China and Taiwan access to the World Trade Organization: implications for U.S. agriculture and trade

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Abstract

This paper investigates the impact of China's and Taiwan's accession to the World Trade Organization (WTO) on U.S. and world agricultural trade by means of a 12-region, 14-sector Computable General Equilibrium model for world trade and production. The simulation results show that integrating China and Taiwan into the global trading system could 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 US$9 billion annually, causing food and agricultural exports from other regions to increase. Total U.S. food and agricultural exports could increase by about US$2.4 billion annually, with the non-grain crop 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 US$30 billion a year for China, a substantial benefit compared with the gains for the USA (US$8.5 billion). © 1997 Elsevier Science B.V.

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1. Introduction

Both China and Taiwan are important players in international trade. Taiwan has been an important trader in the world market since 1970's. Nineteen years' market-oriented economic reforms and integration with Hong Kong have also made China a major trade power in the world, with a total trade volume of about US$290 billion in 1996. [2] Since 1990, both China and Taiwan have been among the 15 world-largest trading countries. Their roles will likely increase as the integration among the three Chinese economies was intensified by the unification of Hong Kong with China in July, 1997 and China continues to industrialize.

Since the early 1990's, China has been a leading market for foreign direct investment (FDI). In 1993, China was the largest single recipient of FDI among developing countries, utilized US$27.5 billion dollars, which was 14% of global FDI and 68% FDI flows to Asian developing countries. FDI (realized) in China reached US$34

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[2] China's Customs Statistics, General Administration of China, Economic Information and Agency, Hong Kong, December, 1995. p. 3.

billion in 1994 and US$37.7 billion [3] in 1995, making China the second largest FDI recipient country in the world after the USA (Development Research Center, 1996). This trend will likely continue in the future, since the FDI to China is not only motivated 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 be a truly universal system.

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 3371 import items and abolished import control of more than 367 commodities. The action reduced the trade-weighted average tariffs by 7.3% (Zhang and Warr, 1995). On April 1, 1996, China lowered its average nominal tariff by about one third. According to China's General Administration of Customs, this new liberalization effort includes substantial tariff cuts on 4994 tariff lines and lowers China's simple average tariff to 23.2%. China also eliminated quotas, licensing, and other import controls on 176 tariff lines, or more than 30% of commodities subject to these restrictions. [4]

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% in 1948 to 4.7% in 1995. A simple average tariff of 15% is currently maintained by most developing countries. After implementation of the Uruguay Round (UR), 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% from the 1992 level upon its accession, and will continue to lower its overall tariff to about 15% 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? Who will gain? Who will lose? What are the geographical and sectoral distributions of those gains and losses? And what are the economic consequences for China and major WTO contracting parties, especially the USA, 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 paper evaluates the impact of China 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 focuses on differences arising from the Uruguay Round trade liberalization on agricultural and manufactured goods with and without China and Taiwan by a multi-region, multi-sector Computable General Equilibrium (CGE) model for world trade and production. 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

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[3] *China Daily* (Business Weekly), English edition, April 28–May 4, 1996, p. 1.
[4] *China Daily*, English edition, April 1, 1996

membership, such as complete removal of non-tariff measures, reduction of barriers in service trade and foreign investment, protection of intellectual property rights, securing market access, enforcement of commitment, and cooperation in dispute settlement.

The evaluation begins with an economic analysis of production factor scarcities and comparative advantages of China and Taiwan and their major trade partners in Section 2. Then followed by an informal description of the structure and major assumptions of the model used in the evaluation. Major simulation results are presented in Section 4. Section 5 concludes the paper with its major policy implications and limitations.

2. Factor endowments and comparative advantage across regions

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) 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 USA, (2) Canada, (3) European Union (EU) (15 member countries), (4) Australia and New Zealand (AUS/NZL), (5) Japan, (6) South 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) manufactured 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 International Standard Industrial Classification (ISIC) is given in Appendix A.

2.1. Factor endowment

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:

2.1.1. Production resources are unevenly distributed across the world

The five high-income regions (USA, Canada, Japan, EU, and AUS/NZL) account for only 15% of the global labor force, but possess more than 75% of the world's capital stock. In contrast, more than half of the global labor force with less than 4% 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. [5]

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[5] There is only one category of labor in GTAP database. Two types of additional information were used to split the total wage bill. One is the share of employment by labor skill categories, which captures different factor proportions in each industry. The other is wage differential among skill categories, which reflects productivity differences among labor categories. By using these two types of information, the share of each labor category in total labor wage bill can be calculated as: $WSH_{fir} = \dfrac{WDR_{fr} \times EMSH_{fir}}{\Sigma_f WDR_{fr} \times EMSH_{fir}}$ where WSH_{fir} is value-added by labor categories in each sectors, WDR_{fr} is wage differential among skill categories, it can be either in absolute term or relative term, $EMSH_{fir}$ is employment share by skill categories in each sector. Subscript f refer to labor categories, i refer to sectors, r refer to countries.

We derived the employment share by skill categories and by sectors primarily from table 2C of International Labor Office (ILO) *Year Book of Labor Statistics*, which covers 10 sectors by eight occupation categories in 110 countries in the world. Statistical publications from related countries were also used. The data about wage differential among skill categories in each region are calculated from wage tables in 'Price and Earnings Around the Globe (1994 edition)', published by Union Bank of Switzerland.

Table 1

Factor endowment, intensity, and relative size of model regions, 1992

Item	USA	Canada	EU15	AUS/NZL	Japan	South Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	R O W
GDP and trade flows: billion U.S. dollars												
GDP	5671.9	572.3	7110.4	323.5	3645.0	307.4	211.5	76.5	388.3	389.9	326.3	3415.1
Exports	573.8	140.0	693.8	55.9	378.4	83.4	92.0	44.0	100.8	176.0	39.6	583.3
Imports	640.5	144.0	736.5	59.2	309.5	90.2	83.3	62.6	103.3	183.2	45.4	674.9
Relative size in the world: percent												
GDP	25.3	2.6	31.7	1.4	16.3	1.4	0.9	0.3	1.7	1.7	1.5	15.2
Exports	19.4	4.7	23.4	1.9	12.8	2.8	3.1	1.5	3.4	6.0	1.3	19.7
Imports	20.5	4.6	23.5	1.9	9.9	2.9	2.7	2.0	3.3	5.9	1.5	21.5
Share in world factor endowment: percent												
Land	13.0	3.2	6.2	3.6	0.3	0.1	0.1	0.0	6.7	3.9	14.2	48.8
Unskilled labor	4.0	0.5	6.0	0.4	2.4	0.8	0.4	0.1	29.5	6.0	18.7	31.2
Skilled labor	15.2	1.3	14.0	0.9	4.0	0.7	0.4	0.2	22.0	3.3	6.0	32.0
Total labor	5.1	0.6	6.9	0.4	2.6	0.8	0.4	0.1	28.8	5.7	17.4	31.3
Capital	23.3	2.2	33.1	1.7	17.5	1.0	0.6	0.4	1.4	1.4	1.1	16.3
Factor share in value added: percent												
Land	0.3	0.6	0.4	1.3	0.8	5.6	1.9	0.1	9.3	6.3	8.5	2.0
Unskilled labor	35.9	36.9	43.3	36.8	44.1	40.7	47.3	28.8	39.3	24.4	44.8	30.1
Skilled labor	28.1	21.0	23.9	23.1	14.8	8.7	10.4	18.9	15.0	8.8	7.3	17.3
Total labor	64.1	57.9	67.3	59.9	58.9	49.4	57.6	47.7	54.3	33.2	52.1	47.4
Capital	35.6	41.5	32.3	38.8	40.3	45.0	40.5	52.2	36.3	60.5	39.5	50.7
Skill distribution of regional labor force: percent												
Unskilled labor	69.9	76.0	79.1	77.3	84.1	90.8	89.6	86.1	92.2	94.1	96.5	89.5
Skilled labor	30.1	24.0	20.9	22.7	15.9	9.2	10.5	13.9	7.8	5.9	3.6	10.5
Annual wages: US$1000 per worker												
Unskilled labor	22.5	19.1	22.7	14.6	27.8	6.1	11.3	8.2	0.2	0.6	0.3	1.4
Skilled labor	40.8	34.4	47.4	31.4	49.3	12.9	21.3	33.3	0.8	3.6	1.4	6.8
Average wages	28.0	22.8	27.8	18.4	31.2	6.7	12.4	11.7	0.2	0.8	0.4	2.0
Land rent: US$1000 per worker												
Average land return	0.1	0.1	0.3	0.1	6.1	7.3	4.1	5.5	0.3	0.4	0.1	0.1
Capital return: percent of capital stock												
Average capital return	12.1	14.6	9.8	10.1	11.2	17.3	19.4	13.9	10.8	20.6	15.5	14.1
Capital (land) intensity: US$1000 per worker												
Capital/labor	128.5	112.0	136.9	118.0	191.0	35.5	44.8	92.1	1.4	7.1	1.7	14.8
Hectares per worker												
Land/labor	1.5	3.3	0.5	5.2	0.1	0.1	0.1	0.0	0.2	0.4	0.5	0.9
Relative factor price: ratio												
Rental:wage	0.4	0.6	0.4	0.6	0.4	2.6	1.6	1.2	47.3	25.6	43.9	7.2
Land rent:wage	0.3	0.3	1.2	0.4	19.6	108.5	32.9	46.5	124.8	46.7	33.8	4.5
Rental:land rent	1.4	2.0	0.3	1.3	0.0	0.0	0.1	0.0	0.6	0.6	1.3	1.6

Data source: Calculated from the 1992 multi-regional SAM estimated by the author from version 3 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*. Factor returns are calculated as value-added data from GTAP divided by their endowments. 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. Detailed methodology is illustrated in [5].

The USA, 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).

2.1.2. 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 unskilled labor in their total labor force, and the highest rental-wage ratios. The reverse is true for the five high-income regions. While South Korea, Hong Kong, and Taiwan, as newly industrialized economies, fall somewhere between the advanced high-income countries and those poor developing countries. Their skilled labor share is larger than low-income developing countries, but only one half that of high-income developed 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 the five industrial countries, they have a much lower capital intensity, but a higher rental-wage ratio (Table 1).

In terms of natural resources, Japan, South Korea, Taiwan, and China [6] 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 condition is just the opposite 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.

2.2. 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. [7] 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 the US and Canada because of their deficit with Japan). The USA, 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 manufactured goods. The trade patterns of China, ASEAN, and South Asia exhibit some similarities. They are all net

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[6] It is well known that the official statistics of China's arable land underestimate its actual area. The real number may be 20–40% larger than the official statistics. However, it does not change the fact that China is an arable-land-scarce country even if this under-estimation is taken into account.

[7] 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 2
Sectoral net trade by region, 1992 (in billion U.S. dollars)

Commodity	USA	Canada	EU15	AUS/NZL	Japan	South Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW
Rice	0.7	−0.1	−0.1	0.1	−0.0	−0.0	0.0	−0.2	0.2	1.0	0.7	−2.4
Wheat	4.2	3.6	2.0	1.1	−1.0	−0.5	−0.2	−0.0	−1.3	−0.9	−0.9	−6.1
Other grains	5.6	0.4	0.8	0.3	−2.4	−0.7	−0.7	−0.0	1.2	−0.3	−0.0	−4.2
Non-grain crops	4.8	−1.2	−17.9	1.8	−7.1	−0.9	−1.0	−1.2	1.7	3.9	1.7	15.5
Crop subtotal	15.3	2.7	−15.2	3.3	−10.5	−2.2	−1.8	−1.4	1.7	3.8	1.5	2.8
Livestock	0.6	1.2	−2.5	4.2	−1.8	−1.4	−0.2	−0.8	0.7	−0.2	−0.3	0.6
Meat and milk	2.0	0.2	4.2	6.5	−6.5	−0.6	0.6	−0.7	0.4	−0.6	−0.1	−5.3
Other food	4.5	0.0	3.6	0.6	−9.6	−0.8	−1.4	−1.8	1.8	6.7	0.1	−3.8
Total agriculture	22.3	4.1	−9.9	14.7	−28.4	−5.0	−2.8	−4.7	4.6	9.6	1.1	−5.6
Forestry and fishery	0.6	1.1	−6.7	1.2	−13.3	−0.2	0.7	−0.7	0.6	4.5	0.8	11.2
Energy and minerals	−48.0	8.6	−72.9	10.6	−52.9	−14.1	−2.7	−3.9	2.1	8.0	−5.3	170.6
Textile and apparel	−25.1	−3.2	−16.8	−2.0	−4.2	11.4	10.5	3.7	14.1	8.1	11.2	−7.8
Other light manufacturing	−31.9	11.5	−8.9	−2.9	4.4	7.8	10.0	0.6	12.0	11.5	2.1	−16.3
Manufacturing intermediates	5.6	0.7	33.4	−0.3	15.5	−0.4	−1.9	−5.0	−12.0	−18.5	−6.0	−11.2
Machinery and equipment	−12.0	−11.1	44.6	−17.9	208.7	2.1	7.3	−10.8	−20.2	−20.8	−8.5	−161.4
Services	57.3	−8.4	33.6	−4.0	−43.7	−3.3	−7.9	5.8	7.0	−0.2	1.4	−37.5
Total	−31.2	3.2	−3.6	−0.7	86.2	−1.6	13.3	−15.0	8.3	2.3	−3.2	−58.1

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

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 (US$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 manufactures are also the largest trade surplus sector (US$20 billion) in the region.

The net trade data for South 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 USA, Canada, and AUS/NZL are net exporters, while Japan, South Korea and Hong Kong are net importers in all products. 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.

2.3. Comparative position of each region according to its factor endowment

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-intensive products. At the other extreme, the USA, Japan, and EU are seen as major suppliers of capital/technology-intensive goods and as the final market for labor-intensive consumer products. South 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 USA, Japan, and EU, while still remaining important suppliers of labor-intensive goods for industrial countries.

Obviously, the comparative advantages of China, Taiwan, and the USA lie in different groups of economies. Tough economic competition occurs within each group, especially within the two extremes. This implies the USA 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 industrial countries and attract FDI on the one hand, Japan, EU, and the USA 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 is a special case in the model as an 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 that in the USA 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% of its capital/skill-intensive manufactures are imported from abroad.

2.4. 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 USA, Canada, and the EU (Hertel, 1997).

The import protection rates show that there are substantial variations among commodity groups and across regions. Most food and agricultural sectors in East Asia countries such as Japan, South Korea, Taiwan, ASEAN and China are highly protected (higher than 100% in some sectors), especially for grains. The high protection rates mainly reflect high non-tariff barriers, such as import licensing and quotas, in those countries. For example, the tariff rates for rice and wheat are nearly zero in China, however, the state control imports tightly by administrative measures. 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 USA, AUS/NZL, South 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 subsidizes some of its agricultural sectors. Only China and Taiwan still tax agricultural production (although the tax rate is quite low). The USA, 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 South Korea, Taiwan, Hong Kong, ASEAN, China, South

Table 3
Ad valorem estimation for domestic tax and protection rate by regions, 1992 (in precent)

Item	USA	Canada	EU15	AUS/NZL	Japan	South Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW
Import protection rates												
Rice	4.5	5.8	65.0	.1	43.0	77.9	81.2	0.0	72.5	46.3	17.0	12.5
Wheat	13.0	26.0	76.6	1.0	308.0	272.0	307.6	0.0	72.4	155.5	15.2	9.9
Other grains	0.4	24.0	87.3	0.2	336.0	327.0	325.6	0.0	82.5	295.8	6.4	5.8
Non-grain crops	47.5	23.8	51.0	3.4	42.0	51.7	72.9	0.0	118.9	44.4	26.5	22.3
Livestock	1.7	0.3	2.0	0.0	0.8	100.3	3.7	0.0	16.9	66.3	14.4	11.8
Meat and milk	25.0	44.1	74.8	16.0	299.3	113.8	51.6	0.0	24.9	95.2	22.2	27.9
Other food	4.5	5.4	13.1	5.3	12.9	34.6	29.1	0.0	51.7	25.7	34.2	24.7
Forestry and fishery	1.4	0.1	5.1	0.1	3.5	8.8	15.9	0.0	15.9	25.2	9.5	12.3
Energy and minerals	1.2	1.1	0.5	3.1	2.2	5.5	5.0	0.0	9.3	6.4	17.5	13.5
Textile and apparel	18.7	13.9	12.9	36.1	10.4	19.9	8.0	0.0	63.5	27.2	58.7	26.7
Other light manufacturing	4.6	4.9	4.5	13.0	5.0	14.7	4.1	0.0	38.9	13.8	32.2	15.5
Manufacturing intermediates	8.5	3.0	9.2	10.1	3.4	15.9	5.0	0.0	20.2	11.8	48.0	12.4
Machinery and equipments	11.8	3.3	8.5	13.7	1.3	16.5	7.6	0.0	32.3	14.6	34.1	15.8
Average	9.8	4.6	9.7	13.0	19.6	22.6	13.6	0.0	34.3	17.0	33.1	16.5
Domestic tax equivalents												
Rice	−15.1	0.8	−0.8	0.6	−5.2	−24.8	0.8	0.0	2.1	−0.8	−2.3	0.4
Wheat	−27.5	−15.6	−6.0	−0.8	−14.8	0.3	1.0	−0.0	1.0	1.1	−4.6	−1.3
Other grains	−26.8	−6.5	−2.3	−0.3	−16.4	−8.1	0.0	−0.0	2.5	−3.3	−0.6	−0.1
Non-grain crops	−3.2	−9.2	−66.7	0.1	−48.9	−36.7	1.0	−0.0	4.1	−0.3	−2.2	0.1
Livestock	−0.8	−4.4	−8.5	0.7	−0.5	−14.5	1.8	0.0	0.9	0.7	0.5	0.3
Meat and milk	−0.1	−14.1	−1.8	2.9	−1.4	−3.0	2.1	−0.0	2.8	1.6	3.2	−0.4
Other food	1.6	1.3	1.1	1.1	12.9	20.5	15.5	−0.0	13.1	9.4	5.9	4.9
Forestry and fishery	1.3	2.0	0.3	5.1	2.5	0.4	0.1	−0.0	7.2	1.5	2.0	1.7
Energy and minerals	2.8	2.2	3.6	3.5	4.5	4.1	5.3	−0.0	11.3	3.8	12.5	3.1
Textile and apparel	1.2	0.7	1.1	0.4	1.9	1.9	0.5	0.0	7.8	2.0	4.6	1.9
Other light manufacturing	1.6	1.5	1.1	1.5	2.1	2.5	0.8	0.0	8.6	3.0	7.7	2.1
Manufacturing intermediates	1.7	1.7	1.7	0.7	5.3	1.8	0.7	0.0	11.3	0.7	9.4	2.5
Machinery and equipment	1.4	0.9	1.5	0.8	3.2	4.2	1.9	−0.0	10.1	2.0	9.4	2.6
Services	1.6	4.4	1.9	2.2	3.2	4.1	2.6	0.0	7.7	2.5	3.7	3.0
Export tax equivalents												
Rice	−1.2	0.0	−23.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Wheat	−16.7	−7.1	−66.5	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Other grains	−1.3	−15.1	−65.5	1.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
Non-grain crops	−0.0	−5.0	−22.6	0.4	0.0	0.0	0.0	0.0	0.0	2.1	0.0	3.8
Livestock	0.0	0.0	−0.2	4.2	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.7
Meat and milk	−6.2	−8.7	−45.4	−1.5	0.0	0.0	0.0	0.0	0.0	0.8	0.0	−0.1
Other food	0.0	−0.2	8.6	0.3	0.0	0.0	0.0	0.0	0.0	3.2	0.0	2.9
Forestry and fishery	0.0	0.0	−1.5	0.8	0.0	0.0	0.0	0.0	0.0	5.0	0.0	1.8
Energy and minerals	0.0	0.0	3.5	1.9	0.0	0.0	0.0	0.0	0.1	1.9	0.0	4.7
Textile and apparel	0.0	0.0	0.1	0.1	0.0	5.8	5.7	12.5	13.0	22.1	19.3	9.3
Other light manufacturing	0.0	0.0	−0.1	0.6	1.3	0.4	0.6	0.5	0.0	2.9	0.0	1.0
Manufacturing intermediates	0.4	0.1	0.4	0.5	1.0	0.4	0.6	0.1	1.5	3.6	1.2	3.4

Table 3 (continued)

Item	USA	Canada	EU15	AUS/NZL	Japan	South Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW
Machinery and equipment	0.0	0.0	0.6	−0.8	5.1	1.8	2.3	1.9	0.0	6.1	0.2	0.5
Services	0.0	0.0	1.6	0.4	0.0	0.0	0.0	0.0	0.0	2.4	0.0	1.1

Data source: Calculated from the 1992 multi-regional SAM estimated by the author from version 3 GTAP database (Hertel, 1997). The import protection rates of food and agricultural sectors in China and South Asia countries were negative in version 3 GTAP. They reflected government consumer price subsidies on living necessities in those countries. I eliminated all negative protections and treated them as consumer price subsidies in the global SAM. Protection rate of food and agricultural sectors in China and South Asia are based on earlier version GTAP database except China's crop sectors, which include tariff equivalence of non-tariff barriers based on Zhang et al. (1997).

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 information 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 which 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. The purpose of above SAM-based economic analysis is to provide intuitions so as to facilitate understanding of simulation results reported later in this paper.

3. Structure of the model

The model used in this paper is an extension of the basic general equilibrium trade model of de Melo and Tarr (1992) to a multi-country setting. In the extension, I follow the tradition of Whalley (1985) to endogenize all regions including rest of the world, and incorporate the macro economic specifications from Devarrajan et al. (1990), as well as an international shipping sector similar to GTAP model (Hertel, 1997). Moreover, the up-level Leontief technology in de Melo and Tarr's model is replaced by CES function, which allows substitution between value-added and aggregate inputs in the upper-level of the production tree, and their ELS demand system has been extended to ELES system thus household saving decisions become endogenous in the model. Because duality approach is used throughout the specification, the model is relatively simple and transparent in structure. A detailed Algebraic description of an earlier version of the model can be found in Wang and Slagle (1996) or Wang (1997), and a detailed equation list of the modified version used in this paper can be found in Wang and Schuh (forthcoming). The model is implemented by General Algebraic Modelling System (GAMS, Brooke et al., 1988).

In this study, 12 regions and 14 production sectors in each region are specified in the model 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.

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[8] Professionals include 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 labor.

3.1. 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 their income from factor returns to savings and expenditures, which buy final consumption goods from the firms. The investor simply collects savings from households, government, and firms, accounts 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.

3.2. Production

There is one competitive firm in each sector for every region, which produces only one product. The production is characterized by two-level nesting of constant elasticity of substitution (CES) functions. At the first level, firms are assumed to use two types of inputs: a composite primary factor and an aggregate intermediate input according to a CES cost function. At the second level, the split of intermediate demand is assumed to follow Leontief specification, therefore, there is no substitution among intermediate inputs. The four primary factors also substitute smoothly through a CES cost function. The degree of substitutability between the composite primary factor and the aggregate intermediate as well as among the four primary factors depends on their base year share in production and on the elasticity of substitution that is assumed to be constant. Technology in all sectors exhibit constant return to scale implying constant average and marginal cost. Firm's output is sold on the domestic market or exported to other regions through a constant elasticity of transformation (CET) function. The structure of production are illustrated in Fig. 1. The CET function can be partially or entirely turn off in the model, in such case, exports and domestic sales become perfect substitutes.
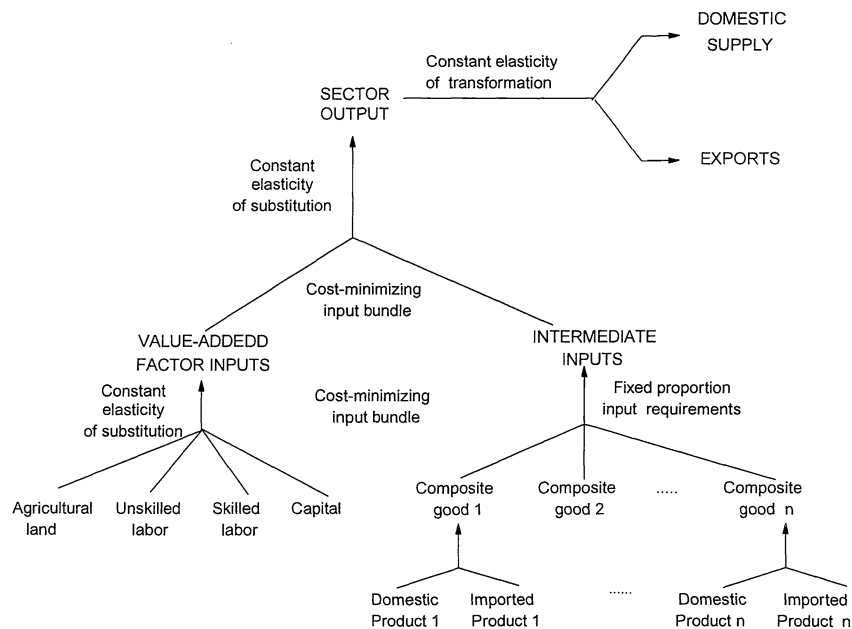

Fig. 1. Structure of production in the model.

3.3. Demands

Agents in each region value products from different regions as imperfect substitutes (the Armington assumption, Armington, 1969). The private household in each region maximizes a Stone–Geary utility function over the 14 composite goods, subject to their budget constraints, which leads to the Extended Liner Expenditure System (ELES) of household demand functions. Household savings are treated as demand for future consumption goods with zero subsistence quantity (Howe, 1975). An economy-wide consumer price index is specified as the price of savings. It represents the opportunity cost of giving up current consumption in exchange for future consumption (Wang and Kinsey, 1994). 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, firm intermediate inputs, 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 domestic 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. The structure of demand is depicted in Fig. 2.

3.4. 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 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.
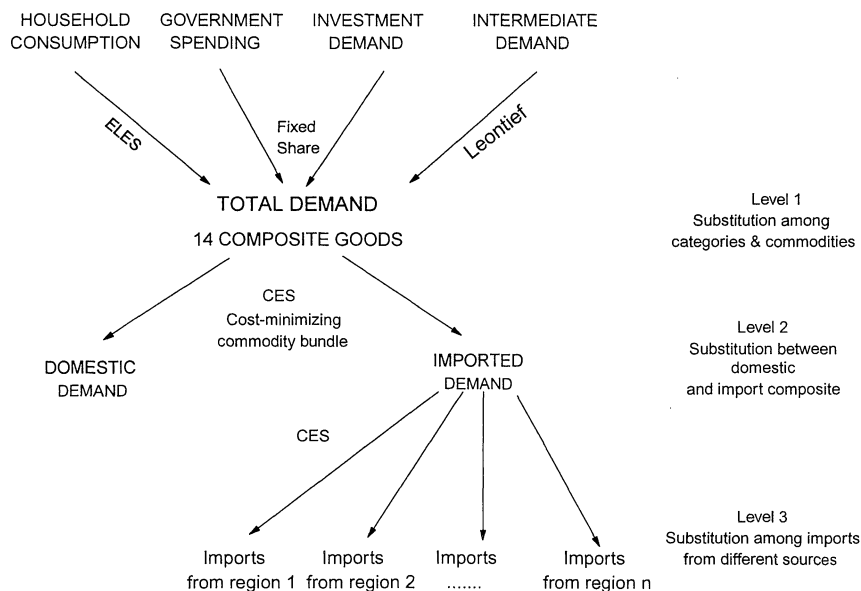

Fig. 2. Structure of demand in the model.

3.5. 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.

3.6. Price system

There are 10 types of prices for the goods with same sector classification in each region. They are value-added prices, aggregate intermediate prices, average output prices, composite good prices, consumer prices, producer prices, export prices, import prices, f.o.b. prices, and c.i.f prices. The value-added price equals the unit cost of primary factor inputs. The aggregate intermediate price is a fixed proportion (IO coefficients) weighted average of composite good prices. A CES aggregation of the two equals the average output prices. Adding to it the production taxes yields the producer prices which are tax inclusive CET aggregation of domestic and export prices. Sellers receive this price. The composite good price is a tax inclusive CES aggregation of domestic and import price, which in turn is an aggregation of tariff inclusive import prices from different sources. The consumer price is the composite good 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 ten categories of prices in the model is illustrated in Fig. 3. An exchange rate, as a conversion factor, translates world market prices into domestic prices. An adjustable exchange rate in the model implies a change in domestic price index is sufficient to sustain a constant current-account balance measured at world prices.
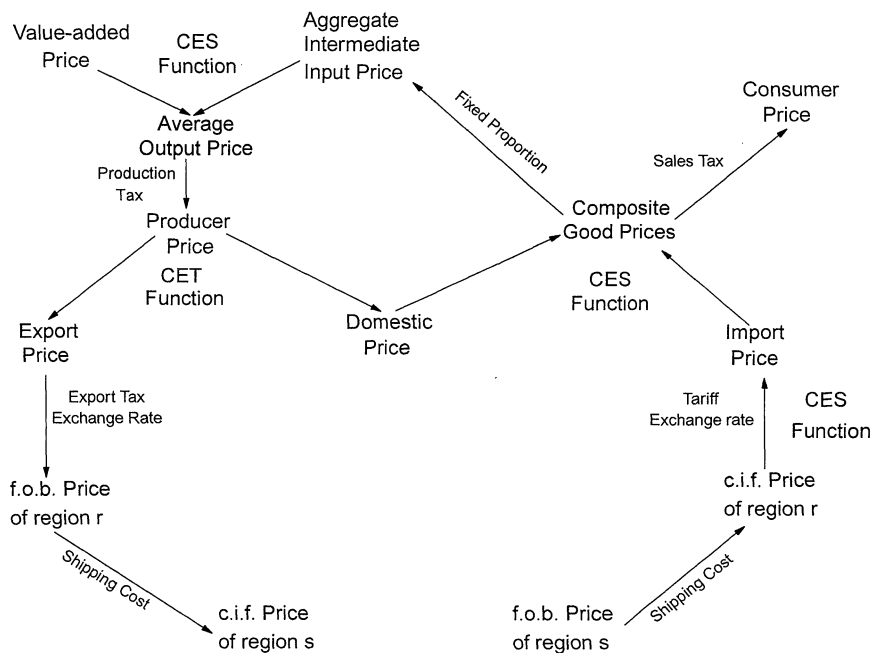

Fig. 3. Price system in the model.

3.7. Equilibrium

Equilibrium is defined as a set of prices and quantities for goods and factors in all regions such that (1) demand equals supply for all goods and factors; (2) each industry earns zero profit; and (3) gross investment equals aggregate savings in each region.

3.8. Choice of numeraire

In common with other CGE models, only relative prices matters. The absolute price level must set exogenously. The aggregate consumer price index in each region, is used as numeraire. The advantage of this normalization choice is that factor returns and household income in model solution are in real terms. Moreover, The equilibrium exchange rates defined in the model are also in real terms, and can be seen as equilibrium price-level-deflated (PLD) exchange rates, using the country's consumer price indices as deflators (Lewis et al., 1995).

3.9. 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: (1) the government deficit (surplus); (2) aggregate saving and investment; and (3) 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 (Devarrajan et al., 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, total real government expenditures, and aggregate real 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 macro economic 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.

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. Prices in each region's product markets are assumed to be flexible to clear the markets. Each region is assumed to have a fixed amount of arable land specific to agriculture.

3.10. 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 long run, 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 can be chosen in the model: one static, one steady-state. Under the static capital market closure, the aggregate productive capital stock is fixed in each region, and the region-specific average 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 until 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 classical 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). [9]

4. Impact of China and Taiwan access to WTO

4.1. Design of alternative scenarios

There are two sets of counterfactual experiments carried out by the model.

4.1.1. 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 version 3 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 20% for developed countries (16.8% for the EU), 13.3% for developing countries, while the reduction of agricultural export subsidies is 36% for developed countries and 24% for developing countries, based on estimates by Francois et al. (1995). To simulate the termination of Multi Fiber Arrangement (MFA) quota system, the quota rent equivalent export taxes are eliminated for all developing countries except China and Taiwan because they are not WTO members under this scenario.

4.1.2. Scenario II—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% cut on top of China's recent tariff schedules (April 1, 1996) is assumed for China's WTO accession (see the column in Table 4, 'China WTO'). China's recent tariff schedules are aggregated from the

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[9] 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.

Table 4
Simulation design: reduction of import protection by sectors and regions (in percent)

	USA	Canada	EU15	AUS/ NZL	Japan	South Korea	Taiwan WTO	Hong Kong	China WTO	ASEAN	South Asia	ROW
Rice	36.4	36.3	1.4	98.5	1.8	47.3	15.3	0.0	35.0	48.0	25.0	2.3
Wheat	69.2	69.2	4.7	36.0	37.3	95.2	15.0	0.0	35.0	95.0	25.0	18.5
Other grains	63.0	74.2	3.0	37.5	46.4	70.9	38.5	0.0	41.5	70.8	25.0	15.0
Non-grain crops	31.8	3.4	0.6	26.2	7.9	7.7	49.5	0.0	45.0	23.3	15.0	6.3
Livestock	41.3	37.5	42.2	3.4	24.3	30.3	19.4	0.0	48.1	31.4	25.0	15.0
Meat and milk	30.6	31.6	6.0	58.9	35.1	66.9	42.2	0.0	35.5	32.1	25.2	3.0
Other food	29.8	31.1	26.8	23.7	17.1	36.9	44.0	0.0	52.3	43.0	19.7	13.0
Forestry and fishery	0.1	0.4	16.1	13.1	32.6	27.8	36.0	0.0	40.2	59.7	0.8	1.3
Energy and minerals	17.9	30.4	22.8	31.2	3.3	14.4	36.0	0.0	51.5	10.0	17.7	2.2
Textile and apparel	11.7	27.9	15.3	38.7	23.5	26.9	36.0	0.0	65.7	35.6	6.9	7.6
Other light manufacturing	28.6	32.9	36.0	32.5	19.7	32.8	36.0	0.0	55.4	21.6	8.8	28.0
Manufacturing intermediates	17.1	32.7	17.2	34.1	46.3	53.1	36.0	0.0	56.0	7.4	33.4	6.9
Machinery and equipment	10.6	22.0	26.0	25.9	0.4	41.4	36.0	0.0	50.7	19.3	26.3	5.6
Average cuts	15.1	24.2	16.3	30.3	32.7	47.8	38.2	0.0	54.8	27.0	24.4	8.5
Before UR average	9.8	4.6	9.7	13.0	19.6	22.6	13.6	0.0	34.3	17.0	33.1	16.5
After UR average	8.3	3.5	8.1	9.0	13.2	11.8	8.4	0.0	15.5	12.4	25.0	15.1

Data Source: calculate from version 3 GTAP database (Hertel, 1997) except China and Taiwan. A 35% reduction on top of China's recent tariff cuts (April 1, 1996) is assumed for China. Data on China's recent tariff cuts were aggregated from the Harmonized Commodity Description and Coding System (HS) tariff schedules published by China's Customs Administration and weighted by 1994 trade data. The data were provided by the Development Research Center, State Council of China. Tariff reductions for agricultural products except rice and wheat for Taiwan were provided by its Council for Agriculture, 36% cuts are assumed for non-agricultural sectors and 15% cuts are assumed for rice and wheat.

Harmonized Commodity Description and Coding System (HS) tariff schedules published by China's Customs Administration and weighted by 1994 trade data. [10] Tariff reductions for agricultural products except rice and wheat for Taiwan are provided by its Council for Agriculture, 36% cuts are assumed for non-agricultural sectors and 15% cuts are assumed for rice and wheat (see the column in Table 4, 'Taiwan WTO'). Because China and Taiwan become WTO members under this scenario, they also obtain the benefit from the elimination of MFA quotas as other developing countries.

For each of the two scenarios, experiments are repeated under the static and steady-state capital market closures described earlier; therefore, there are four simulations conducted in total.

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

[10] 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) in manufacturing sector.

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 interest diversifications 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 et al. (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 from this study.

resource allocation. The *difference* between the two scenarios—Uruguay Round implementation with or without Chinese and Taiwanese participation—is our estimates of the impact of China and Taiwan joining the WTO. However, our estimates should be regarded as results from 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.

4.2. Aggregate effects

Table 5 summarizes the major aggregate economic-wide effects from the two scenarios under both the static and the steady-state capital market closures. It shows that the implementation of the Uruguay Round with and

Table 5
Simulation results: major macro indicators (percentage change from base)

	USA	Canada	EU15	AUS/ NZL	Japan	South Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW	Total
Static capital market closure													
WTO without China and Taiwan													
Social welfare (billion US$)	10.4	0.6	24.8	0.6	15.3	4.9	0.5	−0.5	−1.2	7.3	2.3	−2.3	62.8
As percent of base GNP	0.2	0.1	0.3	0.2	0.4	1.6	0.2	−0.7	−0.3	1.9	0.7	−0.1	0.3
International term of trade	1.0	−0.5	2.6	−1.4	−1.2	−3.7	−0.0	−0.3	−0.5	−2.0	1.1	−2.3	0.0
Real exports (billion US$)	19.3	2.0	23.3	2.8	8.1	14.1	0.4	2.2	−0.3	26.2	12.2	13.9	124.2
As percent of base exports	3.4	1.5	3.4	5.0	2.1	17.0	0.4	5.0	−0.3	14.9	30.8	2.4	4.2
Real imports (billion US$)	29.5	2.4	32.5	3.0	10.0	11.7	1.3	1.2	0.1	20.4	9.5	12.0	133.4
As percent of base imports	4.6	1.6	4.4	5.0	3.2	13.0	1.5	1.9	0.1	11.1	20.8	1.8	4.3
WTO including China and Taiwan													
Social welfare (billion US$)	15.1	1.3	31.4	0.8	17.6	5.0	1.7	−0.2	11.2	6.1	1.3	−3.2	88.1
As percent of base GNP	0.3	0.2	0.4	0.2	0.5	1.6	0.8	−0.2	2.9	1.6	0.4	−0.1	0.4
International term of trade	1.4	−0.2	2.9	−1.3	−0.6	−3.5	−1.9	0.8	−0.9	−2.2	−0.0	−2.5	0.0
Real exports (billion US$)	22.1	2.6	27.6	2.8	9.4	13.6	7.1	2.2	51.7	22.2	10.6	11.2	183.0
As percent of base exports	3.9	1.8	4.0	5.0	2.5	16.3	7.8	5.0	51.0	12.6	26.7	1.9	6.2
Real imports (billion US$)	40.4	4.2	47.2	3.3	14.2	12.0	7.5	2.2	36.4	18.2	7.9	11.0	204.4
As percent of base imports	6.3	2.9	6.4	5.5	4.6	13.3	9.0	3.5	35.1	9.9	17.3	1.6	6.5
Steady-state capital market closure													
WTO without China and Taiwan													
Social Welfare (billion US$)	19.7	1.6	32.5	2.0	33.7	20.0	0.9	0.2	−2.2	35.7	5.2	2.2	151.6
As percent of base GNP	0.3	0.3	0.5	0.6	0.9	6.5	0.4	0.3	−0.6	9.2	1.6	0.1	0.7
International term of trade	0.9	−0.5	2.6	−1.3	−1.2	−3.6	0.1	−0.5	−0.5	−2.1	1.3	−2.4	0.0
Real exports (billion US$)	20.8	2.3	24.9	3.1	10.3	17.7	0.7	2.7	−0.3	38.1	12.6	14.7	147.6
As percent of base exports	3.6	1.6	3.6	5.5	2.7	21.3	0.8	6.1	−0.3	21.7	31.7	2.5	5.0
Real imports (billion US$)	32.2	2.6	35.4	3.4	13.0	14.9	1.7	1.7	0.2	30.2	9.9	13.1	158.2
As percent of base imports	5.0	1.8	4.8	5.7	4.2	16.5	2.1	2.7	0.2	16.5	21.8	1.9	5.1
Percent increase of capital	0.4	0.4	0.3	1.0	1.2	11.2	0.3	2.0	−0.9	12.9	2.2	0.2	0.8
WTO including China and Taiwan													
Social welfare (billion US$)	28.2	3.0	44.2	2.3	37.9	20.1	6.8	1.6	28.1	32.1	3.6	0.3	208.3
As percent of base GNP	0.5	0.5	0.6	0.7	1.0	6.5	3.2	2.1	7.2	8.2	1.1	0.0	0.9
International term of trade	1.4	−0.2	2.9	−1.2	−0.6	−3.5	−1.8	0.4	−0.5	−2.4	−0.0	−2.5	0.0
Real exports (billion US$)	24.3	3.0	29.7	3.1	12.0	17.3	8.9	3.4	57.3	32.9	10.9	11.9	214.7
As percent of base exports	4.2	2.1	4.3	5.6	3.2	20.7	9.7	7.6	56.7	18.7	27.5	2.0	7.2
Real imports (billion US$)	44.3	4.6	51.1	3.8	17.7	15.2	9.4	3.5	41.0	27.3	8.3	12.4	238.7
As percent of base imports	6.9	3.2	6.9	6.4	5.7	16.9	11.2	5.5	39.6	14.9	18.3	1.8	7.6
Percent increase of capital	0.6	0.7	0.5	1.0	1.4	11.2	6.2	4.4	12.1	11.8	1.7	0.2	1.1

without China and Taiwan's participation results in different macro effects across regions. In scenario I, social welfare measured by the Hicksian equivalent variation would increase in all regions except China, Hong Kong, and rest of the world in the static simulations, with a much stronger impact when the medium-term accumulation effect is taken into account. Specifically, the comparative statics show the implementation of the UR excluding China and Taiwan would entail a permanent social welfare loss of about US$1.2 billion and US$0.5 billion per year (or 0.3% and 0.7% of their 1992 GDP) for China and Hong Kong respectively. Taking the medium-term accumulation effects into consideration, China's loss would be much larger (US$2.2 billion), while Hong Kong would gain slightly due to its free port status and flexibility in the world market. ASEAN countries gain the most (1.9% of their base year GDP in the static case, 9.2% of their base GDP in the steady-state case), followed by South Korea (1.6% and 6.5% of its base year GDP, respectively). Taiwan also gains, but the gain is much smaller than that of South Korea and ASEAN since it does not participate in the trade liberalization process. When both China and Taiwan join the WTO (scenario II), social welfare increases in all regions in both the static and steady-state simulation except Hong Kong and rest of the world, which still suffer marginal losses in the static case. All developed and newly industrialized countries would gain more from China's and Taiwan's WTO accessions, while other developing regions would gain slightly less than the case of Uruguay Round without China's participation because their similar factor endowments and directly competition with China in exporting labor-intensive products (this results may change when scale effect is taken into account).

The major beneficiaries from China's and Taiwan's WTO accessions are themselves. WTO membership would bring net social welfare gains about US$25 billion to the world economy in the static simulation, with US$12.4 billion (3.2% of China's base year GDP) accruing to China, and US$1.2 billion to Taiwan (about 0.6% of its base year GDP). With the accumulation effect, China's net gain would more than double to US$30.3 billion (7.8% of its base GDP), and Hong Kong would also gain about US$1.4 billion (1.8% of its base GDP). This is a significant benefit for China compared with the moderate gains for developed countries from China's WTO accession.

The indicators of trade environment and trade performance in Table 5 may help to explain how the aggregate welfare gains and losses may occur.

The USA and the EU enjoy both a substantial improvement in terms of trade and an expansion in real trade volume. Therefore, they are clearly the winners of the Uruguay Round. China suffers from both terms of trade deterioration and decline in real exports, it is definitely a loser because of trade diversion effects if it does not participate the global trade liberalization process. Japan, Canada, AUS/NZL, South Korea, Hong Kong, ASEAN, and rest of the world, are subject to terms of trade losses, but gains in real exports. In the case of Hong Kong and rest of the world, the price effect dominates volume effect (static simulation), while in the case of other regions, the volume effect dominates the terms of trade effect. Joining the WTO would enable China expand its exports by about US$52 billion in the static simulation and US$57.6 billion in the steady-state simulation, thus the region is able to obtain welfare gain in spite of the deterioration of terms of trade. Interestingly, When China participates WTO and the Uruguay Round trade liberalization, the terms of trade improve in all developed and newly industrialized countries, but worsen in other developing regions especially countries in South Asia. Moreover, China and Taiwan's joining the WTO would enable further increase export growth in the USA, Canada, Japan, Hong Kong, and the EU, but decrease export growth in other developing countries, especially China's Asian competitors such as ASEAN and South Asia. Compare to Scenario I, their export growth rates decline by about 3% and 4% respectively.

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 Uruguay Round with or without China and Taiwan entail such different macro economic effects across regions in the world? To fully understand factors underlying these aggregate outcomes, it is necessary to look at the sectoral details, and the resource reallocation that occur in response to the UR trade liberalization. Because results from the static and steady-state simulation have
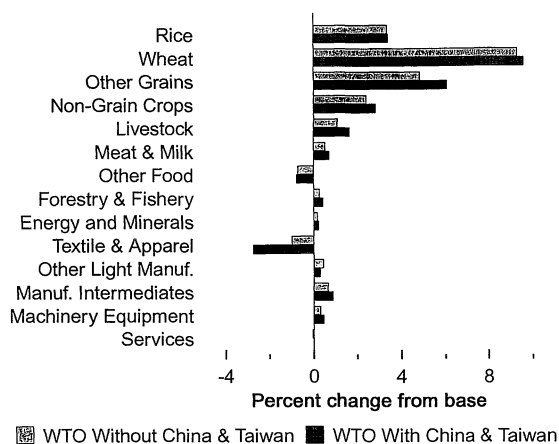
Fig. 4. Changes in world market (c.i.f.) prices.

similar patterns, only the results from steady state calculation are presented in sectorial details due to space limitation.

4.3. Sectoral price effects

Fig. 4 summarizes changes in average c.i.f. prices by commodities in the world market for the two simulation scenarios under the steady-state capital market closure. They show that the c.i.f prices for almost all food and agricultural commodities except other processed food 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. Fig. 4 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 c.i.f. prices for textile and apparel into further decline, while pushing the c.i.f. prices of manufactured intermediates and machinery and equipment into further increase. This explains why China's and Taiwan's joining the WTO will cause a favorable terms-of-trade change for industrial countries but unfavorable for other developing countries such as its direct competitors (ASEAN and South Asia) in world labor-intensive export markets.

In the world agricultural market, China's and Taiwan's admission to the WTO and implementation of Uruguay Round reductions in subsidies and tariffs will increase world grain prices when both China and Taiwan import more grains from the international market, especially feed grains. It also drives up world prices for meat, milk, and other livestock products, 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. However, the world price for other processed food products would decline slightly because of exports expansion in Taiwan.

4.4. Sectoral trade volume effect

Table 6 presents estimates of differences in real trade volumes by sector between scenarios I and II under the steady-state capital market closure. China's and Taiwan's joining the WTO would increase world trade by about

US$147 billion (imports plus exports) at 1992 prices. More than 80% of the export gains would go to China, another 12% would go to Taiwan. Developed countries also gain, but the real export increase for other developing regions would be less if China and Taiwan continue to be excluded from the WTO. There is an

Table 6

Differences in trade volume by sectors between a WTO with and without China and Taiwan (in million U.S. dollars)

Item	USA	Canada	EU15	AUS/NZL	Japan	South Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW	Total
Exports													
Rice	−7	−0	−0	1	−0	−0	1	0	−38	29	52	−2	37
Wheat	168	380	23	20	0	0	0	0	−1	1	4	6	601
Other grains	202	43	11	90	0	0	0	0	−300	1	1	34	84
Total grains	364	423	34	111	−0	−0	2	0	−339	32	57	39	722
Non-grain crops	1106	79	89	46	58	68	170	9	−775	882	363	660	2754
Livestock	95	36	141	64	18	7	93	3	−261	24	7	136	362
Meat and milk	−19	−11	75	−27	6	−4	348	−0	−105	28	84	42	417
Other food	902	20	2098	−43	46	−71	582	329	62	−13	86	112	4110
Food and agriculture	2448	547	2437	152	128	1	1195	340	−1419	952	597	989	8366
Forestry and fishery	107	21	17	132	14	−3	−57	2	−254	230	84	236	528
Energy and minerals	79	63	140	−111	60	6	46	22	710	401	141	477	2034
Textile and apparel	−788	−161	−975	−81	1002	−652	5976	−1786	50401	−8410	−3057	−5441	36027
Other light manufacturing	−57	−127	128	−24	332	−77	267	794	4150	79	113	−63	5513
Manufacturing intermediates	394	106	793	27	369	272	899	793	1196	352	96	181	5478
Machinery and equipment	1171	221	1933	−23	86	22	191	591	2162	787	48	378	7567
Services	118	38	271	−39	−285	−37	−268	−69	692	417	305	434	1577
Total	3471	709	4744	32	1705	−468	8248	686	57639	−5192	−1673	−2808	67092
Imports													
Rice	1	0	3	0	0	0	0	2	43	3	−4	−8	41
Wheat	0	0	−1	0	0	−6	44	1	690	−5	−43	−34	645
Other grains	1	2	−2	0	−4	−26	64	0	140	−25	−1	−57	91
Total grains	3	2	−0	0	−4	−32	108	3	873	−28	−48	−99	778
Non-grain crops	10	16	−7	2	−14	−8	1081	15	2416	−120	−59	−98	3233
Livestock	−11	1	−54	0	1	3	−58	6	588	−12	−29	−23	413
Meat and milk	−11	4	−8	1	144	1	221	10	115	37	−10	−32	472
Other food	84	12	58	22	381	42	631	40	3668	−13	−101	−39	4786
Food and agriculture	75	36	−12	26	508	7	1982	74	7660	−135	−248	−291	9682
Forestry and fishery	−18	−2	24	2	103	6	190	23	383	−50	−10	−3	647
Energy and minerals	231	21	143	42	829	118	495	131	828	−228	−291	−89	2230
Textile and apparel	11514	1776	15828	118	1288	121	568	411	12855	−791	−92	1306	44901
Other light manufacturing	918	77	548	86	614	57	503	183	3749	−174	−63	158	6655
Manufacturing intermediates	−335	4	−347	7	337	−21	1656	231	6575	−760	−428	−691	6228
Machinery and equipment	−472	63	−765	57	444	39	1439	539	8600	−336	−326	−771	8513
Services	213	40	292	61	651	46	775	173	184	−458	−168	−233	1577
Total	12127	2016	15711	398	4774	372	7609	1764	40834	−2931	−1627	−614	80433

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.

opportunity cost for other developing regions. For instance, China and Taiwan's participation would cost ASEAN countries about US$5.2 billion and South Asia about US$1.7 billion in potential exports. Sectoral trade data further show China's and Taiwan's accession to the WTO would intensify competition for labor-intensive exports (their textile and other labor intensive exports would increase by US$60 billion), and drive up the demand for capital- and technology-intensive products (their imports of manufactured intermediates and machinery and equipment would rise more than US$18 billion), thus putting more pressure on developing countries and benefitting industrial countries. The USA and EU would import US$27 billion more in textiles and apparel, and US$1.5 billion more in other labor intensive products, but export about US$4 billion more in machinery and manufactured intermediates. China's exports of manufactures would expand in all sectors, but nearly 90% of such expansion would be textile and apparel products. Therefore, the elimination of the MFA quota for Chinese products in developed countries' markets would be one of the major incentive for China to join the WTO. However, the export expansion in Taiwan is more diversified. Its exports of non-land-intensive agricultural commodities such as vegetables, meats, and other processed food would constitute about 15% of its total export growth from joining the WTO, and capital and technology-intensive products take another 13%, indicating Taiwan's comparative edge would increase in such sectors after it joins the WTO.

Global food and agricultural trade would expand by nearly US$18 billion. The most notable change would be the dramatic increase in net agricultural imports by China (US$9 billion annually, drop in exports plus increased imports). After becoming a member of the WTO, agricultural sectors in China would not be able to hold onto production factors bid away by the expansion of its manufacturing industries, especially the labor-intensive sectors. Among Asian countries, net food and agricultural imports would also increase in Taiwan, Japan, and South Korea, but decline in ASEAN, and South Asia. The major underlying reason for this disparity is that China's participation in the WTO reduces exports of labor-intensive products to the world market from 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, resulting in the expansion of production and exports of agricultural products from those countries. However, the increase of production of labor-intensive sectors in China demands more manufactured inputs from the world market, causing manufacturing sector expansion and agriculture production decline in Japan, South Korea and Taiwan, thus increasing their net imports demand for food and agricultural products.

At the sector level, China's and Taiwan's joining the WTO has the most profound impact on non-grain crops (including cotton) and other processed food trade. Because the non-grain crop is closely tied to the textile industry, China and Taiwan dramatically increase their imports of non-grain crops from the world market by US$3.4 billion. In the meantime, China reduces its exports in this sector 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 attract more production factors after the tariff cut on processed food products upon China's WTO accession. Lower prices will reduce domestic production and increase China's import demand by about US$3.6 billion, thus dramatically increasing its net imports of such commodities. Another notable impact is at the world grain market. China and Taiwan's WTO accession will increase their net grain imports by US$ 1.2 billion and US$106 million respectively. Nearly 95% of those increased grain demand are wheat and feed grains, and will be supplied by the export expansion from the USA, Canada and Australia. However, the increased net imports of rice in China (US$81 million) will be supplied by ASEAN and South Asian, because those two regions are relatively efficient rice producers in the world market.

4.5. Impact on U.S. agricultural production and trade

What do the effects of China's and Taiwan's WTO accession discussed above imply for US agricultural production and trade? Table 7 reports its impact on U.S. agricultural production and factor reallocation. Tables 8

Table 7

Impact on U.S. agricultural production and factor allocation[a] (difference between a WTO with and without China and Taiwan)

Sectors	Structure changes				Factor reallocation			
	Production	Consumption	Exports	Imports	Land	Unskilled labor	Skilled labor	Capital
Rice	−0.19	0.06	−0.93	1.28	−1.47	−0.11	−0.20	−0.03
Wheat	2.32	0.04	3.85	0.08	1.20	2.45	2.37	2.52
Other grains	0.78	0.04	3.22	0.27	−0.32	0.92	0.83	0.99
Non − grain crops	1.64	0.05	6.93	0.10	0.54	1.79	1.71	1.86
Livestock	0.21	0.04	3.43	−0.48	−0.90	0.33	0.24	0.40
Meat and milk	0.07	0.05	−0.22	−0.16	n.a.	0.10	0.00	0.18
Other food	0.41	0.09	4.60	0.56	n.a.	0.39	0.29	0.48
Food and agriculture	0.46	0.07	4.23	0.22	0.00	0.68	0.33	0.70
Forestry and fishery	0.42	0.26	1.85	−0.33	n.a.	0.37	0.29	0.44
Energy and minerals	0.15	0.27	0.41	0.32	n.a.	0.11	0.01	0.20
Textile and apparel	−10.02	1.45	−7.18	17.49	n.a.	−10.90	−11.00	−10.82
Other light manufacturing	−0.13	0.32	−0.16	1.26	n.a.	−0.21	−0.32	−0.11
Manufacturing intermediates	0.10	0.26	0.49	−0.46	n.a.	0.07	−0.04	0.16
Machinery and equipment	0.28	0.18	0.49	−0.28	n.a.	0.27	0.16	0.36
Services	0.15	0.21	0.08	0.25	n.a.	0.15	0.03	0.26
Total	0.03	0.24	0.59	1.78	0	0	0	0.17

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

Table 8

Impact on U.S. Food and Agricultural Trade[a] (difference between a WTO with and without China and Taiwan)

	Canada	EU15	AUS/ NZL	Japan	South Korea	Taiwan	Hong Kong	China	ASEAN	South Asia	ROW	Total
Differences in food and agricultural exports by destination (million U.S. dollars)												
Rice	−0.2	−1.2	0.0	0.0	0.0	0.1	0.0	0.1	−0.0	−0.0	−5.4	−6.6
Wheat	0.0	0.0	0.1	4.3	0.3	29.9	0.8	152.7	−5.5	−14.8	0.6	168.4
Other grain	1.5	−1.4	0.0	57.6	73.7	52.0	0.0	0.1	3.7	0.0	15.2	202.5
Non-grain crop	8.2	−27.3	0.5	56.6	12.5	560.1	32.3	485.0	−2.9	−2.8	−16.2	1105.9
Livestock	1.6	2.3	0.0	1.4	7.5	−8.3	7.0	83.2	0.4	−0.6	0.2	94.7
Meat and milk	2.8	−0.8	0.0	−80.6	6.2	5.2	6.6	51.5	−3.0	−0.4	−6.4	−18.9
Other food	3.5	−12.0	2.0	7.9	5.6	125.4	2.4	822.3	−13.9	−9.3	−31.8	902.0
Total	17.4	−40.4	2.6	47.1	105.9	764.3	49.1	1594.8	−21.2	−27.8	−43.9	2447.9
Differences in U.S. food and agricultural market share across regions (percentage points)												
Rice	−0.44	−0.60	−0.15	−0.09	−0.02	−0.05	0.02	0.00	−0.03	0.00	−0.16	−0.42
Wheat	−0.00	0.17	0.30	0.35	0.19	0.23	0.36	0.21	−0.17	0.23	0.22	−0.57
Other grain	0.01	−0.11	0.60	2.24	4.67	0.05	0.20	0.00	0.50	1.42	1.44	1.40
Non-grain crop	−0.07	−0.10	0.02	0.72	0.82	0.75	2.35	−10.88	0.63	0.00	0.22	0.64
Livestock	0.19	0.17	−0.14	0.07	0.34	0.94	0.78	3.84	0.37	0.04	0.26	0.19
Meat and milk	0.06	−0.01	−0.05	−1.24	0.35	−1.11	0.55	7.38	−0.10	−0.00	−0.02	−0.28
Other food	−0.07	−0.08	−0.11	−0.64	−0.09	0.50	−0.14	10.36	−0.23	−0.03	−0.08	0.11
Total	−0.03	−0.06	−0.09	−0.32	1.08	1.75	0.68	3.71	0.01	0.07	0.06	0.19

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

and 9 summarize its effects on U.S. agricultural exports and U.S. market share in global agricultural goods market, domestic prices of U.S. farm products, and farm income.

Table 7 reports the percentage change in production, consumption, imports, and exports as well as production factor reallocation in major U.S. food and agricultural sectors between a WTO with and without China and Taiwan. To put agriculture in a broad economic context and assess important tradeoffs between agricultural and other sectors in U.S. economy, changes in non-agricultural sectors are also listed in Table 7 for reference. If China and Taiwan join the WTO, U.S. food and agricultural production would expand by less than half percent with output increases in all sectors except rice. U.S. food and agricultural exports would increase by 4.2%. At the sector level, exports of non-grain crop would expand the most, 6.9%, followed by processed food (4.6%), wheat (3.8%), livestock products (3.4%), and feed grains (3.2%), while exports of rice and meat and milk would decline slightly by 0.9 and 0.2%, respectively because of competition from more efficient producers in the world markets (for instance, ASEAN and South Asia in world rice market, and Taiwan in world meat market). The production and export expansion would attract more factors into U.S. food and agricultural sectors from other parts of the economy and reallocate land resources among different crops. The skilled and unskilled labor forces in food and agriculture would increase by 0.3% and 0.4%, respectively, and capital stock in agriculture would increase by 0.5%.

In an economy-wide prospective, almost all U.S. industries except for the two labor-intensive sectors would gain by China and Taiwan's WTO accession. Consumption goes up in every sector, with textile and apparel products gaining the most by 1.5%. Total U.S. exports would increase by 0.6%. U.S. consumers, farmers, food processing firms and capital- and technology-intensive manufacturers are all winners, only apparel firms and workers are the losers. U.S. textile and apparel production and exports will decline by 10% and 7%, respectively, about 11% of workers in those sectors would have to change their jobs. This is a cost for the gain that U.S. policy makers need to consider. However, the proportion of U.S. labor employed in textile and clothing sectors was less then 2% of the U.S. labor force in 1992, and it will decline over time regardless of China's WTO accession. China's joining the WTO would only accelerate this process.

Table 8 shows that China's and Taiwan's WTO accession would increase total U.S. food and agricultural exports by about US$2.4 billion. Most of the increased exports go to China (US$1.6 billion) and Taiwan (US$0.76 billion), with a small portion going to South Korea, Japan, and Hong Kong, replacing exports that had previously come from China. This increase is mainly trade created from admitting China and Taiwan into the WTO (U.S. agricultural exports diverted from other regions are about US$130 million). At the commodity level, the largest gain is in exports from the non-grain crop sector (US$1.1 billion), resulting from the expansion of textile production after China joins the WTO. Exports of other processed foods (US$0.9 billion) and feed grains

Table 9

Impact on U.S. farm income and prices of farm products[a] (difference between a WTO with and without China and Taiwan)[b]

Sectors	Producer prices	Value-added prices	Consumer prices	Export prices (f.o.b.)	Import prices (c.i.f.)	Farm income
Rice	0.12	0.19	0.10	0.15	−0.21	−0.04
Wheat	0.16	0.31	0.17	0.19	0.38	2.54
Other grain	0.18	0.31	0.18	0.21	0.24	1.01
Non-grain crop	0.20	0.31	0.16	0.23	0.09	1.88
Livestock	0.15	0.31	0.15	0.18	0.38	0.41
Meat and milk	0.11	0.07	0.12	0.14	0.24	0.18
Other food	0.05	0.04	0.05	0.08	−0.02	0.47
Total	0.10	0.14	0.08	0.17	0.15	0.74

[a]Results from simulations under steady-state capital market closure.
[b]Values in percent change.

(US$0.2 billion) rank second and third, followed by wheat (US$168 million) and livestock products (US$95 million). U.S. exports of rice and meat and milk decline slightly (US$7 million and US$19 million).

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 (73%), followed by processed food (16%) and grains (11%). The increase in U.S. exports to China would mainly be processed food products (52%) and non-grain crops (30%), followed by wheat (10%), meat and other livestock products take the remaining 8%.

The data in the second block of Table 8 show that U.S. agricultural products would gain additional market shares in China (3.7%), Taiwan (1.8%), South Korea (1.1%), and Hong Kong (0.7), ASEAN, South Asia, and Rest of the World, but slightly lose market shares in other regions when China and Taiwan are admitted to the WTO. This implies that China's and Taiwan's WTO memberships would enlarge US food and agricultural export markets in Asia, especially in the Chinese Economic Area. Total world market share of U.S. food and agricultural exports would increase by 0.2 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 (2.2%), South Korea (4.7%), and South Asia (1.4%) that had been lost to China in the early 1990's. The U.S. share of the world feed grain market would rise 1.4 percentage points to more than 60%. The U.S. share in the other processed food market in China would expand even more, rising 10.3 percentage points. Another notable difference is the U.S. share of meat and livestock product markets in China, which would rise 7.4 and 3.8 percentage points, respectively.

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

How would these domestic structural adjustments and world market expansion 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 (Table 9). The increased price for U.S. food and agricultural exports and more efficient use of production resources translate into higher factor returns and value-added prices, thus raising farm income. Total income earned for all farm sectors except rice would increase because of China's and Taiwan's WTO accession, with wheat and non-grain crop farmers gaining the most by 2.5% and 1.9% respectively.

5. Conclusions

The simulation results reported in this paper provide a quantitative assessment of the 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 as described below.

It would increase total world trade by around US$147 billion (US$67 billion in exports and US$80 billion in imports), and world real consumption by around US$56 billion annually. Net exports of labor-intensive products from China would increase dramatically, by about US$54 billion a year. Competition in the world market for labor-intensive goods would stiffen, 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 exports and would raise its net agricultural imports by about US$9 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 US$1.2 billion and US$106 million, respectively (about 3% of base year world grain exports), putting upward pressure on world grain prices, especially for feed grains.

For the USA, a WTO with China and Taiwan would raise social welfare by about US$8.5 billion a year. Total U.S. exports would increase by US$3.5 billion, with returns to land and labor increasing, although the wage differential between skilled and unskilled labor would widen slightly (Stopler–Samuelson effect). Total U.S. food and agricultural exports would increase by more than US$2.4 billion per year, with non-grain crop and other processed foods 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 US$30 billion per year (US$6 billion for Taiwan), substantially more than the welfare gains for the USA from China's and Taiwan's WTO membership (US$8.5 billion).

The results of this study provide useful insights in understanding the impact of China's and Taiwan's accession to the WTO and demonstrate that CGE models can be a valuable tool for trade policy analysis. However, there are also several obvious limitations. First, neither China nor Taiwan have finalized the terms of their entry to the WTO when this paper was written. The size of their trade concessions, the time schedule of implementation for each of the liberalization measures, and the length of the phase-in period, are all unknown. I used a relatively stylized representation of the future trade liberalization offered by China and Taiwan to meet the requirements of WTO accession by best guess, and finessed the issue of timing by estimating what would have happened if the phase-in period had been completed by 1992 (the latest year a complete base year data set can be constructed). Second, there are uncertainties about the size of parameters, such as elasticities of substitution and the base year rate of protection, especially for China's pervasive non-tariff barriers. [11] Finally, the model used in this study is a highly stylized simplification of the world economy and is far from perfect (Wang, 1997). Therefore, the results reported here need to be interpreted with caution: they can be viewed as indicative but not as precise real outcomes.

Acknowledgements

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[11] The major conclusions from this study are robust. There is a similar study conducted by the author earlier by using an earlier version of the model and pre-release of version 3 GTAP database (Wang, 1997). Although there are substantial changes in base year data, initial protection rate, and assumption of tariff cuts as well as model structures, the basic results obtained from this paper are quite similar to the previous study, in spite of variations in the size of estimated impact. For sensitivity of simulation results due to variations in major substitution elasticities, see appendix B in Wang (1997).

Appendix A. Sector in the model and their GTAP–ISIC concordance

Sector 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 nonmetallic 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 and tobacco	3113–3115, 3116 (P), 3117–3119, 3121, 3122, 3131–3134, 3140
Textile and apparel	18 textiles, 19 wearing	3211, 3212, 3213, 3214, 3215 3219, 3220.
Other light manufactures	21 lumber and wood products, 22 pulp, paper and printing, 20 leather, fur and 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 nonferrous metals, 28 fabricated metal products	3511–3513, 3521–3523, 3529, 3551, 3559, 3560, 3710, 3720, 3811–3818, 3819.
Machinery and transport equipment	29 transport equipment, 30 other 30machinery and equipment	3841–3845, 3849, 3821,–3824, 3829 3831–3833, 3839, 3851–3853
Services	32 electricity, gas and 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

References

Armington, P.S., 1969. A Theory of Demand for Products Distinguished by Place of Production. IMF Staff Papers, Vol. 16. pp. 159–176.
Bach, C., Martin, W., Stevens, J., 1996. China and the WTO: tariff offers exemptions, and welfare implications. Weltwirtschaftliches Arch. 132 (3), 410–430.

Brooke, A., Kendrick, D., Meeraus, A., 1988. GAMS: a User's Guide. Scientific Press, New York.

de Melo, J., Tarr, D., 1992. A General Equilibrium Analysis of US Foreign Trade Policy. MIT Press, Cambridge, MA.

Devarrajan, S., Lewis, J.D., Robinson, S., 1990. Policy lesson from trade-focused, two-sector models. J. Policy Model. 12 (4), 625–657.

Development Research Center, 1996. China Country Report: Promoting Regional Economic Cooperation in FDI Policies and Related Institution Building among Asia and Pacific Developing Countries. State Council, Beijing, China.

Francois, J., McDonald, B., Nordstrom, H., 1995. Assessing the Uruguay Round. In: Martin, W., Winters, A. (Eds.), The Uruguay Round and the Developing Economies. World Bank Discussion Paper 307. Washington, D.C.

Hansen, T., Koopmans, T., 1972. On the definition and computation of a capital stock invariant under optimization. J. Econ. Theory 5, 487–523.

Harrison, G.W., Rutherford, T.F., Tarr, D.G., 1995. Quantifying the Uruguay Round. In: Martin, W., Winters, A. (Eds.), The Uruguay Round and the Developing Economies. World Bank Discussion Paper 307. Washington, D.C.

Hertel, T.W. (Ed.), 1997. Global Trade Analysis: Modelling and Applications. Cambridge Univ. Press, Cambridge.

Hertel, T., Martin, W., Yanagishima, K., Dimaranan, B., 1995. Liberalizing manufactures trade in a changing world economy. In: Martin, W., Winters, A. (Eds), The Uruguay Round and the Developing Economies. World Bank Discussion Papers 307. Washington, D.C.

Howe, H., 1975. Development of the extended linear expenditure system from simple savings assumptions. Eur. Econ. Rev. 6, 305–310.

Lewis, J.D., Robinson, S., Wang, Z., 1995. Beyond the Uruguay Round: the implication of an Asian free trade area. China Econ. Rev. Int. J. 7, 35–90.

Wang, Z., 1994. The Impact of Economic Integration Among Taiwan, Hong Kong and China—A Computable General Equilibrium Analysis. PhD Dissertation. Department of Applied Economics, University of Minnesota.

Wang, Z., 1997. The Impact of China and Taiwan Joining the World Trade Organization on U.S. and World Agricultural Trade: A Computable General Equilibrium Analysis. Technical Bulletin No. 1858. U.S. Department of Agriculture, Economic Research Service.

Wang, Z., Kinsey, J., 1994. Consumption and saving behavior under strict and partial rationing. China Econ. Rev. Int. J. 5, 83–100.

Wang, Z., Schuh, G.E., forthcoming. The impact of economic integration among Taiwan, Hong Kong and China—a Computable General Equilibrium analysis. J. Policy Model.

Wang, Z., Slagle, J., 1996. An object-oriented knowledge-based approach for formulating applied general equilibrium models. J. Econ. Dyn. Cont. 20, 209–236.

Whalley, J., 1985. Trade Liberalization Among Major World Trading Areas. MIT Press, Cambridge, MA.

Zhang, X., Warr, P.G., 1995. China's Re-entry to GATT: A General Equilibrium Analysis of Tariff Reduction. China and East Asia Trade Policy, Pacific Economic Papers No. 250. Australia–Japan Research Center, Canberra.

Zhang, S., Zhang, Y., Wan Z., 1997. Measuring the Costs of Protection in China. Institute for International Economics, Washington, D.C.