.60	7.59
Energy & minerals	3.11	4.44	5.11	4.43	6.33	7.28
Meat & milk	2.94	4.20	4.83	4.48	6.40	7.36
Other food	3.13	4.47	5.14	4.84	6.92	7.96
Textile & apparel	3.54	5.05	5.81	5.40	7.72	8.88
Other light manuf.	3.10	4.43	5.10	4.70	6.71	7.72
Manuf. intermediates	3.02	4.31	4.96	4.57	6.52	7.50
Machinery & equipment	2.48	3.54	4.07	4.88	6.97	8.02
Services	1.36	1.94	2.24	2.74	3.92	4.50

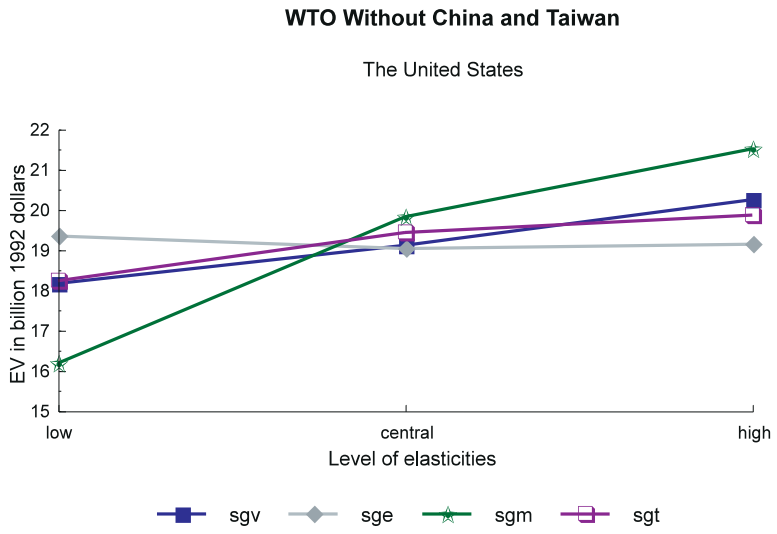
Data sources: Panel A is compiled from the GTAP database (Hertel, 1997), and de Melo and Tarr (1992), Table B.1. Panel B is compiled from the GTAP database.

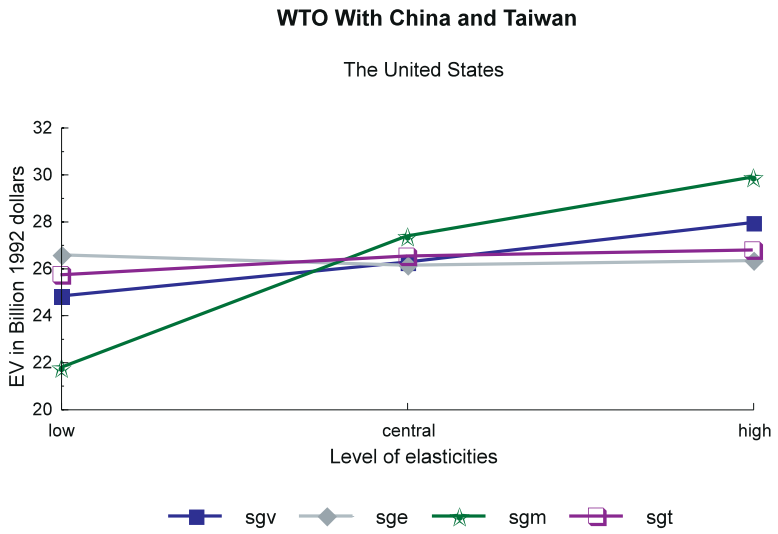
percent), the differences between a WTO with and without China and Taiwan also seem stable. However, the variations for China in the first simulation are significant (the coefficient of variation is very large), despite the differences between Scenarios II and III and Scenario I, which are in our interest, seem robust (for example, China's welfare gain by joining the WTO ranges from $10-$25 billion). These results suggest that although strong qualitative conclusions can be drawn from the model with confidence, the precise magnitudes obtained from the model must be interpreted with caution.

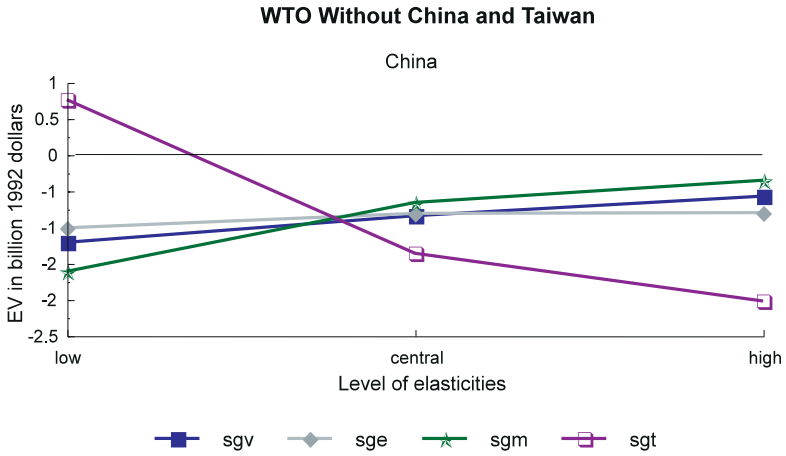
Appendix figure B.1 shows that, in the United States, the elasticity of substitution between aggregate imports and domestic products is the most crucial one in determining welfare effects. As the value of this set of elasticities increases, the welfare gains from trade liberalization increase. The substitution elasticities among different import sources have limited impact. This may be explained by the fact that the United States is the largest importing country in the world, and U.S. consumers do not discriminate among imported products on the basis of their country of origin. In China, the substitution elasticity among different import sources has the largest impact on aggregate welfare. The higher the values of this set of elasticities, the greater the gains in

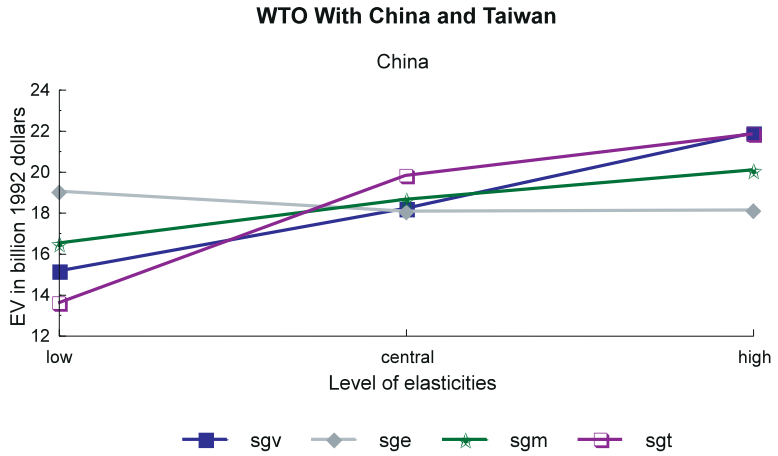
Appendix Figure B.1

Aggregrate welfare (EV) impact by China's and Taiwan's WTO accession and level of trade elasticities







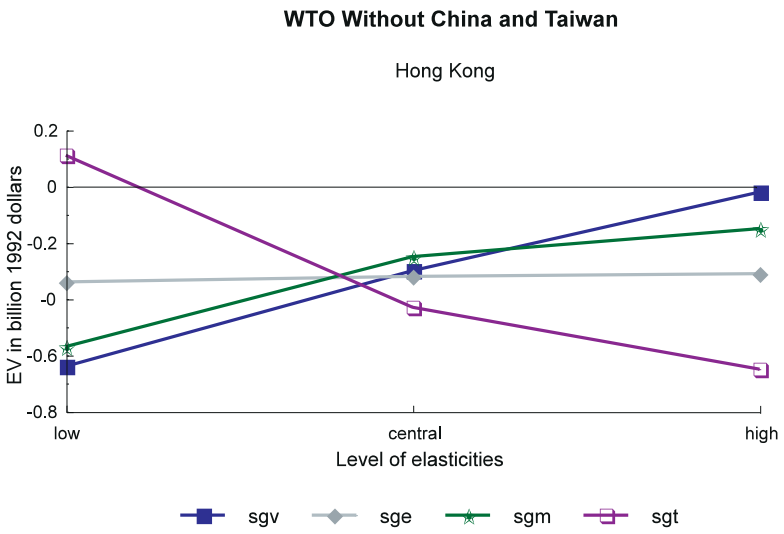


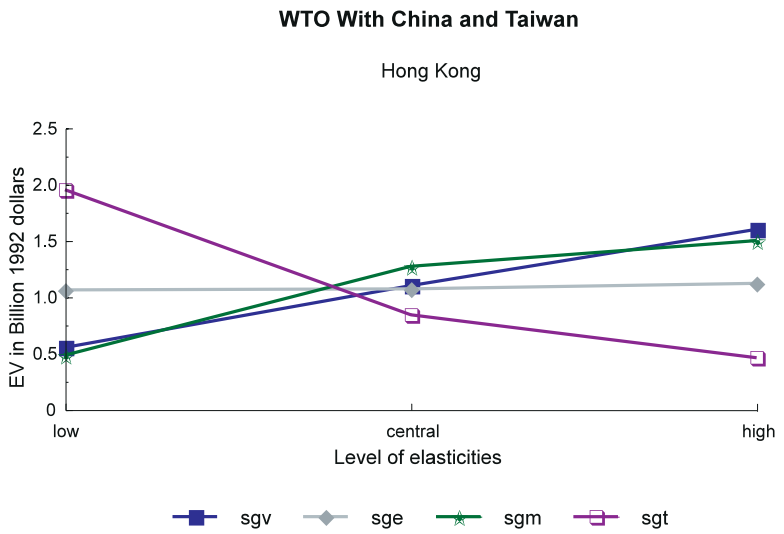
sgv is the elasticities of substitution among different production factors
sge is the elasticities of transformation (domestic sale via exports)

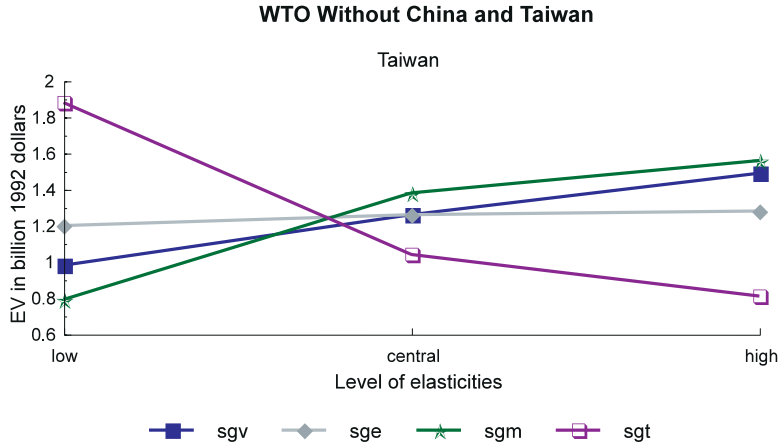
sgm is the substitution elasticities between domestic and foreign products
sgt is the substituion elasticities among different import sources

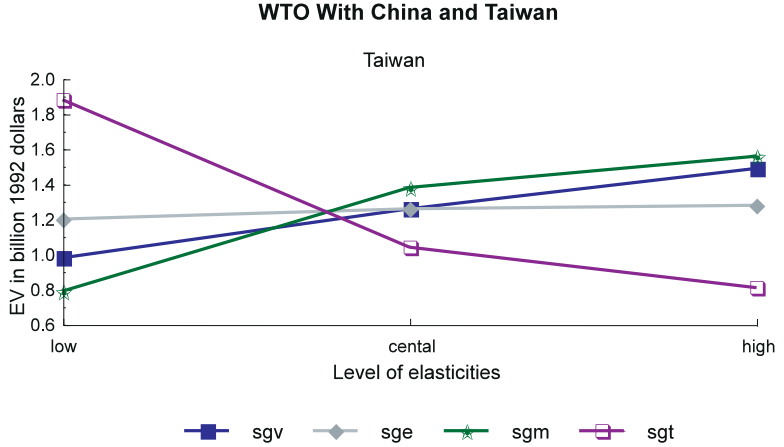
Appendix Figure B.2

Aggregrate welfare (EV) impact by China's and Taiwan's WTO accession and level of trade elasticities









sgv is the elasticities of substitution among different production factors
sge is the elasticities of transformation (domestic sale via exports)

sgm is the substitution elasticities between domestic and foreign products
sgt is the substituion elasticities among different import sources

Appendix table B.4--Sensitivity analysis: U.S. major macro indicators [1]

Experiment number	Social welfare	% as base GNP	Terms of trade	Exports	% as base	Imports	% as base	Induced capital
WTO without China and Taiwan								
1	14.39	0.24	1.20	20.93	3.65	32.89	5.13	0.14
2	18.92	0.32	1.00	34.62	6.03	50.04	7.81	0.19
3	21.15	0.36	0.95	40.67	7.09	57.83	9.03	0.21
4	20.62	0.35	1.05	35.38	6.17	51.74	8.08	0.23
5	20.36	0.34	1.12	39.57	6.90	54.87	8.57	0.24
6	16.35	0.28	1.18	21.48	3.74	34.80	5.43	0.18
7	23.01	0.39	1.10	41.14	7.17	58.43	9.12	0.30
8	17.80	0.30	1.21	21.82	3.80	35.82	5.59	0.22
9	19.93	0.34	1.22	34.58	6.03	49.22	7.68	0.26
Mean(1-9)	19.17	0.32	1.11	32.24	5.62	47.29	7.38	0.22
STD	2.48	0.04	0.09	8.01	1.40	9.54	1.49	0.05
CV	12.95	12.95	8.21	24.84	24.84	20.17	20.17	20.55
China's Recent Tariff Cut								
1	15.22	0.26	1.29	21.08	3.67	34.02	5.31	0.15
2	19.78	0.33	1.09	34.84	6.07	51.52	8.04	0.20
3	22.05	0.37	1.03	40.90	7.13	59.47	9.28	0.23
4	21.49	0.36	1.13	35.47	6.18	53.11	8.29	0.25
5	21.85	0.37	1.24	40.64	7.08	57.52	8.98	0.26
6	17.01	0.29	1.26	21.36	3.72	35.61	5.56	0.19
7	24.25	0.41	1.20	41.63	7.26	60.43	9.43	0.32
8	18.47	0.31	1.28	21.62	3.77	36.56	5.71	0.24
9	21.42	0.36	1.33	35.39	6.17	51.50	8.04	0.29
Mean(1-9)	20.17	0.34	1.21	32.55	5.67	48.86	7.63	0.24
STD	2.66	0.04	0.10	8.27	1.44	10.00	1.56	0.05
CV	13.20	13.20	7.90	25.40	25.40	20.47	20.47	20.87
WTO with China and Taiwan								
1	19.83	0.33	1.67	23.10	4.03	41.21	6.43	0.20
2	25.80	0.43	1.46	38.51	6.71	63.02	9.84	0.28
3	28.78	0.48	1.41	45.23	7.88	73.00	11.40	0.31
4	27.93	0.47	1.52	39.19	6.83	65.09	10.16	0.35
5	28.95	0.49	1.57	45.38	7.91	70.11	10.95	0.36
6	21.82	0.37	1.67	23.27	4.06	43.24	6.75	0.26
7	31.89	0.54	1.57	46.21	8.05	74.03	11.56	0.45
8	23.59	0.40	1.71	23.53	4.10	44.45	6.94	0.33
9	28.32	0.48	1.68	39.49	6.88	62.77	9.80	0.39
Mean(1-9)	26.32	0.44	1.58	35.99	6.27	59.66	9.31	0.33
STD	3.66	0.06	0.10	9.37	1.63	12.41	1.94	0.07
CV	13.91	13.91	6.27	26.03	26.03	20.80	20.80	21.35

[1]Results from simulations under steady-state capital market closure. Absolute value is in billion 1992 dollars.

the case of a WTO with China and Taiwan, and the larger the losses in the case of a WTO without them. The reason for this is also quite obvious. China now is an export-oriented economy with a larger proportion of its total outputs targeted at international markets, especially the markets in developed countries. The higher the elasticity of substitution among import sources, the easier it is for Chinese products entering such markets if there are no cost disadvantages, or the easier for Chinese goods being substituted by similar products from other countries if there is a cost disadvantage.

Appendix figure B.2 shows that the substitution elasticity among different import sources is important in Hong Kong and Taiwan. It is negatively correlated with aggregate welfare in both scenarios. As the value of this elasticity increases, welfare in the two regions declines. As newly industrialized economies, Taiwan and Hong Kong face competitive pressure from two sides: the competition of labor-intensive goods from developing countries and the competition of skill- and capital-intensive goods from developed countries. The higher the substitution elasticities among import sources, the easier their exports being substituted by products from other countries.

There are also common patterns in all regions. First, the elasticities of transformation play a very minor and

Appendix table B.5--Sensitivity analysis: China major macro indicators [1]

Experiment number	Social welfare	% as base GNP	Terms of trade	Exports	% as base	Imports	% as base	Induced capital
WTO without China and Taiwan								
1	-0.45	-0.12	-0.71	0.01	0.01	1.05	1.01	-0.53
2	-1.43	-0.37	-0.84	0.28	0.28	1.23	1.19	-0.86
3	-1.76	-0.46	-0.90	0.41	0.40	1.33	1.28	-0.97
4	-1.90	-0.49	-1.04	0.06	0.06	0.90	0.87	-0.87
5	1.37	0.36	0.16	2.41	2.39	4.21	4.08	-0.50
6	-1.98	-0.51	-1.32	-0.51	-0.50	0.07	0.07	-0.68
7	-0.67	-0.17	-0.63	1.05	1.04	2.22	2.15	-0.66
8	-2.39	-0.62	-1.45	-0.62	-0.61	-0.12	-0.12	-0.71
9	1.35	0.35	0.00	1.78	1.76	3.43	3.32	-0.20
Mean(1-9)	-0.87	-0.23	-0.75	0.54	0.54	1.59	1.54	-0.67
STD	1.33	0.35	0.51	0.96	0.95	1.37	1.33	0.22
CV	-152.20	-152.21	-68.04	177.41	177.41	86.11	86.11	-33.36
China's Recent Tariff Cut								
1	4.11	1.07	-2.05	13.50	13.39	11.11	10.76	1.60
2	6.43	1.67	-1.79	19.80	19.64	17.40	16.84	1.53
3	7.47	1.94	-1.75	22.68	22.50	20.22	19.58	1.52
4	8.54	2.22	-1.73	20.75	20.58	18.41	17.83	2.85
5	7.66	1.99	-2.09	21.72	21.55	18.90	18.30	2.21
6	6.72	1.75	-1.74	14.62	14.50	12.52	12.13	3.08
7	10.51	2.73	-1.85	23.43	23.24	20.83	20.17	3.80
8	8.84	2.30	-1.66	15.42	15.30	13.38	12.96	4.45
9	8.62	2.24	-2.10	19.92	19.76	17.17	16.62	3.48
Mean(1-9)	7.65	1.99	-1.86	19.09	18.94	16.66	16.13	2.72
STD	1.71	0.44	0.16	3.45	3.43	3.29	3.19	1.01
CV	22.30	22.30	-8.63	18.09	18.09	19.77	19.77	37.21
WTO with China and Taiwan								
1	9.03	2.35	-1.10	38.69	38.38	26.67	25.82	3.98
2	16.43	4.27	0.42	64.52	64.01	46.33	44.86	4.36
3	19.93	5.18	0.93	77.78	77.15	56.05	54.26	4.55
4	22.47	5.84	0.98	70.54	69.97	50.68	49.07	7.52
5	14.69	3.82	-1.95	60.89	60.40	43.66	42.27	5.69
6	17.40	4.53	0.73	47.15	46.78	33.18	32.12	7.40
7	25.56	6.65	0.05	75.99	75.38	55.23	53.47	9.85
8	23.05	6.00	1.20	51.52	51.11	36.30	35.14	10.59
9	17.00	4.42	-1.89	55.81	55.36	39.81	38.54	8.16
Mean(1-9)	18.39	4.78	-0.07	60.32	59.84	43.10	41.73	6.90
STD	4.72	1.23	1.18	12.52	12.42	9.48	9.18	2.27
CV	25.64	25.64	NA	20.76	20.76	21.99	21.99	32.95

[1]Results from simulations under steady-state capital market closure. Absolute value is in billion 1992 dollars.

NA = Not applicable.

negative role in determining aggregate welfare. Second, the substitution elasticities among primary factors of production are important in China, Hong Kong, and Taiwan and have a positive effect on welfare (very limited impact in the case of the United States). The reason is that price rigidity has been assumed for capital markets. Behind this assumption is an efficiency gain induced by the accumulation effect (see pages 11-12 for details). When the reduction in trade distortion leads to trade expansion, the higher the factor substitution elasticities, and the more easily that capital can be absorbed into production. Hence, there is a corresponding welfare improvement.

Appendix C: Algebraic Description of the Model

This Appendix provides a detailed description of the structure of the 12-region, 14-sector model for world production and trade. A complete set of core equations describing the model is in appendix table C.1. Definitions of variables and parameters are in appendix tables C.2 and C.3.

Notation

Region name: USA (the United States), CAN (Canada), EU (12 members of European Community), AUS (Australia and New Zealand), JPN (Japan), KOR (Korea), TWN (Taiwan), HKG (Hong Kong), CHN (China), AS5 (Association of South East Asia Nations, includes Indonesia, Malaysia, Thailand, Philippines, and Singapore), SAS (South Asia), ROW (rest of the world).

Sector name: RICE (includes processed rice), WHEAT, GRO (other grains), NGC (non-grain crop), LIV (livestock products), MEAT (meat and milk products), FOOD (processed food products), FAF (forest and fishery products), MINES (mineral and energy products), TEXT (textile and wearing apparel), LMNF (other light manufacture), INTER (manufactured intermediates), MACH (machinery and transport equipment), SV (services).

Factor name: LND (arable land), NLB (unskilled labor), SLB (skilled labor), CAP (capital).

Subscripts and Set Definition:

- Regions are defined in set R and indexed by r or s. $r, s \in R = \{USA, CAN, EU, AUS, JPN, KOR, TWN, HKG, CHN, AS5, SAS, ROW\}$;
- Sectors are defined in set I and indexed by i or j. $i, j \in I = \{RICE, WHEAT, GRO, NGC, LIV, MEAT, FOOD, FAF, MINES, TEXT, LMNF, INTER, MACH, SV\}$;
- Agricultural sectors are defined as a subset of I: $IAG(I) = \{RICE, WHEAT, GRO, NGC, LIV\}$;
- Primary factors are defined in set F and indexed by f. $f \in F = \{LND, ULB, SLB, CAP\}$;

Conventions: Uppercase English letters indicate variables. A variable with a bar on top is always set exogenously. Greek letters or lower case English letters refer to parameters, which need to be calibrated or supplied from exogenous sources. When multiple subscripts of a variable or parameter come from the same set, the first one represents the region or sector supplying the goods; the next one represents the region or sector purchasing the goods.

Equation Description

Equations 1 and 2 define the relationship between border (world) prices and internal prices, while equations 3, 4, and 5 define price indices for composite imported goods, composite demand goods, and the firm's composite output, respectively. In equations 3 and 4, the price indices are the unit cost functions, while in equation 5 they are unit revenue functions, all of which are dual to the corresponding unit quantity aggregator functions. Since CES functions are used as the building blocks of the basic model, and this quantity aggregator function is homogeneous of degree one, the total costs can be written as total quantity multiplied by unit cost (Varian, 1984, p 28). This implies that the average cost, under cost minimization, is independent of the number of units produced or purchased. Thus the unit cost function also stands for the price of the aggregated commodity. Equation 6 states the domestic consumer price is the composite goods price plus sales taxes. Equation 7 defines the unit price for investment goods, which is the sum of all the value of its contents. Equation 8 gives the value-added or net price per unit output. It follows from the unit revenue function (equation 4) and the total production cost function (fixed cost assumed to be zero in constant returns case), given in equation 11 and discussed below. Equation 9 defines the numeraire in the model.

Equation 10 defines the total factor cost, which equals the unit factor cost with a functional form similar to that of equations 3-5, multiplied by the quantities of total output. The total cost function TC_{ir} in equation 11, is composed of factor cost and intermediate cost, plus indirect taxes. It is the result of cost minimization by the representative firm in each sector with respect to its factor and intermediate inputs, subject to the Leontief production function. The strong separability assumption in technology guarantees that the cost function is additively separable in its factor and intermediate cost components. Equation 12 gives the factor demand functions, which are obtained by taking partial derivatives of the factor cost function (equation 10) with respect to the relevant factor price, according to Shephard's lemma. Equation 13 describes the intermediate demand for the composite goods of sector i, which results from the fixed proportion input requirement assumption. Equations 14-17 are the domestic and export supply functions corresponding to the constant elasticity of transformation (CET) function commonly used in today's CGE models. They are derived from revenue maximization, subject to the CET function, in a way similar to the derivation of factor demand functions. Equation 18 aggregates exports by the representative firm in each region, which implies that producers only differentiate output sold in domestic and foreign markets, but do not differentiate exports by destination (foreign markets are perfect substitutes).

Equation 19 is the consumer demand function, which is the Linear Expenditure System derived from maximizing a Stone-Geary utility function subject to household disposable income, which is given in equation 29. Equations 20 and 21 give government and investment demands, which are generated from maximization of Cobb-Douglas utility functions subject to their respective budget constraints (equation 30 and 41). Equations 22-24 are demand functions for domestic goods, for aggregate imported goods, and for imported goods by source, respectively. They describe the cost-minimizing choice of domestic and import purchases, as well as import sources of commodity i by region r. They are derived from corresponding cost functions according to Shephard's lemma in a way similar to the derivation of factor demand functions (taking partial derivatives of the cost function with respect to the relevant component prices). Because of the linear homogeneity of the CES function, the cost function that is dual to the commodity aggregator can be represented by its unit cost function (equations 3 and 4) multiplied by total quantity demanded.

Equations 25 and 26 describe the supply side of the international shipping industry. Equation 25 states that, at equilibrium, the returns from shipping activity must cover its cost. Like other industries in the model, it also earns zero profit. Equation 26 describes the demand for each region's service sector exports to the international shipping industry, which is generated by the assumed Cobb-Douglas technology in this industry. The next two equations (27 and 28) refer to the demand side of the international shipping industry. The demand for shipping services associated with commodity i in region r is generated by a fixed-proportion input requirement (Leontif) coefficient trs_{isr}, which is routine/commodity specific (equation 27). In equilibrium, the total demand of shipping service must equal its total supply (equation 28).

Equations 31-34 determine government revenue from indirect taxes, consumption taxes, tariffs and export taxes (its negative equals a subsidy) respectively, while equations 35-37 define household savings, government

savings, and the balance of trade (foreign savings) in each region.

Equations 38-41 are system constraints that the model economy must satisfy. For every sector in each region, the supply of the composite goods must equal total demand (equation 38), which is the sum of household consumption (C_{ir}), government purchases (GC_{ir}), investment (ID_{ir}) and the firm's intermediate demand (IX_{ir}). Similarly, the demand for each factor in every region must equal the exogenously fixed supply (equation 39). In this dual formulation, output in each region is determined by demand. Sectoral equilibrium is determined in equation 40, unit output price equals average cost, which is also the zero profit condition. Equation 41 describes the macroeconomic equilibrium identity in each region, which is also the budget constraint for the investor. Since all agents in each region (households, government, investor, and firms) satisfy their respective budget constraints, it is well known that the sum of the excess demand for all goods is zero; that is, Walras' law holds for each region. Therefore, there is a functional dependence among the equations of the model. One equation is redundant in each region and thus can be dropped.

The last two equations (42 and 43) define GNP. GNPR is defined from the demand side, which is the sum of the three categories of final demand corrected by the balance of trade. GNPVA is calculated from the supply side and equals the sum of value added (including indirect taxes) plus tariffs, less export subsidies. The two GNP variables can also be used to specify a GNP price deflator as an alternative choice of numeraire for the model.

There are 9,542 equations and 9,638 variables in the static version of the model. Since the 48 factor endowment variables are usually set exogenously, four additional sets of variables have to be set exogenously as macro closures in order to make the model fully determinate. They can be chosen from the following variables: (1) government spending, (2) gross investment, (3) balance of trade or exchange rate, (4) government savings or transfer, (5) household marginal propensity to save in each region.

The model is implemented in GAMS (Brooke et al., 1988). The computer code and related data files are available from the author upon request.