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***GTAP-DD: A Model for Analyzing Trade
Reforms in the Presence of Duty Drawbacks***

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The World Bank

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¹ The author is an economist at the World Bank. The views expressed in this paper are personal and should not be attributed to the World Bank. I would like to thank William Martin for providing an inspiration for this study and comments on earlier drafts of the paper. I am grateful to Thomas Hertel, Terrie Walmsley, Deepak Bhattasali and an anonymous reviewer for their valuable comments; and to Li Yan for helpful advice and data on import tariffs and duty exemptions.

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Elena Ianchovichina²

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Abstract

Duty drawback schemes, which typically involve a combination of duty rebates and exemptions, are a feature of many countries' trade regimes. They are used in highly protected, developing economies as means of providing exporters with imported inputs at world prices, and thus increasing their competitiveness, while maintaining the protection on the rest of the economy. In China duty exemptions have been central to the process of trade reform and have led to a tremendous increase in processed exports utilizing imported materials. Despite the widespread use and importance of duty drawbacks, these "new trade liberalization" instruments have been given relatively little attention in empirical multilateral trade liberalization studies. This paper presents an empirical multi-region trade model GTAP-DD, an extension of GTAP, in which the effects of policy reform are differentiated based on the trade-orientation of the firms. Both GTAP and GTAP-DD are used to analyze the impact of China's WTO accession, which involves liberalization in China from 1997 to post-accession tariffs among a number of other liberalization measures. The analysis shows that failure to account of duty exemptions in the case of China's recent WTO accession will overstate the increase in: (a) China's trade flows by 40 percent, (b) China's welfare by 15 percent, and (c) exports of selected sectors by as much as 90 percent. The magnitude of the bias depends on the level of pre-intervention tariffs and the size of tariff cuts – the larger the initial distortions and tariff reductions, the larger the bias when duty drawbacks are ignored. The bias in GTAP's estimates of China's real GDP, trade flows and welfare changes due to WTO accession increases more three times when China's pre-intervention tariffs are raised from their 1997 levels to the much higher 1995 levels. These results suggest that trade liberalization studies focusing on economies in which protection is high, import concessions play an important role and planned tariff cuts are deep, must treat duty drawbacks explicitly in order to avoid serious errors in their estimates of sectoral, trade flows and welfare changes.

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Duty Drawback Schemes and Trade Reforms

1. Introduction

Duty drawback schemes, which typically involve a combination of duty rebates and exemptions, are a feature of many countries' trade regimes. They are used in highly protected, developing economies as means of providing exporters with imported inputs at world prices, and thus increase their competitiveness, while maintaining the protection on the rest of the economy. Duty drawback programs have been used with varied degrees of success. While in many countries duty drawbacks have not been implemented successfully, largely due to administrative weaknesses, in others these schemes have been very effective in opening up export-oriented sectors by overriding existing protection. In China, duty exemptions at the point of entry have been an essential part of the country's export processing system and trade reform process.

The legal framework for China's export processing (EP) system was introduced in 1979 in order to overcome the anti-export bias created by state-managed exchange rate and pricing policies. In the pre-reform era exchange rates, indirect trade policy instruments such as tariffs, and relative prices had little influence on the magnitude and commodity composition of China's foreign trade. Firms producing for export sold their products to foreign trade companies at officially established domestic prices, fixed in domestic currency. Export producers did not get the foreign exchange income from the sale of their products on international markets, and thus had little incentive to expand production of goods for which foreign demand was strong (Lardy, 2001). The prices of imports also distorted the distribution of resources in the economy. Approximately 80 percent of imports were sold in China at prices similar to those of comparable products, quoted in domestic currency, and adjusted up or down to reflect quality differences. This price setting process isolated domestic firms from the influence of relative domestic and international price and exchange rate changes. For imports without domestic equivalents, which accounted for 20 percent of all imports, domestic prices were based on the cost of imports converted to domestic currency at the official exchange rate. Since this exchange rate was overvalued, the imports were in effect subsidized. The consequences of these policies were lagging exports, low growth in trade volume, and a distorted commodity composition of foreign trade, which did not correspond to China's comparative advantage in the production of labor intensive goods.

The EP system helped remedy these problems. Initially the system provided various incentives for both the processing of raw materials for export and the assembly of imported parts and components to produce finished goods for export (known as processing and assembling or processing with supplied materials). As tariffs became very important in the eighties, these incentives were expanded in 1987 to allow for duty-free imports of all raw materials and intermediate inputs used in the production of exports. These duty exemptions contributed strongly to China's actual collection rate being only one sixth of its weighted average tariff rate

(World Bank, 1994)³ and led to a tremendous increase in processed exports utilizing imported materials in China. In the span of just three years, processed exports produced with inputs purchased from abroad almost tripled, increasing from US\$140 million in 1988 to US\$324 million in 1991, while total exports rose by 50 percent (World Bank, 1994). In 2000, EP trade in China accounted for 50 percent of total trade, with EP accounting for 55 percent of total exports. The share of concessional imports in total imports rose from a third to around a half between 1988 to 1991 and has remained around this level since then.

Duty exemptions increase the competitiveness and efficiency of the economy. In the absence of duty drawbacks the protection of import competing firms is in general positive, while that of export competing firms is negative (Figure 1).⁴ This is because export competing firms face world prices while domestic competing firms are protected by tariffs on final goods. Duty drawbacks reduce the Effective Rates of Protection (ERPs) for export competing firms to 0,⁵ which allows export producers to operate at world prices, and halve the standard deviation in ERPs, which in turn increases the efficiency of the economy.

Despite the presence and vast importance of duty drawbacks in China and other developing countries, these “new trade liberalization” instruments have been given relatively little attention both in trade negotiations and in empirical multilateral trade liberalization studies. Standard global trade models (Hertel, 1997) have abstracted from the presence of concessional imports, while trade liberalization studies using these models have at best offered only partial solutions to the problem (Bach, Martin and Stevens, 1997). Recently, the topic of concessional import arrangements has been considered in papers by Gruen (1999), Cadot, de Melo and Olarreaga (2000), and Fan and Li (2000). Gruen (1999) illustrates the similarities and differences between traditional and “new trade liberalization” instruments such as export processing zones (EPZs) and duty drawback schemes and concludes that, in theory, both can bring about complete free trade. Cadot et al. (2000) consider the political economy implications of duty-drawback schemes for the incentives of export industries to lobby against upstream tariffs on imported intermediates. Acknowledging the importance of duty drawbacks for China’s export processing system, Fan and Li (2000) implement duty exemptions in a one-region recursive dynamic model of China.

This paper introduces duty drawbacks into a multi-region empirical trade model, GTAP (Hertel, 1997). The resulting model GTAP-DD could be used to analyze trade liberalization in the presence of duty drawbacks, assess whether countries should introduce or abolish these types of arrangements, and evaluate the economy-wide impact of improved administration of the duty drawback system. The method is similar to that of Fan and Li (2000) yet it differs in that it allows implementation of partial and/or full duty drawbacks in any number of regions,

³ Concessional imports cannot alone explain the low collection rates. A collection rate of 5.6 percent represents only 17.5 percent of the trade weighted average tariff of 32 percent for 1991 (World Bank 1994). Other imports by the government such as imports used for priority projects were also exempt. It is also possible that there were other leakages in the revenue collection system.

⁴ Figure 1 illustrates these points by showing effective rates of protection (ERP) in China. These ERP are based on protection data in 1995 as presented in version 4 GTAP and are computed for import and export competing firms separately to emphasize differences in protection depending on the orientation of the firms.

⁵ The ERPs for export processing firms with duty exemptions are close but not exactly zero because the domestic components of value added still have import duties embedded in them.

while preserving all other features of GTAP. Indeed, the model is designed so that in the absence of duty exemptions, the solution to GTAP-DD coincides with the solution to GTAP. This feature is attractive as it allows us to use the same modeling framework to evaluate various unilateral, trade reforms, regional and multilateral trade agreements under different assumptions for duty drawbacks in different regions without having to customize the treatment for each particular experiment.

The importance of duty exemptions for the analysis of China's WTO accession is shown by conducting two experiments – one with GTAP and another one with GTAP-DD. The simulation with GTAP ignores duty exemptions while the one with GTAP-DD takes them into account. The comparison of the results from the two experiments suggests that findings of studies that have looked at China's entry to the WTO without taking into account duty exemptions (Martin et al., 1999; Bach et al., 1996; Walmsley and Hertel, 2001) may be seriously biased. This paper shows that failure to take into account duty exemptions on imports for production of exports in China will overstate the impact of China's entry to the WTO on the country's structure of production, trade and welfare. The estimates of the increase in China's aggregate trade flows and welfare obtained with GTAP are respectively 40 percent and 15 percent larger than those obtained with GTAP-DD. The magnitude of the bias depends on the level of pre-intervention tariffs and the size of tariff cuts – the larger the initial distortions and tariff reductions, the larger the bias when duty drawbacks are ignored. The bias in the estimates of China's real GDP, trade flows and welfare changes due to WTO accession increases more three times when China's pre-intervention tariffs are raised from their 1997 levels to the much higher 1995 levels. These results suggest that trade liberalization studies focusing on economies, in which protection is high, import concessions play an important role and planned tariff cuts are deep, must treat duty drawbacks explicitly in order to avoid serious errors in their estimates of sectoral, trade flows and welfare changes.

The paper is structured as follows. Section 2 introduces the theory and its implementation into the GTAP framework. Section 3 discusses data and parameters for this study. Section 4 illustrates the importance of representing duty exemptions explicitly with an example of the impact of China's WTO accession. Section 5 concludes with a summary of the findings.

2. The model

This paper proposes a method for incorporating duty drawbacks into a general equilibrium model that differentiates firms based on their trade orientation, i.e. whether they produce for export or domestic markets. The theory can be easily introduced into any type of empirical model and is general enough to be applied in the context of any country that uses duty drawbacks as part of its export promotion policy. We introduce the methodology as part of the GTAP general equilibrium framework and present in this section only these equations of GTAP that require changes.

We consider a world with R regions each endowed with F types of endowments and producing G types of goods. There is a one-to-one correspondence between goods and industries. In each industry there are two types of firms – export-oriented and domestic-oriented ones. Both types of firms produce the same commodity using the same technology and are

identical in all respects except one – the export-oriented firms produce exclusively for export markets, while the domestic-oriented firms produce no exports and supply exclusively the domestic market. Production for domestic and export markets is therefore completely decoupled.

The choice to fully separate domestic and export production considerably simplifies the representation of duty drawbacks in GTAP – a model that is already very large. It is also a fairly accurate depiction of the trade regime in countries where duty drawbacks are used as export promotion instruments while protection on the rest of the economy is fairly high. In China, the tax arrangements for export processing⁶ discouraged firms from selling in the local market and using domestic intermediate materials. Local content requirements and foreign exchange balancing rules,⁷ on the other hand, encouraged domestic companies selling locally to use mainly local inputs, but these rules did not prevent these firms from exporting. These firms' exports, produced using mainly domestic intermediates and only a small portion of duty/VAT-paid imported materials, are also known as “ordinary” exports. This type of exports however accounts for only a small portion of China's total exports.

All export-oriented firms are identical and form the export-oriented sub-sector of an industry. Similarly, domestic-oriented firms are identical and form the domestic-oriented sub-sector of an industry. Firms are competitive and use both primary and intermediate inputs in their production. Export producers in region r supply $QOEXP(j,r)$ of good j to export markets, while domestic-oriented producers supply $QODOM(j,r)$ of good j to local markets.⁸ The intermediate input demands of the domestic and export-oriented firms $QFDOM(i,j,r)$ and $QFEXP(i,j,r)$ are proportional to the level of activity in sector j and equation (36) in GTAP modifies into the following two equations:

$$\begin{aligned} qfdom(i,j,r) = & -af(i,j,r) + qodom(j,r) - ao(j,r) - ESUBT(j) * [pfdom(i,j,r) - af(i,j,r) \\ & - psdom(j,r) - ao(j,r)] \end{aligned} \quad (36a)^9$$

$$\begin{aligned} qfexp(i,j,r) = & -af(i,j,r) + qoexp(j,r) - ao(j,r) - ESUBT(j) * [pfexp(i,j,r) - af(i,j,r) \\ & - psexp(j,r) - ao(j,r)] \end{aligned} \quad (36b)$$

where $i, j \in TRAD_COMM, r \in REG$; $psdom(j,r)$ ¹⁰ and $psexp(j,r)$ are the supply prices of the domestic and export-oriented firms in sector j of region r , respectively; $pfdom(i,j,r)$ and

⁶ The tax arrangements referred to include duty/VAT exemptions on imported intermediate inputs and VAT refunds on domestic intermediates inputs used in the production of exports.

⁷ The local content requirements and foreign exchange balancing rules required companies selling domestically to source a large share of inputs from domestic producers and to finance imports by selling exports.

⁸ For the sake of brevity we define only variables that are new to GTAP. All other variables are part of GTAP and are defined in Hertel (1997).

⁹ Equation numbers come directly from GTAP and do not reflect the order in which equations appear in the text.

¹⁰ All variables in lower case are in percentage changes.

$pfexp(i,j,r)$ are the demand prices of composite tradeable commodity i for use by domestic and export-oriented firms in sector j of region r , respectively.¹¹

GTAP-DD incorporates explicitly tax concessions for imported capital goods that are popular in many developing countries. For example, capital goods brought into China for export processing by foreign-invested enterprises have been exempt from import duties during most of the nineties.¹² The value of these capital goods rose in parallel with the increases in foreign direct investment during the 1990s. Since in GTAP capital is not specific to the trade orientation of the firm, GTAP-DD does not distinguish between capital goods produced for use by export and domestic-oriented firms. However, it does capture the fact that typically a portion of imported intermediate capital goods are duty exempt. Therefore, GTAP equation (36) for the capital goods sector is modified as follows:

$$qfdom(i,j,r) = -af(i,j,r) + qo(j,r) - ao(j,r) - ESUBT(j) * [pfdom(i,j,r) - af(i,j,r) - psdom(j,r) - ao(j,r)] \quad (36c)$$

$$qfexp(i,j,r) = -af(i,j,r) + qo(j,r) - ao(j,r) - ESUBT(j) * [pfexp(i,j,r) - af(i,j,r) - psexp(j,r) - ao(j,r)] \quad (36d)$$

where $i \in TRAD_COMM$, $j \in CGDS_COMM$, $r \in REG$. These equations tie the level of duty exempt exports by the capital goods sector to the common variable, $qo(j,r)$, which is the change in capital goods production.

Firms purchase both foreign and domestic intermediates, which are imperfect substitutes (Armington, 1969), and GTAP equations (31) and (32) change to:

$$qfmexp(i,j,r) = qfexp(i,j,r) - ESUBD(i,r) * [pfmexp(i,j,r) - pfexp(i,j,r)] \quad (31a)$$

$$qfmdom(i,j,r) = qfdom(i,j,r) - ESUBD(i,r) * [pfmdom(i,j,r) - pfdom(i,j,r)] \quad (31b)$$

$$qfdexp(i,j,r) = qfexp(i,j,r) - ESUBD(i,r) * [pfd(i,j,r) - pfexp(i,j,r)] \quad (32a)$$

$$qfddom(i,j,r) = qfdom(i,j,r) - ESUBD(i,r) * [pfd(i,j,r) - pfdom(i,j,r)] \quad (32b)$$

¹¹ The technical change variables could easily be made specific to the domestic and export-oriented sectors. For instance, in some applications it might be useful to study the impact of faster technical change in export processing firms.

¹² The State Council decided to eliminate these exemptions from tariffs and import related taxes on imported capital goods as of April 1, 1996. Foreign-invested firms approved prior to April 1 were given additional time to take advantage of duty-free imports of capital goods. Investments under \$30 million qualified for exemptions until December 31, 1996. Investments over \$30 million were exempt from import duties until December 31, 1997. These deadlines were not strictly enforced and eventually the exemption program was formally re-established (Lardy, 2001).

where $i \in TRAD_COMM$, $j \in PROD_COMM$, $r \in REG$; $qfmexp(i,j,r)$ and $qfdexp(i,j,r)$ are the demands for imported and domestic intermediates of the export-oriented sector, respectively; $qfmdom(i,j,r)$ and $qfddom(i,j,r)$ are the demands for imported and domestic intermediates of the domestic-oriented sector, respectively; $pfmexp(i,j,r)$ and $pfmdom(i,j,r)$ are respectively the demand prices of imported intermediate good i used by the export and domestic-oriented firms in sector j of region r . $ESUBD(i,r)$ varies by region, whereas in GTAP $ESUBD(i)$ is region generic.

All imported intermediates used by the export sector are assumed to be either exempt from duties or eligible for refunds on the import tax paid. This assumption is a fairly accurate representation of the situation in a number of developing countries where duty drawback schemes have been successful. According to China's Customs, in 2000, 60 percent of imports entered China duty-free, out of which 41 percentage points were imports used for export processing, 13 percentage points were capital goods, and 6 percentage points were goods that fall in the special categories, such as materials used by research institutions and others. Input-output information for 1995 from version 4 GTAP (McDougall et al., 1998) suggests that 23 percent of imports in China were used to produce goods for the domestic market, and only an estimated 3 percent were used to produce ordinary exports.¹³ Therefore, the vast majority of exports were produced with intermediate imports that benefited from the duty drawback system.

Zero profit for the choice of composite inputs implies that GTAP equation (30) changes to:

$$pfexp(i,j,r) = FMESHR(i,j,r)*pfmexp(i,j,r) + [1 - FMESHR(i,j,r)]*pfd(i,j,r) \quad (30a)$$

$$pfdom(i,j,r) = FMDSHR(i,j,r)*pfmdom(i,j,r) + [1 - FMDSHR(i,j,r)]*pfd(i,j,r) \quad (30b)$$

where $i \in TRAD_COMM$, $j \in PROD_COMM$, $r \in REG$; $FMESHR(i,j,r)$ is the share of imported intermediate inputs in the intermediate input composite of the export-oriented sector j of region r ; $FMDSHR(i,j,r)$ is the share of imported intermediate input i used by the domestic-oriented firms of sector j in the intermediate input composite of the domestic-oriented sector j of region r .¹⁴

Composite factor demands $QVADOM(j,r)$ and $QVAEXP(j,r)$ are proportionate to the level of activity of domestic and export-oriented firms, respectively. Equation (35) in GTAP modifies then into the following two equations for the domestic and export sub-sectors, respectively:

¹³ According to version 4 GTAP, in 1995 14 percent of imports were for final consumption and according to China's Customs 40 percent of imports were ordinary imports that were not duty exempt. This means that approximately 26 percent were ordinary imports used as intermediates. According to version 4 GTAP China's firms exported on average 10 percent of their output, implying that approximately less than 3 percent of imports were used for the production of ordinary exports.

¹⁴ All new shares in GTAP-DD are defined in Appendix A.3.

$$\begin{aligned}
qvadom(j,r) &= -ava(j,r) + qodom(j,r) - ao(j,r) \\
&\quad - ESUBT(j) * [pvadom(j,r) - ava(j,r) - psdom(j,r) - ao(j,r)] \quad (35a)
\end{aligned}$$

$$\begin{aligned}
qvaexp(j,r) &= -ava(j,r) + qoexp(j,r) - ao(j,r) \\
&\quad - ESUBT(j) * [pvaexp(j,r) - ava(j,r) - psexp(j,r) - ao(j,r)] \quad (35b)
\end{aligned}$$

where $j \in TRAD_COMM$, $r \in REG$, and $pvadom(j,r)$ and $pvaexp(j,r)$ are respectively the prices of value added in the domestic and export-oriented sub-sectors j of region r . For the capital goods sector equation (35) modifies into the following two equations:

$$\begin{aligned}
qvadom(j,r) &= -ava(j,r) + qo(j,r) - ao(j,r) \\
&\quad - ESUBT(j) * [pvadom(j,r) - ava(j,r) - psdom(j,r) - ao(j,r)] \quad (35c)
\end{aligned}$$

$$\begin{aligned}
qvaexp(j,r) &= -ava(j,r) + qo(j,r) - ao(j,r) \\
&\quad - ESUBT(j) * [pvaexp(j,r) - ava(j,r) - psexp(j,r) - ao(j,r)] \quad (35d)
\end{aligned}$$

where $j \in CGDS_COMM$, $r \in REG$.

The value-added nest of the producers' technology tree, represented by GTAP equations (33) and (34), modifies into two pairs of equations for export and domestic-oriented producers, respectively:

$$pvaexp(j,r) = \text{sum}(k, ENDW_COMM, SVAEXP(k,j,r) * [pfe(k,j,r) - afe(k,j,r)]), \quad (33a)$$

$$\begin{aligned}
qfeexp(i,j,r) &= -afe(i,j,r) + qvaexp(j,r) \\
&\quad - ESUBVA(j) * [pfe(i,j,r) - afe(i,j,r) - pvaexp(j,r)], \quad (34a)
\end{aligned}$$

$$pvadom(j,r) = \text{sum}(k, ENDW_COMM, SVADOM(k,j,r) * [pfe(k,j,r) - afe(k,j,r)]), \quad (33b)$$

$$\begin{aligned}
qfedom(i,j,r) &= -afe(i,j,r) + qvadom(j,r) \\
&\quad - ESUBVA(j) * [pfe(i,j,r) - afe(i,j,r) - pvadom(j,r)], \quad (34b)
\end{aligned}$$

where $i \in ENDW_COMM$, $j \in PROD_COMM$, $r \in REG$; $qfeexp(i,j,r)$ and $qfedom(i,j,r)$ are the demands for endowment i for use in the export and domestic oriented sub-sectors of sector j in region r ; $SVAEXP(k,j,r)$ and $SVADOM(k,j,r)$ are respectively the shares of factor endowment k in total value-added in the export and domestic oriented sub-sector j in region r .

There are two categories of aggregate imports - imports used to produce exports, $qimexp(i,r)$, and imports used for all other purposes, $qimdom(i,r)$, which include imports used to produce domestic goods and imports for final consumption. Bilateral trade flows are determined by cost-minimizing choice, given prices and tax rates. GTAP equation (29) for the demand of bilateral imports changes then into:

$$\begin{aligned} qxs_{exp}(i,r,s) = & -ams(i,r,s) + qim_{exp}(i,s) \\ & - E_{SUBM}(i) * [pm_{exp}(i,r,s) - ams(i,r,s) - pim_{exp}(i,s)] \end{aligned} \quad (29a)$$

$$\begin{aligned} qxs_{dom}(i,r,s) = & -ams(i,r,s) + qim_{dom}(i,s) \\ & - E_{SUBM}(i) * [pm_{dom}(i,r,s) - ams(i,r,s) - pim_{dom}(i,s)] \end{aligned} \quad (29b)$$

where $i \in TRAD_COMM$; $s, r \in REG$; $qxs_{exp}(i,r,s)$ and $qxs_{dom}(i,r,s)$ are export sales of good i from region r to region s for use in the production of exports and for domestic use, respectively; $pm_{exp}(i,r,s)$ and $pm_{dom}(i,r,s)$ are the market prices of imported good i from region r to region s for use in the export-oriented and domestic sectors, respectively. The prices for aggregate imports in the export and domestic-oriented sectors of region s , $PIMEXP(i,r)$ and $PIMDOM(i,r)$, are a weighted combination of the respective import prices from various sources:

$$pim_{exp}(i,r) = \sum(s, REG, MESHRS(i,s,r) * [pm_{exp}(i,s,r) - ams(i,s,r)]), \quad (28a)$$

$$pim_{dom}(i,r) = \sum(s, REG, MDSHRS(i,s,r) * [pm_{dom}(i,s,r) - ams(i,s,r)]), \quad (28b)$$

where $i \in TRAD_COMM$; $r \in REG$; $MESHRS(i,s,r)$ is the share of imports from region s used for export production in the import bill for export processing in region r at market prices; and $MDSHRS(i,s,r)$ is the share of imports from region s for domestic use in the import bill for domestic use in region r at market prices.

The market clearing condition for imported goods – equation (2) in GTAP – changes to the following two market clearing conditions – one for imports used for the production of exports and one for imports for domestic use:

$$qim_{exp}(i,r) = \sum(j, PROD_COMM, SHRIFME(i,j,r) * qfm_{exp}(i,j,r)), \quad (2a)$$

$$\begin{aligned} qim_{dom}(i,r) = & \sum(j, PROD_COMM, SHRIFMD(i,j,r) * qfmdom(i,j,r)) \\ & + SHRIPM(i,r) * qpm(i,r) + SHRIGM(i,r) * qgm(i,r), \end{aligned} \quad (2b)$$

where $i \in TRAD_COMM$; $r \in REG$; $SHRIFME(i,j,r)$ is the share of imported product i used by the export sub-sector j in the import bill for export processing in region r at market prices; $SHRIFMD(i,j,r)$ is the share of imported good i used by the domestic sub-sector j in the import bill for domestic use in region r at market prices; $SHRIPM(i,r)$ and $SHRIGM(i,r)$ are shares of imported good i used by the private and government households, respectively, in the import bill for domestic use in region r at market prices.

Domestic sales meet demand for domestic intermediate products of domestic-oriented and export-oriented firms, final demand and demand for domestic investment goods so equation (3) in GTAP modifies into:

$$qds(i,r) = \sum(j, PROD_COMM, [SHRDFME(i,j,r) * qfdexp(i,j,r)$$

$$\begin{aligned}
& + \text{SHRDFMD}(i,j,r) * \text{qfddom}(i,j,r)) + \text{SHRDPM}(i,r) * \text{qpd}(i,r) \\
& + \text{SHRDGM}(i,r) * \text{qgd}(i,r),
\end{aligned} \tag{3}$$

where $i \in \text{TRAD_COMM}$; $r \in \text{REG}$; $\text{SHRDFME}(i,j,r)$ and $\text{SHRDFMD}(i,j,r)$ are the shares of domestic production of good i in region r for use respectively by the export and domestic sub-sectors of sector j at market prices; $\text{SHRDPM}(i,r)$ and $\text{SHRDGM}(i,r)$ are the shares of domestic production of good i in region r for use by private and government households, respectively.

GTAP equation (1) modifies into three sets of equations. Output of the export sector $\text{QOEXP}(i,r)$ meets import demand of the trading partners:

$$\text{goexp}(i,r) = \text{sum}(s, \text{REG}, \text{SHRXMD}(i,r,s) * \text{qxs}(i,r,s)) + \text{tradexpslack}(i,r), \tag{1a}$$

where $i \in \text{NMRG_COMM}$; $r \in \text{REG}$; $\text{SHRXMD}(i,r,s)$ is the share of exports of good i to region s from region r in total exports of good i from region r ; $\text{tradexpslack}(i,r)$ is a slack variable, and $\text{qxs}(i,r,s)$ is defined as:

$$\begin{aligned}
\text{qxs}(i,r,s) = & \text{SHRVIWSE}(i,r,s) * \text{qxsexp}(i,r,s) \\
& + [1 - \text{SHRVIWSE}(i,r,s)] * \text{qxsgom}(i,r,s),
\end{aligned} \tag{A1}$$

where $i \in \text{TRAD_COMM}$; $r, s \in \text{REG}$; $\text{SHRVIWSE}(i,r,s)$ is the share of imports used in the production of exports in imports of good i from region r to region s valued at cif prices. For the margin commodities, export production equals demand for exports and transport services:

$$\begin{aligned}
\text{goexp}(i,r) = & \text{SHRST}(i,r) * \text{qst}(i,r) + \text{sum}(s, \text{REG}, \text{SHRXMD}(i,r,s) * \text{qxs}(i,r,s)) \\
& + \text{tradexpslack}(i,r),
\end{aligned} \tag{1b}$$

where $i \in \text{MRG_COMM}$; $r \in \text{REG}$; $\text{SHRST}(i,r)$ is the share of sales of good i to global transport services in total exports of good i from region r . Output of the domestic sub-sector equals domestic sales:

$$\text{godom}(i,r) = \text{qds}(i,r) + \text{traddomslack}(i,r), \tag{1c}$$

where $i \in \text{TRAD_COMM}$; $r \in \text{REG}$ and $\text{traddomslack}(i,r)$ is a slack variable.

Primary factor supply equals primary factor demand:

$$\text{qo}(i,r) = \text{sum}(j, \text{PROD_COMM}, [\text{SHREMEXP}(i,j,r) * \text{qfeexp}(i,j,r)$$

¹⁵ Equations in GTAP-DD that are not part of GTAP are numbered A1, etc.

$$+ \text{SHREMDOM}(i,j,r) * \text{qfedom}(i,j,r)] + \text{endwslack}(i,r), \quad (4)$$

where $i \in \text{ENDWM_COMM}$; $r \in \text{REG}$; $\text{SHREMEXP}(i,j,r)$ and $\text{SHREMDOM}(i,j,r)$ are the shares of endowments i used by the export sub-sector j in total use of endowment i in region r at market prices. Aggregate demand for endowments is given as:

$$\begin{aligned} \text{qfe}(i,j,r) &= \text{SHRVFMEXP}(i,j,r) * \text{qfeexp}(i,j,r) \\ &+ [1 - \text{SHRVFMEXP}(i,j,r)] * \text{qfedom}(i,j,r), \end{aligned} \quad (\text{A2})$$

where $i \in \text{ENDWM_COMM}$; $j \in \text{PROD_COMM}$; $r \in \text{REG}$ and $\text{SHRVFMEXP}(i,j,r)$ is the share of expenditure on endowment i by export producers in industry j of region r , valued at market prices, in the expenditure on endowment i by industry j of region r .

Competitive producers in both the export-oriented and domestic-oriented sub-sectors earn zero profit in equilibrium and GTAP equation (6) modifies into:

$$\begin{aligned} &\text{psexp}(j,r) + \text{ao}(j,r) \\ &= \text{sum}(i, \text{ENDW_COMM}, \text{STCEXP}(i,j,r) * [\text{pfe}(i,j,r) - \text{afe}(i,j,r) - \text{ava}(j,r)]) \\ &+ \text{sum}(i, \text{TRAD_COMM}, \text{STCEXP}(i,j,r) * [\text{pfexp}(i,j,r) - \text{af}(i,j,r)]) \\ &+ \text{prftexpslack}(j,r), \end{aligned} \quad (6a)$$

$$\begin{aligned} &= \text{sum}(i, \text{ENDW_COMM}, \text{STCDOM}(i,j,r) * [\text{pfe}(i,j,r) - \text{afe}(i,j,r) - \text{ava}(j,r)]) \\ &+ \text{sum}(i, \text{TRAD_COMM}, \text{STCDOM}(i,j,r) * [\text{pfdom}(i,j,r) - \text{af}(i,j,r)]) \\ &+ \text{prftdomslack}(j,r), \end{aligned} \quad (6b)$$

where $j \in \text{PROD_COMM}$; $r \in \text{REG}$; $\text{STCEXP}(i,j,r)$ and $\text{STCDOM}(i,j,r)$ are the shares of demanded commodity i in region r in total costs (at agents' prices) of the export and domestic-oriented sector j , respectively; $\text{prftexpslack}(j,r)$ and $\text{prftdomslack}(j,r)$ are slack variables.

The following price linkages equations (GTAP equations (15), (23), (24), and (25)) need to be specified separately for export and domestic-oriented firms:

$$\text{psexp}(i,r) = \text{to}(i,r) + \text{pmexp}(i,r), \quad i \in \text{TRAD_COMM}; r \in \text{REG} \quad (15a)$$

$$\text{psdom}(i,r) = \text{to}(i,r) + \text{pmdom}(i,r), \quad i \in \text{TRAD_COMM}; r \in \text{REG} \quad (15b)$$

$$\text{pfmexp}(i,j,r) = \text{tfm}(i,j,r) + \text{pimexp}(i,r),$$

$$i \in \text{TRAD_COMM}; j \in \text{PROD_COMM}; r \in \text{REG} \quad (23a)$$

$$pfmdom(i,j,r) = tfm(i,j,r) + pimdom(i,r),$$

$$i \in TRAD_COMM; j \in PROD_COMM; r \in REG \quad (23b)$$

$$pmsexp(i,r,s) = tmexp(i,s) + tmsexp(i,r,s) + pcif(i,r,s),$$

$$i \in TRAD_COMM; r, s \in REG \quad (24a)$$

$$pmsdom(i,r,s) = tmdom(i,s) + tmsdom(i,r,s) + pcif(i,r,s),$$

$$i \in TRAD_COMM; r, s \in REG \quad (24b)$$

$$prexp(i,r) = pmexp(i,r) - pimexp(i,r), \quad i \in TRAD_COMM; r \in REG \quad (25a)$$

$$prdom(i,r) = pmdom(i,r) - pimdom(i,r), \quad i \in TRAD_COMM; r \in REG \quad (25b)$$

where $pmexp(i,r)$ and $pmdom(i,r)$ are respectively the export and domestic market prices of good i in region r ; $prexp(i,r)$ and $prdom(i,r)$ are respectively the ratio of export and domestic market prices to import prices; $tmexp(i,s)$ and $tmdom(i,s)$ are variable import levies on imports of good i in region s for export processing and for domestic use, respectively.

The variables $tmsexp(i,r,s)$ and $tmsdom(i,r,s)$ are the import taxes on good i from region r to region s for export processing and domestic use, respectively. These import taxes differ for the export and domestic sub-sectors when there are duty drawbacks in a region. If these tax rates are the same for the export and domestic sub-sectors then the treatment is equivalent to the one in GTAP. Thus the method allows us to implement duty drawbacks (partial or full) in any number of regions, while preserving the treatment in GTAP for all other regions. This is an attractive feature as it allows us to use the same modeling framework to evaluate various unilateral trade reforms, regional and multilateral trade agreements under different assumptions for duty drawbacks in different regions without having to customize the treatment for each particular experiment.

The following equations in GTAP are also modified to reflect changes in the theory:

$$ppd(i,r) = atpd(i,r) + pmdom(i,r) \quad i \in TRAD_COMM; r \in REG \quad (18)$$

$$pgd(i,r) = tgd(i,r) + pmdom(i,r) \quad i \in TRAD_COMM; r \in REG \quad (19)$$

$$pfd(i,j,r) = tfd(i,j,r) + pmdom(i,r)$$

$$i \in TRAD_COMM; j \in PROD_COMM; r \in REG \quad (20)$$

$$ppm(i,r) = atpm(i,r) + pimdom(i,r) \quad i \in TRAD_COMM; r \in REG \quad (21)$$

$$pgm(i,r) = tgm(i,r) + pimdom(i,r) \quad i \in TRAD_COMM; r \in REG \quad (22)$$

$$pfob(i,r,s) = pmexp(i,r) - tx(i,r) - txs(i,r,s) \quad i \in TRAD_COMM; r \in REG \quad (27)$$

Finally, some equations in GTAP.TAB v. 6.1 that are not in Hertel (1997) have also been changed as follows:

$$pt(m) = \text{sum}(r, REG, VTSUPPSHR(m,r) * pmexp(m,r)) \quad m \in MARG_COMM \quad (N1)^{16}$$

$$\begin{aligned} & 100.0 * INCOME(r) * del_taxrgc(r) \\ & = \text{sum}(i, TRAD_COMM, VDGA(i,r) * tgd(i,r)) \\ & + \text{sum}(i, TRAD_COMM, DGTAX(i,r) * [pmdom(i,r) + qgd(i,r)]) \\ & + \text{sum}(i, TRAD_COMM, VIGA(i,r) * tgm(i,r)) \\ & + \text{sum}(i, TRAD_COMM, IGTAX(i,r) * [pimdom(i,r) + qgm(i,r)]) \\ & - TGC(r) * y(r) \end{aligned} \quad (N2)$$

$$\begin{aligned} & 100.0 * INCOME(r) * del_taxrpc(r) \\ & = \text{sum}(i, TRAD_COMM, VDPA(i,r) * atpd(i,r)) \\ & + \text{sum}(i, TRAD_COMM, DPTAX(i,r) * [pmdom(i,r) + qpd(i,r)]) \\ & + \text{sum}(i, TRAD_COMM, VIPA(i,r) * atpm(i,r)) \\ & + \text{sum}(i, TRAD_COMM, IPTAX(i,r) * [pimdom(i,r) + qpm(i,r)]) \\ & - TPC(r) * y(r) \end{aligned} \quad (N3)$$

$$\begin{aligned} & 100.0 * INCOME(r) * del_taxriu(r) \\ & = \text{sum}(i, TRAD_COMM, \text{sum}(j, PROD_COMM, VDFAE(i,j,r) * tfd(i,j,r))) \\ & + \text{sum}(i, TRAD_COMM, \\ & \quad \text{sum}(j, PROD_COMM, DFTAXEXP(i,j,r) * [pmdom(i,r) + qfdexp(i,j,r)])) \\ & + \text{sum}(i, TRAD_COMM, \text{sum}(j, PROD_COMM, VIFAE(i,j,r) * tfm(i,j,r))) \\ & + \text{sum}(i, TRAD_COMM, \\ & \quad \text{sum}(j, PROD_COMM, IFTAXEXP(i,j,r) * [pimexp(i,r) + qfmexp(i,j,r)])) \\ & + \text{sum}(i, TRAD_COMM, \text{sum}(j, PROD_COMM, VDFAD(i,j,r) * tfd(i,j,r))) \end{aligned}$$

¹⁶ New equations that are part of GTAP.TAB v. 6.1 are numbered N1, etc.

$$\begin{aligned}
& + \text{sum}(i, \text{TRAD_COMM}, \\
& \text{sum}(j, \text{PROD_COMM}, \text{DFTAXDOM}(i, j, r) * [\text{pmdom}(i, r) + \text{qfddom}(i, j, r)])) \\
& + \text{sum}(i, \text{TRAD_COMM}, \text{sum}(j, \text{PROD_COMM}, \text{VIFAD}(i, j, r) * \text{tfm}(i, j, r))) \\
& + \text{sum}(i, \text{TRAD_COMM}, \\
& \text{sum}(j, \text{PROD_COMM}, \text{IFTAXDOM}(i, j, r) * [\text{pimdom}(i, r) + \text{qfmdom}(i, j, r)])) \\
& - \text{TIU}(r) * y(r) \tag{N4}
\end{aligned}$$

$$\begin{aligned}
& 100.0 * \text{INCOME}(r) * \text{del_taxrout}(r) \\
& = \text{sum}(i, \text{PROD_COMM}, \text{VOA}(i, r) * [-\text{to}(i, r)]) \\
& + \text{sum}(i, \text{TRAD_COMM}, \text{PTAXEXP}(i, r) * [\text{pmexp}(i, r) + \text{qoexp}(i, r)]) \\
& + \text{sum}(i, \text{TRAD_COMM}, \text{PTAXDOM}(i, r) * [\text{pmdom}(i, r) + \text{qodom}(i, r)]) \\
& + \text{sum}(i, \text{CGDS_COMM}, \text{PTAX}(i, r) * [\text{pm}(i, r) + \text{qo}(i, r)]) - \text{TOUT}(r) * y(r) \tag{N5}
\end{aligned}$$

$$\begin{aligned}
& 100.0 * \text{INCOME}(r) * \text{del_taxrimpe}(r) \\
& = \text{sum}(i, \text{TRAD_COMM}, \text{sum}(s, \text{REG}, \text{VIMSE}(i, s, r) * [\text{tmexp}(i, r) + \\
& \text{tmsexp}(i, s, r)])) \\
& + \text{sum}(i, \text{TRAD_COMM}, \text{sum}(s, \text{REG}, \text{MTAXEXP}(i, s, r) * [\text{pcif}(i, s, r) \\
& + \text{qxsexp}(i, s, r)])) - \text{TIMEXP}(r) * y(r) \tag{N6a}
\end{aligned}$$

$$\begin{aligned}
& 100.0 * \text{INCOME}(r) * \text{del_taxrimpd}(r) \\
& = \\
& \text{sum}(i, \text{TRAD_COMM}, \text{sum}(s, \text{REG}, \text{VIMSD}(i, s, r) * [\text{tmdom}(i, r) + \text{tmsdom}(i, s, r)])) \\
& + \text{sum}(i, \text{TRAD_COMM}, \text{sum}(s, \text{REG}, \text{MTAXDOM}(i, s, r) * [\text{pcif}(i, s, r) \\
& + \text{qxsd}(i, s, r)])) - \text{TIMDOM}(r) * y(r) \tag{N7b}
\end{aligned}$$

where $r \in \text{REG}$, $\text{del_taxrimpe}(r)$ is change in the ratio of tax on imports used in export production to income and $\text{del_taxrimpd}(r)$ is change in the ratio of tax on imports for domestic use to income. These two variables replace $\text{del_taximp}(r)$ in GTAP.TAB v. 6.1. Please refer to the Appendix A.1 through A.4 for definitions of new sets, coefficients, data derivatives, and for changed equations in the auxiliary modules of GTAP.TAB, version 6.1.

GTAP-DD is implemented in GEMPACK (Harrison and Pearson, 1996). When imported intermediate inputs used by the export-oriented sub-sector are taxed at the same rates as those used by the domestic-oriented sector, tariff cuts on imported intermediate inputs are

the same regardless of their use, and the input composition of the export-oriented sub-sector is identical to the input composition for the domestic-oriented subsectors, the solutions with GTAP-DD is identical to the solution with GTAP; otherwise the solutions differ.

3. The data

GTAP and GTAP-DD are applied to version 5 GTAP database (Dimaranan and McDougall, 2002), aggregated to 20 regions (Table 1) and 25 sectors (Table 2) and modified using ALTERNATE (Malcolm, 1998) in order to set tax rates based on the following additional information: export subsidies for feedgrains and plant-based fibers at 32% and 10%, respectively, nominal protection rates for agricultural commodities as suggested by Huang and Rozelle (2002) (Table 4, column 2); the tax rate on unskilled nonagricultural labor at 34% as in Ianchovichina and Martin (2002) and based on information in Shi Xinzhen (2002), export taxes on textiles and apparel exports to the United States at 11% and 15%, respectively, and to the European Union at 12% and 15%, respectively.¹⁷

Since GTAP does not distinguish inputs based on whether they are used for export or domestic production, it is necessary to split the factor and intermediate input usage of each sector and region into domestic-oriented and export-oriented firms' usage. For China, ideally, we would like to use information on duty exempt imports by product and sector use and factor usage by sector and sub-sector (for export or domestic use). This information is typically difficult to obtain. China Customs, for instance, keeps track of the use of imported intermediate inputs by product, but not by sector use. We initially tried to split the data on imported intermediate inputs in GTAP using information on duty-exempt imports by product in China at the HS2 level from China Customs. We found it difficult to employ these data because they did not contain information on duty-exempt imports by sector use and the commodity classes at this level of aggregation often overlapped two or more GTAP categories. In some cases, the reported imports of duty-free intermediate inputs for export production from China Customs exceeded the total intermediate use obtained from China's input-output tables in GTAP. Several explanations come to mind including data error, strong substitution towards the duty-free intermediates in the export processing sectors, and fraudulent misclassification of intermediates not destined for exports. As a result of these problems the data set for GTAP-DD produced with this external information seriously distorted the original IO and tax information in GTAP.

In order to get around this problem and the lack of data, the domestic and export sub-sectors are initially created by dividing each sector's intermediate and factor input use in proportion to the domestic and export shares of output in a region.¹⁸ The share of exports in total output of sector j in region s is calculated as:

$$a_{js} = \sum_r VXMD(j, s, r) / VOM(j, s), \quad j \in NMRG_COMM; r, s \in REG.$$

¹⁷ The export tax equivalents were estimated by William Martin.

¹⁸ This method ensures that, for regions other than China, the treatments in GTAP and GTAP-DD are identical when tariffs and tariff reductions for imported intermediate inputs for export and domestic use are the same.

$$\mathbf{a}_{js} = [\sum_r \text{VXMD}(j, s, r) + \text{VST}(j, s)] / \text{VOM}(j, s),$$

$$j \in \text{MARG_COMM}; r, s \in \text{REG}$$

$$\mathbf{a}_{js} = 0, \quad j \in \text{CGDS_COMM}; s \in \text{REG}$$

Then, the use of the imported intermediate product i by the export processing sub-sector of sector j in region s , $\text{VIFAE}(i, j, s)$, and the use of imported intermediates by the domestic sub-sector j in region s , $\text{VIFAD}(i, j, s)$ are given as:

$$\text{VIFAE}(i, j, s) = \mathbf{a}_{js} \text{VIFA}(i, j, s),$$

$$i \in \text{TRAD_COMM}, j \in \text{PROD_COMM}; s \in \text{OTHREG}$$

$$\text{VIFAE}(i, j, s) = \mathbf{a}_{js} \text{VIFA}(i, j, s),$$

$$i \in \text{TRAD_COMM}, j \in \text{TRAD_COMM}; s \in \text{CHNREG}$$

where CHNREG stands for China, OTHREG = REG – CHNREG include all regions other than China.

Data sources suggest that nearly all imports purchased for production of capital goods in China are subject to duty exemptions.¹⁹ Therefore, we assume that the capital goods sector in China uses only duty exempt imported capital intensive manufactures.

$$\text{VIFAE}(i, j, s) = \text{VIFA}(i, j, s),$$

$$i \in \text{MNFC_COMM}, j \in \text{CGDS_COMM}; s \in \text{CHNREG}$$

$$\text{VIFAE}(i, j, s) = 0,$$

$$i \in \text{REST_COMM}, j \in \text{CGDS_COMM}; s \in \text{CHNREG}$$

where MNFC_COMM is the set of traded capital intensive manufactures including metals, autos, electronics, and other manufactures such as machinery and equipment, etc; REST_COMM = TRAD_COMM – MNFC_COMM.

The domestic-oriented subsector uses the remaining part of the imported intermediates.

$$\text{VIFAD}(i, j, s) = \text{VIFA}(i, j, s) - \text{VIFAE}(i, j, s),$$

$$i \in \text{TRAD_COMM}, j \in \text{PROD_COMM}; s \in \text{REG}$$

¹⁹ According to GTAP 11 percent of total imports are used in the production of capital goods and according to the China Council (2001) 13 percent of imports are duty free imports used in the production of investment goods.

The use of factor endowments and domestic intermediates for export and domestic production at agents' prices by sector and region are calculated as follows:

$$EVFAE(i, j, s) = \mathbf{a}_{js} EVFA(i, j, s),$$

$$i \in \text{TRAD_COMM}, j \in \text{PROD_COMM}; s \in \text{REG}$$

$$VDFAE(i, j, s) = \mathbf{a}_{js} VDFA(i, j, s),$$

$$i \in \text{TRAD_COMM}, j \in \text{PROD_COMM}; s \in \text{REG}$$

$$EVFAD(i, j, s) = EVFA(i, j, s) - EVFAE(i, j, s),$$

$$i \in \text{TRAD_COMM}, j \in \text{PROD_COMM}; s \in \text{REG}$$

$$VDFAD(i, j, s) = VDFA(i, j, s) - VDFAE(i, j, s),$$

$$i \in \text{TRAD_COMM}, j \in \text{PROD_COMM}; s \in \text{REG}.$$

To preserve the tax information in GTAP factor endowment, imported and domestic intermediate input use of export and domestic firms at market prices are computed in the same way as the corresponding input use at agents prices.

Once we know the split between imported intermediates for domestic and export production, we then calculate imports of commodity i into region s used for production of exports, $VIMSE(i, r, s)$, and for domestic sales, $VIMSD(i, r, s)$, by source r as follows:

$$VIMSE(i, r, s) = \mathbf{g}_{is} VIMS(i, r, s),$$

$$VIMSD(i, r, s) = (1 - \mathbf{g}_{is}) VIMS(i, r, s),$$

$$\text{where } \mathbf{g}_{is} = \frac{\sum_j VIFME(i, j, s)}{\sum_r VIMS(i, r, s)} \text{ and } i \in \text{TRAD_COMM}; r, s \in \text{REG}, \text{ where}$$

$$j \in \text{TRAD_COMM}; r, s \in \text{REG}.$$

This approach ensures that the sum of imported intermediates i by exporters in region s equals the sum of imported intermediates i from all regions r into region s :

$$\sum_j VIFME(i, j, s) = \sum_r VIMSE(i, r, s),$$

$$i \in \text{TRAD_COMM}; j \in \text{PROD_COMM}; r, s \in \text{REG}$$

Similarly, the sum of imported intermediates i by domestic-oriented producers in region s and imports of good i for final consumption equals the sum of imports of good i used for domestic use from all regions r into region s :

$$\sum_j \text{VIFMD}(i, j, s) + \text{VIPM}(i, s) + \text{VIGM}(i, s) = \sum_r \text{VIMSD}(i, r, s).$$

$$i \in \text{TRAD_COMM}; j \in \text{PROD_COMM}; r, s \in \text{REG}$$

The next step is to eliminate tariffs on intermediate manufactured imports used in the production of exports in the newly created database using the *ALTERTAX* approach that seeks to preserve the initial shares in the GTAP data. However, the result was a database that showed insufficient use of imported intermediates in the export sector.²⁰ In response to this problem, we begin with equal intermediate shares in domestic and export-oriented activities. We then allow for increased use of imported intermediates in the export sector when eliminating tariffs on intermediate manufactured imports used in the production of exports with *ALTERTAX*. This was done by modifying the *ALTERTAX* approach in Malcolm (1998) in that $\text{ESUBD}(j, r)$ is defined so that it varies not only by sector but also by region. We then set the elasticity of substitution between domestic and intermediate goods in China at twice its value in the GTAP database (Dimaranan and McDougall, 2002). In all other regions $\text{ESUBD}(i, r)$ equals 1.

This approach increases the import-intensity of the exporting sectors as tariffs on imports used for export processing are eliminated. It raised the share of imports used by the export activities in China to 30 percent, while preserving key aggregate statistics of the GTAP database (Table 1; columns 3 and 4 of Table 2; last row of Table 3). China's sectoral shares in world output, exports and imports were changed somewhat but in all cases these changes are negligible (Table 3).

Import taxes on imports for domestic use in GTAP-DD data are preserved and equal to the import tax rates on imports in version 5 GTAP database, while taxes on manufactured imports for the production of exports in GTAP-DD are zero (Table 4). Import taxes on farm products used both for domestic and export processing remain unchanged since there is evidence that the use of duty exemptions for farm imports is limited.²¹ Protection on cross-border trade in services also does not differ based on the trade orientation of the firms.

All parameters for the two experiments come from version 5 GTAP (Dimaranan and McDougall, 2002). These include the Allen partial elasticities of substitution that describe the

²⁰ The share of imports used by export firms in total intermediate import use equals 25 percent, which is much lower than the 41 percent implied by Customs data for 2000.

²¹ A number of farm products are still subject to state trading (World Trade Organization, 2001). In addition, Huang and Rozelle (2002) show that a number of products faced negative protection rates (Table 4).

substitutability between domestic and imported intermediates, the substitutability between imported intermediates from different sources, and the substitutability between primary factors. Furthermore, the Allen partial elasticities of substitution in the domestic-oriented sub-sector of a sector are the same as those in the export-oriented sub-sectors of the economy. This reflects the assumption that all firms are identical and ensures that in the absence of duty exemptions and conditional on the assumptions listed above, the solution to the model coincides with the solution to GTAP.

4. Analyzing China's WTO Accession

The importance of duty drawbacks for the analysis of policy reform is illustrated by evaluating the impact of China's WTO accession first using the GTAP model, and then GTAP-DD. The comparison of the results from the two models suggests that results of studies which have abstracted from China's duty exemptions when analyzing China's entry to the WTO (Martin et al., 1999; Bach et al., 1996; Walmsley and Hertel, 2001) may be seriously biased. The presence of duty exemptions is an important determinant of the outcome of trade liberalization. With duty exemptions on imported inputs for export processing, the liberalization in China affects only intermediate imports for domestic use, and therefore its impact on output, trade flows and welfare is smaller than the outcome captured with GTAP which abstracts from duty exemptions. The impact is significantly smaller for those industries that rely heavily on imported intermediates.

4.1 Experimental design

The simulation design for the pair of experiments follows closely Ianchovichina and Martin (2002), but for simplicity and comparison purposes the changes associated with accession are evaluated in a comparative static context. Both experiments are designed to reflect the impact of WTO accession which involves (a) liberalization from 1997 tariffs to post accession tariff rates (2007) (Table 4);²² (b) the elimination of quotas on China's textile and clothing exports to the US and EU markets;²³ (c) the removal of agricultural export subsidies for feedgrains and plant-based fibers (cotton) (see Huang and Rozelle, 2002); (d) the liberalization of cross-border trade in services and (e) the restructuring of the Chinese automobile sector²⁴ (see Francois and Spinanger, 2002). The two experiments differ only in that tariff cuts in GTAP are the same for all imports regardless of their use, whereas tariff cuts on manufactured imports used by the export processing sector are zero in GTAP-DD reflecting the presence of duty exemptions (see Table 4).

The macroeconomic closure assumes full employment, perfect mobility of skilled and unskilled workers between sectors, and fixed trade balance as a share of GDP in China and

²² China's own protection is reduced to the lesser of the tariff binding or the 2001 applied rate.

²³ Quotas on textile and apparel exports have been represented in the analysis as if they were an export tax. William Martin estimated that in 2001 quotas on Chinese textiles and apparel exports to the U.S. were equivalent to an export tax of 11 and 15 percent, respectively, while those to the EU averaged 12 and 15 percent, respectively.

²⁴ The restructuring of the automobile sector is represented as a 20 percent productivity gain to car assembly operations.

Chinese Taipei.²⁵ Since accession to the WTO involves a long run change in the stance of trade policy the elasticity of substitution between imported goods from different sources and between composite imported and domestic goods were doubled.

4.2 Results

China's output, export, and import changes due to WTO accession obtained with GTAP and GTAP-DD are shown in Table 5. Columns 4, 7 and 10 of Table 5 show the bias introduced in the results when duty exemptions are not considered in the analysis.²⁶ Both GTAP and GTAP-DD lead to very similar estimates of world output change. In both cases the increase in China's real GDP due to the country's accession to the WTO is small reflecting the fact that both models do not include the linkage between trade reform and productivity growth.

At the sectoral output level, however, China's WTO accession boosts production in a number of sectors including apparel, textiles, cotton and automobiles. Automobile manufacturing gets a boost as a result of the assumed increase in productivity of assembly-type operations and the tariff reductions on imported intermediate inputs such as auto parts. The expansion of the apparel industry is associated with the lifting of the burdens imposed by the MFA on China's exports and domestic protection on the cost structure of the industry. This expansion in the apparel industry in turn boosts China's textiles and cotton sectors.

The results from the two models differ quantitatively. With GTAP accession to the WTO leads to an increase in China's apparel output by 96 percent (column 5, Table 5), while with GTAP-DD this increase is 81 percent. This implies that with GTAP the increase in China's output of apparel is approximately 20 percent higher than the one predicted with GTAP-DD. The smaller increase with GTAP-DD is due to the fact that GTAP-DD captures the expansion of apparel as a result of export quota removal while taking into account duty exemptions on imported inputs used in the production of apparel exports. These exemptions have essentially opened up the export-oriented apparel sector as they affected two thirds of intermediate inputs in the apparel industry, and imply that the output increases estimated with GTAP-DD are attributed mainly to the lifting of the burdens imposed by the MFA on China's apparel exports.

In some cases the results with the two models differ not only quantitatively but also qualitatively. Given the large importance of export processing arrangements and duty exemptions in the electronics sector (Table 2) and the significant tariff cuts on electronic products (Table 4), GTAP-DD suggests a small contraction in the output of electronics due to China's WTO accession. By contrast GTAP misses the effect of duty exemptions on output and estimates a small export-driven increase in electronics output (Table 5).

The impact of WTO accession on China's share in world trade is much stronger than the one on China's share in world output (Table 5). According to GTAP China's exports and

²⁵ While the trade balance can be expected to vary, particularly if there is a substantial change in foreign investment levels, there is no link between the change in foreign investment and the change in income in the model.

²⁶ The bias is computed as a difference in percentage changes, namely $[(1+x_{GTAP})/(1+x_{GTAP-DD})-1]*100$, where x is the percentage change in the respective variable.

imports rise by 32 percent due to accession.²⁷ GTAP-DD also estimates a strong, however, more modest increase in China's exports and imports (23 percent) because it allows for the partial liberalization implicit in the exemption scheme on intermediate inputs used in the production of exports.

A comparison of the sectoral results with GTAP and GTAP-DD suggests that for some sectors – for example, electronics - the bias introduced by ignoring duty exemptions in China could be significant – a difference of 26 percent in the estimated percentage changes with the two models or an increase in exports with GTAP-DD which is 90 percent smaller than the one with GTAP. In the case of apparel, there is a 13 percent difference in the estimated percentage changes with the two models or an increase in exports with GTAP-DD which is 45 percent smaller than the one with GTAP. For these sectors the export expansion with GTAP-DD is strong but much less so than with GTAP because duty exemptions have already removed much of the burden of protection on the export sector in China and any benefits of tariff cuts have a smaller, indirect impact. Failing to taking into account duty exemptions on imported inputs used in the production of exports also leads to serious bias in the estimation of import changes for a number of products among which textiles (18 percent), apparel (16 percent), automobiles (15 percent), light manufactures (16 percent) and other manufactures (11 percent) (see Table 5).

Table 6 shows regional welfare changes due to China's entry to the WTO computed with GTAP (column 2) and with GTAP-DD (column 3). While qualitatively the changes in regional welfare are broadly the same, quantitatively the results differ substantially. Indeed, GTAP overestimates China's welfare gain by almost 15 percent. This is due to an upward bias in the allocative efficiency gain most of which is due to gains in textiles (46 percent), apparel (23 percent), electronics (13 percent) and other manufactures (11 percent) (last column of Table 6). The presence of a well functioning duty exemption scheme implies that to a large extent China's liberalization has already been captured prior to accession, and therefore the allocative efficiency gains associated with an improved allocation of resources across sectors due to WTO accession will be smaller than suggested by GTAP.

For other regions, this implies that the change in their welfare will be mainly due to the removal of restrictions on Chinese exports and not so much to removal of China's import tariffs. This, in turn, translates into smaller gains for developed countries and smaller losses for developing countries when duty exemptions are modeled explicitly. As a result the global welfare gain with GTAP is approximately 30 percent larger than the gain estimated with GTAP-DD.

4.3 Alternative specifications of duty exemptions for imported investment goods

The data construction of duty exempt intermediate inputs used for the production of capital goods described in section 3 was designed to reflect the fact that in China almost all imported capital goods are exempt from import duties. However, this method led to different input compositions for the export and domestic-oriented subsectors of the capital goods

²⁷ This reflects the assumption that China's trade balance is a fixed share of GDP.

sectors,²⁸ and therefore to different solutions with GTAP-DD and GTAP even when import tariffs and tariffs cuts for the domestic and exported-oriented firms are identical. To ensure that the solutions with GTAP-DD and GTAP coincide when these conditions are met and to study the importance of duty exemptions for imported capital goods in China for the outcome of trade reform, we alter slightly the approach presented earlier and divide the capital goods' intermediate inputs using the share of China's exports in total output:

$$a_{js} = \sum_i \sum_r VXMD(i, s, r) / \sum_i VOM(i, s), \quad j \in CGDS_COMM; s \in REG.$$

We then follow all other steps of the data construction and obtain another database for use with GTAP-DD, GTAP-DD version 2. The data base constructed in section 3 and GTAP-DD v. 2 data are identical except for the much higher share of duty exempt investment goods in the former data. The share of duty free imported capital goods falls from 94 percent in the GTAP-DD data in section 3 to 16 percent in GTAP-DD v.2 data (Table 7).

It can be verified that when tariffs and tariff reductions for imported intermediate inputs for export and domestic use are equal, the solutions obtained with GTAP-DD, using GTAP-DD v.2 database, and GTAP are identical. One can also verify that duty exemptions for imported investment goods have a negligible impact on the outcome of trade reform in a comparative static model (Tables 6 and 8).

4.4 Magnitude of initial protection

The degree of bias in estimating the changes due to trade reform with GTAP depends on the magnitude of the initial tariffs and tariff cuts – the larger the initial distortion and tariff reduction, the larger the bias when duty exemptions are ignored. The increase in the bias results from the fact that GTAP captures additional cost saving and efficiency gains associated with the rise in initial distortions and tariff cuts since it does not take into account duty exemptions for export processing.

In China weighted average tariffs in 1997 were much lower than tariffs in 1995 (Table 9). Consequently, the bias in the estimated impact of tariff reductions from 1995 to post accession tariff levels with GTAP would be much larger than the bias in the estimated impact of tariff cuts from 1997 to post accession tariffs. Tables 10 and 11 show changes in output, trade and welfare due to WTO accession which involves liberalization from 1995 tariff levels. The experimental design is identical to the one presented earlier except for the tariff cuts, which are larger than the ones applied earlier since tariffs in 1995 were higher than tariffs in 1997 (Table 9). Results in Tables 10 and 11 suggest that the bias in GTAP's estimates of China's real GDP, trade flows and welfare changes due to WTO accession increases more than 3 times when China's pre-intervention tariffs are raised from their 1997 levels to the much higher levels in 1995. For example, GTAP overestimates China's welfare gain due to WTO accession from 1995 tariffs by 48 percent (Table 11), whereas the bias in the estimated gain due to WTO

²⁸ The export-oriented sub-sector of the capital goods sector represents all capital goods imported duty free and used by the export processing sectors. The domestic-oriented sub-sector represents capital goods used for all other purposes.

accession from 1997 tariffs is just 15 percent (Table 6). This increase in the bias in the estimated welfare gain is due to the fact that in the face of larger initial distortion and tariff cuts the GTAP model estimates a much larger (4 times) second best efficiency gain as it ignores the fact that the export sector benefits from duty exemptions on imported intermediate inputs.

The bias in the sectoral results is also worse in the case of liberalization from 1995 tariffs compared to liberalization from 1997 tariffs. It is largest for the those sectors such as automobiles in which 1995 tariffs are much larger than 1997 tariffs. The bias is doubled in the case of electronics, 3 times larger for apparel, 46 time larger in the case of automobile output and 15 times larger in the case of automobile exports and imports (Tables 5 and 10).

5. *Conclusions*

Concessional import rights, such as duty exemptions, which override existing protection, have been an important element of the process of gradual trade liberalization that boosted growth in China and other countries. Despite the vast importance of these “new trade liberalization” instruments, they have been given relatively little attention both in trade negotiations and in multilateral trade liberalization studies. Standard global trade models have largely abstracted from the presence of concessional imports, while trade liberalization studies using these models have at best only acknowledged their importance and have not offered in-depth solution to the problem.

This paper presents an extension of GTAP in which the effects of policy reform are differentiated based on the trade orientation of the firms. The model treats explicitly both duty drawbacks on imported intermediate inputs and investment goods used for the production of exports. The paper evaluates the importance of duty exemptions in China by assessing the impact of China’s WTO accession, which involves liberalization from 1997 to post-accession tariffs among a number of other liberalization measures, on the country’s output, trade and welfare. The analysis, which uses first GTAP and then the extended model with duty drawbacks, GTAP-DD, suggests that the absolute magnitudes of changes in *sectoral* output and trade flows due to accession are larger, sometimes substantially, with GTAP compared to GTAP-DD. The analysis shows that failure to account of duty exemptions in the case of China’s recent WTO accession will overstate the increase in China’s aggregate trade flows by 40 percent and China’s welfare by 15 percent. This reflects the fact that duty exemptions have reduced substantially border protection in China prior to WTO accession. Consequently, any boost to trade and efficiency gains associated with an improved allocation of resources across sectors due to WTO accession will be smaller with GTAP-DD than with GTAP.

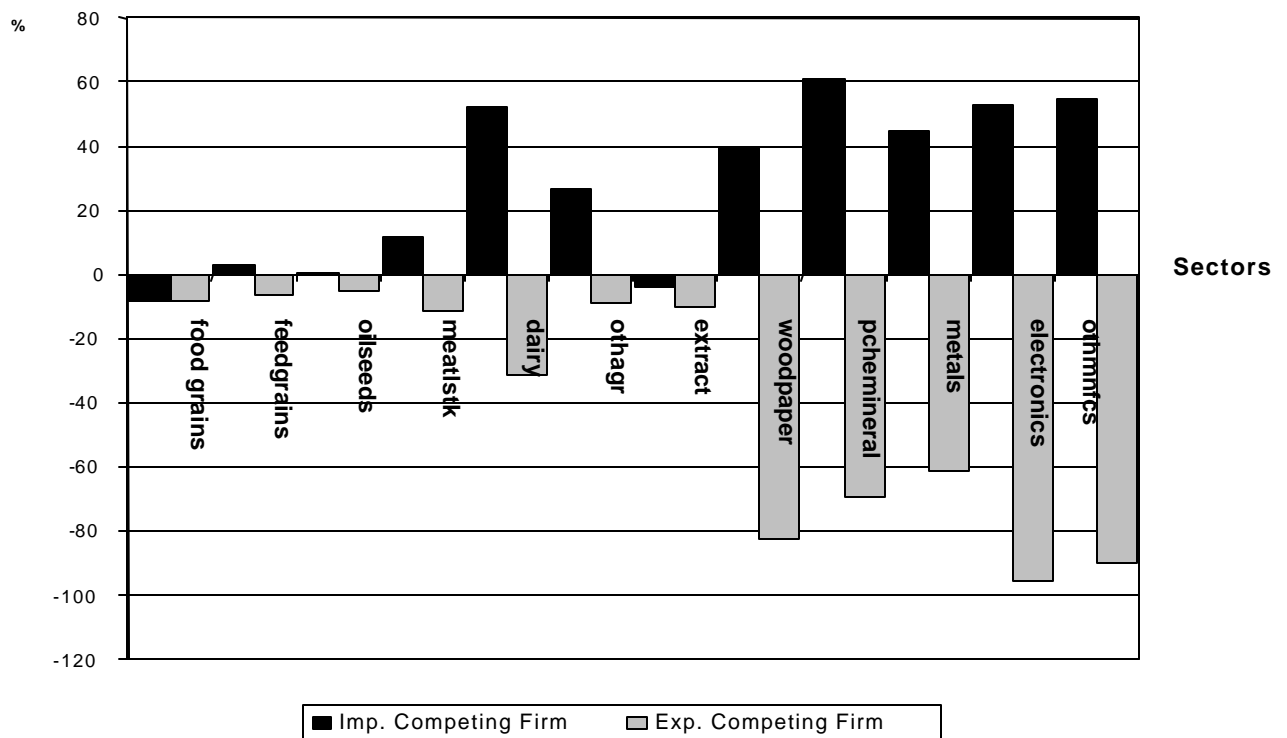
The magnitude of the bias in estimating the changes due to trade reform with GTAP depends on the level of initial tariffs and the size of the tariff cuts – the larger the initial distortion and tariff reductions, the larger the bias when duty exemptions are ignored. The bias in GTAP’s estimates of China’s real GDP, trade flows and welfare changes due to WTO accession increases more three times when China’s pre-intervention tariffs are raised from their 1997 levels to the much higher 1995 levels. These results suggest that trade liberalization studies focusing on economies, in which protection is high, import concessions play an important role and planned tariff cuts are deep, must always treat duty drawbacks explicitly in order to avoid serious errors in their estimates of sectoral, trade flow and welfare changes.

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Figure 1. China's Effective Rates of Protection in 1995.



Source: Calculations by Emiko Fukase based on version 4 of GTAP Data Base, 1995 tariff rates.

Table 1. Key dimensions of version 5 GTAP (in italics) and GTAP-DD Data
Bases (shares of GDP)

Regions	Private Consumption	Investment	Government Consumption	Exports	Imports
North America	0.68 <i>0.68</i>	0.18 <i>0.18</i>	0.15 <i>0.15</i>	0.14 <i>0.14</i>	0.15 <i>0.15</i>
Western Europe	0.61 <i>0.61</i>	0.19 <i>0.19</i>	0.19 <i>0.19</i>	0.31 <i>0.31</i>	0.30 <i>0.30</i>
Australia/New Zealand	0.62 <i>0.62</i>	0.22 <i>0.22</i>	0.17 <i>0.17</i>	0.20 <i>0.20</i>	0.20 <i>0.20</i>
Japan	0.60 <i>0.60</i>	0.29 <i>0.29</i>	0.10 <i>0.10</i>	0.12 <i>0.12</i>	0.10 <i>0.10</i>
China	0.48 <i>0.48</i>	0.36 <i>0.36</i>	0.12 <i>0.12</i>	0.30 <i>0.30</i>	0.27 <i>0.27</i>
Taiwan	0.57 <i>0.57</i>	0.20 <i>0.20</i>	0.14 <i>0.14</i>	0.46 <i>0.46</i>	0.37 <i>0.37</i>
Other NICs	0.57 <i>0.57</i>	0.38 <i>0.38</i>	0.11 <i>0.11</i>	0.52 <i>0.52</i>	0.58 <i>0.58</i>
Indonesia	0.64 <i>0.64</i>	0.29 <i>0.29</i>	0.07 <i>0.07</i>	0.27 <i>0.27</i>	0.27 <i>0.27</i>
Vietnam	0.71 <i>0.71</i>	0.33 <i>0.33</i>	0.10 <i>0.10</i>	0.43 <i>0.43</i>	0.57 <i>0.56</i>
Other Southeast Asia	0.55 <i>0.55</i>	0.34 <i>0.34</i>	0.11 <i>0.11</i>	0.61 <i>0.61</i>	0.61 <i>0.61</i>
India	0.65 <i>0.65</i>	0.24 <i>0.24</i>	0.12 <i>0.12</i>	0.12 <i>0.12</i>	0.12 <i>0.12</i>
Other South Asia	0.76 <i>0.76</i>	0.19 <i>0.19</i>	0.09 <i>0.09</i>	0.17 <i>0.17</i>	0.21 <i>0.21</i>
Brazil	0.64 <i>0.64</i>	0.20 <i>0.20</i>	0.18 <i>0.18</i>	0.08 <i>0.08</i>	0.10 <i>0.10</i>
Other Latin America	0.75 <i>0.75</i>	0.21 <i>0.21</i>	0.08 <i>0.08</i>	0.19 <i>0.19</i>	0.22 <i>0.22</i>
Turkey	0.67 <i>0.67</i>	0.26 <i>0.26</i>	0.12 <i>0.12</i>	0.23 <i>0.23</i>	0.28 <i>0.28</i>
Other Middle East & N. Africa	0.57 <i>0.57</i>	0.22 <i>0.22</i>	0.22 <i>0.22</i>	0.33 <i>0.33</i>	0.33 <i>0.33</i>
Economies in Transition	0.64 <i>0.64</i>	0.22 <i>0.22</i>	0.16 <i>0.16</i>	0.31 <i>0.31</i>	0.32 <i>0.32</i>
S. African Customs Union	0.59 <i>0.59</i>	0.18 <i>0.18</i>	0.21 <i>0.21</i>	0.26 <i>0.26</i>	0.24 <i>0.24</i>
Other Sub-Saharan Africa	0.76 <i>0.76</i>	0.16 <i>0.16</i>	0.12 <i>0.12</i>	0.27 <i>0.27</i>	0.31 <i>0.31</i>
Rest of World	0.78 <i>0.78</i>	0.18 <i>0.18</i>	0.10 <i>0.10</i>	0.15 <i>0.15</i>	0.21 <i>0.21</i>
Total	0.63 <i>0.63</i>	0.22 <i>0.22</i>	0.15 <i>0.15</i>	0.22 <i>0.22</i>	0.22 <i>0.22</i>

Source: Author's calculations based on version 5 GTAP and GTAP-DD data.

Table 2. Distribution of Imported Intermediates Use by Sector in China (%)

	GTAP-DD		GTAP		GTAP-DD	
	Share in total import use of				Share in sectoral import use of	
	Export-oriented firms	Domestic oriented firms	All firms	All firms	Export-oriented firms	Domestic oriented firms
Rice	0.0	0.7	0.5	0.6	1	99
Wheat	0.0	0.2	0.2	0.2	0	100
Feedgrains	0.2	0.5	0.4	0.4	12	88
Vegetables-fruits	0.1	1.8	1.3	1.4	2	98
Oilseeds	0.0	0.1	0.1	0.1	5	95
Sugar	0.0	0.0	0.0	0.0	12	88
Plantfibers	0.0	0.7	0.5	0.5	0	100
Livestock-meat	0.3	1.7	1.3	1.3	6	94
Dairy	0.0	0.0	0.0	0.0	4	96
Other food	0.7	1.6	1.3	1.4	17	83
Beverages-tobacco	0.2	1.1	0.8	0.8	6	94
Extract	0.6	3.0	2.3	2.4	8	92
Textiles	6.5	7.5	7.2	7.1	27	73
Apparel	7.3	1.7	3.4	2.5	65	35
Light manufactures	5.1	1.0	2.2	1.7	69	31
Petrochemicals	4.9	17.6	13.8	14.1	11	89
Metals	2.4	7.5	6.0	6.1	12	88
Autos	0.4	2.0	1.5	1.6	8	92
Electronics	17.5	6.7	9.9	9.2	53	47
Other manufactures	15.3	18.4	17.5	16.9	26	74
Trade-transport	2.4	6.4	5.2	5.2	14	86
Construction	0.1	7.0	4.9	5.2	0	100
Communication	0.1	0.7	0.5	0.5	3	97
Commercial services	0.2	2.5	1.8	1.9	3	97
Other services	0.2	8.5	6.0	6.4	1	99
Capital goods	35.4	1.0	11.4	12.6	94	6
Total	100.0	100.0	100.0	100.0	30	70

Source: Author's calculations based on version 5 GTAP and GTAP-DD data.

Table 3. China's Shares of World Output, Exports and Imports in 1997 (Percent)

	<i>Output</i>		<i>Exports</i>		<i>Imports</i>	
	<i>GTAP</i>	<i>GTAP-DD</i>	<i>GTAP</i>	<i>GTAP-DD</i>	<i>GTAP</i>	<i>GTAP-DD</i>
Rice	19.3	18.8	6.2	6.2	3.1	2.8
Wheat	10.7	10.5	0.1	0.1	3.1	2.9
Feedgrains	9.0	8.9	6.1	6.1	3.1	3.0
Vegetables & fruits	17.7	17.3	2.9	2.9	1.3	1.2
Oilseeds	8.5	8.4	1.8	1.8	8.3	7.9
Sugar	1.1	1.1	1.3	1.3	2.0	1.9
Plantfibers	15.0	14.4	0.0	0.0	13.2	12.3
Livestock & meat	8.8	8.6	3.9	3.9	2.9	2.6
Dairy	0.6	0.6	0.2	0.2	0.7	0.7
Processed food	3.4	3.4	3.2	3.2	3.2	3.1
Beverages & tobacco	6.7	6.5	2.1	2.1	2.6	2.7
Extract	8.5	8.4	1.5	1.5	2.1	2.0
Textiles	15.7	14.9	10.8	10.6	10.6	11.4
Apparel	9.7	9.6	18.7	18.7	1.5	1.6
Light manufactures	18.7	18.2	27.6	27.4	3.4	3.8
Petrochemicals	7.5	7.4	2.9	2.9	5.0	4.9
Metals	6.9	6.8	3.3	3.3	4.4	4.2
Automobiles	2.1	2.1	0.3	0.3	1.0	0.9
Electronics	4.5	4.3	4.5	4.4	4.2	4.3
Other manufactures	6.4	6.3	4.2	4.2	3.9	3.7
Trade & transport	2.3	2.2	3.3	3.3	2.7	2.5
Construction	5.0	5.0	1.5	1.5	4.1	3.8
Communications	2.4	2.4	1.3	1.3	1.4	1.3
Commercial Services	0.9	0.9	0.5	0.5	0.9	0.9
Other services	2.0	2.0	0.8	0.8	1.5	1.4
Total	4.1	4.0	3.9	3.8	3.5	3.5

Source: Author's calculations based on version 5 GTAP and GTAP-DD data.

Table 4. Pre- and post-accession import protection (tariff or tariff equivalent)

	China				Chinese Taipei	
	For domestic use		For export processing		1997	Post-accession
	1997	Post-accession	1997	Post-accession		
Rice	-5.0	-3.3	-5.0	-3.3	2.2	0.0
Wheat	25.0	12.0	25.0	12.0	6.5	6.5
Feedgrains	20.0	32.0	20.0	32.0	1.0	0.0
Vegetables & fruits	-10.0	-4.0	-10.0	-4.0	35.7	16.0
Oilseeds	30.0	3.0	30.0	3.0	1.8	0.2
Sugar	44.0	20.0	44.0	20.0	21.9	22.7
Plantfibers	20.0	20.0	20.0	20.0	0.0	0.0
Livestock & meat	-20.0	-15.0	-20.0	-15.0	7.5	4.0
Dairy	30.0	11.0	30.0	11.0	16.6	5.9
Processed food	35.1	9.9	0.0	0.0	14.9	9.9
Beverages & tobacco	63.2	15.6	0.0	0.0	48.1	13.0
Extract	0.7	0.6	0.0	0.0	5.5	4.1
Textiles	25.1	8.9	0.0	0.0	6.1	5.6
Apparel	31.7	14.9	0.0	0.0	12.8	11.2
Light manufactures	12.1	8.4	0.0	0.0	4.0	3.4
Petrochemicals	13.1	7.1	0.0	0.0	4.2	2.9
Metals	9.7	5.7	0.0	0.0	4.0	1.5
Automobiles	34.4	13.8	0.0	0.0	23.9	13.3
Electronics	11.9	2.3	0.0	0.0	2.9	0.3
Other manufactures	13.0	6.6	0.0	0.0	4.4	2.1
Trade & transport	1.9	0.9	1.9	0.9	1.3	0.7
Construction	13.7	6.8	13.7	6.8	5.9	2.9
Communications	9.2	4.6	9.2	4.6	9.2	4.6
Commercial Services	29.4	14.7	29.4	14.7	3.7	1.9
Other services	24.5	12.7	24.5	12.7	7.1	3.5
Total – Agriculture	4.2	3.6	1.7	1.0	9.1	4.6
Total – Manufactures	15.0	6.9	0.0	0.0	6.3	3.5
Total merchandise trade*	14.4	6.8	0.0	0.0	6.5	3.6

Source: Version 5 GTAP for protection in 1997 and Ianchovichina and Martin (2002) for post-accession protection.

*The estimates in the table are based on trade weights for the respective years. If trade weights for 2000 at the six-digit level of the harmonized system are used the total weighted average tariffs in 2001 and 2007 are 12.2% and 6.3%, respectively, for China, and 4.5% and 3.1%, respectively, for Chinese Taipei.

Table 5. Impact of Accession on Output, Exports and Imports (% changes)

	Output			Exports			Imports		
	GTAP-			GTAP-			GTAP-		
	GTAP	DD	Bias*	GTAP	DD	Bias	GTAP	DD	Bias
Rice	-1.9	-1.6	-0.3	-7.5	-4.0	-3.6	-6.9	-8.7	2.0
Wheat	-10.9	-9.9	-1.1	19.9	21.9	-1.6	29.1	28.9	0.2
Feedgrains	-4.6	-4.7	0.1	-77.9	-77.6	-1.3	-15.7	-16.5	1.0
Vegetables & fruits	-3.9	-3.4	-0.5	1.9	3.0	-1.1	-20.5	-21.5	1.3
Oilseeds	-15.1	-14.3	-0.9	26.0	27.8	-1.4	42.8	44.7	-1.3
Sugar	-12.4	-11.0	-1.6	5.5	7.5	-1.9	38.8	37.8	0.7
Plantfibers	16.6	15.8	0.7	-55.5	-56.0	1.1	15.8	13.6	1.9
Livestock & meat	2.6	2.5	0.1	4.4	1.8	2.6	-26.2	-27.9	2.4
Dairy	-8.1	-7.3	-0.9	7.3	6.3	0.9	65.3	64.2	0.7
Processed food	-17.6	-16.0	-1.9	13.8	12.8	0.9	116.5	106.0	5.1
Beverages & tobacco	-19.4	-17.5	-2.3	9.9	0.5	9.4	566.3	453.6	20.4
Extract	-1.9	-1.5	-0.4	10.0	7.5	2.3	-8.0	-7.9	-0.1
Textiles	17.8	16.7	0.9	38.8	27.2	9.1	92.3	63.7	17.5
Apparel	96.2	81.2	8.3	213.6	177.3	13.1	154.7	120.4	15.6
Light manufactures	-0.2	0.0	-0.2	2.8	0.9	1.9	29.9	12.0	16.0
Petrochemicals	-4.0	-3.4	-0.6	1.0	-0.6	1.6	17.2	13.2	3.5
Metals	-6.4	-4.8	-1.7	-0.7	-0.4	-0.3	15.4	11.4	3.6
Automobiles	16.5	15.7	0.7	440.1	391.4	9.9	43.1	34.7	6.2
Electronics	5.0	-3.9	9.3	28.4	2.0	25.9	22.2	6.2	15.1
Other manufactures	-6.2	-4.2	-2.1	1.9	-1.4	3.3	27.0	14.2	11.2
Trade & transport	-0.3	-0.1	-0.2	-2.5	-2.1	-0.4	4.0	2.2	1.8
Construction	0.7	0.4	0.3	-3.5	-2.0	-1.5	22.2	19.4	2.3
Communications	-1.1	-0.8	-0.3	-8.3	-6.7	-1.7	16.7	14.2	2.2
Commercial Services	-2.9	-2.5	-0.4	-9.3	-7.0	-2.5	41.3	38.6	1.9
Other services	-1.0	-0.8	-0.2	-4.4	-3.6	-0.8	40.5	37.6	2.1
Capital goods	1.1	0.7	0.4	N/A	N/A	N/A	N/A	N/A	N/A
Total	2.3	1.8	0.5	32.4	22.8	7.8	32.3	22.5	8.0

Source: Author's simulations with GTAP and GTAP-DD.

Table 6. Welfare Changes due to China's WTO Accession* (\$US Millions)

	GTAP	GTAP-DD	GTAP-DD Data v.2	Contribution to the Difference between GTAP and GTAP-DD Allocative Efficiency Gains in China by Product:	
North America	4384	3480	3548		%
Western Europe	7345	6009	6062		
Australia and New Zealand	103	40	39		
Japan	2394	1513	1632	Agriculture	0.1
China	10317	8970	9086	Processed food	4.0
Taiwán, China	592	337	367	Beverages & tobacco	0.1
Other NICs	1249	734	805	Extract	-0.5
Indonesia	-313	-286	-285	Textiles	45.9
Vietnam	-93	-83	-85	Apparel	23.2
Other Southeast Asia	-466	-411	-417	Light manufactures	1.0
India	-716	-625	-633	Petrochemicals	1.9
Other South Asia	-808	-718	-722	Metals	-1.6
Brazil	1214	1068	1054	Automobiles	3.8
Other Latin America	-542	-516	-528	Electronics	13.4
Turkey	-281	-252	-255	Other manufactures	11.2
Other Middle East & N. Africa	-371	-409	-424	Trade & transport	-0.9
Economies in Transition	-190	-239	-249	Construction	0.4
South African Customs Union	24	3	3	Communications	-0.1
Other Sub-Saharan Africa	-84	-89	-93	Commercial Services	-1.5
Rest of World	-178	-182	-183	Other services	-0.3
Total	23580	18344	18722	Total	100.0

Source: Author's simulations with GTAP and GTAP-DD.

*These are welfare changes due to reforms implemented between 1997 and 2007.

Table 7. Distribution of Imported Intermediates Use in China: A Comparison (%)

	Share in total import use of all firms in :			GTAP-DD		GTAP-DD v.2	
				Share in sectoral import use of		Share in sectoral import use of	
	GTAP	GTAP-DD	GTAP-DD v.2	export-oriented firms	domestic oriented firms	export-oriented firms	domestic oriented firms
Rice	0.6	0.5	0.5	1	99	1	99
Wheat	0.2	0.2	0.1	0	100	0	100
Feedgrains	0.4	0.4	0.4	12	88	12	88
Vegetables-fruits	1.4	1.3	1.3	2	98	2	98
Oilseeds	0.1	0.1	0.1	5	95	5	95
Sugar	0.0	0.0	0.0	12	88	12	88
Plantfibers	0.5	0.5	0.5	0	100	0	100
Livestock-meat	1.3	1.3	1.3	6	94	6	94
Dairy	0.0	0.0	0.0	4	96	4	96
Other food	1.4	1.3	1.3	17	83	17	83
Beverages-tobacco	0.8	0.8	0.8	6	94	6	94
Extract	2.4	2.3	2.3	8	92	8	92
Textiles	7.1	7.2	7.2	27	73	27	73
Apparel	2.5	3.4	3.3	65	35	65	35
Light manufactures	1.7	2.2	2.2	69	31	69	31
Petrochemicals	14.1	13.8	13.6	11	89	11	89
Metals	6.1	6.0	5.9	12	88	12	88
Autos	1.6	1.5	1.5	8	92	8	92
Electronics	9.2	9.9	9.9	53	47	53	47
Other manufactures	16.9	17.5	17.3	26	74	26	74
Trade-transport	5.2	5.2	5.1	14	86	14	86
Construction	5.2	4.9	4.8	0	100	0	100
Communication	0.5	0.5	0.5	3	97	3	97
Commercial services	1.9	1.8	1.8	3	97	3	97
Other services	6.4	6.0	6.0	1	99	1	99
Capital goods	12.6	11.4	12.3	94	6	15	85
Total	100.0	100.0	100.0	30	70	21	79

Source: Author's calculations based on version 5 GTAP and the data for GTAP-DD.

Table 8. Impact of Accession on Output, Exports and Imports (% changes)

	Output		Exports		Imports	
	GTAP-DD		GTAP-DD		GTAP-DD	
	GTAP-DD	v.2	GTAP-DD	v.2	GTAP-DD	v.2
Rice	-1.6	-1.6	-4.0	-3.1	-8.7	-9.2
Wheat	-9.9	-9.8	21.9	22.7	28.9	28.7
Feedgrains	-4.7	-4.7	-77.6	-77.5	-16.5	-16.6
Vegetables & fruits	-3.4	-3.4	3.0	3.8	-21.5	-21.7
Oilseeds	-14.3	-14.1	27.8	28.5	44.7	45.1
Sugar	-11.0	-10.9	7.5	8.4	37.8	37.5
Plantfibers	15.8	16.5	-56.0	-55.9	13.6	14.0
Livestock & meat	2.5	2.6	1.8	2.7	-27.9	-28.2
Dairy	-7.3	-7.0	6.3	7.2	64.2	64.7
Processed food	-16.0	-15.7	12.8	13.7	106.0	105.7
Beverages & tobacco	-17.5	-17.3	0.5	1.9	453.6	450.7
Extract	-1.5	-1.4	7.5	8.0	-7.9	-8.2
Textiles	16.7	17.4	27.2	28.0	63.7	64.0
Apparel	81.2	82.5	177.3	179.8	120.4	118.8
Light manufactures	0.0	0.8	0.9	2.0	12.0	11.5
Petrochemicals	-3.4	-3.3	-0.6	0.2	13.2	12.8
Metals	-4.8	-4.8	-0.4	0.8	11.4	10.6
Automobiles	15.7	17.4	391.4	396.1	34.7	29.6
Electronics	-3.9	-4.5	2.0	2.9	6.2	7.7
Other manufactures	-4.2	-5.1	-1.4	-0.2	14.2	19.9
Trade & transport	-0.1	0.0	-2.1	-1.1	2.2	1.6
Construction	0.4	0.7	-2.0	-1.0	19.4	19.1
Communications	-0.8	-0.8	-6.7	-5.6	14.2	13.5
Commercial Services	-2.5	-2.5	-7.0	-5.9	38.6	37.8
Other services	-0.8	-0.8	-3.6	-2.5	37.6	36.8
Capital goods	0.7	1.0	N/A	N/A	N/A	N/A
Total	1.8	1.9	22.8	23.9	22.5	23.9

Source: Author's simulations with GTAP and GTAP-DD.

Table 9. China's import protection (tariff or tariff equivalent)

	For domestic use		For export processing		For domestic use		For export processing	
	Post-		Post-		Post-		Post-	
	1997	accession	1997	accession	1995	accession	1995	accession
Rice	-5.0	-3.3	-5.0	-3.3	-5.0	-3.3	-5.0	-3.3
Wheat	25.0	12.0	25.0	12.0	25.0	12.0	25.0	12.0
Feedgrains	20.0	32.0	20.0	32.0	20.0	32.0	20.0	32.0
Vegetables & fruits	-10.0	-4.0	-10.0	-4.0	-10.0	-4.0	-10.0	-4.0
Oilseeds	30.0	3.0	30.0	3.0	30.0	3.0	30.0	3.0
Sugar	44.0	20.0	44.0	20.0	44.0	20.0	44.0	20.0
Plantfibers	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Livestock & meat	-20.0	-15.0	-20.0	-15.0	-20.0	-15.0	-20.0	-15.0
Dairy	30.0	11.0	30.0	11.0	30.0	11.0	30.0	11.0
Processed food	35.1	9.9	0.0	0.0	20.1	9.9	0.0	0.0
Beverages & tobacco	63.2	15.6	0.0	0.0	137.2	15.6	0.0	0.0
Extract	0.7	0.6	0.0	0.0	3.4	0.6	0.0	0.0
Textiles	25.1	8.9	0.0	0.0	56.0	8.9	0.0	0.0
Apparel	31.7	14.9	0.0	0.0	76.1	14.9	0.0	0.0
Light manufactures	12.1	8.4	0.0	0.0	32.3	8.4	0.0	0.0
Petrochemicals	13.1	7.1	0.0	0.0	20.2	7.1	0.0	0.0
Metals	9.7	5.7	0.0	0.0	17.4	5.7	0.0	0.0
Automobiles	34.4	13.8	0.0	0.0	123.1	13.8	0.0	0.0
Electronics	11.9	2.3	0.0	0.0	24.4	2.3	0.0	0.0
Other manufactures	13.0	6.6	0.0	0.0	22.0	6.6	0.0	0.0
Trade & transport	1.9	0.9	1.9	0.9	1.9	0.9	1.9	0.9
Construction	13.7	6.8	13.7	6.8	13.7	6.8	13.7	6.8
Communications	9.2	4.6	9.2	4.6	9.2	4.6	9.2	4.6
Commercial Services	29.4	14.7	29.4	14.7	29.4	14.7	29.4	14.7
Other services	24.5	12.7	24.5	12.7	24.5	12.7	24.5	12.7
Total – Agriculture	4.2	3.6	1.7	1.0	4.8	3.6	1.7	1.0
Total – Manufactures	15.0	6.9	0.0	0.0	25.3	6.9	0.0	0.0
Total merchandise trade*	14.4	6.8	0.0	0.0	24.3	6.8	0.0	0.0

Source: versions 4 and 5 GTAP for protection in 1995 and 1997, respectively and Ianchovichina and Martin (2002) for post-accession protection.

*The estimates in the table are based on trade weights for the respective years.

Table 10. Impact of WTO Accession - Liberalization from 1995 Tariffs (% changes)

	Output			Exports			Imports		
	GTAP	GTAP-DD	Bias	GTAP	GTAP-DD	Bias	GTAP	GTAP-DD	Bias
Rice	-3.1	-2.2	-0.9	-11.0	7.8	-17.4	-4.2	-13.2	10.4
Wheat	-8.5	-5.1	-3.6	6.6	22.3	-12.8	43.5	37.7	4.2
Feedgrains	-3.9	-3.3	-0.6	-79.3	-77.0	-10.0	-15.7	-18.8	3.8
Vegetables & fruits	-5.1	-3.7	-1.5	0.2	12.0	-10.5	-23.0	-27.5	6.2
Oilseeds	-13.6	-10.2	-3.8	14.1	28.5	-11.2	58.3	61.1	-1.7
Sugar	-15	-9.7	-5.9	1.4	16.4	-12.9	41.5	36.2	3.9
Plantfibers	7.3	8.8	-1.4	-46.7	-45.9	-1.5	5.3	1.6	3.6
Livestock & meat	3	3.5	-0.5	-7.6	9.8	-15.8	-18.9	-28.1	12.8
Dairy	-6.9	-3.7	-3.3	-0.8	16.2	-14.6	77.1	67.8	5.5
Processed food	-6.5	-1.8	-4.8	7.8	23.2	-12.5	33.7	23.6	8.2
Beverages & tobacco	-65.7	-58.6	-17.1	36.3	21.2	12.5	2409.3	1425.3	64.5
Extract	-2.9	-0.9	-2.0	23.2	18.0	4.4	-2.5	-3.6	1.1
Textiles	7.5	8.4	-0.8	92.9	49.4	29.1	231.5	99.1	66.5
Apparel	142.4	91	26.9	378.0	242.6	39.5	804.1	478.1	56.4
Light manufactures	4.8	6.1	-1.2	36.5	19.7	14.0	234.0	53.2	118.0
Petrochemicals	-6.4	-3.7	-2.8	12.3	14.9	-2.3	35.5	22.9	10.3
Metals	-11.1	-5.2	-6.2	16.1	24.7	-6.9	44.7	27.2	13.8
Automobiles	3.8	-21.4	32.1	1526.2	560.8	146.1	428.3	167.7	97.3
Electronics	28.6	1.4	26.8	97.6	21.9	62.1	58.2	19.1	32.8
Other manufactures	-8.7	-4.2	-4.7	22.6	20.6	1.7	59.2	36.7	16.5
Trade & transport	0.6	1.6	-1.0	4.6	10.6	-5.4	1.9	-7.2	9.8
Construction	2.3	1.7	0.6	3.9	16.9	-11.1	19.7	8.3	10.5
Communications	-0.9	-0.1	-0.8	-5.6	8.0	-12.6	15.1	3.1	11.6
Commercial Services	-2.6	-1.3	-1.3	-8.6	7.4	-14.9	40.8	27.2	10.7
Other services	-0.8	-0.3	-0.5	2.0	13.1	-9.8	37.1	23.0	11.5
Capital goods	2.7	1.9	0.8	N/A	N/A	N/A	N/A	N/A	N/A
Total	5.5	3.6	1.8	78.7	47.2	21.4	75.8	46.0	20.4

Source: Author's simulations with GTAP and GTAP-DD.

Table 11. Welfare Changes due to China's WTO Accession* - Liberalization
from 1995 Tariffs (\$US Millions)

	GTAP	GTAP-DD
North America	7576	4488
Western Europe	14506	9634
Australia and New Zealand	386	109
Japan	6550	3759
China	27710	18891
Taiwán, China	2529	1559
Other NICs	5432	3197
Indonesia	-503	-376
Vietnam	-168	-114
Other Southeast Asia	-792	-599
India	-1057	-763
Other South Asia	-1185	-841
Brazil	94	-14
Other Latin America	-520	-550
Turkey	-416	-310
Other Middle East & North Africa	-171	-462
Economies in Transition	-16	-283
South African Customs Union	90	10
Other Sub-Saharan Africa	-39	-97
Rest of World	-89	-133
Total	59918	37104

Source: Author's simulations with GTAP and GTAP-DD.

*These are welfare changes due to reforms implemented between 1995 and 2007.

Appendix

A.1 New *SET* declarations

Set

NTRAD_COMM # non-tradeable commodities # = ENDW_COMM union
CGDS_COMM ;

Subset NTRAD_COMM is subset of NSAV_COMM ;

A.2 New *COEFFICIENTS* and/or *update* statements:

Update (all,i,TRAD_COMM)(all,r,REG) VDGM(i,r) = pmdom(i,r) * qgd(i,r);

Update (all,i,TRAD_COMM)(all,r,REG) VIGM(i,r) = pimdom(i,r) * qgm(i,r);

Update (all,i,TRAD_COMM)(all,r,REG) VDPM(i,r) = pmdom(i,r) * qpd(i,r);

Update (all,i,TRAD_COMM)(all,r,REG) VIPM(i,r) = pimdom(i,r) * qpm(i,r);

Update (all,m,MARG_COMM)(all,r,REG) VST(m,r) = pmexp(m,r) * qst(m,r);

Coefficient (ge 0)(all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG) EVFAE(i,j,r)
! producer expenditure on i by the export side of industry j in region r valued at agent's prices
! ;

Update (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)
EVFAE(i,j,r) = pfe(i,j,r) * qfeexp(i,j,r);

Read EVFAE from file GTAPDATA header "EVAE";

Coefficient (ge 0)(all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG) EVFAD(i,j,r)
! producer expenditure on i by the domestic side of industry j in r valued at agent's prices ! ;

Update (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)
EVFAD(i,j,r) = pfe(i,j,r) * qfedom(i,j,r);

Read EVFAD from file GTAPDATA header "EVAD";

Coefficient (ge 0)(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) VDFAE(i,j,r)
! purchases of domestic i for use in the export side of industry j in region r ! ;

Update (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
VDFAE(i,j,r) = pfd(i,j,r) * qfdexp(i,j,r);

Read VDFAE from file GTAPDATA header "VDAE";

Coefficient (ge 0)(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) VDFAD(i,j,r)
! purchases of domestic i for use in the domestic side of industry j in region r ! ;

Update (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
VDFAD(i,j,r) = pfd(i,j,r) * qfdom(i,j,r);

Read VDFAD from file GTAPDATA header "VDAD";

Coefficient (ge 0)(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) VIFAE(i,j,r)
! purchases of imported i for use in the export side of j in region r ! ;
Update (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
 $VIFAE(i,j,r) = pfmexp(i,j,r) * qfmexp(i,j,r);$
Read VIFAE from file GTAPDATA header "VIAE";

Coefficient (ge 0)(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) VIFAD(i,j,r)
! purchases of imported i for use in the domestic side of j in region r ! ;
Update (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
 $VIFAD(i,j,r) = pfmdom(i,j,r) * qfmdom(i,j,r);$
Read VIFAD from file GTAPDATA header "VIAD";

Coefficient (ge 0)(all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG) VFMEXP(i,j,r)
! producer expenditure on i by the export side of j in r valued at mkt prices ! ;
Update (all,i,ENDWM_COMM)(all,j,PROD_COMM)(all,r,REG)
 $VFMEXP(i,j,r) = pm(i,r) * qfeexp(i,j,r);$
Update (all,i,ENDWS_COMM)(all,j,PROD_COMM)(all,r,REG)
 $VFMEXP(i,j,r) = pmes(i,j,r) * qfeexp(i,j,r);$
Read VFMEXP from file GTAPDATA header "VFME";

Coefficient (ge 0)(all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG) VFMDOM(i,j,r)
! producer expenditure on i by the domestic side of j in r valued at mkt prices ! ;
Update (all,i,ENDWM_COMM)(all,j,PROD_COMM)(all,r,REG)
 $VFMDOM(i,j,r) = pm(i,r) * qfedom(i,j,r);$
Update (all,i,ENDWS_COMM)(all,j,PROD_COMM)(all,r,REG)
 $VFMDOM(i,j,r) = pmes(i,j,r) * qfedom(i,j,r);$
Read VFMDOM from file GTAPDATA header "VFMD";

Coefficient (ge 0)(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) VIFME(i,j,r)
! purchases of imports i for use in the export side of j in region r ! ;
Update (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
 $VIFME(i,j,r) = pimexp(i,r) * qfmexp(i,j,r);$
Read VIFME from file GTAPDATA header "VIME";

Coefficient (ge 0)(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) VIFMD(i,j,r)
! purchases of imports i for use in the domestic side of j in region r ! ;
Update (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
 $VIFMD(i,j,r) = pimdom(i,r) * qfmdom(i,j,r);$
Read VIFMD from file GTAPDATA header "VIMD";

Coefficient (ge 0)(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) VDFME(i,j,r)
! purchases of domestic i for use in the export side of j in region r ! ;
Update (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)
 $VDFME(i,j,r) = pmdom(i,r) * qfdexp(i,j,r);$
Read VDFME from file GTAPDATA header "VDME";

Coefficient (ge 0)(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) VDFMD(i,j,r)
! purchases of domestic i for use in the domestic side of j in region r ! ;
Update (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{VDFMD}(i,j,r) = \text{pmdom}(i,r) * \text{qfddom}(i,j,r);$$

Read VDFMD from file GTAPDATA header "VDMD";

Coefficient (ge 0)(all,i,TRAD_COMM)(all,r,REG)(all,s,REG) VIMSE(i,r,s)
! imports of i from r to s for export production, valued at domestic mkt prices ! ;
Update (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)

$$\text{VIMSE}(i,r,s) = \text{pmsexp}(i,r,s) * \text{qxsexp}(i,r,s);$$

Read VIMSE from file GTAPDATA header "VMSE";

Coefficient (ge 0)(all,i,TRAD_COMM)(all,r,REG)(all,s,REG) VIMSD(i,r,s)
! imports of i from r to s for domestic use, valued at domestic market prices ! ;
Update (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)

$$\text{VIMSD}(i,r,s) = \text{pmsdom}(i,r,s) * \text{qxsdm}(i,r,s);$$

Read VIMSD from file GTAPDATA header "VMSD";

Coefficient (ge 0)(all,i,TRAD_COMM)(all,r,REG)(all,s,REG) VIWSE(i,r,s)
! imports of i from r to s used of export production, valued cif (tradeables only) ! ;
Update (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)

$$\text{VIWSE}(i,r,s) = \text{pcif}(i,r,s) * \text{qxsexp}(i,r,s);$$

Read VIWSE from file GTAPDATA header "VWSE";

Coefficient (ge 0)(all,i,TRAD_COMM)(all,r,REG)(all,s,REG) VIWSD(i,r,s)
! imports of i from r to s for domestic use, valued cif (tradeables only) ! ;
Update (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)

$$\text{VIWSD}(i,r,s) = \text{pcif}(i,r,s) * \text{qxsdm}(i,r,s);$$

Read VIWSD from file GTAPDATA header "VWSD";

A.3 New *data base derivatives* and changes to existing ones

Coefficient (all,i,DEMD_COMM)(all,j,PROD_COMM)(all,r,REG) VFAEXP(i,j,r)
! producer expenditure on i by the export side of industry j, in region r, valued at agent's prices ! ;
Formula (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{VFAEXP}(i,j,r) = \text{EVFAE}(i,j,r);$$

Formula (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,s,REG)

$$\text{VFAEXP}(i,j,s) = \text{VDFAE}(i,j,s) + \text{VIFAE}(i,j,s);$$

Coefficient (all,i,DEMD_COMM)(all,j,PROD_COMM)(all,r,REG) VFADOM(i,j,r)
! producer expenditure on i by the domestic side of j, in region r, valued at agent's prices ! ;
Formula (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{VFADOM}(i,j,r) = \text{EVFAD}(i,j,r);$$

Formula (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,s,REG)

$$\text{VFADOM}(i,j,s) = \text{VDFAD}(i,j,s) + \text{VIFAD}(i,j,s);$$

Coefficient (all,i,DEMD_COMM)(all,j,PROD_COMM)(all,r,REG) VFA(i,j,r)
 # producer expenditure on i by j in r valued at agents' prices #;
 Formula (all,i,DEMD_COMM)(all,j,PROD_COMM)(all,s,REG)

$$VFA(i,j,s) = VFAEXP(i,j,s) + VFADOM(i,j,s);$$

Coefficient (all,i,PROD_COMM)(all,r,REG) VOAEXP(i,r)
 ! value of commodity i exports in region r. ! ;
 Formula (all,i,PROD_COMM)(all,r,REG)

$$VOAEXP(i,r) = \text{sum}(j, DEMD_COMM, VFAEXP(j,i,r));$$

Coefficient (all,i,PROD_COMM)(all,r,REG) VOADOM(i,r)
 ! value of commodity i output for domestic use in region r. ! ;
 Formula (all,i,PROD_COMM)(all,r,REG)

$$VOADOM(i,r) = \text{sum}(j, DEMD_COMM, VFADOM(j,i,r));$$

Coefficient (all,i,NSAV_COMM)(all,r,REG) VOA(i,r)
 # value of commodity i output in region r at agents' prices #;
 Formula (all,i,ENDW_COMM)(all,r,REG)

$$VOA(i,r) = EVOA(i,r);$$

Formula (all,i,PROD_COMM)(all,r,REG)

$$VOA(i,r) = VOAEXP(i,r) + VOADOM(i,r);$$

Coefficient (all,i,TRAD_COMM)(all,r,REG) VDM(i,r)
 # domestic sales of i in r at mkt prices (tradeables only) #;
 Formula (all,i,TRAD_COMM)(all,r,REG)

$$VDM(i,r) = VDPM(i,r) + VDGM(i,r) + \text{sum}(j, PROD_COMM, VDFME(i,j,r) + VDFMD(i,j,r));$$

Coefficient (all,i,TRAD_COMM)(all,r,REG) VOMEXP(i,r)
 ! value of commodity i exports in region r. ! ;
 Formula (all,i,MARG_COMM)(all,r,REG)

$$VOMEXP(i,r) = \text{sum}(s, REG, VXMD(i,r,s)) + VST(i,r) ;$$

Formula (all,i,NMRG_COMM)(all,r,REG)

$$VOMEXP(i,r) = \text{sum}(s, REG, VXMD(i,r,s)) ;$$

Coefficient (all,i,TRAD_COMM)(all,r,REG) VOMDOM(i,r)
 ! value of commodity i domestic sales in region r. ! ;
 Formula (all,i,TRAD_COMM)(all,r,REG)

$$VOMDOM(i,r) = VDM(i,r) ;$$

Coefficient (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG) VFM(i,j,r)
 ! producer expenditure on i by industry j, in region r, valued at market prices ! ;
 Formula (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)

$$VFM(i,j,r) = VFMEXP(i,j,r) + VFMDOM(i,j,r) ;$$

Coefficient (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG) SHRVMEXP(i,j,r)
 ! share of producer expenditure on i for exports by j, in region r, valued at market prices ! ;
 Formula (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)

$$SHRVMEXP(i,j,r) = VFMEXP(i,j,r)/VFM(i,j,r) ;$$

Coefficient (all,i,NSAV_COMM)(all,r,REG) VOM(i,r)
 # value of commodity i output in region r at market prices #;
 Formula (all,i,ENDW_COMM)(all,r,REG)

$$VOM(i,r) = \text{sum}(j, \text{PROD_COMM}, \text{VFM}(i,j,r));$$
 Formula (all,m,TRAD_COMM)(all,r,REG)

$$VOM(m,r) = \text{VOMDOM}(m,r) + \text{VOMEXP}(m,r);$$
 Formula (all,h,CGDS_COMM)(all,r,REG)

$$VOM(h,r) = \text{VOA}(h,r);$$

Coefficient (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) DFTAXEXP(i,j,r)
 ! tax on use of domestic intermediate good i by the export side of industry j in r ! ;
 Formula (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{DFTAXEXP}(i,j,r) = \text{VDFAE}(i,j,r) - \text{VDFME}(i,j,r);$$

Coefficient (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) DFTAXDOM(i,j,r)
 ! tax on use of domestic intermediate good i by the domestic side of industry j in r ! ;
 Formula (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{DFTAXDOM}(i,j,r) = \text{VDFAD}(i,j,r) - \text{VDFMD}(i,j,r);$$

Coefficient (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) IFTAXEXP(i,j,r)
 ! tax on use of imported intermediate good i by the export side of industry j in r ! ;
 Formula (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{IFTAXEXP}(i,j,r) = \text{VIFAE}(i,j,r) - \text{VIFME}(i,j,r);$$

Coefficient (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) IFTAXDOM(i,j,r)
 ! tax on use of imported intermediate good i by the domestic side of industry j in r ! ;
 Formula (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{IFTAXDOM}(i,j,r) = \text{VIFAD}(i,j,r) - \text{VIFMD}(i,j,r);$$

Coefficient (all,r,REG) TIU(r)
 # firms' tax payments on intermediate goods usage in r #;
 Formula (all,r,REG)

$$\text{TIU}(r) = \text{sum}(j, \text{PROD_COMM}, \text{sum}(i, \text{TRAD_COMM}, \text{DFTAXEXP}(i,j,r) + \text{DFTAXDOM}(i,j,r) + \text{IFTAXEXP}(i,j,r) + \text{IFTAXDOM}(i,j,r)));$$

Coefficient (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG) ETAXEXP(i,j,r)
 ! tax on use of endowment good i by the export side of industry j in region r ! ;
 Formula (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{ETAXEXP}(i,j,r) = \text{VFAEXP}(i,j,r) - \text{VFMEXP}(i,j,r);$$

Coefficient (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG) ETAXDOM(i,j,r)
 ! tax on use of endowment good i by the domestic side of industry j in region r ! ;
 Formula (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{ETAXDOM}(i,j,r) = \text{VFADOM}(i,j,r) - \text{VFMDOM}(i,j,r);$$

Coefficient (all,i,TRAD_COMM)(all,r,REG) PTAXEXP(i,r)
 # output tax on exports of good i in region r #;
 Formula (all,i,TRAD_COMM)(all,r,REG)

$$\text{PTAXEXP}(i,r) = \text{VOMEXP}(i,r) - \text{VOAEXP}(i,r);$$

Coefficient (all,i,TRAD_COMM)(all,r,REG) PTAXDOM(i,r)
 # output tax on domestic sales of good i in region r #;
 Formula (all,i,TRAD_COMM)(all,r,REG)

$$PTAXDOM(i,r) = VOMDOM(i,r) - VOADOM(i,r);$$

Coefficient (all,i,TRAD_COMM)(all,r,REG)(all,s,REG) MTAXEXP(i,r,s)
 ! tax on imports of good i from source r in destination s to be used for export production ! ;
 Formula (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)

$$MTAXEXP(i,r,s) = VIMSE(i,r,s) - VIWSE(i,r,s);$$

Coefficient (all,i,TRAD_COMM)(all,r,REG)(all,s,REG) MTAXDOM(i,r,s)
 ! tax on imports of good i from source r in destination s to be used for domestic market
 production ! ;
 Formula (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)

$$MTAXDOM(i,r,s) = VIMSD(i,r,s) - VIWSD(i,r,s) ;$$

Coefficient (all,r,REG) TIMEXP(r)
 # tax payments on imports used for export production in r #;
 Formula (all,r,REG)

$$TIMEXP(r) = \text{sum}(i, \text{TRAD_COMM}, \text{sum}(s, \text{REG}, \text{MTAXEXP}(i,s,r)));$$

Coefficient (all,r,REG) TIMDOM(r)
 # tax payments on imports for domestic use in r #;
 Formula (all,r,REG)

$$TIMDOM(r) = \text{sum}(i, \text{TRAD_COMM}, \text{sum}(s, \text{REG}, \text{MTAXDOM}(i,s,r)));$$

Coefficient (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,s,REG) FMESHR(i,j,s)
 ! share of firms' imports in the export side of the domestic composite, agents' prices !;
 Formula (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,s,REG)

$$FMESHR(i,j,s) = VIFAE(i,j,s) / VFAEXP(i,j,s);$$

Coefficient (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,s,REG) FMDSHR(i,j,s)
 ! share of firms' imports in the dom. side of the domestic composite, agents' prices ! ;
 Formula (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,s,REG)

$$FMDSHR(i,j,s) = VIFAD(i,j,s) / VFADOM(i,j,s);$$

Coefficient (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG) SVAEXP(i,j,r)
 # share of i in total value-added in j in r #;
 Formula (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)

$$SVAEXP(i,j,r) = VFAEXP(i,j,r) / \text{sum}(k, \text{ENDW_COMM}, VFAEXP(k,j,r));$$

Coefficient (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG) SVADOM(i,j,r)
 # share of i in total value-added in j in r #;
 Formula (all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)

$$SVADOM(i,j,r) = VFADOM(i,j,r) / \text{sum}(k, \text{ENDW_COMM}, VFADOM(k,j,r));$$

Coefficient (all,i,DEMD_COMM)(all,j,PROD_COMM)(all,r,REG) STCEXP(i,j,r)
 # share of i in total costs of the export side of j in r #;
 Formula (all,i,DEMD_COMM)(all,j,PROD_COMM)(all,r,REG)

$$STCEXP(i,j,r) = VFAEXP(i,j,r) / \text{sum}(k, \text{DEMD_COMM}, VFAEXP(k,j,r));$$

Coefficient (all,i,DEMD_COMM)(all,j,PROD_COMM)(all,r,REG) STCDOM(i,j,r)
 # share of i in total costs of the domestic side of j in r #;
 Formula (all,i,DEMD_COMM)(all,j,PROD_COMM)(all,r,REG)

$$STCDOM(i,j,r) = VFADOM(i,j,r) / \text{sum}(k, DEMD_COMM, VFADOM(k,j,r));$$

Coefficient (all,i,TRAD_COMM)(all,r,REG)(all,s,REG) MESHRs(i,r,s)
 ! share of imports for export production from r in import bill of s at mkt prices ! ;
 Formula (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)

$$MESHRs(i,r,s) = VIMSE(i,r,s) / \text{sum}(k, REG, VIMSE(i,k,s)) ;$$

Coefficient (all,i,TRAD_COMM)(all,r,REG)(all,s,REG) MDSHRs(i,r,s)
 ! share of imports for domestic use from r in import bill of s at mkt prices ! ;
 Formula (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)

$$MDSHRs(i,r,s) = VIMSD(i,r,s) / \text{sum}(k, REG, VIMSD(i,k,s)) ;$$

Coefficient (all,i,TRAD_COMM)(all,r,REG)(all,s,REG) VIWS(i,r,s)
 ! imports of commodity i from region r to s valued cif (tradeables only) ! ;
 FORMULA (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)

$$VIWS(i,r,s) = VIWSE(i,r,s) + VIWSD(i,r,s) ;$$

Coefficient (all,i,TRAD_COMM)(all,r,REG)(all,s,REG) SHRVIWSE(i,r,s)
 ! share of imports for exports of commodity i from region r to s valued cif (tradeables only) ! ;
 ;
 Formula (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)

$$SHRVIWSE(i,r,s) = VIWSE(i,r,s) / VIWS(i,r,s) ;$$

Coefficient (all,m,MARG_COMM)(all,r,REG) SHRST(m,r)
 # share of sales of m to global transport services in r #;
 Formula (all,m,MARG_COMM)(all,r,REG)

$$SHRST(m,r) = VST(m,r) / VOMEXP(m,r);$$

Coefficient (all,i,TRAD_COMM)(all,r,REG)(all,s,REG) SHRXMD(i,r,s)
 # share of export sales of i to s in r #;
 Formula (all,i,TRAD_COMM)(all,r,REG)(all,s,REG)

$$SHRXMD(i,r,s) = VXMD(i,r,s) / VOMEXP(i,r);$$

Coefficient (all,i,TRAD_COMM)(all,r,REG) VIMEXP(i,r)
 ! value of imports of commodity i for production of exports in r at domestic market prices ! ;
 Formula (all,i,TRAD_COMM)(all,r,REG)

$$VIMEXP(i,r) = \text{sum}(j, PROD_COMM, VIFME(i,j,r)) ;$$

Coefficient (all,i,TRAD_COMM)(all,r,REG) VIMDOM(i,r)
 ! value of imports of commodity i for domestic uses in r at domestic market prices ! ;
 Formula (all,i,TRAD_COMM)(all,r,REG)

$$VIMDOM(i,r) = \text{sum}(j, PROD_COMM, VIFMD(i,j,r)) + VIPM(i,r) + VIGM(i,r);$$

Coefficient (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) SHRIFME(i,j,r)
 ! share of import i used by the export side of sector j in r ! ;
 Formula (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{SHRIFME}(i,j,r) = \text{VIFME}(i,j,r) / \text{VIMEXP}(i,r);$$

Coefficient (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) SHRIFMD(i,j,r)
 ! share of import i used by the dom. side of sector j in r ! ;
 Formula (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{SHRIFMD}(i,j,r) = \text{VIFMD}(i,j,r) / \text{VIMDOM}(i,r);$$

Coefficient (all,i,TRAD_COMM)(all,r,REG) SHRIPM(i,r)
 # share of import i used by private hhlds in r #;
 Formula (all,i,TRAD_COMM)(all,r,REG)

$$\text{SHRIPM}(i,r) = \text{VIPM}(i,r) / \text{VIMDOM}(i,r);$$

Coefficient (all,i,TRAD_COMM)(all,r,REG) SHRIGM(i,r)
 # the share of import i used by gov't hhlds in r #;
 Formula (all,i,TRAD_COMM)(all,r,REG)

$$\text{SHRIGM}(i,r) = \text{VIGM}(i,r) / \text{VIMDOM}(i,r);$$

Coefficient (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) SHRDFME(i,j,r)
 ! share of dom. prod i used by the export side of sector j in r at mkt prices ! ;
 Formula (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{SHRDFME}(i,j,r) = \text{VDFME}(i,j,r) / \text{VDM}(i,r);$$

Coefficient (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG) SHRDFMD(i,j,r)
 ! share of dom prod i used by the domestic side of sector j in r at mkt prices ! ;
 Formula (all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{SHRDFMD}(i,j,r) = \text{VDFMD}(i,j,r) / \text{VDM}(i,r);$$

Coefficient (all,i,ENDWM_COMM)(all,j,PROD_COMM)(all,r,REG) SHREMEXP(i,j,r)
 # share of mobile endowments i used by sector j at mkt prices#;
 Formula (all,i,ENDWM_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{SHREMEXP}(i,j,r) = \text{VFMEXP}(i,j,r) / \text{VOM}(i,r);$$

Coefficient (all,i,ENDWM_COMM)(all,j,PROD_COMM)(all,r,REG) SHREMDOM(i,j,r)
 # share of mobile endowments i used by sector j at mkt prices#;
 Formula (all,i,ENDWM_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\text{SHREMDOM}(i,j,r) = \text{VFMDOM}(i,j,r) / \text{VOM}(i,r);$$

Coefficient (all,i,TRAD_COMM)(all,r,REG) VOW(i,r)
 # value of output in r at fob including transportation services #;
 Formula (all,m,MARG_COMM)(all,r,REG)

$$\text{VOW}(m,r) = \text{VDM}(m,r) * \text{PW_PM}(m,r) * (\text{VOMEXP}(m,r)/\text{VOMDOM}(m,r))$$

$$+ \text{sum}(s,\text{REG}, \text{VXWD}(m,r,s)) + \text{VST}(m,r);$$
 Formula (all,i,NMRG_COMM)(all,r,REG)

$$\text{VOW}(i,r) = \text{VDM}(i,r) * \text{PW_PM}(i,r) * (\text{VOMEXP}(i,r)/\text{VOMDOM}(i,r))$$

$$+ \text{sum}(s,\text{REG}, \text{VXWD}(i,r,s));$$

A.4 New variables and changes to equations in modules A,B and C in GTAP.TAB v. 6.1

Equation REGSUPPRICE

estimate change in index of prices received for tradeables i produced in r

(all,r,REG)

$$\text{VXWREGION}(r) * \text{psw}(r) = \text{sum}(i, \text{TRAD_COMM}, \text{sum}(s, \text{REG}, \text{VXWD}(i, r, s) * \text{pfob}(i, r, s))) \\ + \text{sum}(m, \text{MARG_COMM}, \text{VST}(m, r) * \text{pmexp}(m, r)) ;$$

Equation VGDP_r # change in value of GDP (HT 70) #

(all,r,REG)

$$\text{GDP}(r) * \text{vgdp}(r) = \text{sum}(i, \text{TRAD_COMM}, \text{VGA}(i, r) * [\text{qg}(i, r) + \text{pg}(i, r)]) \\ + \text{sum}(i, \text{TRAD_COMM}, \text{VPA}(i, r) * [\text{qp}(i, r) + \text{pp}(i, r)]) \\ + \text{REGINV}(r) * [\text{qcgds}(r) + \text{pcgds}(r)] \\ + \text{sum}(i, \text{TRAD_COMM}, \text{sum}(s, \text{REG}, \text{VXWD}(i, r, s) * [\text{qxs}(i, r, s) + \text{pfob}(i, r, s)])) \\ + \text{sum}(m, \text{MARG_COMM}, \text{VST}(m, r) * [\text{qst}(m, r) + \text{pmexp}(m, r)]) \\ - \text{sum}(i, \text{TRAD_COMM}, \text{sum}(s, \text{REG}, \text{VIWS}(i, s, r) * [\text{qxs}(i, s, r) + \text{pcif}(i, s, r)])) ;$$

Variable (all,j,TRAD_COMM)(all,r,REG) vo(j,r) # value of output j in region r # ;

Equation VO_r ! change in value of output at agent prices!

(all,j,TRAD_COMM)(all,r,REG)

$$\text{VOA}(j, r) * \text{vo}(j, r) = \text{VOAEXP}(j, r) * (\text{qoexp}(j, r) + \text{psexp}(j, r)) \\ + \text{VOADOM}(j, r) * (\text{qodom}(j, r) + \text{psdom}(j, r)) ;$$

Equation PS_r ! change in output price !

(all,j,PROD_COMM)(all,r,REG)

$$\text{VOA}(j, r) * \text{ps}(j, r) = \text{VOAEXP}(j, r) * \text{psexp}(j, r) + \text{VOADOM}(j, r) * \text{psdom}(j, r) ;$$

Equation QO_r ! change in aggregate output !

(all,j,TRAD_COMM)(all,r,REG)

$$\text{qo}(j, r) = \text{vo}(j, r) - \text{ps}(j, r) ;$$

Equation VREGEX_ir_MARG

the change in FOB value of exports of m from r

(all,m,MARG_COMM)(all,r,REG)

$$\text{VXW}(m, r) * \text{vxwfob}(m, r) = \text{sum}(s, \text{REG}, \text{VXWD}(m, r, s) * [\text{qxs}(m, r, s) + \text{pfob}(m, r, s)]) \\ + \text{VST}(m, r) * [\text{qst}(m, r) + \text{pmexp}(m, r)] ;$$

Equation VWLDOUTUSE # change in value of world output of commodity i at user prices #

(all,i,TRAD_COMM)

$$\text{VWOU}(i) * \text{valuwu}(i) = \text{sum}\{s, \text{REG}, \text{VPA}(i, s) * [\text{pp}(i, s) + \text{qp}(i, s)] \\ + \text{VGA}(i, s) * [\text{pg}(i, s) + \text{qg}(i, s)] \\ + \text{sum}\{j, \text{PROD_COMM}, \text{VFAEXP}(i, j, s) * [\text{pfexp}(i, j, s) + \text{qfexp}(i, j, s)]\} \\ + \text{sum}\{j, \text{PROD_COMM}, \text{VFADOM}(i, j, s) * [\text{pfdom}(i, j, s) + \\ \text{qfdom}(i, j, s)]\}\} ;$$

Equation PREGEX_ir_MARG # change in FOB price index of exports of m from r #
(all,m,MARG_COMM)(all,r,REG)
 $VXW(m,r) * pxw(m,r) = \text{sum}(s, \text{REG}, VXWD(m,r,s) * pfob(m,r,s)) + VST(m,r) * pmexp(m,r) ;$

Equation PWLDUSE # change in index of user prices for deflating world production of i #
(all,i,TRAD_COMM)
 $VWOU(i) * p w u(i) = \text{sum}\{s, \text{REG}, VPA(i,s) * pp(i,s) + VGA(i,s) * pg(i,s) \\ + \text{sum}[j, \text{PROD_COMM}, VFAEXP(i,j,s) * pfexp(i,j,s)] \\ + \text{sum}[j, \text{PROD_COMM}, VFADOM(i,j,s) * pfdom(i,j,s)]\};$

Equation EV_DECOMPOSITION # decomposition of Equivalent Variation #
(all,r,REG)
 $EV_ALT(r) = [0.01 * UTILELASEV(r) * INCOMEVEV(r)] * \\ [DPARPRIV(r) * \log e(UTILPRIVEV(r) / UTILPRIV(r)) * dppriv(r) \\ + DPARGOV(r) * \log e(UTILGOVEV(r) / UTILGOV(r)) * dpgov(r) \\ + DPARSAREV(r) * \log e(UTILSAVEVEV(r) / UTILSAVE(r)) * dpsave(r)] \\ + [0.01 * EVSCALFACT(r)] * \\ [\text{sum}\{i, \text{NTRAD_COMM}, PTAX(i,r) * [qo(i,r) - pop(r)]\} \\ + \text{sum}\{i, \text{TRAD_COMM}, PTAXEXP(i,r) * [qoexp(i,r) - pop(r)]\} \\ + \text{sum}\{i, \text{TRAD_COMM}, PTAXDOM(i,r) * [qodom(i,r) - pop(r)]\} \\ + \text{sum}\{i, \text{ENDW_COMM}, \\ \text{sum}\{j, \text{PROD_COMM}, ETAXEXP(i,j,r) * [qfeexp(i,j,r) - pop(r)]\} \\ + \text{sum}\{i, \text{ENDW_COMM}, \\ \text{sum}\{j, \text{PROD_COMM}, ETAXDOM(i,j,r) * [qfedom(i,j,r) - pop(r)]\} \\ + \text{sum}\{j, \text{PROD_COMM}, \\ \text{sum}\{i, \text{TRAD_COMM}, IFTAXEXP(i,j,r) * [qfmexp(i,j,r) - pop(r)]\} \\ + \text{sum}\{j, \text{PROD_COMM}, \\ \text{sum}\{i, \text{TRAD_COMM}, IFTAXDOM(i,j,r) * [qfmdom(i,j,r) - pop(r)]\} \\ + \text{sum}\{j, \text{PROD_COMM}, \\ \text{sum}\{i, \text{TRAD_COMM}, DFTAXEXP(i,j,r) * [qfdexp(i,j,r) - pop(r)]\} \\ + \text{sum}\{j, \text{PROD_COMM}, \\ \text{sum}\{i, \text{TRAD_COMM}, DFTAXDOM(i,j,r) * [qfddom(i,j,r) - pop(r)]\} \\ + \text{sum}\{i, \text{TRAD_COMM}, IPTAX(i,r) * [qpm(i,r) - pop(r)]\} \\ + \text{sum}\{i, \text{TRAD_COMM}, DPTAX(i,r) * [qpd(i,r) - pop(r)]\} \\ + \text{sum}\{i, \text{TRAD_COMM}, IGTAX(i,r) * [qgm(i,r) - pop(r)]\} \\ + \text{sum}\{i, \text{TRAD_COMM}, DGTAX(i,r) * [qgd(i,r) - pop(r)]\} \\ + \text{sum}\{i, \text{TRAD_COMM}, \text{sum}\{s, \text{REG}, XTAXD(i,r,s) * [qxs(i,r,s) - pop(r)]\} \\ + \text{sum}\{i, \text{TRAD_COMM}, \text{sum}\{s, \text{REG}, MTAXEXP(i,s,r) * [qxsexp(i,s,r) - \\ pop(r)]\} \\ + \text{sum}\{i, \text{TRAD_COMM}, \text{sum}\{s, \text{REG}, MTAXDOM(i,s,r) * [qxsdm(i,s,r) - \\ pop(r)]\} \\ + \text{sum}\{i, \text{ENDW_COMM}, VOA(i,r) * [qo(i,r) - pop(r)]\} \\ - VDEP(r) * [kb(r) - pop(r)] \\ + \text{sum}\{i, \text{PROD_COMM}, VOA(i,r) * ao(i,r)\} \\ + \text{sum}\{j, \text{PROD_COMM}, VVA(j,r) * ava(j,r)\} \\ + \text{sum}\{i, \text{ENDW_COMM}, \text{sum}\{j, \text{PROD_COMM}, VFA(i,j,r) * afe(i,j,r)\} \\ + \text{sum}\{j, \text{PROD_COMM}, \text{sum}\{i, \text{TRAD_COMM}, VFA(i,j,r) * af(i,j,r)\} \\ + \text{sum}\{m, \text{MARG_COMM}, \text{sum}\{i, \text{TRAD_COMM},$

$$\begin{aligned}
& \text{sum}\{s, \text{REG}, \text{VTMFSD}(m, i, s, r) * \text{atmfsd}(m, i, s, r)\} \} \} \\
& + \text{sum}(i, \text{TRAD_COMM}, \text{sum}(s, \text{REG}, \text{VIMSE}(i, s, r) * \text{ams}(i, s, r))) \\
& + \text{sum}(i, \text{TRAD_COMM}, \text{sum}(s, \text{REG}, \text{VIMSD}(i, s, r) * \text{ams}(i, s, r))) \\
& + \text{sum}\{i, \text{TRAD_COMM}, \text{sum}\{s, \text{REG}, \text{VXWD}(i, r, s) * \text{pfob}(i, r, s)\}\} \\
& + \text{sum}\{m, \text{MARG_COMM}, \text{VST}(m, r) * \text{pmexp}(m, r)\} \\
& + \text{NETINV}(r) * \text{pcgds}(r) \\
& - \text{sum}\{i, \text{TRAD_COMM}, \text{sum}\{s, \text{REG}, \text{VXWD}(i, s, r) * \text{pfob}(i, s, r)\}\} \\
& - \text{sum}\{m, \text{MARG_COMM}, \text{VTMD}(m, r) * \text{pt}(m)\} \\
& - \text{SAVE}(r) * \text{psave}(r) \\
& + 0.01 * \text{INCOMEEV}(r) * \text{pop}(r);
\end{aligned}$$

Equation CONT_EV_qor (all,r,REG)
 $\text{CNTqor}(r) = \text{sum}\{i, \text{NTRAD_COMM}, 0.01 * \text{EVSCALFACT}(r) * \text{PTAX}(i, r) * [\text{qo}(i, r) - \text{pop}(r)]\}$
 $+ \text{sum}\{i, \text{TRAD_COMM}, 0.01 * \text{EVSCALFACT}(r) * \text{PTAXEXP}(i, r) * [\text{qoexp}(i, r) - \text{pop}(r)]\}$
 $+ \text{sum}\{i, \text{TRAD_COMM}, 0.01 * \text{EVSCALFACT}(r) * \text{PTAXDOM}(i, r) * [\text{qodom}(i, r) - \text{pop}(r)]\};$

Equation CONT_EV_qoir1
(all,i,NTRAD_COMM)(all,r,REG)
 $\text{CNTqoir}(i, r) = \text{PTAX}(i, r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qo}(i, r) - \text{pop}(r)];$

Equation CONT_EV_qoir2
(all,i,TRAD_COMM)(all,r,REG)
 $\text{CNTqoir}(i, r) = \text{PTAXEXP}(i, r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qoexp}(i, r) - \text{pop}(r)]$
 $+ \text{PTAXDOM}(i, r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qodom}(i, r) - \text{pop}(r)];$

Equation CONT_EV_qfer
(all,r,REG)
 $\text{CNTqfer}(r) = \text{sum}(i, \text{ENDW_COMM}, \text{sum}(j, \text{PROD_COMM},$
 $\text{ETAXEXP}(i, j, r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfeexp}(i, j, r) - \text{pop}(r)])$
 $+ \text{sum}(i, \text{ENDW_COMM}, \text{sum}(j, \text{PROD_COMM},$
 $\text{ETAXDOM}(i, j, r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfedom}(i, j, r) - \text{pop}(r)]));$

Equation CONT_EV_qfeir
(all,i,ENDW_COMM)(all,r,REG)
 $\text{CNTqfeir}(i, r) = \text{sum}(j, \text{PROD_COMM},$
 $\text{ETAXEXP}(i, j, r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfeexp}(i, j, r) - \text{pop}(r)])$
 $+ \text{sum}(j, \text{PROD_COMM},$
 $\text{ETAXDOM}(i, j, r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfedom}(i, j, r) - \text{pop}(r)]);$

Equation CONT_EV_qfeijr
(all,i,ENDW_COMM)(all,j,PROD_COMM)(all,r,REG)
 $\text{CNTqfeijr}(i, j, r) = \text{ETAXEXP}(i, j, r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfeexp}(i, j, r) - \text{pop}(r)]$
 $+ \text{ETAXDOM}(i, j, r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfedom}(i, j, r) - \text{pop}(r)];$

Equation CONT_EV_qfmr

(all,r,REG)

$$\begin{aligned} \text{CNTqfmr}(r) = & \text{sum}(j, \text{PROD_COMM}, \text{sum}(i, \text{TRAD_COMM}, \\ & \text{IFTAXEXP}(i,j,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfmexp}(i,j,r) - \text{pop}(r)])) \\ & + \text{sum}(j, \text{PROD_COMM}, \text{sum}(i, \text{TRAD_COMM}, \\ & \text{IFTAXDOM}(i,j,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfmdom}(i,j,r) - \text{pop}(r)])); \end{aligned}$$

Equation CONT_EV_qfmir

(all,i,TRAD_COMM)(all,r,REG)

$$\begin{aligned} \text{CNTqfmir}(i,r) = & \text{sum}(j, \text{PROD_COMM}, \\ & \text{IFTAXEXP}(i,j,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfmexp}(i,j,r) - \text{pop}(r)]) \\ & + \text{sum}(j, \text{PROD_COMM}, \\ & \text{IFTAXDOM}(i,j,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfmdom}(i,j,r) - \text{pop}(r)]); \end{aligned}$$

Equation CONT_EV_qfmijr

(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\begin{aligned} \text{CNTqfmijr}(i,j,r) = & \text{IFTAXEXP}(i,j,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfmexp}(i,j,r) - \text{pop}(r)] \\ & + \text{IFTAXDOM}(i,j,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfmdom}(i,j,r) - \text{pop}(r)]; \end{aligned}$$

Equation CONT_EV_qfdr

(all,r,REG)

$$\begin{aligned} \text{CNTqfdr}(r) = & \text{sum}(j, \text{PROD_COMM}, \text{sum}(i, \text{TRAD_COMM}, \\ & \text{DFTAXEXP}(i,j,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfdexp}(i,j,r) - \text{pop}(r)])) \\ & + \text{sum}(j, \text{PROD_COMM}, \text{sum}(i, \text{TRAD_COMM}, \\ & \text{DFTAXDOM}(i,j,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfddom}(i,j,r) - \text{pop}(r)])); \end{aligned}$$

Equation CONT_EV_qfdir

(all,i,TRAD_COMM)(all,r,REG)

$$\begin{aligned} \text{CNTqfdir}(i,r) = & \text{sum}(j, \text{PROD_COMM}, \\ & \text{DFTAXEXP}(i,j,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfdexp}(i,j,r) - \text{pop}(r)]) \\ & + \text{sum}(j, \text{PROD_COMM}, \\ & \text{DFTAXDOM}(i,j,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfddom}(i,j,r) - \text{pop}(r)]); \end{aligned}$$

Equation CONT_EV_qfdijr

(all,i,TRAD_COMM)(all,j,PROD_COMM)(all,r,REG)

$$\begin{aligned} \text{CNTqfdijr}(i,j,r) = & \text{DFTAXEXP}(i,j,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfdexp}(i,j,r) - \text{pop}(r)] \\ & + \text{DFTAXDOM}(i,j,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qfddom}(i,j,r) - \text{pop}(r)]; \end{aligned}$$

Equation CONT_EV_qimr

(all,r,REG)

$$\begin{aligned} \text{CNTqimr}(r) = & \text{sum}(i, \text{TRAD_COMM}, \text{sum}(s, \text{REG}, \\ & \text{MTAXEXP}(i,s,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qxsexp}(i,s,r) - \text{pop}(r)])) \\ & + \text{sum}(i, \text{TRAD_COMM}, \text{sum}(s, \text{REG}, \\ & \text{MTAXDOM}(i,s,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qxsdm}(i,s,r) - \text{pop}(r)])); \end{aligned}$$

Equation CONT_EV_qimistr

(all,i,TRAD_COMM)(all,s,REG)(all,r,REG)

CNTqimistr(i,s,r) =

$$\begin{aligned} & \text{MTAXEXP}(i,s,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qxsexp}(i,s,r) - \text{pop}(r)] \\ & + \text{MTAXDOM}(i,s,r) * [0.01 * \text{EVSCALFACT}(r)] * [\text{qxsdm}(i,s,r) - \text{pop}(r)]; \end{aligned}$$

Equation CONT_EV_alleffr

(all,r,REG)

CNTalleffr(r)

$$\begin{aligned} & = [0.01 * \text{EVSCALFACT}(r)] * [\text{sum}\{i, \text{NTRAD_COMM}, \text{PTAX}(i,r) * [\text{qo}(i,r) - \\ & \text{pop}(r)]\} \\ & + \text{sum}\{i, \text{TRAD_COMM}, \text{PTAXEXP}(i,r) * [\text{qoexp}(i,r) - \text{pop}(r)]\} \\ & + \text{sum}\{i, \text{TRAD_COMM}, \text{PTAXDOM}(i,r) * [\text{qodom}(i,r) - \text{pop}(r)]\} \\ & + \text{sum}\{i, \text{ENDW_COMM}, \\ & \quad \text{sum}\{j, \text{PROD_COMM}, \text{ETAXEXP}(i,j,r) * [\text{qfeexp}(i,j,r) - \text{pop}(r)]\} \\ & + \text{sum}\{i, \text{ENDW_COMM}, \\ & \quad \text{sum}\{j, \text{PROD_COMM}, \text{ETAXDOM}(i,j,r) * [\text{qfedom}(i,j,r) - \text{pop}(r)]\} \\ & + \text{sum}\{j, \text{PROD_COMM}, \\ & \quad \text{sum}\{i, \text{TRAD_COMM}, \text{IFTAXEXP}(i,j,r) * [\text{qfmexp}(i,j,r) - \text{pop}(r)]\} \\ & + \text{sum}\{j, \text{PROD_COMM}, \\ & \quad \text{sum}\{i, \text{TRAD_COMM}, \text{IFTAXDOM}(i,j,r) * [\text{qfmdom}(i,j,r) - \text{pop}(r)]\} \\ & + \text{sum}\{j, \text{PROD_COMM}, \\ & \quad \text{sum}\{i, \text{TRAD_COMM}, \text{DFTAXEXP}(i,j,r) * [\text{qfdexp}(i,j,r) - \text{pop}(r)]\} \\ & + \text{sum}\{j, \text{PROD_COMM}, \\ & \quad \text{sum}\{i, \text{TRAD_COMM}, \text{DFTAXDOM}(i,j,r) * [\text{qfddom}(i,j,r) - \text{pop}(r)]\} \\ & + \text{sum}\{i, \text{TRAD_COMM}, \text{IPTAX}(i,r) * [\text{qpm}(i,r) - \text{pop}(r)]\} \\ & + \text{sum}\{i, \text{TRAD_COMM}, \text{DPTAX}(i,r) * [\text{qpd}(i,r) - \text{pop}(r)]\} \\ & + \text{sum}\{i, \text{TRAD_COMM}, \text{IGTAX}(i,r) * [\text{qgm}(i,r) - \text{pop}(r)]\} \\ & + \text{sum}\{i, \text{TRAD_COMM}, \text{DGTAX}(i,r) * [\text{qgd}(i,r) - \text{pop}(r)]\} \\ & + \text{sum}\{i, \text{TRAD_COMM}, \text{sum}\{s, \text{REG}, \text{XTAXD}(i,r,s) * [\text{qxs}(i,r,s) - \text{pop}(r)]\} \\ & + \text{sum}\{i, \text{TRAD_COMM}, \text{sum}\{s, \text{REG}, \text{MTAXEXP}(i,s,r) * [\text{qxsexp}(i,s,r) - \\ & \text{pop}(r)]\} \\ & + \text{sum}\{i, \text{TRAD_COMM}, \text{sum}\{s, \text{REG}, \text{MTAXDOM}(i,s,r) * [\text{qxsdm}(i,s,r) - \\ & \text{op}(r)]\} \}]; \end{aligned}$$

Equation EXPPRICE_MARG

Price index for total exports of m from r

(all,m,MARG_COMM)(all,r,REG)

$$\text{px_ir}(m,r) = \text{sum}(s, \text{REG}, \text{SX_IRS}(m,r,s) * \text{pfob}(m,r,s)) + \text{SXT_IR}(m,r) * \text{pmexp}(m,r);$$